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Towards A Field Theory of Innovating Multinational Firms in the Digital Economy: Creative Capital in a POLIS

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Abstract

In the fast developing digital technological revolution connectedness has emerged as a major characteristic of both firms and markets. For multinational firms in high technology area in general this raises some interesting and fundamental theoretical questions. How is connectedness to be formalized? What is the role of increasing returns in the new connected structure? How should we formulate the firm's activities in multiproduct, multiple activities environment? A somewhat novel theoretical approach is suggested for modeling the activities of the multiproduct, multiple activities oriented. MNC. This paper discusses some of the most important economic issues conceptually by relying on the idea of each MNC as a node in the global economy as a connected field. The basic problem of innovation for a high technology firm in a connected field can be explored via the theory of a positive feedback loop innovation system (POLIS) in a nonlinear, path-dependent world where the connectedness within the firm and between the firms and its evolution matter crucially. By investing strategically in physical, creative intellectual and other forms of human and organizational capital as well as building new institutions of cooperation some firms are able to create micro-innovation systems of their own that can be extended to region-wide systems. Under the emerging globally competitive market environment this will be the best way to compete dynamically. However, creating competitive advantage in this way requires capabilities that many firms will need to promote. Creative capital acquisition as an important dimension of the MNC behavior is one implication of this new field theory and can be tested at the microlevel.

Introduction:

The digital age has been heralded with great fanfare. However, if hyberboles are set aside and a sober assessment is made, we find the beginnings of a technological revolution that has already created much uncertainty. So far the benefits have also been largely confined to the developed countries, and even there the distribution of these benefits has been highly uneven.. Even the newly industrialized economies (the NIEs) have found it hard to catch up and maintain the pace required for not falling behind. Firms in both developed countries such as the US and in the NIEs face much uncertainty in product development and core process innovation. Both leaders and followers are uncertain about the technological trajectories and competitive dynamics. One example of this is the Flat Panel Display(FPD) where the core processes was discovered in the developed countries' universities and research laboratories. The leading Japanese firms developed the idea of mass producing for particular product types; but were then followed by a number of NIEs such as Korea, Taiwan and Singapore. We need a new theory of the firm as a connected system in a field[1] both internally and externally to explain features of fast product development and fast followership.[2]

In this paper, a field theory based on the idea of connectivity of an innovating MNC in the global economy is developed in the context of an overall macro innovation system called POLIS--- *POSITIVE FEEDBACK LOOP INNOVATION SYSTEM*. The framework can be used to understand the nature and pace of innovation both systemically and within the MNCs as part of the global system. It can also be used for analyzing the strategic options for the MNCs in both the developed economies and in the NIEs in the 21st century.

Specifically, in the next section, the basic problem of the creation of a new technology system such as the ICT(information and communications technologies) within the global economy by a group of MNCs is explored via the Schumpeterian concept of creative destruction. Section 3 sketches out the links between the innovation in leading sectors such as the such as the ICT(information and communications technologies) sectors, overall innovation, growth and development. Section 4 briefly outlines some special economic features related to the ICTs. Most important among these are the increasing returns to scale, network externalities and a disequilibrium process that can result in multiple possible equilibria at the end. Section 5 gives a model for the multi-product and process firm with R and D as

[1] The idea of a field, as far as I am aware, was formalized in Physics in describing the actions of various forces at a point in space(since Einstein's work, in space-time). In economics and international business studies the idea is analogous but necessarily broader. It is not enough to describe a firm as a point in the economic space endowed with a technology. One must go further inside the firm and pinpoint the internal connections that hold a firm together. At the same time the connections between firms and other actors in the economic space must be specified.

[2] "Fast follower ship" is a term developed by John Mathews(2003) to describe the industrial dynamics in East Asia in the FPD industry.

specialized activities. Some substantive empirical implications are explored. The study leads towards a recognition of the importance of creative human capital and the strategy for attracting and deepening such a capital base. Although the MNCs in the ICT sectors are chosen as the exemplars behind the theory, the theory itself is quite general and can be used for many other high technology firms in the world economy.

2. ICTs and Creative Destruction: the importance of the *competitive field*

Writing in another era, Joseph Schumpeter seems to have been quite prescient in terms of describing the essence of what is happening globally today. In his book *Capitalism, Socialism and Democracy*, he averred:

> The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers' goods, the new methods of production or transportation, the new markets,.... (This process) incessantly revolutionizes the economic structure *from within,* incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism.[3]

The ICT revolution in progress today is indeed a Schumpeterian process of creative destruction. The essence of capitalism in this view, is the constant revolutionizing of the economic structure from within. Marx had made a similar observation about the endogenous nature of technical change (Marx, 1867, 1945). Aghion and Howitt (1992) have proposed a model of creative destruction by treating the innovation process as intense inter-firm rivalry, as in the patent-race literature.

The present approach assumes, following Schumpeter, and Aghion and Howitt, that innovation in specific multinational firms can have global economy-wide effects. The expected growth rate of the global economy depends on the economy-wide amount of research generated by the leading MNCs in particular ; but the process of this growth, precisely because research leads to the development of new products and processes, is characterized by creative destruction.

The relationship between R&D and growth of individual firms and of the global economy is therefore both intimate and complex. A model of the innovating MNC needs to be embedded in a global competitive field. Such a model intending to capture the complex micro-macro relationship will need to posit non-linearities and complex feedback rules. One possible way this can be done is by defining non-linear production structures at the level of the firm and of the global economy so that increasing returns and endogenous innovations are possible. Formally, one can explore the properties of fixed points that define equilibria at any point in time. A sequence of such equilibria over time, picked by an appropriate selection procedure, can then show the evolution of both the

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[3] Schumpeter (1942) p. 83

micro- and the macro- systems.[4] In section 5, a prototype model is presented with two different existence proofs, first on a vector lattice, and then on the Banach space.
The problem of the firms that are behind in both developed economies and the NIEs in this ICT revolution is precisely that they face the destructive side of this process without being able to benefit necessarily from the creative side. The prospects for benefits exist but to realize them will require specific strategic reorientation of the MNCs which are somewhat behind the technological frontier.

3. ICT, Innovation, Growth and Development:

Before discussing the relation between ICT sectors and economic growth, innovation and development, it is first necessary to have a clear definition of the ICT sectors. The most widely accepted definition so far is the one agreed to at the April 1998 meeting of the Working Party on Indicators for the Information Society (WPIIS) and subsequently endorsed at the September 1998 meeting of the Committee for Information, Computer and Communication Policy of OECD. The following principles underlie the definition.

For *manufacturing industries*, the products of a candidate industry:

- Must be intended to fulfill the function of information processing and communication including transmission and display.
- Must use electronic processing to detect, measure and/or record physical phenomena or to control a physical process.

For *services industries*, the products of a candidate industry:

- Must be intended to enable the function of information processing and communication by electronic means.

Based on these principles the ICT sectors are identified within the revised classes of the International Standard Industrial Classification (ISIC). In manufacturing and services the following four digit sectors are included:

Manufacturing

- 3000-Office, accounting and computing machinery
- 3130-Insulated wire and cable
- 3210-Electronic valves and tubes and other electronic components
- 3220-television and radio transmitters and apparatus for line telephony and line telegraphy
- 3230-Television and radio receivers, sound or video recording or reproducing apparatus, and associated goods
- 3312-Instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process equipment
- 3313-Industrial process control equipment

[4] For an extended formal treatment , see Khan (1998) and Khan(2001a). Existence proofs for multiple equilibria are also given in these sources.

Services

- 5150-Wholesaling of machinery, equipment and supplies
- 7123-Renting of office machinery and equipment (including computers)
- 6420-telecommunications
- 7200-Computer and related activities

In short, roughly there are three broad categories of the new ICTs: (1) computing (2) communicating (3) Internet-enabled communication and computing.
Strictly speaking, not all of ICT sectors are digital, or at least not yet. Even within the digital part, the pre- and post- internet distinction is historically important and relevant for the developing economies, as Tschang(2000) points out.
We can roughly dissect the digital economy's infrastructure into its pre-Internet and Internet eras. Before the Internet, a host of information technologies came into existence, which provided computing power on a platform-specific system, usually centralized (e.g. a central mainframe with terminals) or distributed within a local area. The advent of the Internet (and its precursors, the U.S. government-funded research networks like the defense research network - ARPANET) was a critical event because it set up the basic infrastructure, standards (e.g. protocols for communication) and technologies, that enabled large scale, distributed and platform-independent information exchange and manipulation. This "single" system allowed the introduction of literally unlimited sources of information, or access points to it, in a *scaleable* fashion, i.e., without increasing numbers of constraints or decreasing economic "returns to scale". The first computing functions consisted of basic email and file transfer capabilities like *ftp* and *gopher*, but these were soon coupled with basic "Web" technologies, like the development of the first browsers and the standards and technologies of the "World Wide Web". This latter further improved the remote accessing and manipulation of information, and ensured that all information could be "web-based", and therefore potentially viewable/downloadable by anyone connected to the Web. All these set the stage for electronic commerce to take place, since the connection of such large numbers of people to all the sources of information provided a potential market never possible in the history of markets.

Today, the developing countries may be able to leapfrog, as Soete (1985) had earlier conjectured for microelectronics; but there is a real danger of just lagging behind.The situation can be summarized by simply looking at the state of e-commerce infrastructure. OECD (1999) offers a classification of the infrastructure sectors for e-commerce: (1) hardware (PCs, routers, servers etc.), (2) software to run the hardware and e-commerce packages, (3) network service providers (e.g. providing Internet access), and (4) enabling services (e.g. e-payment, authentication/certification services, advertising and delivery). The revenue for these four categories have been estimated as follows:

Table 1. Value of E-commerce (billions of U.S. dollars)

	1995-97	2000-02
Hardware	11-30	43-72
Software and computer services	0.9	3.8-5.1
Network service providers	0.3-6.3	5-46.4
Enabling services	0.5-1	7.6-10
E-commerce		
Total e-commerce (median of multiple studies)	0.7	155
Business-to-business e-commerce (average over various years: 1996-2002)	78	

Source: (Tschang (2000), OECD (1999))

The state of the developing economies is underlined by the fact that this table does not even include them as a category via a breakdown into developed and developing economies. One reason why this idea may not even have crossed the minds of the OECD volume authors is that even if the suggested breakdown were to be carried out, the percentage share within each category (in table 1 above) for the developing economies would have been less than one per cent. Along the key dimensions of a digital economy such as computers per capita, internet providers, telecommunications infrastructure and cellular telephony etc. also the developing countries are far behind the developed ones. Even advanced developing countries, i.e., NIEs and other large economies such as the Asian tigers, China, India, Brazil or Mexico are in danger of falling further behind. What can explain this tendency and how best can the leading MNCs in the NIEs catch up? A conceptual clarification of the basic economics involved will help guide policy discussions in this area. It is to this task that the rest of the paper is devoted.

4. The Basic Economics of ICT and Knowledge Sectors:

The key to understanding the economics of ICT and knowledge sectors is to realize that a disequilibrium process has set in within the world economy and the advanced countries of the world that is leading to rapid economic changes. These changes include intersectoral shifts toward the ICT and knowledge sectors, changing skill requirements, high volatility of wages, profits and financial variables and consequent increase in uncertainty about the future states of the economy. The dynamics of this disequilibrium process must be studied through methods of understanding complexity.Clearly, our knowledge of such dynamic systems is still in its infancy; but much can be learned by studying some known features.

In the last twenty years, the frontiers of economics have moved far beyond the standard models of decreasing or constant returns where costs can not be decreased beyond a certain point, unless factor markets behave in a peculiarly decreasing marginal cost fashion. Leaving the perfectly competitive world behind, economists at the frontiers have been focusing on increasing returns to scale, economies of scope and network externalities.[5] The world of high technology in general and the ICT and knowledge sectors in particular, are characterized much better through these approaches than the old perfectly competitive models. Many models of imperfect competition have also been developed to study interesting and relevant phenomena such as R&D rivalry and R&D expenditures. The upshot of these developments is that economists at the frontiers of their discipline are much closer to understanding many aspects of the digital economy than they were ten years ago. In this paper I want to illustrate this point by discussing a recently developed theoretical and modeling approach. The policy implications for the ICT and knowledge sectors of both developed and developing countries are quite striking.

At the micro-level, for the MNCs from the developed countries, there already exists a network of supply chain and marketing arrangements. These firms also have a ready R and D structure with connected nodes going through the universities and strategic alliance partners in various parts of the world. There are in many cases, even in the US, a government-industry partnership. For an NIE, the last factor is often the most significant. However, unless the quality of research in both the industrial and university laboratories is improved rapidly, there is a danger that these firms will fall further behind. At best, they will assume the status of subcontractors for the developed country MNCs.

5. Positive Feedback Loops, Connected Firms and Innovation: A Field-Theoretic Model

Technological systems in the advanced industrial countries (Freeman:1987;Nelson: 1993;Anderson and Lundvall: 1992;) can be thought of as networks of firms and other

[5] Among the sources cited in the references see in particular, Arthur(1994), Matsuyama (1991), Khan(1998) among others.

institutions. As a systems-oriented, holistic way of thinking about technological change it has undoubted strengths. By drawing the link between R&D, human resources development, formal education and training as well as innovating firms,

at the macro-level NIS (national innovation system) presents an analytical schema for relating a cross cutting array of activities that lead to a dynamic innovative economy. The proponents of this approach also advocate an `evolutionary' as opposed to a mechanistic approach based on classical physics type study of equilibria for studying the economics of innovation.

However, for the MNCs, the global dimension is important. The locational imperatives of MNCs are driven by the global input-output characteristics of the firm and its resource base.

Khan(1998, 2001a; 2002) has formalized an alternative approach at the economy wide level and has coined the abbreviation POLIS to emphasize both the disequilibrium positive feedback loop features and the politico-social dimensions of the technological transitions. For the current ICT transitions in developing countries this model has been applied to South Korea, Taiwan, China and India, with work underway for Indonesia. Here, the model is further applied to study the microeconomic structure of MNCs in a connected global economy.

In order to give the reader some idea of the problem of formalizing the problems of innovation for MNCs with complex technological systems, in this section, I present a 'simple' non-linear model embodying distinct technological systems. The model is presented as a matrix representation of the production and innovation activities of the multinational firm within the world economy. The key distinction here is the explicitly non-linear nature of the functional input-output relationships. In particular, the R and D activities of this multi-product innovating MNC are nonlinearly connected to the production structure. The key theorem shows the existence of equilibrium. It is important to underline that the equilibrium is not necessarily unique. Some further considerations (using Herbert Amann's theorems on fixed points of increasing maps) show that multiple equilibria are the natural outcomes in such models.One important implication of this theoretical finding is that the firm may be able to operate at a high level of efficiency and innovating capacity. However, it may also stagnate at a low-level equilibrium. Thus the world of MNCs is an uneven world. Even among the key players there is constant shifting of positions. However for NIEs there is a real prospect of losing competitive advantage, or simply being confined to produce as an export platform for the developed country MNC. More formally, if there are "n" production activities then there are mappings connecting each activity with as many relevant other activities globally (including other production activities) as possible. In terms of the MNCs technology systems, the production activities can be broken down into a production (sub-) system and a set of innovative activities. One major component of the entire innovation system is, of course, the expenditures on R&D. This can appear either as an aggregate expenditure along the column labeled R&D, or as a set of disaggregated expenditures.[1] In the latter case these may be specified according to productive activities (e.g., construction, electrical equipment, the "digital sectors" etc.) or by institutions (e.g., private R&D expenditures, government R&D expenditures, etc.). It should be emphasized that the dynamic effects of R&D on the economy can be captured only in a series of such matrices over time. This approach is still at the conceptual stage, but appears to be quite appealing. One can contrast the possible strategic questions for the MNCs that can be asked within such a framework with the apparently ad hoc type of advice given by the business strategy Gurus. In particular, the impact over time of a particular strategy(e.g., product diversification, market niche etc.) can be traced by building and maintaining such matrices with changing linkages and structures.

In the following model, the main result establishes a multiplicity of equilibria when the innovation system of the MNC exhibits a non-linear relationship between parts of the network. Such a relationship may obtain simply because of the existence of increasing returns to scale in production. Other types of non-linearities may also be present. However, the non-linearities in the production relations are the most relevant ones from the perspective of an MNC. Among other things this creates the possibility of moving from a technologically stagnant equilibrium to an equilibrium.

We begin with a number of productive activities reflecting the existing technological structure of the MNC. We also incorporate the possibility of R&D as a separate productive activity. At the level of abstraction we are working, it is always possible to break R&D down into as many finite components as we want. The key relationship in this context is that between the endogenous accounts (usually, production activities, factors and households) and the exogenous ones. It is this relationship that is posited to be non-linear and this together with some assumptions on the mathematical space can lead to the existence of multiple equilibria, as shown below. We now turn to the formal part of the analysis. The analysis is carried out in abstract function spaces. In the first part the relevant space is a vector lattice over a real field R. In the second part some results on ordered Banach space are discussed.

I. The Model on a Lattice

Define X as a vector lattice over a subring M of the real field R.

Let $x_+ = \{x \mid x \in X, x \geq 0\}$

A non-linear mapping N is defined such that $N : X_+ \to X_+, N_0 = 0$. Given a vector of exogenous variables d, the following non-linear mapping describes a simultaneous non-linear equations model of an economy, E:

$$x = Nx + d$$
(1)

for a given $d \in X_+$.

This non-linear system represents a production and innovation field for the MNC, as described previously. In order to specify the model further, the following assumptions are necessary.

1. X is order complete
2. N is an isotone mapping
3. $\exists \hat{x} \in$ such that $\hat{x} \geq N\hat{x} + d$

In terms of the economics of the model, the non-linear mapping from the space of inputs to the space of the outputs allows for non-constant returns to scale and technical progress over time. The 3 assumptions are minimally necessary for the existence of an equilibrium. Assumption 3, in particular ensures that there is some level of output vector which can be produced given the technical production conditions and demand structure.

<u>Existence of Multiple Equilibria:</u>

Theorem: Under the assumptions 1 - 3, there exists $x^* \in X_+$ so that x^* is a solution of $x = Nx + d$

Proof: Consider the interval $[0, x] = \{\hat{x} \mid \hat{x} \in X_+, 0 \le \hat{x} \le x\}$ where $\hat{x}$ is defined as in assumption 3. Take a mapping F.

$F : x \in X_+ \to Nx + d$

F is isotone and maps $[0, x]$ into itself.

Define a set $D \equiv \{x | x \in [0, x], x \ge Fx\}$.

By assumption 3, D is non-empty.

We now show $x^* \equiv \inf D$ is a solution to $x = Nx + d$. $x^* \equiv \inf D$; therefore $x^* \le x, \forall x \in D$. F is isotone; therefore $Fx^* \le Fx \le x$ for each $x \in D$ implying.

$$Fx^* \le x^*$$

From (2) we have $F(Fx^*) \le Fx^*$. Thus $Fx^* \in D$; hence $x^* \equiv \inf D \le Fx^*$ so, $Fx^* \le x^* \le Fx^*$. Therefore $x^* = Fx^*$.

This is an application of Tarski's and Birkhoff's theorem. The key feature to note here is that the equilibrium is not necessarily unique.

II. Multiple Equilibria on Banach Space:

In this section the results for multiple equilibria are extended to functionals on Banach Space. We can define the model again for monotone iterations, this time on a non-empty subset of an ordered Banach space X. The mapping $f : X \to X$ is called <u>compact</u> if it is continuous and if $f(x)$ is relatively compact. The map f is called <u>completely continuous</u> if f is continuous and maps bounded subsets of X into compact sets. Let X be a non-empty subset of some ordered set Y. A fixed point x of a map $N : X \to X$ is called minimal (maximal) if <u>every</u> fixed point y of N in X satisfies

$$x \le y (y \le x)$$

Theorem: Let (E, P) be an ordered Banach space and let D be a subset of E. Suppose that $f : D \to E$ is an increasing map which is compact on every order interval in D. If there exist y, $\hat{y} \in D$ with $y \le \hat{y}$ such that $y \le f(y)$ and $f(\hat{y}) \le \hat{y}$, then f has a minimal fixed point x. Moreover, $x \le y$ and $x = \lim F^k(y)$. That is, the minimal fixed point can be computed iteratively by means of the iteration scheme

$$x_0 = y$$

$$x_{k+1} = f(x_k) \qquad k = 0,1,2,....$$

Moreover, the sequence (x_k) is increasing.

Proof: Since f is increasing, the hypotheses imply that f maps the order interval $[\bar{y}, y]$ into itself. Consequently, the sequence (x_k) is well-defined and, since it is contained in $f[\bar{y}, y]$, it is relatively compact. Hence it has at least one limit point. By induction, it is easily seen that the sequence (x_k) is increasing. This implies that it has exactly one limit point $\bar{x}$ and that the whole sequence converges to $\bar{x}$. Since f is continuous, $\bar{x}$ is a fixed point of f. If x is an arbitrary fixed point in D such that $x \geq \bar{y}$, then, by replacing y by x in the above argument, it follows that $\bar{x} \leq x$. Hence $\bar{x}$ is the minimal fixed point of f in $(\bar{y}+P) \cap D$. It should be observed that we do not claim that there exists a minimal fixed point of f in D.

We can also show that if $F : x \in X_+ \rightarrow Nx + d$ is an intersecting compact map in a non-empty order interval $[x, \hat{x}]$ and $x \leq Fx$ and $F\hat{x} \leq \hat{x}$ then F has a minimal fixed point x^* and a maximal fixed point x^{**}. Moreover, $x^* = \lim F^k(x)$ and $x^{**} = \lim F^k(\hat{x})$. The first of the above sequences is increasing and the second is decreasing.

The above results are applications and extensions of fixed point theorems for increasing maps on abstract spaces due to Herbert Amann (1976). It is intriguing that they find such natural applications in economics with evolving technology systems and non-constant returns to scale. Although those theorems provide some structure for the equilibria in the MNCs production structure with evolving technology systems, it is not specified a priori which equilibrium will be reached. The problem of equilibrium selection thus remains open. The idea behind the field theory of the MNC can now be stated more formally. It is to reach a sequence of equilibria so that the maximal fixed points that are attainable are in fact reached through a combination of market forces and the MNCs strategic policy maneuvers over time. It is also to be understood that path-dependence of technology would rule out certain equilibria in the future. Thus initial choices of strategies and technologies can matter crucially at times.This highlights the need for choosing the appropriate types of ICTs and creating complementary human and knowledge capital right from the beginning.

6. Conclusions:Complex Technological Systems, Creative Capital and the Innovating MNC

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It has been known for some time that technological systems of the MNCs are complex structures with many types of feedback loops and nonlinear relations. In this context, strategies of technological development of MNCs assume new importance. services, etc.

Therefore, it is the creation of an innovation system within the MNC and the global economy in a mutually reinforcing way that will determine the viability of a technology-based growth process. This process of building an innovation system at the macro-level is very much an evolutionary and path-dependent process.(Nelson 1981, 1989, 1993, 1994; Nelson and Winter 1974, 1977, 1982) The central idea is that the provision of appropriate types of capital, labor and forms of organization for high value-added industries will lead to rapid productivity increases. However, to sustain such an increase, firm-specific innovation systems by MNCs connected to other such systems must be set up. There is a further requirement that this innovation system must fulfill. This is the requirement of a positive feedback loop or a virtuous cycle of innovations. I have emphasized the role of creative human resources--- “creative capital”--- as a central aspect of the innovating MNC at the microeconomic level within the context of a global economy.

This problem of creating the optimal human and physical capital mix for an innovating MNC, as I have emphasized, is intimately connected formally with the existence of multiple equilibria within the firm as a complex organization and within complex economies as macro-structures. A positive feedback loop leading to a virtuous cycle of growth and technology development is one particular sequence of micro- and macro-equilibria in this context.[6] In general, such a sequence also involves increasing returns.

In a market economy, ‘success’ is often cumulative or self-reinforcing. Typically outcomes are not predictable in advance. However, once an equilibrium gets selected out of a number of long-run equilibria, there is a tendency to be locked in. Thus the MNCs in advanced economies that are already established do enjoy some advantages. Technically, economic processes both within the firms and in the global economy exhibit non-convexities -- violating the generic assumption of competitive equilibrium economics. The presence of self-reinforcing mechanisms sharing common features found in fields as far apart as enzyme reactions and the economics of technical change underlines the importance of such mechanisms in governing the dynamics of self-reinforcing processes regardless of the field in which they occur.[7]

It is easy to see that the virtue of a field-theoretic approach to the problem of innovating MNCs in developed economies. By their connectivity internally and strategic locational nodes in the global network, they have the opportunity to innovate continuously as long as the institutional environment does not change drastically. However, temporary or permanent disturbances in the global economy may create opportunities for the less advanced firms within both the developed countries and in the NIEs. Whether these firms can take advantage of these occasional opportunities depend on both internal field characteristics such as their resource access capacity and organizational capital, and on external field characteristics such as governmental linkages, strategic alliances with other firms, export opportunities and financing from outside.

If one follows the field-theoretic reformulation of the Schumpeterian approach to technology creation as a cascade of interlinked systemic activities, the possibilities for economies of scale and scope leading to the establishment of a POLIS arise out of the conjunction of a market system open to the world economy and selective interventions. For developed economy MNCs, strategies involve maintaining and improving both physical and

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[6] If there is more than one such sequence, we may be tempted to choose from among them, the “optimal” sequence, according to some well-defined criterion, e.g., present value maximization.
[7] See the essays in Arthur(1994) for some illuminating discussions.

human capital component of the firms. In particular, the knowledge capital that is both tacit and codified must be maintained and enhanced. For the NIEs, much more is needed. Creative capital must be attracted from abroad through a proper set of incentives. In some cases, this would require “reverse brain drain” policies.
Promotion of targeted infant industries leading ultimo,ately to high tech industries has also been part of this strategy of selective interventions in Korea, for instance. Examples include cement, fertilizer and petroleum refining in the 1960s. These were followed by steel and petrochemicals. In the late 1970s, shipbuilding, other chemicals, capital goods and durable consumer goods appeared on the list. More recently, electronic and information technologies are being promoted. Do these industries innovate? Even if they individually do innovate, do the industrial, governmental and social institutions connected to the innovation process add up to an innovation system? Furthermore is the innovation system, if it exists, characterized by positive feedbacks? These are questions that have not been answered definitively yet. Much further research is required. However, our theoretical explorations make one point clear.

As long as the connectivity of firms internally and externally can be expanded there is a good chance for a large firm from an NIE such as Korea or Taiwan to develop an internal innovation system. With the accumulation of knowledge, creative human capital and financial capital, such firms can grow and eventually become MNCs themselves. However, both the formal field-theoretic models and our nonformal analysis show that such a process is far from inevitable. The dynamics of MNC formation is partly path dependent and partly stochastic. This should be an area of extensive theoretical and empirical research in the future.

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