Cross-national and Cross-industrial Comparison of Two Strategy Approaches for Global Industrial Evolution

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Abstract--**This research focuses on analyzing the two prime science and technology (S&T) strategy approaches for industrial evolution based on the concept of S&T gap, namely, the optimist and pragmatist approaches. Particularly, the cases of global IC, pharmaceutical, and computer industries, are used to make cross-national and cross-industrial comparison of these two approaches. The optimist approach is developed based on the product life cycle theory which envisions technology transcending everyday limitations. With this perspective, market demand is the most critical factor in selecting the S&T strategy approaches. The pragmatist approach is formed based on the new trade theory which recognizes the power of science and technology but seeks to fit it into structures that already exist, and government must manage resources pouring into science and technology. Case studies of global IC, pharmaceutical, and computer industries during the 2nd half of the 20th century are used as research targets to reflect policy impacts on the technological evolution. The results of this study reveal that, strategy approaches have to be adapted and turned to the specific stage, technology level, and market segment that have been selected for intervention. This result of comparison also offers the criteria of strategy approach selection for developing different industry based on distinct national base.**

I. INTRODUCTION

The debates of economic policy have been devoted to increasing attention to the design and selection of policies to aid the growth of high-technology industries. The emergence of "science and technology policy" (S&T policy) as an area of debate and controversy in the United States had been influenced by the different visions for technological evolution at the postwar period, and increasingly evolved to two different strategy approaches – the optimist and pragmatist approach [126].

This research focuses on analyzing these two prime S&T visions and the corresponding firm-level strategies and policy-level approaches based on the change of S-T gap. The optimist approach is developed based on the product life cycle theory which envisions technology transcending everyday limitations. With this perspective, market demand is the most critical factor in selecting the S&T strategy approaches. The pragmatist approach is formed based on the new trade theory which recognizes the power of science and technology but seeks to fit it into structures that already exist, and government must manage resources pouring into science and technology. This research elaborates benefits and detriments of these two approaches, and the evolution patterns resulting from the variation of S&T gap also are discussed.

It is vital to verify the industrial circumstantial conditions and national economic strategy prior to decision-making for S&T policy, including selection between the optimistic or pragmatic approaches. As a result, this research intends to develop the analytical criteria for the circumstantial conditions of industrial development by an anatomy of the benefits and detriments of these two approaches, and the industrial evolution patterns derived from different S&T approaches.

Case studies of global IC, pharmaceutical, and computer industries during the 2nd half of the 20th century are used as research targets to reflect policy impacts on the industrial evolution. A cross-national and cross-industrial comparison would be analyzed, to offer criteria of strategy approach selection. Not only does it provide firm-level strategy approaches in different industrial stages, it also makes a policy-level approach comparison for future reference.

II. LITERATURE REVIEW

A. The Dynamics of Comparative Advantage

At one time in the history of industries, firms located in one country developed superior technologies or products, ways of organizing production, or market strategies that gave them significant advantages over other firms based in other countries. The traditional absolute advantage theory [121] could not explain the situation where one country is more efficient than another in developing some technologies or producing specific goods. Thus, the comparative advantage theory proposed by David Ricardo [107] stated that both countries would gain from trade by their comparative advantages in producing a good relative to the other nation.

Economists often expressed the concept of comparative advantage in static terms, under the assumption that many key variables, such as technologies, never change over time. In addition to Ricardo, the Heckscher-Ohlin theorem [55, 92] also assumed that the technology factor remains essentially unchanged in all trading countries and the production function is identical anywhere in the world. However, a number of theories examined changes in the nature of a technology to describe realistic industrial situations, in firms, industries, and supporting institutions as a technology matures. These theories in turn yielded several different views of the dynamics of comparative advantage that are germane to this research [87, 115].

Two broad theories considered the interaction of technological and industrial dynamics in the changing locus of comparative advantage. One group of theories is the product life cycle theory developed initially by Posner [99], Hufbauer [59], and Vernon [135]. Abernathy and Utterback [1] are the names most frequently associated with the theory that suggests a systematic pattern of change in a technology as the technology evolves from novelty to maturity. This theory argued that high-income countries generally pioneer in new technology for two reasons. One is that these countries tend to be abundant in industry R&D investment and a comparative advantage in new technology, and the other reason is that high-income domestic markets also tend to demand higher-quality goods [132].

Additionally, the Posner-Vernon life cycle theory [135] stated that outflows of technology through foreign investments and other channels erode the comparative advantages in the formerly high-income countries. As a product technology matures, comparative advantages rely more heavily on low cost, where lower-wage countries may become more competitive production sites for these specific products [87].

Another theory to explain technological and industrial dynamics in the changing locus of comparative advantage is the new trade theory originally expounded in a series of papers by Dixit and Norman [38], Lancaster [72], Helpman [56], Ethier [40], and Krugman [71]. These theorists argued that countries take advantage of not only their differences; also trade because of increasing returns, which makes specialization advantageous per se. It stated that economies of scale are reduction of manufacturing cost per unit as a result of increased production quantity during a given time period, and intra-industry trade (international trade involving the same industry) is largely driven by increasing returns resulting from specialization within the industry [115].

Thus, this new trade theory suggests that successful early entrants into an industry may establish an advantage that latecomers are unable to offset. These first-mover advantages are rooted in fixed investments to lower a learning curve and are specific to an industry.

These two theories, describe dynamic comparative advantages, were broadly used to explain the systematic shift in locus of industrial leadership [87], and evaluate the impacts of technological evolution on industrial development [27]. The concepts were also developed to formulate a theoretical basis of traditional S&T policy that identify the factors that led to the emergence of national leadership, and the reasons behind the shifts that occurred [126].

B. S-T Gap and Industrial Evolution

The concept of S-T gap was widely investigated to explain the dynamics of comparative advantage since the discussion of the relationship between science and technology have gathered great importance in recent years. An early development [18, 101] in this discussion was the claim that science and technology were path-independent and seldom interacted in progress. More recently, several studies [15, 12, 3, 68] have noted that some links exist between science and technology, and scientific discoveries have provided the knowledge bases for technological innovations in a pattern. Betz [14] clarified that, by definition, science understands nature and technology manipulates nature for human purposes, and also offered a sounder theoretical basis for the science and technology information tracks to explain that once science has created a new phenomenal knowledge base, inventions for a new technology may be made at this time to begin investment in a technological revolution and a new industries or even fuel a new economic expansion. Another finding of studies [103] also examined a relationship between science and technology through the knowledge creation process and classified it into self-motivated creativity, system understanding, advanced skill and cognitive knowledge.

The relationship between science and technology has also been addressed, by Teitelman [126], that here is a model of how a steadily narrowing gap between science and technology actually alters the dynamics of comparative advantages and industrial structure. The definition of S-T gap was depicted as the maturity of scientific knowledge in support of technology development. Thus, the ease with which a technology is commercialized varies with the maturity of its underlying science, which determines speed of technological evolution and shapes industrial structure. This research concluded that we could judge this maturity and the width of gap through the following circumstantial evidence, like "how much of a consensus exists on fundamental theory and have the lines between science and engineering begun to blur? " or "there is a theoretical model that helps the design of commercial products? ".

Another corresponding concept of S-T gap to explain the dynamics of comparative advantage is the evolution of innovation. A growing number of studies about life cycle are now available to describe the linkage of technological evolution and comparative advantage, because each technology possesses its own individual dynamics in its life cycle, capital needs and time required to mature [126]. Several studies [140, 132, 87] have revealed that the shifts in locus of industrial leadership and firm-level strategies have been heavily determined by the path of innovation or the type of technology. Some models [45, 130] have also been reported to describe or predict the technological evolution such as the concept of S-curve. The nature of technological discontinuity in S-curve has been further explained by Christensen [29] to posit the emergence of disruptive innovation instead of traditional sustaining innovation, and provided extensive discussions of the competition between existing large corporations and newly small entrants [46, 114, 89]. A lot of research findings [58, 31, 30] have been done in this issue to seek for the difference of firm-level strategies corresponding with the distinct industrial stages and innovative types.

III. TWO DIFFERENT VISIONS OF STRATEGY APPROACH

The concepts of dynamic comparative advantages respectively in the product life cycle theory and the new trade theory provide a theoretical framework of two different visions for science and technology developments at the postwar period in the United State after the glorious science achievements resulted in war-related researches sponsored by government, the federal government suspected that the development of basic research, nurtured during the war, should be fed during the peace again. It is uncertain for policymakers whether the government should play a major role in postwar science and technology development, and corporations continue to pursue wartime businesses, thus remaining dependent on government funding.

This new environment produced two different visions of how to manage highly charged technological change throughout the postwar period [84, 90, 126]. The first, the optimist view, based on the concept of product life cycle theory, envisions technology transcending everyday limitations and would reshape the postwar world. This vision suggests that the only role of the less interventionist government is to maintain a well-established free-market. The second view, the pragmatist view, developed by the new trade theory, recognizes the power of science and technology but seeks to fit it into structures that already exist. This vision depicts that technology had to be dammed and channeled, not released to wander, and does not quite believe in technological revolutions or a golden age of science. Accordingly, government should control and manage resources pouring into science & technology, and lead the direction of industrial development [128, 10, 76].

As Figure 1 shows, the optimist approach, emphasizes free-market mechanism and natural evolution of technology, is developed based on the concept of product life cycle theory. By contrast, the pragmatist approach, notices the leading role of governments to create the first-mover advantage or reach the economies of scale, has a theoretical thinking developed by the new trade theory. S&T policy could be devised by the dynamic comparative advantages and locus of industrial leadership based on these two theories to formulate two kinds of strategic views - optimist and pragmatist approaches.

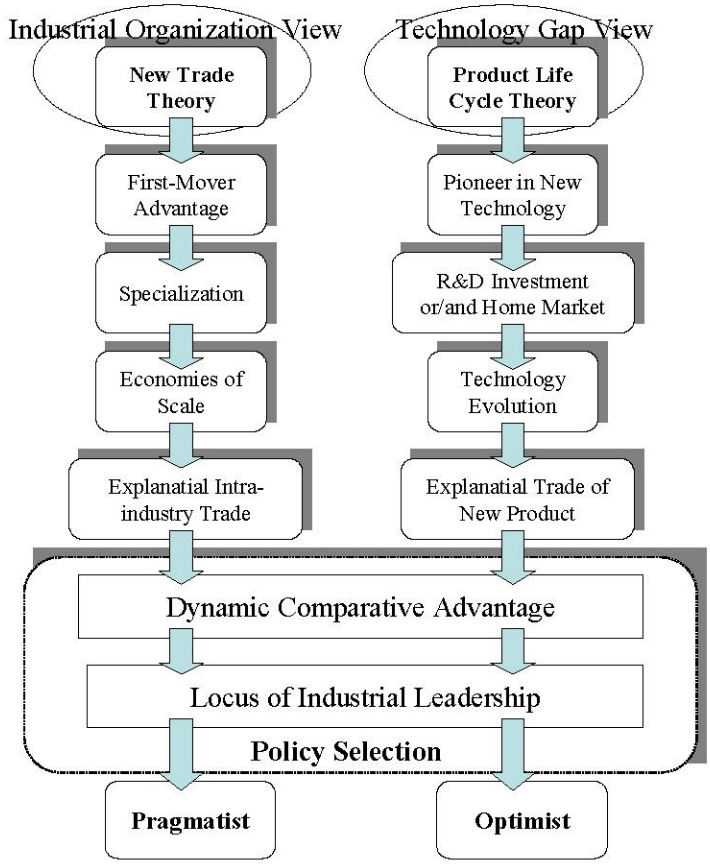

Figure 1 The dynamic comparative advantage theory and visions of strategy approach

IV. POLICY-LEVEL COMPARATIVE ANALYSIS

A. Policy Comparison of Optimist and Pragmatist Approaches

In the application of policy approach, the manifestation of optimist and pragmatist in S&T policy firstly was unfolded in wartime in the United State, among policymakers struggling to forge a role for the government in this new scientific age [106, 126, 19, 6]. The initiator of optimistic policy approach, Vannevar Bush, a computer scientist, advocated that the government should continue funding R&D after the war, but disagree intervene too much to influence the free-market mechanism [20, 137]. Bush argued that market demand is the primary incentive of technological economic, and the role of the less interventionist government is to establish a free-market system. This bottom-up optimistic policy approach, appreciated by Republican Party, emphasizes natural evolution of industry and formulates the ideology of small government to be generally applied in a large, stable, or well-developed country with affluent resources [117].

In contrast to optimist, the initiator of pragmatic policy approach, Harley Kilgore, an attorney and Senator, proposed to establish a National Science Foundation (NSF) to control resources pouring into R&D programs and suggested that patents generated through government's direct research or its funding would fall into the public domain [69, 33]. This top-down pragmatic policy approach, appreciated by Democratic Party, emphasizes industrial forced evolution shaped by governments and formulates the ideology of big government to be extensively applied in a small, chaotic, or developing country with insufficient resources [117].

The results of comparative analysis in these two different policy approaches are summarized in Table1, which shows the practical measures adopted by governments respectively in these two approaches.

TABLE 1 COMPARATIVE POLICY ANALYSIS OF THE TWO STRATEGY APPROACHES

	Pragmatist	Optimist
Concepts & Basis	◆ Top-down ◆ Forced evolution ◆ Big government	◆ Bottom-up ◆ Natural evolution ◆ Small government
Typical Political Party of U.S.	Democratic party	Republican party
Applications	Small country, insufficient resource, chaotic and developing economies	Large country, affluent resource, stable and well-developed economies
Contents	Government should control and manage resources pouring into science & technology, and lead the direction of industrial development	Market demand is the primary incentive of technological economic, and the role of the less interventionist government is to establish a free-market system
Practical Measures	◆ Sponsor large R&D programs ◆ Pour resources into the selected target industry ◆ Develop the application technology ◆ Develop the social science projects ◆ Notice the technological demand of politics and society	◆ Invest fundamental research ◆ Establish infrastructure ◆ Develop well-established free-market ◆ Encourage entrepreneurship & venture capital business ◆ Education investment
Initiator in U.S.	Harley Kilgore (1893~1956)	Vannevar Bush (1890~1974)
Claims & Rationale	Propose to establish a National Science Foundation (NSF) to control resources pouring into R&D, and President Truman signed the NSF legislation in 1950	Advocate that the government should continue funding R&D after the war, but disagree intervene too much to influence the free-market mechanism
Opinions to S&T Development	Recognize the power of science & technology but seek to fit it into structures that already exist, and not quite believe in technological revolutions or a golden age of science	Envision science & technology transcending everyday limitation to reshape the postwar world

For policymakers, it is vital to verify the cross-national and cross-industry differences before decision-making. As Table 2 shows, these two policies both have benefits and detriments individually. For the optimistic approach, firms give up time to entry for autonomous maturation of technology and market, and gain competitive advantages formulated for the most favorable position in the industry. However, the drawbacks for this approach are that, in an amorphous market, visionary and luck to generate industrial leadership is required. Also, it takes more time and resources over a long period which demands a long-term commitment by the top management.

For the pragmatic approach, it offers strategic advantages in speed, first-mover advantage, channel dominance, economies of scale and scope. The setbacks for this approach is that it only focuses on the narrow segments in a specific industry and bears tremendous risks in changing marketing conditions, regulatory policy, and standardized product offerings. Moreover, it also requires visionary leadership to select the strategic target industry, and demands that the core competencies in firms or industries are unique, non-substitutable, and expandable.

TABLE 2 BENEFITS AND DETRIMENTS OF THE TWO POLICY APPROACHES

	Pragmatist	Optimist
Benefits	◆ First-mover advantage ◆ Channel dominance ◆ Economies of scale/scope ◆ Policy additionality	◆ Competitive advantages formulated for the most favorable position in the industry ◆ Broad industrial development segments ◆ Autonomous maturation of technology and market
Detriments	◆ Tremendous risk ◆ Focus on narrow segments in a specific industry ◆ Require visionary leadership ◆ More suitable for maturity technology	◆ Time-consuming ◆ Require sizeable potential market & marketing networks ◆ Take more resources ◆ Demand a long-term commitment by the top management

B. Policy-level Strategies of Two Different Approaches

For evaluating and selecting two different policy approaches to apply, some national or industrial criteria must be examined to verify which policy is appropriate to the present scenarios, or the mix of both is better. Figure 2 shows three basic criteria to judge the market conditions and firm's capabilities or resources for policy selection.

As the figure shows, national or industrial competitive advantages can be estimated by the analysis of industrial leadership involving the factors of resources, institutions, technology, and market. Second, the static evaluation, analysis of source of competitive advantage, can be used to understand the core competencies, strength and weakness of firms or industry, and judge whether it possesses the circumstantial conditions for specific approach. Finally, policymakers can analysis the industrial life cycle, the dynamic evaluation, to estimate the present situation of technology, market, and industrial pattern, thereby selecting the policy tools derived from the most appropriate policy approaches according to the national economic mission.

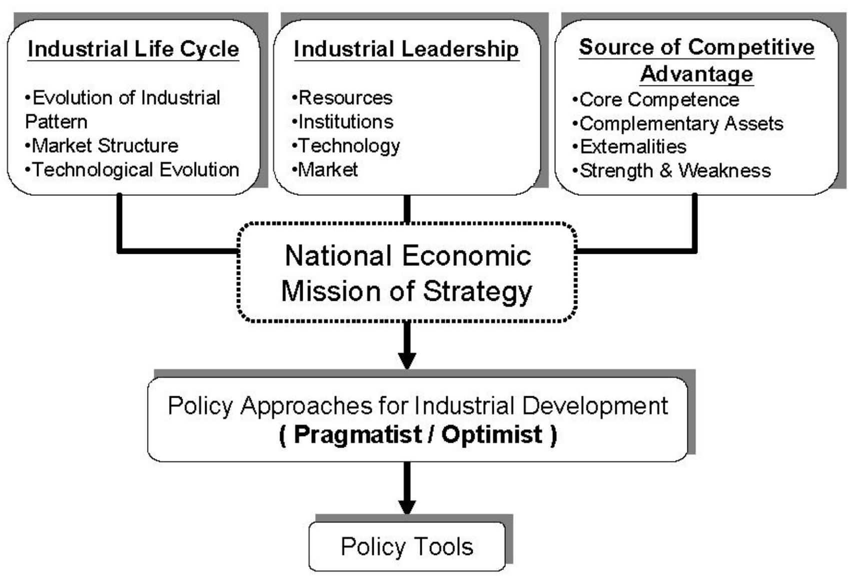

Figure 2 Criteria for policy selection

The circumstantial conditions of optimistic and pragmatic policy approaches are summarized in Table 3. As the table shows, some specific capabilities and resources of firms must be possessed when applying the corresponding approach. Moreover, the evaluation of market conditions domestically and internationally is also necessary for policy selection.

TABLE 3 CIRCUMSTANTIAL CONDITIONS OF THE TWO POLICY APPROACHES

	Pragmatist	Optimist
Firm's Capabilities and Resources	• First-mover advantage • Resources limited • Intensive market competition • Substitutable core competencies • Control complementary assets	• Unique, non-substitutable, and expandable core competencies • Market and technology leadership • Competitive advantages are derived from innovative enabling functions in quality, performance, and costs • Market applications are slowly evolving, requiring various marketing networks • Technology in growth stage, while market in burgeoning stage (amorphous structure)
Market Conditions	• Limited size and growth potential of markets • Insurmountable marketing networks • Maturity status of markets • Sources of competitive advantage are derived from Chandlerian economics • Many substituting offerings • Oligopoly in nature	• Global, sizeable, and growing • Require close affiliation with various market applications • Extensive user-producer interactions required • Booming economic turns and bull capital markets • Monopolistic competition in nature

Based on the above discussion, the strategic concept of pragmatist and optimist mentioned can be applied to devise the policy approaches under different S-T gap and industrial stages. Figure 3 offers a scheme that reflects our given segmentations in industrial life cycle by the difference of S-T gap, and the corresponding industrial situation and applied policies between large and small country in these segmentations have been illustrated in Table 4.

As Table 4 shows, in Stage I, S-T gap is simply too wide to traverse effectively, and fundamental scientific advances fail to generate products and have little effect in corporate R&D [126]. The industrial situation of this epoch tends to be science-based product leadership and technology intensive competition. Thus, the optimistic policy approach can be firstly adopted by large countries with affluent resource and sizeable domestic market in the emergent stage based on their science foundation, to invest in the industrial infrastructure and market mechanism for autonomously formulating the industrial capabilities while technology and market gradually developing. On contrary, for small countries, due to the lack of resource and science base, the pragmatic policy approach must be selected to pour resources into the target industrial segment and take some protectionist measures, for nourishing the competitiveness of local firms [128, 76].

With S-T gap beginning to shrink, large countries can try to apply the pragmatic policy approach such as government sponsored or procurement program, to foster the speed of technology development and the growth of domestic market, thereby achieving the economies of scale/scope. It is also appropriate for small countries in this stage to adopt pragmatic policy approach such as trade barrier, local industrial standards, and national champion policies, for maintaining the competitive advantage of local industry in the domestic market [10].

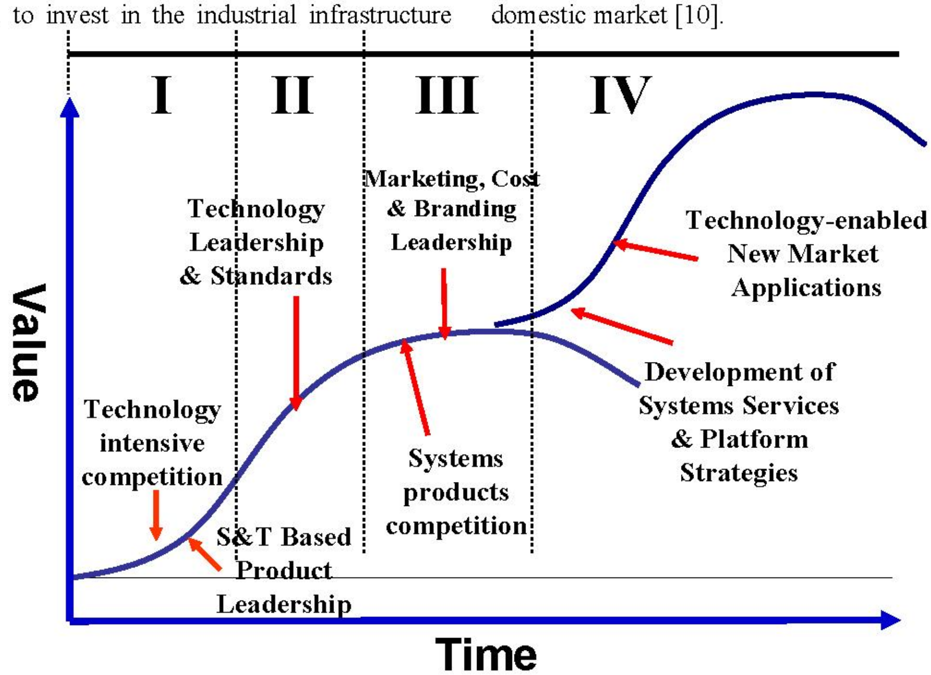

Figure 3 Industrial life cycle

Next, with S-T gap becoming close, in Stage III and IV, the industrial competition changes into marketing-based product and consumer-centric leadership [95, 41]; cost, brand, channel, or customization advantages become essential due to the maturity of technology [131]. Thus, the optimistic policy approach is suitable for both large and small countries. In this period, market demand is the primary incentive of technology development, and the role of the less interventionist government is to establish a free market mechanism. Large countries with profound industry base could use this policy approach to strengthen the status of their established vertical integration industry giants. On the other hand, governments in small countries could also apply the policy tools of optimistic approach to assist their local firms for developing specialization strategy based on the legacy and capabilities formulated by industrial evolution [61]. However, pragmatic policy approach could be continuously adopted by small countries if the global competitiveness is still relatively weak in the industrial value chain [76].

TABLE 4 POLICY-LEVEL STRATEGIES OF TWO DIFFERENT APPROACHES

Stage	S-T Gap	Industrial Situation	Applied Policies: Large Country	Applied Policies: Small Country
I	Wide	◆ Slow technology innovation ◆ Require large amounts of capital to make incremental improvements ◆ Industry structure is oligopoly in nature by large corporations ◆ Science-based product leadership & Technology intensive competition	◆ **Optimist** to formulate the competitive advantages for the most favorable position in the industry	◆ **Pragmatist** to pour resources into specific industrial segment to protect local industry
II	Become narrow	◆ Capital advantages shrink and science becomes accessible ◆ Productivity and entrepreneurship prevail ◆ Industries may undergo wracking changes	◆ **Pragmatist** to foster the speed of technology development and the growth of domestic market	◆ **Pragmatist** to maintain the competitive advantage of local industry in the domestic market
III	Close	◆ Commoditization & maturity ◆ Competition and capital cost occur over marketing and distribution ◆ Cost and system product competition	◆ **Optimist** to strengthen the technology and market status of established vertical integration industry giants	◆ **Optimist** / **Pragmatist** to develop specialization strategy based on the legacy and capabilities under industrial mature situation
IV	Close but technology diversify	◆ Knowledge-based economy & knowledge intensive competition ◆ Competition-driven network effects ◆ Customer-centric leadership		

V. FIRM-LEVEL COMPARATIVE ANALYSIS

A. Industrial Development Based on the Evolution of S-T Gap

Different firm-level strategic approaches should be applied in the distinct stage of industrial evolution by the variation of S-T gap and the nature of technology. On the basis of these two philosophies of strategy approaches, specific firm-level strategies respectively in large corporations and small newly entrants can be deduced in accordance with the distinct stage of industrial life cycle. Table 5 summarizes the industrial situation and the corresponding firm-level strategies in the given segmentation of industrial life cycle described in Figure 3.

The relationship between firm size and technology R&D has drawn considerable attention from studies for over several decades [32, 2, 111, 134, 75]. The findings in Table 4 refer to these literatures to make an analysis of life cycle in different technology level. Firstly, in Stage I, S-T gap is simply too wide to traverse effectively, and fundamental scientific advances fail to generate products and have little effect in corporate R&D. The industrial situation schematized in Figure 2 tends to be science-based product leadership and technology intensive competition. In such a circumstance, technological innovation is slow and halting, and it requires large amounts of capital to make incremental improvements. Thus, the industry may be dominated by a number of large corporations that have the financial resources to operate R&D and patent protection. Market control may come from dominating innovation through patents or a stranglehold on marketing or distribution channels [126]. In this stage, most of market users are innovators and early adopters [83], and therefore large amounts of capital must be invested in the complementary assets of technological products [125] to acquiring the first-mover advantage and crossing the chasm of mass market. That is also why the industrial structure in this period may be oligopoly in nature by large corporations with capital advantages. In this stage, first-mover advantage could be acquired by the science and technological innovation due to the technological uncertainty and undefined industry rule [98].

As the S-T gap begins to narrow, the industrial development gets into the Stage II after the inflection point of life cycle curve. In this stage, capital advantages shrink and erode. Science becomes accessible and builds more models allowing product engineers to extrapolate from given conditions. Thus, the time required to move from lab to market dramatically shrinks and the risk declines as a result of lower uncertainties. The small corporations with particular strengths of speed, flexibility and productivity may prevail before the dominant design or technology standard appears [79, 34, 43]. They can develop the new technological applications by the existing science models to occupy these markets that large corporations disdain due to the long-term investment in the increasing return products (with increasing slope) before the inflection point of life cycle curve [114]. With competition changing, industrial structure may undergo wracking shifts in this stage. For large corporations, in addition to investing in sustaining innovation [31], the best strategy is to develop systems products and establish the dominant design or standard to accelerate the narrow of S-T gap and the move from this stage to commoditization or cost competition. In this stage, first-mover advantage could appear in the corporations possessing the dominant design or technology standard [123, 124].

TABLE 5 FIRM-LEVEL STRATEGIES BASED ON THE EVOLUTION OF S-T GAP

Stage	S-T Gap	Industrial Situation	Firm-level Strategies	
			Large Corporation	Small Corporation
I	Wide	◆ Slow technology innovation ◆ Require large amounts of capital to make incremental improvements ◆ Industry structure is oligopoly in nature by large corporations ◆ Science-based product leadership & Technology intensive competition	◆ Dominate the market and form the hegemony ◆ Form a stronghold on patents, market, & channels	◆ Capital disadvantages to exploit science ◆ Long-term R&D investment
II	Become narrow	◆ Capital advantages shrink and science becomes accessible ◆ Productivity and entrepreneurship prevail ◆ Industries may undergo wracking changes	◆ Establish the standard of technology ◆ Develop systems products	◆ Develop the applications by the existing science model ◆ Speed, flexibility , & productivity advantages
III	Close	◆ Commoditization & maturity ◆ Competition and capital cost occur over marketing and distribution ◆ Cost and system product competition	◆ Vertical/Horizontal Integration ◆ Outsourcing ◆ Channel & Brand ◆ SCM & logistic	◆ Affiliation ◆ Development of disruptive innovation
IV	Close but technology diversify	◆ Knowledge-based economy & knowledge intensive competition ◆ Competition-driven network effects ◆ Customer-centric leadership	◆ Dynamic specialization ◆ Development of market intelligence ◆ Diversity ◆ Technology-enabled new market application	◆ Development of systems services ◆ Platform strategy ◆ Technology-enabled new market application

With S-T gap closing even further, commoditization sets in and industrial development gets into the Stage III. Now competition and capital cost occur over control of marketing, distribution and supply chain management, and the industrial situation [126] illustrated in Figure 3 becomes oversupply and tends to be marketing, cost and branding leadership and systems products competition. In addition to the strategies of branding, channel, or logistic, large corporations can also form the monopoly by vertical/horizontal integration to obtain the scale or scope advantages under this price competition. Furthermore, another strategy [35] is to outsource the low-profit segment in value chain to small corporations through production modularity based on the theory of value chain evolution (VCE) developed by Christensen and Raynor [31]. This stage seems not to be favorable for small corporations. The better way is to integrate themselves into the supply chain of large corporations and form the affiliation based on their core capabilities. Another opportunity for small corporations with research strength is to focus on the demands of low-end or new markets to develop the disruptive innovation [29, 46], thereby yielding new value to enable the next stage or curve depicted in Figure 3. Thus, first-mover advantage could be seized by the corporations with cost advantage.

With knowledge dynamically evolving and globally proliferating, industries upgrade and create new values shown graphically as the second S-curve in Figure 3. This Stage IV of knowledge-based economy is defined under the assumption of several industrial driving forces such as diversity of highly segmented markets, systems and platform services, network effect derived from internet, and technology-enabled new markets [134, 39, 41]. Thus, the industrial situation under this still close S-T gap is transformed into customer-centric leadership and knowledge intensive competition due to the diversity of technology or market application and the destroy of commoditization [95]. According to the theory of VCE [31], in this stage, high-profit segments of value chain may concentrate on the interfaces of industrial supply chain, production of key components, or process integration segments. It provides considerable opportunities for small corporations to develop dynamic specialization and innovation-intensive services based on the platform strategy and network externality [64, 26]. The size of these corporations with the nature of speed, flexibility and efficiency may be out of proportion to their leveraged capability enabled by expandable core competences [52]; however, it can be just proper to prevail in the increasing return industry of this knowledge-based stage [65, 9]. For large corporations, the strategies of experience marketing and customization can be adapted for the development of dynamic specialization by the manipulation of the above-mentioned platform operation [94, 129]. In addition, scale and scope advantages of these corporations can be applied to develop vertical integration strategy by the existing cluster effect or diversity strategy by the control of market intelligence and technology base. Finally, technology innovation should be more emphasized in this stage for both large and small corporations to seize the opportunities of technology-enabled new market application, resulting in the acquirement of first-mover advantages due to the network characteristics of increasing return industries [66, 116, 54]. In addition, the appropriate strategies of platform and specialization based on the core competences could also turn these capabilities into first-mover advantage in this stage [78, 25].

B. Firm-level Strategies of Two Different Approaches

The strategic concept of pragmatist and optimist mentioned above can be applied to devise the firm-level strategies under different S-T gap and industrial stages in accordance with the above analysis. The result is summarized in Table 6 to illustrate the distinctions of applied strategy approaches between large and small corporations.

As Table 6 shows, in Stage I and II, industrial competition tends to be located in technology-based product leadership because of the obvious boundary between science and technology. Thus, the optimistic firm-level approach can be firstly adopted by large corporations in the emergent stage based on their technology and market hegemony, and competitive advantages can also be gradually formulated for the most favorable position in the industry under this approach. With S-T gap beginning to shrink, large corporations can try to apply the pragmatic firm-level approach to develop vertical/horizontal integration, relying on their core competences to achieve the economies of scale/scope due to the maturation of technology and market. Contrary to large corporations with resource and technology or market dominance, it is appropriate for small corporations in this stage to adopt optimistic firm-level approach for waiting the autonomous maturation of industry. Specialization strategies can be develop by small corporations under this approach to focus on their competitive advantages formulated for the optimal value position in the industry while technology and market maturing.

TABLE 6 FIRM-LEVEL STRATEGIES OF TWO DIFFERENT APPROACHES

Stage	S-T Gap	Competition Situation	Applied Strategies: Large Corporation	Applied Strategies: Small Corporation
I	Wide	◆ Technology-based product leadership	◆ **Optimist** to gradually formulate the optimal competitive advantages	◆ **Optimist** to wait the opportunities of industrial mature for specialization
II	Become narrow		◆ **Pragmatist** to develop the integration strategy for economies of scale/scope	
III IV	Close Close but technology diversify	◆ Market-based product leadership	◆ **Pragmatist** to sustain the legacy and 1st-mover advantages	◆ **Optimist** to enable the next evolution for platform strategy

With S-T gap becoming close, in Stage III and IV, the industrial competition changes into marketing-based product leadership and cost, brand, or channel advantages become essential. Thus, the pragmatic firm-level approach is suitable for large corporations to sustain their legacy, resource, and first-mover advantages due to the dominance of market and complementary assets. Under this approach, the firm-level intended strategy [81, 80] should be formulated through the deliberated planning process in this stage [31, 30] and be applied to develop their branding strategy by belief marketing. In addition, while the next S-curve and technology-enabled new markets occur, large corporations can diversify the technology application in accordance with their legacy based on the concept of pragmatic firm-level approach. According to the theory of RPV [31], it will likely to be opportunities or threats for large corporations depending on the difference between new applications and the resources, process, and value activities they presently possess.

For small corporations, optimistic firm-level approach is obviously better choice to enabling the next evolution for developing the platform strategy and systems services. The leverage effect can be expanded by their core capabilities and the nature of speed or flexibility under this approach. Thus, the firm-level emergent strategy [81, 80] should be formulated by small service business according to the circumstantial conditions [31, 30] and be applied to develop their branding strategy by experience marketing in this knowledge-based stage [96].

VI. CROSS-NATIONAL AND CROSS-INDUSTRIAL COMPARISON OF GLOBAL INDUSTRIAL EVOLUTION

A cross-national and cross-industrial comparison of optimistic and pragmatic approaches would be applied to manifest the validity of the above policy-level and firm-level analysis in Table 4 and Table 6, by the empirical cases of global industries, that is, case studies of global IC, pharmaceutical, and computer hardware industries during the 2nd half of the 20th century are used as research targets to elaborate these two strategy approaches both on policy and firm levels.

A. Case Study of Global IC Industrial Development

In this section, the case studies of IC industrial development of Taiwan, Korea, Japan, and United States., are used to demonstrate the effectiveness of these two optimistic and pragmatic strategy approaches. In what follows, we chronicle in order five major episodes of regional competitive advantage in global IC industry [73]: the early rise of American industry, the IC era, the Japanese challenge in the late 1970s and 1980s, the recent resurgence of American industry, coupled with the rise of Taiwan and Korea, and the globalization age after 2000. The results of IC industrial development and policy selection of these four countries are respectively summarized in Table 7 by five industrial periods. The applied policy tools listed in the table can be used to describe the distinct strategy approaches in every country at different periods.

During the first and second periods with wide S&T gap, the invention of transistor and integrated circuit, American dominated the IC market by strong corporate research laboratories and rapid technology diffusion and commercialization of patent cross-licensing [85]. The market for semiconductor began with the demand of United States military, and it was the Cold War that nurtured this industry in its infancy. Military demand for semiconductors provided several spillovers from the development of military devices to civilian applications, and indirectly accelerated the development of commercial semiconductor markets in the late 1950s. In addition to investing in education and infrastructure, the only role of federal government is to provide direct support both for R&D and production as well as indirect support through military systems contractors [23, 88, 104]. Thus, the ideology of S&T policy for IC industry at this period is nearly the optimist due to the wide S-T gap and amorphous market conditions. In the meanwhile, Japanese firms just committed early to IC mass production and remained dependent on U.S. sources of supply, and were successfully export-oriented because of less military and domestic commercialized demand. Also, Japanese government subsidized virtually no basic research during this period.

During the third period, the comparison was found in the dynamics of competition between American and Japanese companies in the new generation of IC products introduced in the late 1970s [11, 88, 44]. This competition involved issues of productive efficiency, investment rates and timing, and design strategy. The success of Japanese companies was aided by the nature of end-use markets in Japan, the timing of market developments, and the patterns of investment by American and Japanese companies. Japanese government essentially adopted pragmatic policy approach at this period to pour resources into this industry, with the S-T gap gradually shrinking. The VLSI Program initiated by the Nippon Telephone and Telegraph (NTT) and the Ministry of International Trade and Industry (MITI) is the most famous efforts made by the government to deepen their technological competences to a level at which it could challenge American dominance [62, 95].

The typical pragmatic policy approach was also applied at this period by Taiwanese and Korean government because of the lack of national resource [51]. They both chose the specific segments in the IC industrial value chain or market application as a national strategic industry, and developed by government funding and hiring of American-trained Chinese or Korean talent [118].

During the fourth period, shown as Table 7, the American resurgence has been largely the result of the industry's ability to improve manufacturing and achieve a dominant position in the fastest-growing and design-intensive segment of the industry due to the narrowing of S&T gap [136]. Moreover, organization innovation and specialization also allowed the American industry to take advantage both of its own structural advantages and global manufacturing capabilities [13, 104]. On the contrary, Japanese firms were facing threats to their manufacturing leadership from elsewhere in Taiwan and Korea during a sustained period of pragmatic policy supports. Korean entry was based upon an aggressive investment program and government funding support in minor specific consortia [74, 91]. For instance, much of Samsung's output was focused on DRAMs and became the world's largest memory chip producer. In contrast to Korea, Taiwan has developed into a highly diversified producer of semiconductors, with significant and growing capabilities in design as well as in fabrication [119]. The Taiwanese industry has its origins that encouraged foreign direct investment, strategic alliances with foreign firms, and high mobility of engineers, especially to and from the United States, to serve for years as an offshore site for American manufactures [24, 118, 112].

After 2000, during the fifth period, the optimistic policy approach was continuously applied to IC industry by American and Japanese government as a result of their international firm's capabilities about core competencies, market and technology leadership, and competitive advantages derived from innovative enabling functions in quality or performance [86]. The greatest difference between these two countries is the distinction of globalization strategies derived from their economic systems according to the national varieties of capitalism model [5, 21]. For liberal market economies, like the United States' and Britain's, in which allocation and coordination of resources take place mainly through markets [5, 53], the American firms have always been accustomed to buying their resources in the market and were well-prepared for the world of fragmentation and outsourcing. It explains that American IC firms outsource the manufacturing of their chips to Asian firms and benefit from them. In contrast, for coordinated market economies, like Japan's and Germany's, in which negotiation, long-term relationships, and other non-market mechanisms are used to resolve the major issues, the Japanese firms that cannot find the home-base resources abroad, are likely to be more reluctant to move abroad. It explains that Japanese IC industry continues to make many of its own chips in-house in Japan [60, 36, 93].

TABLE 7 COMPARATIVE ANALYSIS OF GLOBAL IC INDUSTRIAL DEVELOPMENT

		American's Rise to Dominance (1955~1965)	IC Era (1965~1975)	Japanese Challenge (1975~1990)	American Resurgence & Far Eastern Production (1990~2000)	Globalization (2000~)
United States	Industrial development	◆Corporate research laboratory ◆Commercialize & diffuse by cross-licensing ◆Majority demand in military, and minority demand in computer & consumer-electronics (like radio)	◆IC technology reinforced American dominance ◆Trend of vertically dis-integration ◆Demand : rapid growth of American computer industry	◆Focused on growth rather than on profit margins ◆Insisted on radical new designs and process technology ◆Government demand fell	◆Manufacturing improvements, imitated TQM practice of Japanese, focused on higher-margin, design-intensive chips ◆Trend of decoupling of design from production, benefits American industrial organization ◆Offshore strategy for cost reduction ◆Shifts in the pattern of demand (ASICs, MPU, Logic chips), benefits American companies	◆Market & technology leadership ◆Outsourcing strategy
	Applied policy tools	◆Government procurement : military & space program ◆Military R&D support ◆Education / Infrastructure	◆Government procurement : military & space program ◆Military R&D support ◆Education / Infrastructure	◆Essentially laissez-faire policy ◆Government demand fell	◆Trade policy (Section 301, Dumping) ◆Imitate Japanese model to encourage R&D consortium ◆Direct subsidy to cooperative research ◆Reduce obstacles of antitrust policy	◆Trade policy for globalization
Japan	Industrial development		◆Committed to IC mass production ◆Export orientation	◆Gain a significant foothold in the American market in DRAMs ◆Larger companies in comparison with American counterparts ◆Manufacturing advantage & price-cutting	◆Japanese IC demand for computer fell ◆Threats to manufacturing leadership from elsewhere in Asia ◆Appreciation of Japanese yen	◆Market & technology leadership ◆Vertical integration
	Applied policy tools		◆Prevention of direct foreign investment ◆Support for the licensing of foreign tech. ◆Domestic demand by NTT	◆The VLSI Program by NTT & MITI ◆R&D consortium between companies & joint laboratory	◆Trade policy ◆Future Electronic Device Project (no significant commercial effect)	◆Trade policy for globalization
Korea	Industrial development			◆Select specific segments in the industrial value chain to develop by government	◆Economics of capacity investment or productivity in manufacturing ◆Modern facilities & growing share of the market ◆Samsung become the world's largest memory chip producer	◆Diverse and massive conglomerate
	Applied policy tools			◆Government support & target industry ◆Hiring of American-trained Korean talent	◆Government support & target industry ◆Aggressive investment program ◆Funding support in minor consortia	◆Support of funding
Taiwan	Industrial development			◆Select specific segments in the industrial value chain to develop by government	◆Develop highly diversified producers ◆Offshore site for American manufactures ◆Joint ventures with American fabless firms	◆Originally design manufacturing
	Applied policy tools			◆Government support & target industry ◆Quasi-governmental research institution licensed tech. from foreign firms ◆Hiring of American-trained Chinese talent	◆Cluster effect of Science Park ◆Encourage foreign direct investment, strategic alliances with foreign firms ◆New companies spun off from quasi-governmental research institution	◆National industrial programs ◆Investment regulation

In developing economies of Asia, supports of pragmatic policy approach sustain to be applied by Taiwan and Korea governments at this period owing to the limited resources and intensive market competition. The globalization strategies of these two countries are nearly like the dynamic legacies model proposed by Suzanne Berger [21], emphasizes that globalization starts from a company and its reservoir, or legacy, of resources that have been shaped by the past. Thus, the way of Taiwanese and Korean industry is to position itself in the global IC value chain based on their individual legacies of firms which are composites, with capabilities, talents, and aspirations shaped by diverse experiences as well as national imprinting [24, 28]. In addition, instead of deficiency of brand or system product firms in Taiwan, the optimistic policy approach has begun to be applied in Korean IC industry, relies on the formation of diverse or massive conglomerate by technology and market leadership of firms like Samsung [100].

The research of Christensen [30] for the value migration of global IC industry also provided the similar observation to demonstrate the above discussion. According to the theory of value chain evolution (VCE) proposed by Christensen and Raynor [31], with the S-T gap narrowing and the modularity production through the design tools of EDA (Electronic Design Automation) occurring, the high-profit segments of value activities have shifted to the interdependent interfaces of value chain in global IC industry such as fabless companies, customizing fabs, or equipment corporations with the characteristics of speed, flexibility, and efficiency under the trends of diverse applications and customization. This result explained the shift of strategy approaches in this industry and the opportunities of far-eastern IC companies due to the occurrence of outsourcing activities in global value chain.

B. Case Study of Global Pharmaceutical Industrial Development

The pharmaceutical industry has been one of the most enduring pillars of postwar prosperity in the United States and Europe. As the customer base for pharmaceuticals has expanded, the priorities have also changed. Value has migrated from a design centered on serendipitous science, to a design focused on the creation of blockbuster products, to a design that responds to the changing structure of the customer base in the 1990s by focusing on low-cost distribution and market access-the managed health care design [120].

In this section, the case studies of global pharmaceutical industrial development of United States, Europe, and Japan are selected to demonstrate the conclusion of the above mentioned analysis in strategy approaches. In this research, the history of the pharmaceutical industry is divided into three major epochs, referring to the definition of Henderson et al [57]. As shown in Table 8, corresponding roughly to the first period 1850-1945, was one in which little new drug development occurred, and in which the minimal research that was conducted was based on relatively primitive methods. The large-scale development of penicillin during World War II marked the emergence of the second period of the industrial evolution, dating as running from 1945 to 1990. This period was characterized by the institution of formalized in-house R&D programs and a method of so-called "random screening" for finding new drug. The third epoch of the industry has its roots in the 1970s but did not come to full flower until quite recently as the use of the tools of genetic engineering in the production and discovery of new drugs has come to be more widely dispersed [109]. The results of pharmaceutical industrial development and policy selection of these countries are respectively summarized in Table 8 by three industrial epochs. The applied policy tools listed in the table can explain the distinct policy approaches in every country at different periods.

During the first period with wide S&T gap, the pharmaceutical industry was not tightly linked to formal science in the early history. Until the 1930s, drug companies undertook little formal research, and most new drugs were based on existing organic chemicals or were derived from natural sources such as herbs and little formal testing was done to ensure either efficacy or safety. Next, with the outbreak of World War II, the U.S. government organized a massive research and production effort that focused on commercial production techniques and chemical structure analysis. This system led to major gains in productivity and R&D investment, and, more important, laid out a architecture for the process in which future improvements could took place [48]. In this stage, for United States and Europe, the pharmaceutical industries were roughly developed by the base of university and related industry, including chemical, dye, textile, silk, and food, using essentially laissez-faire policy, until World War II. Thus, the ideology of strategy approach at this epoch is nearly the optimist due to the nature of wide S-T gap in this industry, for developing pharmaceutical giants in German, Swiss, or Netherlands based on the established chemical industry [108, 63], or founding the specialized pharmaceutical producers in United States and United Kingdom.

During the second epoch after the World War II, the S-T gap in global pharmaceutical industry still remains wide, and there were many physical ailments and diseases for which no drugs existed in the early postwar years. Faced with such a target-rich environment but very little detailed knowledge, pharmaceutical firms invented an approach referred to as "random screening" that natural and chemically derived compounds are randomly screened in test tube experiments and laboratory animals for potential therapeutic activity. Furthermore, the industry also began to benefit more directly from the explosion in public funding for health related research that followed the war, particularly as a source of knowledge about the cause of disease. The substantial advances in physiology, pharmacology, enzymology, and cell biology from these publicly funded researches led to enormous progress in the ability to understand the mechanism of action of some existing drugs and the molecular roots of many diseases, making it possible to design significantly more sophisticated screens. Meanwhile, because random screening capabilities were based on internal organizational processes and tacit skills, they were difficult for potential new entrants to imitate and thus became a source of first-mover advantage. These advantages, combined with the presence of scale economies in pharmaceutical research, may explain the lack of new entry prior to the mid-1970s. Small firms, those farther from the centers of public research, and those that were most successful with the older techniques of rational drug discovery appear to have been much slower to adopt the new techniques than their rivals. Moreover, the organizational capabilities developed to manage the process of drug development and delivery-competencies in the management of large-scale clinical trials, the process of gaining regulatory approval, and marketing and distribution- also appear to have acted as powerful barriers to new entry into the industry [47].

There was also significant geographical difference in adoption. Whereas the larger firms in the United States, the United Kingdom, and Switzerland were among the pioneers of the new technology and dominated the postwar pharmaceutical industry, other European and Japanese firms appear to have been slow in responding to the opportunities afforded by the new science [113, 127]. Although Japan is the second largest pharmaceutical market in the world and is dominated by local firms, Japanese firms have to date been consciously absent form the global industry. Only Takega ranks among the top 20 pharmaceutical firms in the world. As a result, except few measures of public research program and procurement, optimistic policy approach was still applied by United States and most Europe countries in this stage, such as infrastructure and education investment, openness of domestic market, development of venture capital and entrepreneurship, and deregulation policy, like the passage of Bayh-Dole act in United States [4]. In contrary, the ideology of strategy approach in Japan was similar with the pragmatist at this epoch due the relatively weak competitiveness in science, including the policy tools like protectionist measures of domestic market and international competition, pricing policy, and drug coerced licensing [105].

During the third period, the biotechnology revolution represents that the emergence of biotechnology and molecular biology narrow the S-T gap in pharmaceutical industry. Application of these technological advances initially followed two relatively distinct trajectories. One was rooted in the use of genetic engineering as a process technology to manufacture proteins whose existing therapeutic qualities were already quite well understood in large enough quantities to permit their development as therapeutic agents [77]. The second trajectory used advances in genetics and molecular biology as tools to enhance the productivity of the discovery of conventional chemical drugs [50]. In United States, the large-scale new biotechnology start-ups were primarily university spin-offs and were usually formed through collaboration between scientists and professional mangers, backed by venture capital [67, 139]. Established pharmaceuticals initially played a less direct role in this application of biotechnology, and invested in biotechnology R&D through collaborative arrangements, R&D contracts, and joint ventures with the new biotechnology start-ups and university laboratories [8, 97, 138]. With the S-T gap becoming close by the bridge of biotechnology, the typical optimistic policy was adopted in this epoch by U.S. government by the development of local scientific base, patent protection, access to capital, favorable environment for entrepreneurship, and high mobility in scientific labor market [48, 49].

In contrary, the exploitation of genetics as a tool to produce proteins as drugs in Europe and Japan lagged considerably behind that in the United States and proceeded along different lines [82]. The most striking difference is the absence of the phenomenon of the specialized biotechnology start-ups in Europe and Japan, with the exception of the United Kingdom [127]. Governments in Europe and Japan have devised a variety of measures to foster industry-university collaboration and the development of venture capital to favor the birth of new biotechnology ventures, but not particularly impressive. In the absence of extensive new firm founding, most of the innovation in biotechnology in Europe has occurred within established firms. Thus, in mainland Europe, a few firms account for a large proportion patents in biotechnology on the activities of a small group of large established companies. For instance, the British and the Swiss companies moved earlier in the direction pioneered by the large U.S. firms in collaborating with or acquiring American star-ups. Firms in the rest of Europe tended to focus primarily on the establishment of a network alliance with local research institutes. As a result, in this stage, two kinds of policy approaches would be both adopted in Europe based on the technology and market segment for intervention. Some countries still used the ideology of optimist to foster the industry-university collaboration and the birth of biotechnology start-ups. Other countries lagging to adopt biotechnology as a research tool, like France and Italy, may apply pragmatic approach in the development of minor products for the domestic markets based on the legacy of core capabilities [127, 4].

TABLE 8 COMPARATIVE ANALYSIS OF GLOBAL PHARMACEUTICAL INDUSTRIAL DEVELOPMENT

		Early Epoch (1850~1945)	After World War II (1945~1990)	Biotechnology Revolution (1990~)
United States	Industrial development	◆Mass production pharmaceuticals began in the later 19th century ◆Specialized pharmaceutical producers ◆Discover & commercialization of Penicillin ◆R&D investment & gain in productivity in World War II	◆Benefit directly from the explosion in public funding for health related research, as a source of knowledge about disease ◆Larger firms of economies were the pioneers of the new technology, and had a number of isolating mechanisms working in their favor ◆Great internal organizational processes & tacit skills of large firms ◆Approach of "random screening" for potential therapeutic activity	◆Large-scale new entry into the industry, being primarily university spin offs through collaboration between scientists & professional managers, backed by VC ◆Established pharmaceuticals initially played a less direct role in the application of biotechnology ◆Established pharmaceuticals acquire the technology through collaboration- both with small biotech firms &university laboratories
	Applied policy tools	◆Essentially laissez-faire policy ◆Government support for health related research in World War II ◆Collaboration between firms, government, & university in wartime	◆Public funded research in the postwar years ◆Passage of the Bayh-Dole Act (1980) ◆Entrepreneurship in university ◆Emergence of venture capital ◆Open to international competition in domestic market	◆Investment of education & local science base ◆Deregulation in high mobility of scientific labor market ◆Patent protection ◆Venture capital for new start-up
Europe	Industrial development	◆Emergence of synthetic dye industry in German & Switzerland in mid-19th century ◆Swiss & German pharmaceutical activities emerge within larger chemical producing enterprises ◆Specialized pharmaceutical producers (United Kingdom) ◆Up until World War I German dominated the industry (80% of world's output)	◆Larger firms of scale economies seize the new technology (United Kingdom, Switzerland) ◆Slow in responding to the opportunities afforded by new science (other countries) ◆Postwar Europe pharmaceutical industry was dominated by Switzerland, Germany, & United Kingdom, French & Italy have not played major international role ◆Approach of "random screening" for potential therapeutic activity	◆Initial absence of the specialized biotech start-up (exception of the United Kingdom) ◆Many of the new firms not involved in drug research, but instead in instrument, reagents, diagnostics, & agriculture ◆Start-up were founded through the support of both government and large pharmaceuticals rather than through VC ◆Most of innovation in biotech occurred within few established firms ◆British and Swiss companies moved earlier in collaborating with U.S. start-up, the rest of Europe focus primarily on the network of alliances with local research institution
	Applied policy tools	◆Essentially laissez-faire policy ◆University science base ◆Base of chemical, silk, & textile industry	◆Public funded research in the postwar years ◆Public research institution (France & Germany) ◆Open international competition (Britain & Switzerland) ◆Development of minor products for domestic market (Italy & France)	◆Foster industry-university collaboration ◆Development of VC for the birth of new biotech star-up ◆Government program for funding start-up ◆Licensing technology from U.S. firms
Japan	Industrial development		◆Slow in responding to the opportunities afforded by new science ◆The 2nd largest pharmaceutical market in the world ◆Dominated by local firms (for regulatory reasons)	◆Initial absence of the specialized biotech start-up ◆Disadvantage of entering the innovative market relatively late instead of U.S. ◆Entry in biotechnology was pioneered by the large food & chemical firms with strong capabilities in process technology ◆Lack capabilities in basic drug research
	Applied policy tools		◆Trade regulation ◆Protection from foreign competition ◆Drug licensing & reimbursement regime ◆Clinical testing & pricing policy	◆Foster industry-university collaboration ◆Licensing technology from U.S. firms ◆Government research program ◆Protectionist measures

In Japan, entry in biotechnology was pioneered by the large food and chemical companies with string capabilities in process technologies. Although having strong capabilities in process technologies, these firms generally lack abilities in basic drug research. Meanwhile, as a result of the combination of patent laws, the policies surrounding drug licensing, and the reimbursement regime, Japanese pharmaceutical firms had little incentive to develop world-class product development capabilities, and in general concentrated on finding novel processes for making existing foreign or domestically originated molecules [82]. Thus, pragmatic approach like protectionist measures was still applied in Japan for protecting local pharmaceuticals in domestic market.

C. Case Study of Global Computer Industrial Development

The computer hardware industry is one of the most dramatic value-growth stories of the 20th century. In this section, global computer industrial development of United States, Europe, and Japan are analyzed to make a comparison of these two optimistic and pragmatic approaches. For most of the postwar era, corporate, institutional, and government users constituted the entire computing market. In the 1980s, the influx of millions of individual users, both in households and businesses, radically changed the customer base of computer companies. The evolution of its needs drove the shift in successful business design from integration to specialization [120].

Thus, in this research, the history of global computer hardware industry is divided into three major epochs, referring to the definition of Bresnahan and Malerba [16]. As shown in Table 9, corresponding roughly to the first period 1940-1970, was one in which creation and persistence of IBM's leadership in mainframes occurred [102]. Mainframe computers are systems used for large departmental or company-wide applications, and IBM arose from an early competitive struggle to dominate supply, in marketing capabilities needed to make computers commercially useful, and the management structures that could link technology and its use. The second industry epoch from 1970 to 1990 saw the founding and evolution of new computer segments and market. For instance, minicomputers are machines intended for scientific and engineering use in business applications, and microcomputers, namely, personal computers, are low-price, small systems for individual applications, both in business sites and at home. The third epoch of the industry saw competitive convergence of computers of all sizes in the 1990s. Existing types of small computers were networked together and offered to conventional customers, to erode the earlier market segmentation among mainframe, mini, and micro. This networked computer became the platform on which large applications could be built, and the buyers in this area are a complex mix of individuals, departments, and enterprises [17, 16].

During the first epoch, for mainframe computers, the S-T gap in the industry was not so wide due to the nature of technology instead of pharmaceutical industry. Thus, public policy has been of a pragmatic approach with top-down mission-oriented type. The effect has been quite different in the United States, Europe, and Japan. Early U.S. military policies supported early exploration and opening windows to different technological alternatives. Moreover, nonmilitary procurement fostered competition through buying from multiple sources. This military and government pursued goals driven by military – government needs, but also helped the technological and commercial development of the industry [110, 42]. In Europe, there has been major involvement of various governments in the support of national champions and protectionist measures in an attempt to create strong competitors to IBM from the United States. These policies such as research subsidies and public procurement were not so successful because they did not foster competition in the domestic market. Moreover IBM was already in a dominant position in the various European countries and the national champions in Europe had already accumulated technological and commercial lags [76, 102]. In Japan, on the other hand, public policy has been successful in the catching-up process with IBM, because it nurtured multiple competitors, coordinated imitation of IBM through coerced licensing, and sponsored collaborative research [62, 7, 122, 44].

During the second and third epochs, in microcomputers and computer networks, with the S-T gap gradually closing, public policy has contrarily been focused mainly on infrastructure, education, and standards establishment, and been of a bottom-up optimistic approach. Direct or indirect support for the creation of favorable conditions, such as an advanced infrastructure or the creation of skills, has proved quite successful in enlarging the size and fostering the growth of the market, increasing communication and interaction, and assisting entrepreneurship. Particularly, antitrust policy played a critical role in the United States, to make IBM unbundled hardware from software and facilitate the emergence of start-ups under the optimistic policy approach. Meanwhile, in Europe and Japan, the trade barrier was dismantled to foster the growth of market in this stage. Optimistic policies have both been emphasized in developing infrastructure and opening the market. Surely, several protectionist measures of pragmatic approach were also alternately adopted by Japan government, to develop local computer brand or technology standard [70, 37].

TABLE 9 COMPARATIVE ANALYSIS OF GLOBAL COMPUTER INDUSTRIAL DEVELOPMENT

		Creation & Persistence of IBM (1940~1970)	Creation of New Market Segments & Entry (1970~1990)	Network of Small Computers (1990~)
United States	Industrial development	◆ Related industry base of office equipment & electrical-electronic industry ◆ Government & military act as a source of fund & a consumer of technology ◆ University cooperate with government ◆ Basic research funded by private firms (IBM) ◆ 3 new entrants: office equipment, electronics, & new firms ◆ IBM became world leader in mainframes and remained for 30 years	◆ A large number of new specialized minicomputer firms entered the field, such as instrument firms (HP) ◆ Entrepreneurial start-up with roots at university ◆ New technology at the component level to satisfy new demands ◆ Emergence of personal computer & new application ◆ Brand & complementary technology competition ◆ IBM linked with Intel & Microsoft	◆ Networked computer systems were highly complex & rich in opportunities in all various components, and no single firm could innovate in all subsystems ◆ Importance of open platform, complementarities, & standard ◆ New entrants: spin-offs from established computer firms, science-based firms built by university scientists, & new firms with market competencies
	Applied policy tools	◆ Federal & military research funding ◆ Public procurement ◆ Strategic trade policy ◆ Federal support to the creation of IBM as a worldwide leader	◆ Emergence of venture capital ◆ Passage of the Bayh-Dole Act (1980) ◆ Entrepreneurship in university ◆ Anti-trust policies to IBM for unbundling ◆ Base of supporting industry (IC, software, instrument, & electronics)	◆ Support for the creation of favorable conditions, such as an advanced infrastructure or creation of skills in market, interaction, & entrepreneurship ◆ Technology standard ◆ Anti-trust law
Europe	Industrial development	◆ Related industry base of office equipment & electrical-electronic industry ◆ Government & military act as a source of fund & a consumer of technology (Britain & Germany) ◆ Science base in university ◆ Declined in competitiveness for IBM's challenge	◆ Limited new entrants enter the minicomputer industry ◆ The lack of venture capital & low spin-off rate from university (except of Britain) ◆ Main mainframe producers enter the PC market late and unsuccessful (Siemens, ICL) ◆ Niche strategies in diversification from consumer electronics into low-price components	◆ Survival in niches of system integration and custom software ◆ Tied up with key microprocessor producers ◆ Moved into vertical markets and applications like banking, hospitals, mobile phones, university, and infrastructure
	Applied policy tools	◆ International alliance with U.S., Japan, or other Europe firms ◆ Intervened by supporting mergers between unsuccessful firms to create national champion ◆ Public procurement to protect national champion's market ◆ Pan-European joint venture to fight IBM ◆ Anti-trust policies to IBM	◆ Public procurement & research subsidies ◆ National champions policies ◆ Protectionist measure	◆ Dismantling of trade barriers ◆ Setting of European standards ◆ Harmonization of technical norms ◆ Infrastructure & education
Japan	Industrial development	◆ Technology transfer from IBM ◆ New entrants: established heavy electric equipment, consumer electronics, & communications	◆ Build strong hardware competencies while IBM unbundled ◆ Technology leapfrogging by multi-company collaborative project in mainframe (Supercomputer/5^{th} Generation Computer Project) ◆ Threat to IBM's dominance in mainframe ◆ Minicomputer business were largely unsuccessful	◆ Focused on domestic market of PC industry ◆ Faced little competition from international computer ◆ Japanese-only PC standard began to look much less attractive as worldwide PC standard bundles ◆ Traditional giants declined or exited some business
	Applied policy tools	◆ Public & telephone firm's procurement to create domestic market ◆ Government sponsored or consortia project (FONTAC) ◆ Low-interest loan to local firms ◆ Encourage users to select local brand ◆ Nurtured multiple competitors, coordinated imitation of IBM through coerced licensing	◆ Government sponsored R&D program ◆ Government sponsored joint venture ◆ Develop local standard	◆ Develop local standard ◆ Encourage local brand ◆ Strategic trade policy ◆ Infrastructure & education

D. Cross-national and Cross-industrial Comparison

The discussion of the cross-national and cross-industrial case studies clearly show that policy-level or firm-level strategies have to be adapted and turned to the specific stage and market segment that have been selected for intervention. These comparative findings were highly effective to demonstrate the efficacy of these two strategy approaches that are time- and path-dependent on distinct scenarios. In cross-national comparison, for United States, a typical large country with science base and sizeable domestic market, the government often adopted the optimistic policy approach to manipulate the national resource for natural evolution of industrial development. In addition, pragmatist policy approach was often applied such as some protectionist measures by most of Europe countries and Japan in the emergent stage of industry, to strengthen the competitiveness of local industry as national champion firms, and then transfer into the optimistic policy approach based on the established capabilities or legacy of local industry while the industry gradually becomes mature. As to other small countries, due to the lack of industry resource, it seems to be necessary to maintain the policy tools based on the pragmatic approach to select the target industrial segment for developing.

Next, in cross-industrial comparison, the selection of policy approach for policymakers was strongly influenced by the nature of industrial S-T gap. In the long early days of pharmaceutical development, only optimistic policy approach was used by most countries due to the tremendously wide S-T gap until the process of "random screening" or the tools of biotechnology have been used in new drug development after 1980s. However, for computer industry with relatively narrow S-T gap, policy approach has been of a top-down pragmatic type by public support in the emergence of industry. Lastly, in IC industry, it reveals a complete transformation of policy approaches through the industrial evolution. For large countries, optimistic policy approach was firstly adopted to formulate the competitive advantages for the most favorable position in the industry, and then, transfer into pragmatic policy approach for fostering the development of technology and market, and finally, apply optimistic policy approach again to strengthen the hegemony of established industry giants. On the contrary, government in small countries must firstly adopt pragmatic policy approach to pour resources into specific industrial segment and maintain its progress while industrial development is amorphous, and changed to apply optimistic or sustain pragmatic approaches after industrial maturing, to develop specialization strategies based on the local legacy and capabilities.

VII. CONCLUSIONS

Different strategy visions and their deriving firm-level or policy-level approaches have been applied in distinct stage of industrial evolution by the resources and demands of different countries so as to aid their national industry to prevail in the global competition conditions. These cross-national and cross-industrial experiences were highly effective to demonstrate the efficacy of these two strategy approaches that are time- and path-dependent on distinct scenarios.

The conclusion of research also shows that the circumstantial conditions of optimistic approach for firms or industries are to possess the core competencies, market and technology leadership, or the competitive advantages derived from innovative enabling functions in quality, performance, and costs. It was often applied by the developed economies with affluent resources while market in burgeoning stage or technology in growth stage with an amorphous industrial structure. By contrast, circumstantial conditions of pragmatic approach for firms or industries are to possess the first-mover advantages under the limited resources and intensive market competition, and the sources of competitive advantages are derived from economies of scale and scope. It was often adopted by the newly developing economies with insufficient resources at the maturity status of markets.

Based on the findings of the cross-national and cross-industrial comparison for global IC, pharmaceutical, and computer industry, it also clearly reveal that policy-level or firm-level strategies have to be adapted and turned to the specific stage, S-T gap, and market segment that have been selected for intervention. In this sense, policy-level or firm-level approaches should be flexible and sensitive and keep open windows on a wide range of technologies and market situation.

REFERENCES

[1] Abernathy, W., Utterback, J. (1978). "Patterns of Industrial Innovation". *Technology Review*, pp.41-47.

[2] Acs, Z. J., and Audretsch, D. B., (1988). "Innovation in Large and Small Firms", *American Economics Review*, Vol.78, pp.678-690.

[3] Afuah, A. (1998). *Innovation Management: Strategies, Implementation, and Profits*. Oxford University Press. pp.84-85.

[4] Afuah, A. (1998). "Practical Case: The Case of the Global Pharmaceutical Industry", In Afuah, A. (Eds.) *Innovation Management: Strategies, Implementation, and Profits*. Oxford University Press, pp.323-332.

[5] Albert, M. (1991). *Capitalism vs. Capitalism*. New York: Four Wall Eight Windows.

[6] Alic, J. A., Branscomb, L. M., Brooks, H., Carter, A. B., and Epstein, G. L., (1996). *Beyond Spinoff: Military and Commercial Technologies in a Changing World*, The President and Fellows of Harvard Colledge.

[7] Anchordoguy, M. (1989). *Computers Inc.: Japan's Challenge to IBM*, Cambridge, Mass., Harvard University Press.

[8] Arora, A., and Gambardella, A., (1990). "Complementarity and External Linkage: The Strategies of the Large Firms in Biotechnology", *Journal of Industrial Economics*, Vol.37 (4), pp.361-379.

[9] Arthur, B. (1996). "Increasing Returns and the New World of Business". *Harvard Business Review.* July-August, pp.100-109.

[10] Averch, H.A. (1985). *A Strategic Analysis of Science and Technology Policy*. The John Hopkins University Press, pp.47-56.

[11] Barfield, C. (1994). *Science Policy from Ford to Reagan, Change and Continuity.* American Enterprise Institute for Public Policy Research.

[12] Bayraktar, B. (1990). "On the Concept of Technology and

Management of Technology". In Khalil, Bayraktar, B. (Eds.) *Management of Technology II: The Key to Global Competitiveness*. Industrial Engineering and Management Press, Norcross, GA.
[13] Berman, E., and Khalil, T., (1992). "U.S. Technological Competitiveness in the Global Economy: A Survey", *Production and Technological Innovation Management*, Vol.7, N.4/5, pp347-358.
[14] Betz, F. (2003). *Managing Technological Innovation: Competitive Advantage from Change*. John Wiley & Sons.
[15] Braun, E. (1984). *Wayward Technology*. Greenwood Press, Westport, Conn.
[16] Bresnahan, T., and Malerba, F. (1999). "Industrial Dynamics and the Evolution of Firm's and Nation's Competitive Capabilities in the World Computer Industry". In: Mowery, D., Nelson, R. (Eds): *Sources of Industrial Leadership – Studies of Seven Industries*. Cambridge University Press, pp.79-132.
[17] Bresnahan, T., and Greenstein, S., (1999). "Technological Competition and the Structure of the Computer Industry", *Journal of Industrial Economics*, Vol.47, n.1, pp.1-40.
[18] Brooks, H. (1965). "The Interaction of Science and Technology: Another View". In Wanner, W., Morse, D. Eicher, A. (Eds.) *The Impact of Science and Technology*. Columbia University Press, New York.
[19] Brooks, H., (1996). "The Evolution of U.S. Science Policy". In Smith, B. and Barfield, C. (Eds.) *Technology, R&D, and the Economy*, Brookings Institution Press, pp15-48.
[20] Bush, V. (1980). *Science, the Endless Frontier*. Arno Press Reprint.
[21] Berger, S. (2006). *How We Compete*. Doubleday, 29-55.
[22] Callon, S. (1995). *Divided Sun: MITI and the Breakdown of Japanese High Tech Industrial Policy, 1975-1993*. Stanford, California: Stanford University Press.
[23] Chandler, Jr. (1990). *Scale and Scope: The Dynamics of Industrial Capitalism*. Cambridge. Harvard University Press, pp.51-89.
[24] Chen, C. F., Sewell, G. (1996). "Strategies for Technological Development in South Korea and Taiwan: The Case of Semiconductors". *Research Policy* 25(5): pp.759-783.
[25] Chen, H. C., (2006). An Integrated Value-Creation Process for Innovation-Intensive Industries. Ph.D. Dissertation, Institute of Management of Technology, National Chiao Tung University, pp.1-3.
[26] Chen, H. C., Shyu, Joseph Z. (2004). Innovation Intensive Service as actors of Platform Strategy Adapted to Emerging Industry Development, *Portland International Conference on Management of Engineering and Technology,* Seoul, Korea.
[27] Chiu, Y. C., (2003). A Research of Impacts of National Innovation Systems on the Developments of Taiwan's High-tech Industries. Ph.D. Dissertation, Institute of Management of Technology, National Chiao Tung University, 41-42. (in Chinese)
[28] Chiu, Y. C., Chen, B., Shyu, Joseph Z., and Tzeng G. H., (2006). "An Evaluation Model of New Product Launch Strategy", *Technovation*, Vol.26, pp.1244-1252.
[29] Christensen, C. (1997). *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*. Harvard Business School Press.
[30] Christensen, C., Anthony, S., and Roth, E. (2004). *Seeing What's Next: Using the Theories of Innovation to Predict Industry Change*. Harvard Business School Press.
[31] Christensen, C., and Raynor, M. (2003). *The Innovator's Solution: Creating and Sustaining Successful Growth.* Harvard Business School Press.
[32] Cohen, W. M., Levin, R. C., and Mowery, D. C., (1987). "Firm Size and R&D Intensity: A Re-examination", *Journal of Industrial Economics*, Vol.35, pp.543-563.
[33] Colton, R. M., Ryan, T. M., and Senich, D., (1985). "National Science Foundation Experiences in Stimulating Industrial Innovation", In Landon, R., and Rothwell, R., (Eds.), *Design and Innovation: Policy and Management*, St. Martin's Press, New York, pp.103-114.
[34] Cool, K., and Schendel, D., (1988). "Performance Differences among Strategic Group Members", *Strategic Management Journal,* Vol.9, pp.207-223.
[35] Corbett. M. F. (2004), *The Outsourcing Revolution*, Free Press.
[36] Cottrell, T. (1995). "Japanese Microcomputer Software: Standards Compatibility and Competitiveness". In: Mowery, D. (Editors): *The International Computer Software Industry: A Comparative Study of Industrial Evolution and Structure*. New York: Oxford University Press.
[37] Cottrell, T. (1994). "Fragmented Standards and the Development of Japan's Microcomputer Software Industry", *Research Policy,* Vol.23, n.2, pp.143-174.
[38] Dixit, A., and Norman, V. (1980). *Theory of International Trade*. Cambridge: Cambridge University Press.
[39] Economides, N., (1996). "The Economics of Networks", *International Journal of Industrial Organization,* Vol.14, pp673-699.
[40] Ethier, W. (1982). "National and International Returns to Scale in the Modern theory of International Trade". *American Economic Review*, 72, pp.389-405.
[41] Evans, P. B., and Wurster, T. S., (1999) "Strategy and the New Economics of Information", In Tabscott, D. (Eds.), *Creating Value in the Network Economy*, Harvard Business School Press, Boston, pp.13-34.
[42] Ferguson, C., and Morris, C., (1990). "Computers and the Coming of the U.S. Keiretsu", *Harvard Business Review*, V.68, n.4, pp.55-70.
[43] Fiegenbaum. A., and Karnani, A., (1991). "Output Flexibility-A Competitive Advantage for Small Firms", *Strategic Management Journal*, Vol.12, pp.101-114.
[44] Forsberg, A., (2000). *America and the Japanese Miracle: The Cold War Context of Japan's Postwar Economic Revival, 1950-1960*, The University of North Carolina Press.
[45] Foster, R. (1986). *Innovation: The Attacker's Advantage*. New York: Summit Books.
[46] Foster, R., and Kaplan, S. (2001). *Creative Destruction*. McKinsey & Company, Inc.
[47] Gambardella, A., (1992). "Competitive Advantages from In-house Scientific Research: The US Pharmaceutical Industry in the 1980s", *Research Policy*, Vol.21, pp.391-407.
[48] Gambardella, A., (1995). *Science and Innovation in the U.S. Pharmaceutical Industry*, Cambridge University Press, Cambridge.
[49] Gay, B., and Dousset, B., (2005). "Innovation and Network Structural Dynamics: Study of the Alliance Networks of a Major Sector of the Biotechnology Industry", *Research Policy*, Vol.34, pp.1457-1475.
[50] Grabowski, H., and Vernon, J., (1994). "Innovation and Structural Change in Pharmaceuticals and Biotechnology", *Industrial and Corporate Change*, Vol.3 (2), pp.435-450.
[51] Granstand O., and Sigurdson, J., (1985). "Innovation Policies in East Asia", In Landon, R., and Rothwell, R., (Eds.), *Design and Innovation: Policy and Management,* St. Martin's Press, New York, pp.137-163.
[52] Hagel III, J., and Brown, J., S. (2006). *The Only Sustainable Edge,* Harvard Business School Press, Boston, MA.
[53] Hall, P., and Soskice, D. (2001). *Varieties of Capitalism*. Oxford: Oxford University Press.
[54] Hauknes, J., and Hales, K. (1998). "Service in Innovation – Innovation in Services", SI4S Synthesis Paper S1: 1998, Oslo.
[55] Heckscher, E. (1949). "The Effects of Foreign Trade on the Distribution of Income". In: Ellis, H.; Metzler, L. (Eds): *Readings in the Theory of International Trade*. Homewood, IL: Irwin.
[56] Helpman, E. (1981). "International Trade in the Presence of Product Differentiation, Economies of Scale, and Monopolistic Competition-A Chamberlinian Heckscher-Ohlin Approach", *Journal of International Economics*, 11, pp.305-340.
[57] Henderson, R., Orsenigo, L., and Pisano, G. P., (1999). "The Pharmaceutical Industry and the Revolution in Molecular Biology: Interactions among Scientific, Institutional, and Organizational Change". In: Mowery, D., Nelson, R. (Eds): *Sources of Industrial Leadership – Studies of Seven Industries*. Cambridge University Press, 267-311.
[58] Hill, C., and Jones, G. (2001). *Strategic Management: An Integrated Approach*. Houghton Mifflin Company.
[59] Hufbauer, G.R. (1966). *Synthetic Materials and the Theory of International Trade.* Cambridge, MA, Harvard University Press.
[60] Imai, K. I., (1992). "The Japanese Pattern of Innovation and Its Evolution", In Rosenberg, N., Landau, R., and Mowery, D., (Eds.): *Technology and the Wealth of Nations*, Stanford University Press,

California, pp.225-244.
[61] Jacobs, D., (1998). "Innovation Policies within the Framework of Internationalization", *Research Policy*, Vol.27, pp.711-724.
[62] Johnson, C., (1986). *MITI and the Japanese Miracle: the Growth of Industrial Policy: 1925-1975*, Charles E. Tuttle Co.
[63] Kaiser, R., and Prange, H., (2004). "The Reconfiguration of National Innovation Systems-the Example of German Biotechnology", *Research Policy*, Vol.33, pp.395-408.
[64] Kash, D. E. and Rycoft, R. W. (2000). "Patterns of Innovating Complex Technologies: A Framework for Adaptive Network Strategies", *Research Policy*, Vol.29, pp.819-831.
[65] Katz, M. L., and Shapiro, C. (1985). "Network Externalities, Competition and Compatibility", *American Economic Review*, 75(3), pp.424-40.
[66] Katz, M. L., and Shapiro, C. (1992) "Product Introduction with Network Externalities", *Journal of Industrial Economics*, Vol.40, No.1, pp55-84.
[67] Kenney, M., (1986). "Schumpeterian Innovation and Entrepreneurs in Capitalism: A Case Study of the U.S. Biotechnology Industry", *Research Policy,* Vol.15, pp.21-31.
[68] Khalil, T. (2000). *Management of Technology: the Key to Competitiveness and Wealth Creation*. The McGraw-Hill Companies.
[69] Kilgore, H. (1945). "Science and Government". *Science*, Dec. 21, pp.630.
[70] Kobayashi, (1985). "Japanese Industrial Policy: Competition and Collaboration", In Landon, R., and Rothwell, R., (Eds.), *Design and Innovation: Policy and Management*, St. Martin's Press, New York, pp.115-122.
[71] Krugman, P. ed. (1987). *Strategic Trade Policy and the New International Economics*. Cambridge, MA, MIT Press.
[72] Lancaster, K. (1980). "Intra-industry Trade under Perfect Monopolistic Competition". *Journal of International Economics*, 10, pp.151-175.
[73] Langlois, R., and Steinmueller, E. (1999). "The Evolution of Competitive Advantage in the Worldwide Semiconductor Industry". In: Mowery, D., Nelson, R. (Eds): *Sources of Industrial Leadership – Studies of Seven Industries.* Cambridge University Press, pp.19-78.
[74] Lee, M., Son, B., and Om, K., (1996). "Evaluation of National R&D Projects in Korea", *Research Policy*, Vol.25, pp.805-818.
[75] Lee, C. Y., and Sung, T., (2005). "Schumpeter's Legacy: A New Perspective on the Relationship between Firm Size and R&D", *Research Policy*, Vol.34, pp.914-931.
[76] Malerba, F., (1992). "The Organization of the Innovative Process", In Rosenberg, N., Landau, R., and Mowery, D., (Eds.): *Technology and the Wealth of Nations*, Stanford University Press, California, pp.247-278.
[77] McMillan, G. S., Narin, F., and Deeds, D. L., (2000). "An Analysis of the Critical Role of Public Science in Innovation: The Case of Biotechnology", *Research Policy*, Vol.29, pp.1-8.
[78] Meyer. M. H., and Dalal, D., (2002). "Managing Platform Architectures and Manufacturing Processes for Nonassembled Products", *The Journal of Product Innovation Management*, Vol.19, pp.277-293.
[79] Mills, D., and Schumann, L., (1985). "Industry Structure with Fluctuating Demand", *American Economic Review,* 75(4), pp.758-767.
[80] Mintzberg, H. (1987). "Five Ps for Strategy". *California Management Review*, Fall.
[81] Mintzberg, H., McGugh, A. (1985). "Strategy Formation in an Adhocracy". *Administrative Science Quarterly*, Vol. 30, No. 2.
[82] Mitchell, W., Roehl, T., and Slattery, R. J., (1995). "Influences on R&D Growth Among Japanese Pharmaceutical Firms, 1975-1990", *Journal of High Technology Management Research*, Vol.6(1), pp.17-31.
[83] Moore, G. A. (1991). *Crossing the Chasm.* New York: HarperCollins.
[84] Moravcsik, M. J., (1986). "Two Perceptions of Science Development", *Research Policy,* Vol. 15, pp1-11.
[85] Mowery, D. (1994). "The Beginning of the Commercial Exploitation of Science by U.S. Industry", In Mowery, D., (Eds.) *Science and Technology Policy in Interdependent Economies*. Klumer Academic Publishers, pp.35-58..
[86] Mowery, D. (1998). "The Changing Structure of the US National Innovation System: Implications for International Conflict and Cooperation in R&D Policy", *Research Policy*, Vol.27, pp.639-654.
[87] Mowery, D., and Nelson, R. (1999). *Sources of Industrial Leadership –Studies of Seven Industries*. Cambridge University Press, pp.10-13.
[88] Mowery, D., and Steinmueller, E. (1994). "Prospects for Entry by Developing Countries into the Global Integrated Circuit Industry: Lessons from the United States, Japan, and the NIEs, 1955-1990". In: Mowery, D. (Eds): *Science and Technology Policy in Interdependent Economies*. Klumer Academic Publishers, pp.199-253
[89] Nasheim, J. (2005). *The Power of Unfair Advantage*. Free Press.
[90] Nelson, R. (1989). "U.S. Technological Leadership: Where Did It Come from and Where Did It Go?" In: Jasanoff, S. (Eds): *Comparative Science and technology Policy*. An Elgar Reference Collection, pp.222-237.
[91] OECD. (1996). *Reviews of National Science and Technology Policy, Republic of Korea*. OECD Publication.
[92] Ohlin, B. (1933). *International and Interregional Trade*. Cambridge, MA: Harvard Economic Studies.
[93] Omi Koji, (2003). *Technological Revolution: The Emergence of Japan*, TOKYO KEIZAI INC., Tokyo. (in Japanese)
[94] O'Sullivan, E., L., Spangler, K., J., (1998). *Experience Marketing,* Venture Publishing, State College, PA.
[95] Pine II, B. J. (1993). *Mass Customization: the Next Frontier of Business Competition*. Harvard Business School Press: Boston, MA.
[96] Pine II, B. J., and Gilmore, J., H. (1999). *The Experience Economy*, Harvard Business School Press.
[97] Pisano, G., (1991). "The Governance of Innovation: Vertical Integration and Collaborative Arrangements in the Biotechnology Industry", *Research Policy,* Vol.20, pp.237-249.
[98] Porter, M. (1980), "Competitive Strategy in Emerging Industries", In *Competitive Strategy: Techniques for Analyzing Industries and Competitors*, Free Press, pp.215-236.
[99] Posner, M.V. (1961). *International Trade and Technical Change*. Oxford Economic Papers.
[100] Prestowitz, C. (2005). *Three Billion New Capitalists: The Great Shift of Wealth and Power to the East*. Basic Books, pp.36-138.
[101] Price, D. J. (1984). "Is Technology Historically Independent of Science?", *Technology and Culture* 6(4):553, 1965. Allen, T. Managing the Flow of Technology.
[102] Pugh, E., (1995). *Building IBM: Shaping an Industry and Its Technology*, Cambridge, Mass, MIT Press.
[103] Quinn, J. B., Anderson, P., and Finklestein, S. (1996). "Managing Professional Intellect: Making the Most of the Best". *Harvard Business Review*. March-April.
[104] Reid, T.R. (2001). *The Chip: How Two Americans Invented the Microchip and Launched a Revolution.* Random House.
[105] Reich, M., (1990). "Why Japanese Don't Export More Pharmaceuticals: Health Policy as Industrial Policy", *California Management Review*, Winter, pp.124-150.
[106] Reingold, N. (1991). *Science, American Style*. Rutgers University Press, 284-333.
[107] Ricardo, D. (1948). *On the Principles of Political Economy and Taxation*. New York: Dutton.
[108] Rip, A., and Nederhof, A. J., (1986). "Between Dirigism and Laissez-faire: Effects of Implementing the Science Policy Priority for Biotechnology in the Netherlands", *Research Policy*, Vol.15, pp.253-268.
[109] Roberts, E., and Hauptman, O., (1986). "The Process of Technology Transfer to the New Biomedical and Pharmaceutical Firm", *Research Policy*, Vol.15, pp.107-119.
[110] Rossner, J. D., (1985). "Prospects for a National Innovation Policy in the United States", In Landon, R., and Rothwell, R., (Eds.), *Design and Innovation: Policy and Management*, St. Martin's Press, New York, pp.63-72.
[111] Rothwell, R., and Dogson, M., (1994). "Innovation and Size of Firm", In Dogson, M., and Rothwell, R., (eds.) *Handbook of Industrial Innovation* , Edward Elgar, pp.310-324.
[112] Saperstein, J., and Rouach, D. (2002). *Creating Regional Wealth in*

the Innovation Economy: Models, Perspectives, and Best Practices. Financial Times Prentice Hall.
[113] Sakakibara, K., and Wetney, D. E., (1992). "Japan's Management of Global Innovation: Technology Management Crossing Borders", In Rosenberg, N., Landau, R., and Mowery, D., (Eds.): *Technology and the Wealth of Nations*, Stanford University Press, California, pp.247-278.
[114] Shane, S. (2005). *Finding Fertile Ground: Identifying Extraordinary Opportunities for New Ventures*. Pearson Education, Inc.
[115] Shenkar, O., and Luo, Y. (2004). *International Business*. John Wiley & Sons, 23-29.
[116] Shy, O., (1996). "Technology Revolutions in the Presence of Network Externalities", *International Journal of Industrial Organization,* Vol.14, pp785-800.
[117] Shyu, Joseph Z. (1995). *Global Science and Technology Policy and Corporation Operation*. Hwatai, 95-117. (in Chinese)
[118] Shyu, Joseph Z., Chiu, Y. C., and You, C. C., (2001). "A Cross-national Comparative Analysis of Innovation Policy in the Integrated Circuit Industry", *Technology in Society*, Vol.23, pp.227-240.
[119] Shyu, Joseph Z., and Chiu, Y. C., (2002). "Innovation Policy for developing Taiwan's Competitive Advantages", *R&D Management*, Vol.32 (4), pp.69-374.
[120] Slywotzky, A. J. (1996). *Value Migration: How to Think Several Moves ahead of the Competition*, Corporate Decisions.
[121] Smith, A. (1869). *An Inquity into the Nation and Causes of the Wealth of Nations*, Book IV, Oxford: Clarendon Press, pp.29-31.
[122] Sobel, R., (1986). *IBM vs. Japan: The Struggle for the Future*, New York, Stein & Day.
[123] Suarez, F., F., and Utterback, J. M., (1995). "Dominant Designs and the Survival of Firms", *Strategic Management Journal,* Vol.16, pp.415-430.
[124] Suarez, F., F., (2004). "Battles for Technological Dominance: An Integrative Framework", *Research Policy*, Vol.33, pp.271-286.
[125] Teece, D. J. (1986). "Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy", *Research Policy*, Vol.15, pp.285-306.
[126] Teitelman, R. (1994). *Profits of Science*. Basic Books, pp.33-51.
[127] Thomas, L. G., (1994). "Implicit Industrial Policy: The Triumph of Britain and the Failure of France in Global Pharmaceuticals", *Industrial and Corporate Change*, Vol.3 (2), pp.451-489.
[128] Tisdell, C.A. (1981). *Science and Technology Policy: Priorities of Governments*. Chapman and Hall, London and New York.
[129] Tsoi, S. K., Cheung, C. F., and Lee, W. B., (2003). "Knowledge-based Customization of Enterprise Applications", *Expert System with Application,* Vol.25, pp.123-132.
[130] Tushman, M. L., and Rosenkopf. L. (1992). "Organizational Determinants of Technological Change: Towards a Sociology of Technological Evolution". *Research in Organizational Behavior* Vol.14, pp.311-347.
[131] Uiardot, E., (1998). *Successful Marketing Strategy for High-Tech Firms*, Artech House.
[132] Utterback, J. (1994). *Mastering the Dynamics of Innovation*, Boston, MA, Harvard University Press.
[133] Van Dijk, B., Hertog, R. D., Menkveld, B., and Thurik, R., (1997). "Some New Evidence on the Determinants of Large- and Small-Firm Innovation", *Small Business Economics*, Vol.9, pp.335-343.
[134] Varian, H. R., (1994). "Systems Competition and Network Effect", *Journal of Economic Perspective*, Vol.8, No. 2, pp.93-115.
[135] Vernon, R. (1979). *The Product Cycle Hypothesis in a New International Environment.* Oxford Bulletin of Economics and Statistics, 255-267.
[136] Vogel, E., (1986). *Comeback: Building the Resurgence of American Business*, Holiday House.
[137] Zachary, G. (1999). *Endless Frontier: Vannevar Bush, Engineer of the American Century.* The MIT Press.
[138] Zucker, G., L., and Darby, M. R., (1997). "Present at the Revolution: Transformation of Technical Identity for a Large Incumbent Pharmaceutical Firm After the Biotechnological Breakthrough", *Research Policy*, Vol.26 (4,5), pp.429-447.
[139] Zucker, G., L., Darby, M. R., and Brewer, M., (1997). "Intellectual Human Capital and the Birth of U.S. Biotechnology Enterprises", *American Economic Review,* June, Vol.87 (3).
[140] Zuscovitch, E., (1986). "The Economic Dynamics of Technologies Development", *Research Policy*, Vol.15, pp.175-186.