Conclusion

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Abstract In this concluding chapter of the present book, we first summarize the research results of the previous 14 chapters, including theoretical frameworks (Chapters "A Design-Information-Flow View of Industries, Firms, and Sites," "The Nature of International Competition Among Firms," "Product Variety for Effective Demand Creation," "Capability Building and Demand Creation in 'Genba-Oriented Firms'," and "Evolution of Business Ecosystems"), cases of capability building of firms and sites in global competition (Chapters "Evolution of Organizational Capabilities in Manufacturing: The Case of the Toyota Motor Corporation," "The Nature of Surviving Japanese Factories in the Global Competition: An Empirical Analysis of Electrical and Electronics Factories," "The Effectiveness of Group Leaders in the Lean Production System: Time Study and Agent-Based Model of Leaders' Behavior," "The Diversity and Reality of Kaizen in Toyota," "Balancing Standardization and Integration in ICT Systems: An Architectural Perspective"), and cases of architectural strategies and demand creation by firms in digital industries (Chapters "Creating New Demand: The Impact of Competition, the Formation of Submarkets," "Decline in Demand Creation: The Development Productivity Dilemma and Its Consequences," "Investigating the Creation and Diffusion of Knowledge for Demand Creation: The Case of the Telecommunications Industry," and "The Impact of Platform Providers' Knowledge on Interfirm Division of Labor: The Case of the Mobile Phone Industry").

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After that, we present an augmented version of the capability-architecture-performance framework, which was initially proposed in chapter "A Design-Information-Flow View of Industries, Firms, and Sites." That is, based on our research results, which demonstrate the multilayered nature of capability building and demand creation, we reconstruct our capability-architecture framework as follows. On the supply side, the evolution of manufacturing capabilities and production technologies leads to capability building and productivity improvements at the level of sites, firms, and industries, which makes it possible for production and development sites in high-wage nations to survive intense global cost competition. On the demand side, the evolution of technologies and architectures at the level of products, components, and platforms results in great product variety and quality, which drives up the products' demand curves and expands their effective demand quantities. Capability-building capability for the former and architecture-building capability for the latter are the key dynamic capabilities allowing both firms and sites to survive and grow in the long run.

Thus, our conclusion is that the design-flow view of manufacturing and the capability-architecture-performance framework for analyzing the evolution of industries and firms can explain rather consistently the main industrial phenomena of the late twentieth century and early twenty-first century, i.e., intense global competition and rapid digitalization.

1 Summary of the Book

1.1 Explaining Evolution in the Age of Globalization and Digitalization

The present book illustrates an evolutionary framework based on the social sciences for analyzing the dynamics of firms, industries, and industrial sites. In its empirical and historical application, we focus on globalization and digitalization of firms and industries between the 1990s and 2010s, since we believe these to be the two trends that most significantly changed our society during that period. In other words, this book tries to identify the basic logic that can consistently explain what happened to national economies, industries, firms, and their sites (*genba*) looking mostly at Japan, one of the countries most heavily affected by this coincidence of globalization and digitalization.

More specifically, we explore three main trends of this period: (i) *global cost competition between advanced nation*s *and emerging nation*s, whose average wage rates are extremely low (e.g., roughly speaking $100 per month in China versus $2000 per month in Japan); (ii) *minute interindustrial trade*, which is significantly affected by the firms' choice of locations for both design sites and production sites; and (iii) *new forms of competition and complementation in digital (ICT) industries*, in which rapid demand creation is achieved by effective platform formation, in addition to effective product development. This book aims to identify a theoretical framework that may thoroughly interpret the industrial phenomena mentioned above.

For the purpose of explaining the phenomena occurring in high-wage industrialized national economies during the era of global competition and digitalization, the authors present empirical, historical, and theoretical evidence, including field studies and statistical analyses. We investigate both conventional physical goods sectors and information/computer/software sectors, capability building and demand creation, product competition and platform competition, as well as advanced nations and emerging economies.

1.2 Summary of the Chapters

Before proposing an overall framework for analyzing the aforementioned industrial phenomena of the late twentieth and early twenty-first century, let us summarize the previous 14 chapters of the present book.

1.2.1 Theoretical Foundations

The first part of this book, chapters "A Design-Information-Flow View of Industries, Firms, and Sites," "The Nature of International Competition Among Firms," "Product Variety for Effective Demand Creation," "Capability Building and Demand Creation in 'Genba-Oriented Firms'," and "Evolution of Business Ecosystems," explored theoretical concepts and frameworks that may explain the evolution of economic entities, such as industries, firms, and manufacturing sites (genba), as well as that of economic artifacts, such as products, components, and platforms.

Although different chapters focused on subtly different topics, they shared certain common concepts, among which industries as flows of economic value, organizational routines and capabilities that govern such flows, productivity and overall productive performance as effectiveness of such flows. cost competition as a handicapped productivity race with international wage gaps, the manufacturing site as the foundation of a firm/industry/region, demand creation for stable employment, design as a source of value added, technology and architecture as the two sides of design, industries as networks of competing/complementing/transacting products, and firms' strategies that take into account the capabilities of manufacturing sites and/or architectures of platforms/products/components.

Chapter "A Design-Information-Flow View of Industries, Firms, and Sites" proposed an overall evolutionary framework for analyzing firms, industries, and manufacturing sites (genba), as well as products and platforms. Manufacturing sites were broadly defined as the places where value-carrying design information flows to the customers. Within this manufacturing site-based view, a firm was regarded as a collection of various sites under the control of single capital, whereas an industry was defined as a collection of similar sites in terms of their product design information.

By dynamically reinterpreting the classical concept of comparative advantage and applying it not only to production costs but also to design costs, this introductory chapter tried to explain what happened to the trade goods industrial sectors of postwar Japan in terms of economic growth, labor shortage, yen appreciation, capability building, international competition during the Cold War, global competition after the Cold War, and relative wage/productivity divergence and convergence vis-à-vis other advanced/emerging nations.

Chapter "The Nature of International Competition Among Firms" presented a modern and dynamic reinterpretation of the Ricardian-Sraffian theories of international values and trade (Ricardo 1951, Fujimoto and Shiozawa 2012) and applied it to the cases of *handicapped productivity competition* with large wage gaps between advanced and emerging nations. We started from Ricardo's original two-country, two-commodity cases and moved on to the determination of international values in M-country, N-commodity cases (mainly $M < N$), defined by a spanning tree (a term from graph theory) of competitive production techniques, which we may call a "new theory of international values." This theory of international values was also applied to some actual industrial and trade phenomena during the period of global competition and digitalization, mainly between the 1990s and 2010s.

Chapter "Product Variety for Effective Demand Creation" introduced a conceptual framework explaining *effective demand creation by product variety*. Using a coverage function linking product variety with the coverage ratios of effective demand achieved as a percentage of potential demand, we identified the optimal product variety that can maximize cumulative profit, as a firm increases the number of products introduced to the market. This tool makes it possible to predict how optimal product variety is affected by such strategic factors as fixed costs, variable costs, mark-up ratios, product cycle positions, and potential sales volumes.

Chapter "Capability Building and Demand Creation in 'Genba-Oriented Firms'" argued that building capabilities for productivity improvements (mostly chapters "A Design-Information-Flow View of Industries, Firms, and Sites" and "The Nature of International Competition Among Firms") and enhancing product design variety and quality for effective demand creation (Chapter "Product Variety for Effective Demand Creation") are not separate issues but interconnected activities for certain types of firms, i.e., *genba-oriented firms*. The analysis relied on a simple approach with Ricardian linear cost functions (flat supply curves) and product differentiation by design (downward-sloping demand curves). We illustrated a four-quadrant model with four main variables, supply price (P), demand quantity (X), number of employees (N), and wage rates (W), which we called *PXNW model*. By analyzing it, we argued that genba-oriented firms may reach a steady state that ensures the achievement of target profit (mark-up) rate and target number of employees at the same time. Moreover, they can move from one steady state to another, improved steady state with higher wage-to-price ratio by combining (i) capability building for enhancing physical productivities and (ii) product design improvements for generating additional demand at the firm level.

Chapter "Evolution of Business Ecosystems" turned to the evolution of *business ecosystems* under global digitalization, where the platforms and/or products in question are characterized by open-modular (open) architectures with many complementary goods. The key to this industrial transformation is modularization, or the decomposition of a complex artifact into functionally nearly complete (i.e., nearly decomposable) modules by creating open industry-standard interfaces among them. In such an open-modular system of products and components, or *platform*, the interrelations among products and/or components are not only competitive or transactive but also complementary. In this case, cumulative effects among mutually complementary goods (i.e., network externalities) make for extremely rapid demand creation through the cumulative expansion of successful platforms.

In business ecosystems, proactive strategic changes to product architectures made by platform-leading firms (e.g., establishing global standard interfaces among complementary products) can cause drastic and rather swift changes in the industry's structures. From this point of view, clear differences are detected between the patterns of industrial competition in traditional product-to-product sectors (discussed in chapters "The Nature of International Competition Among Firms," "Product Variety for Effective Demand Creation," and "Capability Building and Demand Creation in 'Genba-Oriented Firms'"), in which the relative quality and variety of a firm's products vis-à-vis those of the competitors are key to success, and in the emerging platform-based environments illustrated in chapter "Evolution of Business Ecosystems," in which creating large clusters of complementary products and firms against rival platforms is the crucial factor.

Our capability-architecture framework can be effectively applied to both product competition and platform competition. On the side of architecture, we think that the difference between the two can be attributed to the architectural transformations of the products and platforms in question; on the side of capability, we argue that capability-building capabilities are important in product competition, whereas architecture-building capabilities are critical in platform competition. In any case, it is our opinion that these two industrial phenomena must be analyzed together, partly because product competition continues inside the ecosystem and partly because platform competition sometimes emerges in the middle of intense product competition in today's world of globalization and digitalization.

1.2.2 Capability Building of Firms and Sites Facing Global Competition

Chapters "Evolution of Organizational Capabilities in Manufacturing: The Case of the Toyota Motor Corporation," "The Nature of Surviving Japanese Factories in the Global Competition: An Empirical Analysis of Electrical and Electronics Factories," "The Effectiveness of Group Leaders in the Lean Production System: Time Study and Agent-Based Model of Leaders' Behavior," and "The Diversity and Reality of Kaizen in Toyota" discussed manufacturing capability building to improve physical productivity at multiple levels, including firms, factories, and organizational units within them.

Chapter "Evolution of Organizational Capabilities in Manufacturing: The Case of the Toyota Motor Corporation" investigated the formation of a firm's complex operation-based competency, such as that of the Toyota Motor Corporation in manufacturing. We suggested combining the resource-capability view of the firm and the evolutionary framework, i.e., a dynamic perspective that separately explains an observed system's survival (functional logic) and its formation (genetic logic). To shed light on the evolution of complex manufacturing systems, two main concepts were proposed: *multipath system emergence*, for analyzing unpredictable variations in such manufacturing systems, and *evolutionary learning capability*, or simply evolutionary capability, for explaining why certain firms can develop complex manufacturing capabilities faster and enjoy sustainable competitive advantages longer than their rivals. The chapter tried to apply these concepts and frameworks to a historical analysis of organizational routines in the manufacturing system at Toyota.

Chapter "The Nature of Surviving Japanese Factories in the Global Competition: An Empirical Analysis of Electrical and Electronics Factories" discussed manufacturing capabilities and competitiveness mostly at the level of factories (manufacturing sites). To do so, the authors used questionnaire-based surveys of about 100 Japanese factories in the electrical and electronics industries, the Japanese sectors most affected by the combination of globalization and digitalization in the period between the 1990s and 2010s.

As for competitiveness, the surveys measured both productive performance (deep-level competitiveness) and market performance (surface-level competitiveness), introduced in chapter "A Design-Information-Flow View of Industries, Firms, and Sites." In relation to the former, the questionnaires focused on the perceived relative performance levels of industrial sites regarding quality, productivity, cost, delivery, flexibility, and development vis-à-vis their toughest competitors, including foreign factories within the same company. In terms of the latter indicator, price and service competitiveness was evaluated against that of main rivals.

The results of the surveys indicated that, even in the case of apparently declining industries in Japan, manufacturing capabilities and productive performance were still at world-class level, but this was not true for unit production costs. This evidence confirms the basic nature of global cost competition as a productivity race with international wage gaps as handicaps (Chapter "The Nature of International Competition Among Firms"). On the other hand, high responsiveness to customer demands was these factories' most effective capability to overcome unit cost disadvantages. Moreover, multifunctionality of production sites was a supporting factor to boost the performance of these struggling factories, and new product proposals/development improved shop-floor organizational openness and effectively activated shop-floor communication.

Chapter "The Effectiveness of Group Leaders in the Lean Production System: Time Study and Agent-Based Model of Leaders' Behavior" explored the level of work groups and group leaders inside individual factories. Although the literature on Japanese manufacturing, the Toyota System, and Lean Production has often emphasized the importance of group leaders in manufacturing capability building (e.g., *kaizen*), there has been little research on the role and behavior of real group leaders based on in-depth field studies.

Against this background, the chapter combined detailed time studies of actual group leaders inside a Toyota-style factory and simulation analyses of the cellular automation model that may reproduce the behavioral patterns found in the empirical results. The model focused on four main variables: task flow continuity in the production line, task load, problem occurrence, and help actions by group leaders. The results of the simulation suggested that help from a leader significantly improves task flow continuity when task workload is high and problem frequency is low, but a slight increase in problem occurrence disrupts such continuity. The findings of the field studies confirmed that high-productivity lines, supported by help actions from group leaders, tended to suffer from sudden drops in performance when additional inexperienced workers increased problem frequency and the leaders were forced to do heavy work.

Chapter "The Diversity and Reality of Kaizen in Toyota" focused on continuous capability building, or *kaizen*, by work organizations and their leaders, as well as production engineers at the factory or corporate level. It pointed out that the ranges or spans of coordination for a particular kaizen activity may differ depending upon its nature, despite the stereotyped image of kaizen activities as a collection of mutually independent incremental process innovations solely at the level of work groups on the shop floor. A long-term observation of kaizen activities indicated that they may also include product innovations and rather larger-scale innovations in budget, human inputs, and outcomes not only at the level of work groups but also in the higher layers of production organizations. Furthermore, individual kaizen activities may be interconnected, since solutions from a certain kaizen activity may trigger another problem-solving cycle.

The results of the field studies in this chapter also underlined the important role of shop-floor production engineers as *staff-in-line organization*, i.e., the interface for vertical and horizontal coordination between shop-floor work organizations and corporate production engineers, as well as between smaller and larger kaizen activities. Thus, kaizen activities in real factory contexts are more diversified, multifaceted, and multilayered than their stereotyped notion suggests.

Chapter "Balancing Standardization and Integration in ICT Systems: An Architectural Perspective" discussed the role of IT (information technology) in supporting both manufacturing and capability building of firms and sites. Based on field observations of better-performing cases in the manufacturing industries, this chapter concentrated on the challenges of globalization and digitalization. It argued that firms should aim to achieve a good balance between a Global Standard IT System (GSIS), provided as a standard package by global IT firms, and an Integrated Manufacturing IT System (IMIS), which is more site-specific or firm-specific, and merge them into a Global Integrated Manufacturing IT System (GIMIS) as an effective hybrid of both.

The overall IT system supporting a firm's manufacturing, or flows of design information to customers, is likely to adopt GSIS or IMIS or both as its components. Thus, we predict that an IT system adopting GSIS as its standard component will tend toward an open-modular architecture, while an IT system adopting IMIS will be architecturally more closed-integral. It follows from this that firms adopting GIMIS as a balanced solution are likely to go for hybrid architectures with open and integral subsystems. For instance, the Japanese firm Komatsu, known as a leader in competitive manufacturing IT, actually uses GSIS (e.g., SAP) for its global accounting system but has chosen an internally developed (i.e., firm-specific or site-specific) IT system, or IMIS, for its engineering and manufacturing bills of materials (E-BOM and M-BOM). We can regard this combination as a typical case of GIMIS with both open and integral components.

1.2.3 Architectural Evolution and Platform Formation in Digitalized Industries

Whereas Part II of this book dealt mostly with capability building for higher productive performance (i.e., better flows of value-carrying design information) by firms and sites manufacturing physical goods and facing intense global competition, Part III (Chapters "Creating New Demand: The Impact of Competition, the Formation of Submarkets," "Decline in Demand Creation: The Development Productivity Dilemma and Its Consequences," "Investigating the Creation and Diffusion of Knowledge for Demand Creation: The Case of the Telecommunications Industry," and "The Impact of Platform Providers' Knowledge on Interfirm Division of Labor: The Case of the Mobile Phone Industry") turned to another major trend of this period, i.e., the global emergence of the digital economy. We discussed design and architectural strategies for cumulative demand creation at the level of economic artifacts, including products and their key components, as well as platforms and their ecosystems, which involve many complementary products (Chapter "Evolution of Business Ecosystems").

We first looked at the prototypical case of platforms and ecosystems in the Japanese home video game industry in chapters "Creating New Demand: The Impact of Competition, the Formation of Submarkets" and "Decline in Demand Creation: The Development Productivity Dilemma and Its Consequences" and then analyzed more advanced and global cases, i.e., cellular phones and smartphones, in chapters "Investigating the Creation and Diffusion of Knowledge for Demand Creation: The Case of the Telecommunications Industry" and "The Impact of Platform Providers' Knowledge on Interfirm Division of Labor: The Case of the Mobile Phone Industry." Today's platform leaders are mostly US-based companies, such as Intel, Microsoft, Google, Apple, and Facebook. Yet, some Japanese companies may be seen as precursor platform leaders, e.g., Nintendo, Sega, and Sony Computer Entertainment. They set up a basic business model relying on the simplest form of platform and created huge demand worldwide. To start our analysis of the digital economy, we examined this old but simple type of platform business and revealed the mechanisms behind it.

Chapter "Creating New Demand: The Impact of Competition, the Formation of Submarkets" focused on the early 1980s, when an entirely new market, that of home video game software (console game software), was established in Japan. The so-called Family Computer (or NES, Nintendo Entertainment System) was a platform with (quasi) open-modular architecture that induced more than 100 firms to enter this market. Such firms released home video game software titles in rapid succession, and some managed to develop new submarkets within the home video game industry. They competed with one another by differentiating their products, and product diversity grew considerably thanks to this competition, attracting many consumers and generating huge demand.

Chapter "Decline in Demand Creation: The Development Productivity Dilemma and Its Consequences" also examined the case of home video game software to investigate the consequences of demand creation by firms. Firms that succeeded in creating demand invested in development activities for further growth. To meet the strong demand of the new market, they accumulated knowledge on new product development (development know-how). As time passed, they tended to create ever more similar products, relying on their accumulated development know-how to achieve higher development productivity. At the same time, firms with rich development know-how started to have an implicit bias against working on completely new products, because it was difficult for them to move away from the old ideas inherent in their development know-how.

The above resulted in a stalemate in product diversification, and customers began to spend their time and money on other forms of entertainment, because the repetitiveness of titles failed to provide the expected enjoyment. This is what we regard as a decline in the power to create demand. In particular, when an open-modular architecture is adopted, customers may move to other areas of consumption through the platform. As a result, the boundaries of the industry as a place for demand creation become blurred, and the sector eventually dissolves by merging with other industries.

Chapter "Investigating the Creation and Diffusion of Knowledge for Demand Creation: The Case of the Telecommunications Industry" looked at "modern" open architecture, i.e., a more complex case of open architecture. As theoretically shown in chapter "Evolution of Business Ecosystems," entry barriers preventing access to an industry are lowered by the appearance of a platform with open architecture. Many new entrants aggressively work by trial and error to achieve rapid product evolution. This, in turn, allows consumers to easily find desirable products, and demand booms over a short period of time. The mobile phone industry is such a case, and this chapter examined it to understand the factors behind rapid industry evolution and demand creation.

Our analysis of SEPs (standard-essential patents) revealed the importance of a particular firm, Qualcomm, which supported the evolution of its industry and products by disclosing or licensing its technologies. Qualcomm changed its business model at the end of the 1990s and specialized in technological consulting, licensing of technology, and the provision of system knowledge. It continued to learn from the product development activities of other companies while providing them with the technological knowledge needed for such product development. Through this mutual learning, Qualcomm accumulated unique system knowledge and secured a strong competitive advantage. At the same time, it promoted the diffusion of technological foundations by providing SEPs and related information to other companies. That is, Qualcomm simultaneously attained capability building, diffusion of technological foundations, and increased demand creation within its industry.

Chapter "The Impact of Platform Providers' Knowledge on Interfirm Division of Labor: The Case of the Mobile Phone Industry" focused on how firms boost capability building under the open architecture framework and how the capability building of each company affects collaboration among companies, i.e., the interfirm division of labor. To shed light on these issues, the results of questionnaire surveys of 50 smartphone product development projects were presented and analyzed.

In the smartphone industry, there are three types of firms. The *brand firms* launch products under their own brand, the *contract manufactures* undertake development and manufacturing of products on behalf of the brand firms, and the *platform providers* provide both technological information and core components. As confirmed by the questionnaire surveys, both the brand firms and the contract manufactures derive the necessary information from the platform provider and utilize it to build their organizational capabilities. Our evidence also showed that the performance of development projects increases by allocating decision-making rights to match organizational (development) capabilities. In addition, the organizational capabilities of brand firms and contract manufactures not only enhance the performance of development activities but also prevent opportunistic behavior by their partners. The implication of this chapter is that, even under an open architecture framework, the capability building of firms is still fundamental.

2 Theoretical Implications

2.1 Revisiting Our Evolutionary Framework of Industries and Firms

2.1.1 Augmented Capability-Architecture Framework

After summarizing the chapters of our book, let us discuss the overall framework that may explain our research findings in a consistent way. In Part I, we proposed a design-based evolutionary framework for analyzing the dynamics of industries and firms that consists of three major components: (1) *capability* of manufacturing sites, (2) *architecture* of products and platforms, and (3) *competitiveness* of industries and firms (Fig. 3 of chapter "A Design-Information-Flow View of Industries, Firms, and Sites"). This framework aims to answer our research questions regarding some seemingly important industrial phenomena occurred during the post-Cold-War period (mostly the 1990s, 2000s, and 2010s), including intense global cost competition between advanced and emerging nations, minute interindustrial trade, and new forms of competition and complementation in digital industries.

We also proposed additional theoretical models to explore the relations among manufacturing capabilities, physical productivities, and comparative production costs (Chapter "The Nature of International Competition Among Firms"), product design variety for additional demand creation (Chapter "Product Variety for Effec tive Demand Creation"), interactions between capability building and demand

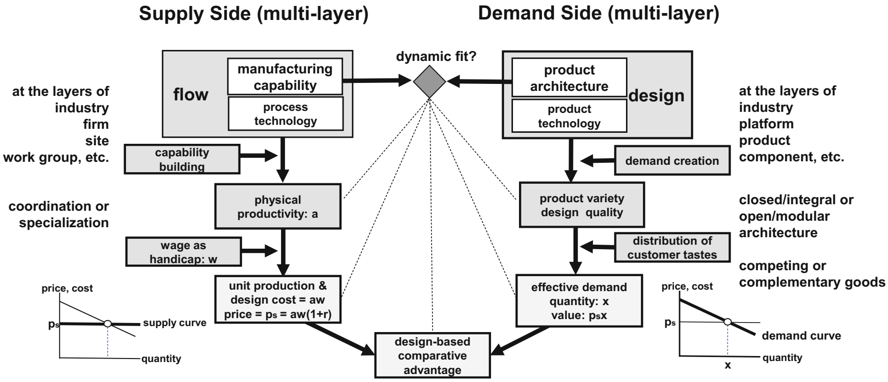

Fig. 1 Multilayered framework of capability building and demand creation

creation in firms that aim to achieve both profit and employment (Chapter "Capability Building and Demand Creation in 'Genba-Oriented Firms'"), and ecosystem formation and cumulative demand creation in open-modular architecture industries (Chapter "Evolution of Business Ecosystems").

The present book then tried to apply these theoretical tools to the actual evolution of industries and firms during the period following the end of the Cold War. Specifically, we chose two industrial phenomena to be explained in detail: (i) *capability building* for productivity improvements at manufacturing sites in advanced nations facing intense global cost competition vis-à-vis their lower-wage rivals in emerging nations and (ii) cumulative *demand creation* through the multiplying effect of network externalities in digital industries, characterized by products and platforms with open-modular architecture. Part II of this book dealt with the first topic (i.e., capability building) on the supply side, whereas Part III tackled the second topic (i.e., demand creation) on the demand side.

In order to apply our analytical framework to these two topics in relation to global competition and digitalization over the past few decades, the framework itself had to be enriched, so as to better explain the abovementioned industrial phenomena in a consistent way.

Figure 1 displays the augmented capability-architecture framework. The left side shows how *manufacturing capability building* that aims at better *flows of value-carrying design information*, even when process technologies are unchanged, can enhance physical productivities (i.e., input coefficients) and other productive performance features by which industrial sites in advanced nations, with the *handicap of higher wage rates*, try to prevail in the intense *global competition* against sites in lower-wage countries by lowering the *supply curves*, given the target profit (mark-up) ratios.

On the other hand, the right side (demand side) of Fig. 1 shows how the firms' *design-based efforts for demand creation*, such as *architectural strategies* and development of new *product technologies*, bring about improvements in *design quality*, expansion of *product variety*, formation of open-modular architecture platforms, and other positive effects of the economic artifacts' improved design features on increasing *effective demand* (outward expansion of the products' *demand curves*), given the patterns of *customer tastes* and the achievement of *innovation*. Note here again that technologies and architectures are the two main features of design information.

In this augmented framework, we retain the basic triangle of capability, architecture, and competitive performance and enrich it for our empirical research in Parts 2 and 3. Here, manufacturing sites and their capability building for better flows of value-carrying design information are regarded as the foundation of the supply side of our economy, whereas architectures and other design attributes of products, platforms, and components are the starting point for our analysis of effective demand creation on the demand side. We also argue that capabilities and architectures both evolve over time and that the comparative advantage of a certain country's products is affected by dynamic interactions between the capabilities of sites and the architectures of products (Chapter "A Design-Information-Flow View of Industries, Firms, and Sites").

Let us now explain the supply (left) side and demand (right) side of Fig. 1 in greater detail.

2.1.2 Evolution of Manufacturing Capabilities

The left side of Fig. 1, or the supply side, comprises such key concepts as manufacturing capability building, productive resources, flow of value-carrying design information, physical productivity, unit production, design cost, as well as other indicators of productive performance.

On the supply side, our basic notion of industries and firms is both site-based and product-based. The *manufacturing sites* (genba) can be analyzed as systems of value-carrying design information that flows between productive resources and eventually to the customers in the market. It is worth underlining that, since today's firms are essentially multiproduct, multi-industry, and multinational, a national industry is not a collection of firms but rather a collection of manufacturing sites (genba). In other words, sites can be seen as *flows* of value-carrying design information and *stocks* called productive resources. Using key concepts by E. Penrose (1959), we regard a firm or its manufacturing site as a collection of productive resources as stocks of potential values, which generate productive services as *flows of value-carrying design information to the customers*. In this context, it is the *manufacturing capability* that connects the underutilized resources (stocks) and realized productive services (flows) of firms and sites.

We also argue that the effectiveness of productive services can be measured by certain indicators of productive performance, including physical productivity, production lead times, and manufacturing quality (Fujimoto 1999). In the case of physical goods, or hardware products, structural design information is embedded in tangible (material-based) media, whereas in software products, it is embedded in intangible, electronic media. In the case of services, functional design information is embedded in intangible (energy-based) media (Chapter "A Design-Information-Flow View of Industries, Firms, and Sites"). Thus, our broad concept of manufacturing covers both hardware and software products and both manufacturing and service industries.

In our evolutionary framework, *capability* is a collection of organizational routines that govern the flow of value-carrying design information, whereas *competitive performance* is conceived as the ability of some objects or agents to be selected by other agents under the condition of free choice by the latter. Capabilities may be not only static but also dynamic or evolutionary. First, *static capability*, or ordinary manufacturing capability, is an organization's ability to maintain certain levels of productive performance, or speed, efficiency, accuracy, and flexibility of the flows of value-carrying design information within a given set of productive resources. Second, *dynamic capability* is an organization's ability to improve its performance by changing its flows, as well as its productive resources and organizational capabilities themselves. Thus, our definition of dynamic capability is broad, in that it includes organizational capability for continuous and repetitive improvements (kaizen, chapter "The Diversity and Reality of Kaizen in Toyota"), enhancement of human resources (Chapters "The Nature of Surviving Japanese Factories in the Global Competition: An Empirical Analysis of Electrical and Electronics Factories" and "The Effectiveness of Group Leaders in the Lean Production System: Time Study and Agent-Based Model of Leaders' Behavior"), redeployment of productive resources, and evolution of manufacturing capabilities and routines themselves (Teece and Pisano 1994; Fujimoto 1999, Chap. 6).

In this context, *evolutionary capability* refers to a firm's ability to improve performance in the long run, even when it does not know if it needs deliberate actions/decisions based on ex ante rational plans or emergent processes that may capture unintended results in the next phases of its competition and evolution.

2.1.3 Evolution of Architectures

The right side of Fig. 1, or the demand side, is related to demand creation, design attributes such as product architecture and product technology, product variety, design quality, and effective demand quantity. In other words, it aims to describe the evolution of the design aspects of products, platforms, and other economic artifacts.

In this context, again, a *product* is an artifact with economic value that can be exchanged among economic agents. As such, a product tends to be structurally coherent and functionally complete. A *component* is a structural part of the product, which may also be exchangeable. A *platform* means a collection of products or components that are functionally and structurally linked to one another by certain common design information (e.g., industry-standard interfaces, application programming interfaces (APIs), common component/module designs) shared among firms or across the whole industry. As such, a platform includes products that are complementary to one another, or complementary goods, among which cumulative network externality effects are often observed.

A platform is shared by a collection of firms and sites, which may constitute a *business ecosystem* (Chapter "Evolution of Business Ecosystems"). More than one platform with similar functions may coexist and compete within an industry, and the architecture-building capability of competing platform-leading firms (platform leaders) is critical for generating cumulative network effects among complementary goods.

The design information/knowledge of the abovementioned artifacts, such as products, processes, parts, and platforms, has two aspects: *technology*, which is related to concrete causal knowledge or information between the structures and functions of certain artifacts, and *architecture*, which refers to abstract graphical relations or correspondences between the structures and functions of various artifacts (Chapter "A Design-Information-Flow View of Industries, Firms, and Sites"). Both technologies and architectures that are related to an industry or firm tend to evolve over time, and, in order to analyze the evolution of industries and firms, we have to look at the dynamics of both technological and architectural aspects of the artifacts related to them.

The concept of architecture consists of two basic types: integral and modular architecture. An artifact's overall (macro) architecture is *integral* when its functional and structural elements are connected by means of many-to-many correspondences. It is *modular* when the functional-structural connections are linked through one-to-one correspondences. Actual artifacts are usually placed somewhere in between these two extremes of the architectural spectrum.

Another important distinction regarding product architecture is between closed and open (open-modular). When the basic design information is shared only within a single firm (e.g., firm-specific, common component designs shared across its products), this is a case of *closed architecture*. When the design information is open to the public (e.g., industry-standard interfaces linking components and products shared across firms), we call it open architecture. Thus, by combining the integral/modular and closed/open dimensions of architectures, we can identify three basic types: closed-integral, closed-modular, and open (open-modular) architecture.

An additional aspect is that of internal and external architecture. A component's *internal architecture* refers to the architecture of its design, while its *external architecture* is that of its client's product architecture. If the external architecture of a product or component is open-modular, the item is likely to be an industry-standard product/component. If it is externally closed-integral, the item is likely to be custom-designed and optimized for the upper system. To the extent that design activities involve coordination between an artifact's functions and structures, we may regard a product with integral architecture as relatively coordination-intensive, whereas a product with open-modular architecture is relatively coordination-saving (Chapter "The Impact of Platform Providers' Knowledge on Interfirm Division of Labor: The Case of the Mobile Phone Industry").

As for the *platform* (i.e., a collection of interconnected products), when it is open-modular, core products (e.g., smartphones) and complementary products (e.g., software products) enhance one another through the cumulative effect of network externalities. In other words, increases in demand for the core product will boost demand for complementary periphery products in the case of a platform with open-modular architecture. Thus, in the traditional *inter-product competition* with product differentiation (i.e., a downward-sloping demand curve for each product model), increases in demand for a product tend to cause decreases in demand for competing products, whereas *within a business ecosystem characterized by an open-modular architecture platform*, expansion of effective demand for a product is likely to result in greater demand for complementary products within the same platform (Chapters "Evolution of Business Ecosystems" and "Creating New Demand: The Impact of Competition, the Formation of Submarkets").

Firms will choose different competitive strategies as the above types of architectural positioning vary. For instance, a platform-leading firm is likely to choose an open architecture platform strategy to set up a rapidly growing platform/ecosystem and profit from it (Chapter "Investigating the Creation and Diffusion of Knowledge for Demand Creation: The Case of the Telecommunications Industry").

2.2 Multilayered Evolution of Capabilities and Architectures

2.2.1 The Hierarchical Nature of Complex Economic Artifacts

One of the main features of the augmented evolutionary framework explained above (Fig. 1) is that efforts in terms of both capability building and demand creation are essentially multilayered. This is a natural consequence of the fact that today's products and processes, seen as economic artifacts, are becoming increasingly complex, as well as of the logic that complex artifacts tend to become hierarchical (Simon 1969).

To the extent that a complex artifact is conceived as a hierarchical system (Simon 1969; Langlois and Robertson 1992), we can analyze its internal and external architectures (e.g., products, components). Moreover, an industry can be seen as interconnected hierarchies of artifacts on the stock side (Clark and Fujimoto 1991; Fujimoto 1999). We can lay out such hierarchies of artifacts moving along the design information flow from upstream to downstream: hierarchies of product functional design (perceived needs), product structural design, process structural design, actual production process, actual product structure, and actual process structure. Firms and sites interact with each other within this system of multiple hierarchies. Hence, in this book, we see an industry as a system of interconnected hierarchies of value-carrying artifacts, as well as flows and interactions among them.

Within the aforementioned industry as interconnected multiple hierarchies, firms, sites, and products interact with each other in three basic ways: transaction, competition, and complementation (Brandenburger and Nalebuff 1996). Specifically, we may define the following interactions in an industry as multiple hierarchies: *physical transaction*, mostly along the vertical axis of the hierarchy; d*esign transaction*, between the upstream and downstream hierarchies; *complementation*, mostly along the horizontal axis within a hierarchy; and *competition*, mostly among alternative hierarchies. When there are alternative platforms that the customers can use for similar purposes, *inter-platform competition* will involve developing additional complementary goods to enhance the attractiveness of the platform as a whole—a very different pattern of industrial competition compared with traditional inter-product competition (Chapters "A Design-Information-Flow View of Industries, Firms, and Sites" and "Evolution of Business Ecosystems").

Even in these cases, however, ordinary inter-product or inter-component competition does exist at the lower levels of the hierarchies. Product or component firms competing within the platform may need to deal with both traditional competition and the challenge of making other firms accept their industry-standard interfaces. In other words, they may need to carry out traditional capability-building competition internally and implement newer types of architectural strategies externally at the same time. In any case, depending upon the architecture of products, processes, components, and platforms, the behavior of the firms in an industry (or a network of connected industries) will have to be analyzed in terms of capability building at their sites and architectural choices for their products.

2.2.2 Multilayered Capability Building to Increase Productivity

As shown in the top-left area of Fig. 1 (supply side), *manufacturing capability* affects the competitive performance of manufacturing sites, or the efficiency and accuracy of the flows of value-carrying design information to the customers, including physical productivity (inverse of input coefficient), unit production cost, and unit design cost. When global cost competition is intense, with market prices decreasing rapidly, physical productivity increases through capability building are crucial for the survival of the domestic manufacturing sites in high-wage countries, as such efforts drive down the supply curve of the products in question (bottom-left part of Fig. 1).

Our definitions of production, as the transfer of value-carrying design information from the process to the product, and of physical productivity, as multiplication of design-information-transfer density and speed, provide some insight into the events happening at many manufacturing sites in Japan, one of the high-wage countries facing intense global cost competition.

Physical labor productivity (unit per person-hour) equals the *speed* (unit per value-adding time) times the *density* (value-adding time per person-hour) of the design information transfer from the workers to the product. Continuous improvements that increase the density of the design information transfer by n times can increase the physical productivity by n times, other things being equal. That is, dramatic increases in physical productivities (e.g., 5 times in 5 years), through capability building for reducing non-value-adding time (*muda* in Japanese) and increasing density of design information transfer, played a critical role in the survival of many manufacturing sites in Japan in the post-Cold-War global competition with large international wage gaps as handicaps (e.g., salaries of $100 versus $2000 per month), as suggested by the surveys and case studies in this book (Chapters "The Effectiveness of Group Leaders in the Lean Production System: Time Study and Agent-Based Model of Leaders' Behavior" and "The Diversity and Reality of Kaizen in Toyota"). In addition, productivity improvements occurred even when the introduction of new production/process technologies to boost the speed of design information transfer was restricted, which was partly due to limited financial resources during the recession.

Lastly, such capability building for survival was observed at multiple levels of the supply side, including the firm as a whole (e.g., Toyota, chapter "Evolution of Organizational Capabilities in Manufacturing: The Case of the Toyota Motor Corporation"), factories as manufacturing sites (Chapter "The Nature of Surviving Japanese Factories in the Global Competition: An Empirical Analysis of Electrical and Electronics Factories"), and work organizations inside each factory (Chapters "The Effectiveness of Group Leaders in the Lean Production System: Time Study and Agent-Based Model of Leaders' Behavior" and "The Diversity and Reality of Kaizen in Toyota"). These research results suggest that *multilayered capability building* is necessary for national economies, industries, firms, factories, and other genba in high-wage advanced countries facing global cost competition as *handicapped productivity competition*, due to large wage differences vis-à-vis low-wage emerging nations (Chapter "The Nature of International Competition Among Firms").

2.2.3 Multilayered Demand Creation in Mature National Economies

On the demand side, design information that carries value added plays a pivotal role in *demand creation*. As shown in the right-hand part of Fig. 1, an increase in the quality or variety of product designs, given the distribution of the customers' tastes, will generate additional demand quantity through the outward expansion of the demand curve in question. That is, a new and functionally improved product design with new technological innovation, or a new combination of the product's functions and structures, will shift its demand curve outward. The introduction of an additional product with a new design may reduce the actual demand for competing (functionally similar) products, under the circumstances of product differentiation. However, the net effect of the expansion of product variety on the total demand of the whole industry in question (i.e., a collection of functionally similar products) is likely to be positive (Chapter "Product Variety for Effective Demand Creation").

The research results in this book also suggest the possibility of *multilayered demand creation* or multilevel efforts for effectively creating demand by nations, regional industries, firms, platforms, products, and components. This is particularly true in advanced nations, including Japan in the 1990s and 2000s, where total demand growth was rather slow.

During the Great Depression of the 1930s, J.M. Keynes emphasized the importance of demand creation by national governments through fiscal and other policies

(Keynes 1936). This book argues that, to the extent that regional industries, firms, and sites aim at survival and stable employment, these economic entities may all pursue demand creation through product/business diversification, product/process innovation, platform formation, and other marketing efforts.

J. Schumpeter identified discontinuous innovations by entrepreneurs as the driver of national economic development (Schumpeter 1934). The present book pays special attention to *grassroots innovations* for stable employment at the level of regions, industries, firms, and manufacturing sites (Lecler et al. 2012, Chap. 4) and points out that multilayered demand creation is an essential tool for mature national economies that need to secure employment by generating additional demand.

2.2.4 Multilayered Demand Creation in Open-Modular Architecture Platforms

The previous section discussed *multilayered demand creation* by local manufacturing sites, site-oriented firms, regional industries, and national governments within traditional product competition in mature national economies. Let us now turn to the newer industrial phenomenon of *inter-platform competition* with *platform-leading firms* (platform leaders) and its hierarchical nature. As explained repeatedly in other sections, when the platform in question is architecturally open-modular, with industry-standard interfaces linking complementary products, the addition of a new product will drive up the demand for complementary products through the effect of network externalities, which may result in rapid demand expansion across the whole industry as a collection of competing platforms (Chapter "Evolution of Business Ecosystems").

In this volume, we discussed the case of a prototypical open-modular platform that emerged in the 1980s, i.e., console game hardware and its software (Chapters "Creating New Demand: The Impact of Competition, the Formation of Submarkets" and "Decline in Demand Creation: The Development Productivity Dilemma and Its Consequences"). Although the sector was first developed in the USA, fully fledged platform-leading firms were established mainly in Japan (e.g., Nintendo, Sega, and Sony). The video game industry of those days was characterized by a relatively simple *two-layer platform* with complementary demand creation between the core products (i.e., console game hardware) and their complementary peripheral products, (i.e., game software; see Fig. 2). It ought to be underlined that the core products, the console game hardware, were architecturally closed-inside and were developed/produced/sold by the platform-leading firms, a situation similar to more recent cases of core products tending toward the closed-inside architecture (e.g., Apple's iPhone).

As suggested here, however, there exist more complex cases, such as *three-layer open platform* with open-inside core products and closed-inside core components (Fig. 3). Empirically, we can apply this model to such cases as personal computer systems (e.g., IBM PCs), conventional cellular phone systems (e.g., GSM), current smartphone systems (e.g., Android phones), and so on.

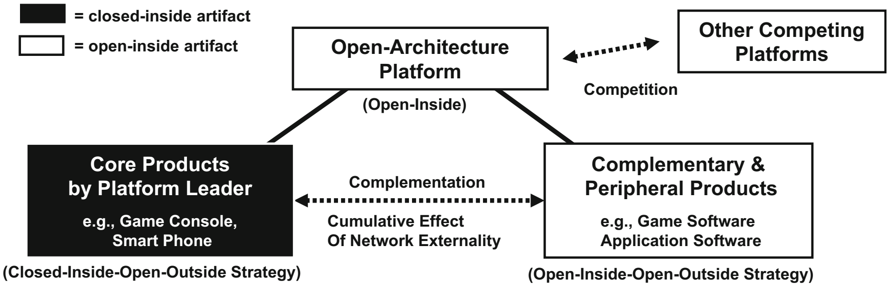

Fig. 2 Two-layer (simple) platform

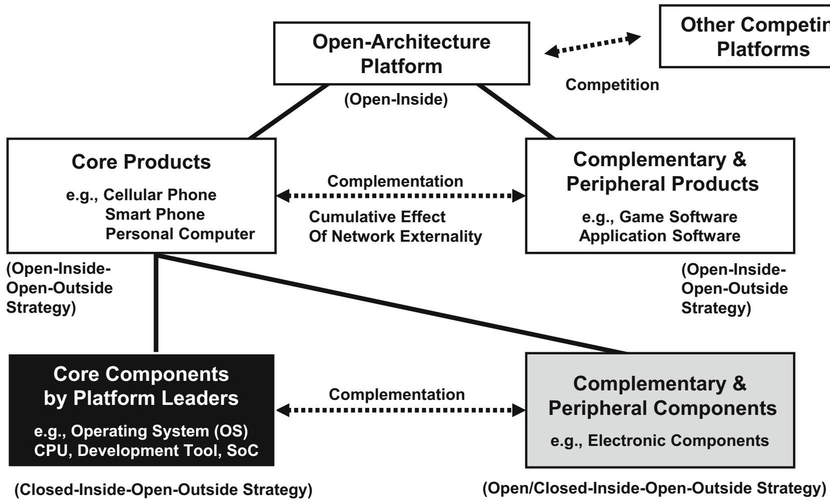

Fig. 3 Three-layer (complex) platform

It is important to emphasize once more that the architectural positioning of *core products*, such as personal computers, cellular phones, and Android phones, is fundamentally open-inside in the second layer. These products heavily rely on industry-standard hardware/software components, APIs, and development tools that are provided by the core component suppliers as platform-leading firms (e.g., Intel, Microsoft, Media-Tech, Google, and Qualcomm). On the other hand, the core component suppliers adopt a closed-inside-open-outside architectural strategy in the third layer (see the lower part of Fig. 3), by disclosing a portion of the design information about the core components to other firms while keeping the rest secret. In other words, there is a clear contrast between the *classic* platform strategy (Fig. 2) and the *modern* platform strategy (Fig. 3). Whereas the platform-leading firms are positioned in the second layer as core product suppliers in the simple, two-layer platform (Fig. 2), their position is in the third layer as core component suppliers in the case of a three-layer platform (Fig. 3).

Note also that, because of the historical coincidence of globalization and digitalization after the 1990s, the core product producers (e.g., brand firms manufacturing PCs, cellular phones, and smartphones) were often younger firms in emerging nations with lower technological capabilities and higher cost competitiveness vis-à-vis their rivals in high-wage advanced nations. Due to the release by the platform-leading core component suppliers (e.g., Intel, Media-Tech, and Qualcomm) of key design information for developing such open-inside core products, technological barriers to entry were significantly lowered, so that the core product producers, often with the help of low-cost manufacturing contractors based in emerging countries, enjoyed strong cost competitiveness. The prices of the core products dropped accordingly, which further accelerated cumulative demand creation by network externality in both advanced and emerging nations (Chapters "Evolution of Business Ecosystems," "Investigating the Creation and Diffusion of Knowledge for Demand Creation: The Case of the Telecommunications Industry," and "The Impact of Platform Providers' Knowledge on Interfirm Division of Labor: The Case of the Mobile Phone Industry"). This is the evolution of multilayer platforms revolving around open architectures and cumulative demand creation through network effects at the level of platforms, products, and components.

As illustrated in the first part of this book, the architectures of economic artifacts evolve over time (Chapters "A Design-Information-Flow View of Industries, Firms, and Sites" and "Evolution of Business Ecosystems") and gain greater complexity when customer requirements and social-technological constraints become stricter. In the case of conventional physical products, this often means that the designs of individual products tend to become more complex, with more integral architectures (e.g., high-performance motor vehicles). In the case of digital products, by contrast, the evolution of multilayer platforms with open-modular architectures has so far been the industry's response to the challenge of increasing requirements in terms of product functionalities and varieties in the twenty-first century.

2.2.5 Capability-Building Capability and Architecture-Building Capability

Within the context of the capability-architecture-performance framework summarized in Fig. 1, it is worth focusing also on the dual nature of the so-called dynamic capabilities: *capability-building capability* and *architecture-building capability* (Penrose 1959; Teece and Pisano 1994; Fujimoto 1999; Teece 2007). In our book, we predicted that the dynamic fit between the organizational capabilities of industries, firms, and sites (left-hand side of Fig. 1) and the architectures of platforms, products, and components (right-hand side of Fig. 1) will positively affect their competitive performance, including productive performance of the manufacturing sites, market performance of the products, and profit performance of the firms (Chapter "A Design-Information-Flow View of Industries, Firms, and Sites"). We also explained that competitive performance refers to the ability of sites, products, firms, and industries to be selected by other economic entities (e.g., firms, customers, investors). As such, competitive performance is itself multilayered.

Regarding this capability-architecture fit, we argue that, to the extent that design and production are coordinative activities of organizations, we should pay special attention to the *coordination richness* of the sites and firms, on the one hand, and *coordination intensity* of the products' design and production, on the other hand. In other words, it is important to consider the allocation of coordination in relation to artifacts and organizations. If one allocates the coordination embedded in the artifacts (products, components, and processes) by designing technology and/or architecture, the coordination requirements of the organization may become lighter. A typical case is that of digital products (e.g., Android phones), where the platform-leading core component suppliers, core product producers, and low-cost manufacturing contractors from emerging countries join forces and attain strong competitiveness. Conversely, if one allocates the coordination embedded in the organizations (well-organized routines, strong dynamic capabilities, and superior evolutionary capability) by management, both firms and sites can handle complex artifacts efficiently and flexibly. We can see such a case in highly complex and integral products (e.g., high-performance motor vehicles). The features mentioned above, i.e., well-organized routines, strong dynamic capabilities, and superior evolutionary capability, are called here *capability-building capabilities*.

Using this concept of coordination in organizations, we proposed the framework of *design-based comparative advantage*. A country endowed with coordination-rich manufacturing sites (e.g., Japan) will tend to enjoy Ricardian comparative advantages in terms of unit design cost in coordination-intensive products, that is, tradable goods with relatively integral architectures. On the other hand, a country endowed with human resources possessing high levels of specialized expertise (e.g., the USA) will probably have design-based comparative advantages in relatively coordination-saving or modular products (Chapter "The Nature of International Competition Among Firms").

Besides, when the architecture of the system of complementary goods is open-modular, this product system will tend to evolve into a platform, in which the platform-leading firms, with profit models based on the size of the platform, will enjoy exceptional profit performance, mostly thanks to the high-speed growth of the platform through the cumulative effect of network externalities (Chapter "Evolution of Business Ecosystems"). Thus, the architectures of products, components, and platforms will significantly affect the ways in which firms and sites compete, as well as their performance. In addition, the platform itself evolves and is shaped through an emergent process, and this is why no firm can design and produce all the artifacts in the ecosystem. So, firms must determine the position of their sites within the ecosystem as such process occurs. In other words, while platforms are being shaped, firms need to evaluate their sites' capabilities and performance and make strategic choices as to where they should be positioned within the platform (i.e., platform positioning). We regard the capabilities linked to this strategic choice as *architecture-building capabilities*.

For what concerns the targets of the changes, let us explore the effects of the two types of dynamic capabilities. *Capability-building capabilities* enhance performance in competition among sites and products, including kaizen capability and evolutionary capability (Teece and Pisano 1994; Fujimoto 1999). A*rchitecture-building capabilities* help establish industry standards, generate network externalities, and be successful in inter-platform competition (Teece 2007). Indeed, in many of today's forms of competition in platform-driven industries, both types of capabilities are needed for survival and growth. In conventional market competition among products, capability-building capabilities are required for long-term success, while in the newer platform competition, architecture-building capabilities become key. Motor vehicles are a good example to illustrate conventional competition among physical products. Given that their architectures were relatively stable, capability-building capabilities were of crucial importance to the firms' long-term success (Fujimoto 1999). In the new competition among digital platforms for products such as smartphones, instead, the architectures are less constrained by physical and technological characteristics and more easily shaped by the potential platform-leading firms (e.g., setting industry standards), which increases the relevance of architecture-building capabilities. In other words, focusing only on product competition and capability building may not guarantee sustainable firm growth in this situation.

However, this does not mean that today's firms should disregard capability building and shift their efforts entirely toward architecture building. As mentioned later, even as digital transformation changes the nature of industrial competition, what both new and existing firms need for long-term survival and growth is a combination of tenacious capability building at their genba and smart architectural strategy at their headquarters.

In this sense, our capability-architecture-based evolutionary framework seems to be reasonably effective in providing broader and more balanced views. By using this framework, we can consider both the physical and digital domains of industries, closed- and open-modular architectures, capability building and architecture building, as well as product competition and platform competition.

3 Conclusion

3.1 Empirical Questions and Our Tentative Answers

The findings of this book seem to be generally consistent with our evolutionary capability-architecture-performance framework, as shown in Fig. 1, which involves multilayered efforts on both the supply and demand side. In other words, our empirical and historical research on the late twentieth and early twenty-first century reveals the presence of both capability building for productivity increases on the supply side and demand creation by developing new products, components, or platforms and enhancing variety and/or design quality on the demand side. Indeed, the period in question is characterized by the *evolution of capabilities* of manufacturing industries and firms facing intense global competition and by the *evolution of architectures* of products and platforms facing rapid technological digitalization.

As already mentioned, our volume tackles three main questions in order to understand and analyze the significant changes happening between the 1990s and 2010s:

1. *Intense global competition between high-wage and low-wage nations*
2. *Minute-level intraindustrial trade mainly between advanced nations*
3. *New forms of competition and complementation in digitalized industries*

By applying our design-flow-based evolutionary framework of industries and firms, we reinterpret these issues as follows.

1. The *global cost competition* of this period is essentially *physical productivity competition with the handicap of international wage gaps*, as suggested by our new Ricardian model of comparative advantages and international values (Chapter "The Nature of International Competition Among Firms"). Organizational capability building for improved flows of value-carrying design information to the customers (i.e., manufacturing in a broad sense) is key for the survival of manufacturing firms (Chapters "A Design-Information-Flow View of Industries, Firms, and Sites" and "Evolution of Organizational Capabilities in Manufacturing: The Case of the Toyota Motor Corporation").

   Besides, our genba-based view of industries also suggests that local firms and sites facing global competition are, in many cases, motivated not only by profitability and survival, achieved through cost reductions, but also by stable employment, pursued through demand creation. After all, many of the Japanese manufacturing firms struggling to cope with global competition, particularly small and medium ones, are genba-oriented and community-oriented, aiming at target profit rates and stable employment at the same time (Chapter "Capability Building and Demand Creation in 'Genba-Oriented Firms'").
2. *Minute-level intraindustrial trade* occurs when there are internationally competing products that are functionally similar but mutually differentiated in their designs (Chapters "The Nature of International Competition Among Firms" and "Product Variety for Effective Demand Creation"), i.e., when product design-development sites for certain functionally similar products are located in multiple countries. In this situation, the question is not only "where to produce" but also "where to design" the products in question, so as to predict the international trade structure. Thus, the *design-based comparative advantage* framework is proposed here to analyze international trade phenomena of this type (Chapter "A Design-Information-Flow View of Industries, Firms, and Sites").
3. As for *global digitalization*, a thorough explanation of *cumulative demand creation in the digital industries* (e.g., PCs, video game consoles, cellular phones, smartphones, Internet services) includes the following concepts and logics (Chapter "Evolution of Business Ecosystems"): platforms comprising many complementary goods, industry-standard interfaces among them, open (open-modular)

architectural strategies by platform-leading firms, cumulative demand creation through network externalities among complementary goods, and extremely rapid growth of platform-leading firms and business ecosystems that consist of many competing/complementing/transacting firms (Brandenburger and Nalebuff 1996).

Two relevant aspects of most digital business ecosystems play a central role: the architecture of the platforms themselves is essentially open-modular with industry-standard interfaces, while the architecture of the subsystems inside a given platform, such as products, key components, and production processes, may still be closed-inside and/or integral-inside. In other words, the overall structure of a platform may be hierarchical and complex, with mixed architectures in its various layers. Therefore, when practitioners and researchers focus on an individual layer, the degree of openness of the platform observed by them might vary, the corresponding business ecosystem may be different, and it may seem maneuverable in different ways. Thus, the business ecosystem may still be complex, with an intertwined network of competition, complementation, and transaction among firms and products.

By tackling the three main questions above through both theoretical and empirical studies, we reach the tentative conclusion that, even when digital technology rapidly shifts the nature of the industrial game toward inter-platform competition, by setting industry standards and pursuing cumulative demand creation thanks to mutually complementary players, traditional inter-product competition and continuous capability building keep being vital for many of the manufacturing and service firms involved in the platform in question. What has happened in the age of globalization and digitalization is not the simple substitution of conventional product competition by completely new platform competition, but rather an evolution toward more complex industry and firm structures that involve both product and platform competition among competing, complementary, and transacting firms.

3.2 Toward a Framework for Exploring Our Complex World

The main observation put forward in this volume is that today's industries and firms are growing in complexity. Product designs as well as manufacturing processes and capabilities have become complex, but also the process of demand creation (i.e., how value-carrying design information flows to the customers in the market) and the nature of industrial competition clearly appear more intricate. In order to capture such complex and rapidly evolving phenomena, our analytical framework has to be dynamic, multilayered, and multifaceted. In addition to our analytical framework, other key concepts that have guided our analysis are as follows.

Emergent View Our evolutionary framework needs to capture both the intended and unintended behavior of firms and sites, since complex systems cannot be created through deliberate (i.e., ex ante rational) decision-making alone (Chapters "A Design-Information-Flow View of Industries, Firms, and Sites" and "Evolution of Organizational Capabilities in Manufacturing: The Case of the Toyota Motor

Corporation"). The process of generating complex systems involves both deliberate and emergent courses of actions by firms and their sites (Mintzberg and Waters 1985; Fujimoto 1999).

Multilayered Perspective To the extent that complex systems are designed and built hierarchically (Simon 1969), our framework needs to be multilayered on both the supply and demand side. On the supply side, our framework includes not only national/global economies, industries, and firms but also manufacturing site or genba, in which value-carrying design information flows to the customers in the market (Chapter "A Design-Information-Flow View of Industries, Firms, and Sites"). Our multilayered framework featuring genba has led to the concept of genba-oriented firms. On the demand side, our design-based view that product design information is the source of economic value added has led to our notion of effective demand creation at multiple levels (economies, industries, firms, and sites). Another important concept in the present book is that product design quality, variety, and architecture can effectively generate additional demand at multiple levels (Chapters "Product Variety for Effective Demand Creation," "Capability Building and Demand Creation in 'Genba-Oriented Firms'," and "Evolution of Business Ecosystems").

Conventional product competition entails rather simple causality, in that greater design quality and product variety expand effective demand, whereas in the current platform and/or product competition, we must assume rather complex causality between design quality and effective demand. In the latter case, positive interactions among complementary goods trigger a cumulative process of demand creation—the design quality of the core product (e.g., smartphones) attracts many complementary products (e.g., application software) and increases variety, which in turn enhances the attractiveness of the core product to customers. Considering the difference between conventional competition and the current form of competition, our multilayered framework of platform, product, and component designs seems to capture the evolution of both the physical and digital domains of today's industrial economy reasonably well.

As already noted, products and components that are part of an open-modular architecture platform may have some closed and/or integral features. Thus, we need a multilayered approach to the firms' architectural strategies regarding which parts of the platforms and/or products are open (or closed). In fact, many rather successful manufacturing firms actually adopt a mixed architecture strategy (i.e., closed-inside and open-outside) by adopting for different architectures at different layers.

Multifaceted Perspective Our evolutionary framework is multifaceted so as to cover a wide range of today's industrial phenomena in a consistent way, including both physical and digital industries, open-modular and closed-integral architectures, product competition and platform competition, technology and architecture as the concrete and abstract sides of design information, flows and forms of value-carrying design information to the customers, both manufacturing and nonmanufacturing industries. capability building and demand creation, profit and employment, and industries and communities. In other words, our design-based and site-based framework of capability-architecture-performance for analyzing the evolution of industries, firms, and sites seems to be a reasonably effective tool to understand today's complex industrial phenomena.

Redefinition of an Industry We have chosen to adopt a multifaceted design-flow-based view of an industry, rather than describing it as an abstract intersection of supply and demand curves, That is, we regard an industry as aggregate *flows of similar value-carrying design information* among productive resources, such as product concepts, product designs, process designs, actual processes, direct materials, work-in-process, and actual products. Since each productive resource can be described as a hierarchy of a system and its components, we may also see it as interconnected multiple hierarchies of design information.

On the supply side, an industry is a *collection of manufacturing sites* (*genba*) as a physical place, each of which has flows of value-carrying design information to the customers. A genba is also an organizational unit that belongs to a firm, an industry, and a local community at the same time. In other words, a genba is the linking pin among firms, industries, and communities. On the demand side, an industry is conventionally a *collection of products* with similar designs. The products in an industry (e.g., cars) are functionally similar (e.g., mobility), and they may be decomposed into functionally complementary components (e.g., engines, bodies, suspensions, etc.).

According to the above conventional definition, an industry is a collection of functionally similar products, while an open-modular architecture platform is a collection of functionary complementary products. Hence, a *platform* can be regarded as a concept akin to that of industry, in that it is *a collection of functionary complementary products* that customers can buy in the market (e.g., smartphones and application software). Thus, we may redefine an industry broadly as a collection of either functionally similar or functionally complementary products, including the concept of platform.

To sum up, our concept of industry is indeed multifaceted, but it is consistently based on the concepts of *design* as a source of economic value and of its *flow* to customers.

Interdisciplinary Approach Finally and theoretically, our analytical framework is rather multidisciplinary, in that it combines evolutionary economics, Ricardian classical theories of production and international trade, theories of product differentiation and monopolistic competition, theories of network externality, axiomatic design theories in engineering sciences, flow-oriented theories of operations management (e.g., Toyota System), and resource-capability view of strategic management. We have tried to integrate these theories into the capability-architecture-performance framework (Fig. 1) in order to explain in an internally consistent manner the variety of phenomena that happened during the period under investigation.

We have not adopted the core part of standard neoclassical economics, including the general equilibrium theory, not necessarily because we disagree with it theoretically but simply because the theories used here, such as the Ricardian trade theory, seem to be able to explain both the industrial phenomena and economic aspects of production observed more effectively. In short, the concept of equilibrium is difficult to apply to the reality of this period, characterized by rapid and continuous changes in both capabilities and architectures.

After all, the main purpose of this book is empirical, i.e., explaining the diversity and dynamics of the industrial phenomena happening in this period in a consistent way, and our theoretical framework is not a set of assumptions but rather the result of our empirical research. By reflecting on what we have observed in the countries most affected by globalization and digitalization, we have developed a capability-architecture framework that has turned out to be interdisciplinary, evolutionary, design-based, flow-based, and genba-based.

3.3 For Future Research

The present book explores the evolution of industries and firms during the late twentieth century and the early twenty-first century from the perspective of both capability and architecture. We have paid special attention to two major trends characterizing this period: global competition and digitalization.

Accordingly, after presenting our theoretical concepts and frameworks in Part I, Part II (Chapters "Evolution of Organizational Capabilities in Manufacturing: The Case of the Toyota Motor Corporation," "The Nature of Surviving Japanese Factories in the Global Competition: An Empirical Analysis of Electrical and Electronics Factories," "The Effectiveness of Group Leaders in the Lean Production System: Time Study and Agent-Based Model of Leaders' Behavior," "The Diversity and Reality of Kaizen in Toyota," and "Balancing Standardization and Integration in ICT Systems: An Architectural Perspective") focused on multilayered capability building efforts by firms, factories, and work groups facing global competition. Then, Part III (Chapters "Creating New Demand: The Impact of Competition, the Formation of Submarkets," "Decline in Demand Creation: The Development Productivity Dilemma and Its Consequences," "Investigating the Creation and Diffusion of Knowledge for Demand Creation: The Case of the Telecommunications Industry," and "The Impact of Platform Providers' Knowledge on Interfirm Division of Labor: The Case of the Mobile Phone Industry") mainly discussed cumulative demand creation in the digitalized industries with open-modular architecture. Part II dealt with product competition in physical goods industries, while Part III tackled platform competition. As for dynamic capabilities, the former emphasized capability-building capability (e.g., evolutionary capability) under the condition of architectural stability, while the latter highlighted architecture-building capability in the context of rapid architectural evolution. We aimed to analyze these two apparently different research themes as consistently as possible through the framework of capability and architecture or, more fundamentally, the design-flow view of industries. By contrast, in the existing literature, capability building in physical products and architectural transformation in digital industries are mostly discussed separately.

However, the emerging trend in the 2010s is the connection between the digital layer (e.g., Internet, ICT) and the physical layer (e.g., motor vehicles, factory equipment) by means of an interface layer. We may describe this through an analogy by calling *high sky* the digital/cyber/ICT layer, *ground* the physical layer, and *low sky* the interfacing (cyber-physical) layer. Connected cars, automatic driving, connected factories, and the Internet of Things (IoT) are popular words that capture this emerging trend of *sky-ground* connection.

When the *high sky*, in which revolutionary architectural changes and explosive demand creation take place, and the *ground*, which is severely constrained by physical laws and environment/energy/safety regulations, come together, the resulting total system and its behavior will be extremely complex. In order to understand this complexity of physical-digital industrial systems, we need a comprehensive research framework that can cover in a consistent manner both physical and digital layers, closed- and open-modular architectures, product competition and platform competition, continuous improvement (kaizen) and discontinuous innovation, organizational capability and architectural strategies, as well as capability building and demand creation.

The present book mainly aims to develop an evolutionary economic framework that can be applied not only to the industrial changes of the recent past (e.g., globalization and digitalization) but also to the aforementioned emerging trend of *sky-ground* integration. This may also be seen as an attempt to rebuild what Sir John Hicks called plutology, or *production economy* in modern terms (Hicks 1976). About 100 years after the publication of *Industry and Trade* by Alfred Marshall (Marshall 1919), it may be a good time to put forward a new version of the production economy framework for analyzing industrial performance and evolution in the early twenty-first century.

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