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A Capability-Architecture-Performance Approach

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Abstract: This Element applies the capability-architecture-performance (CAP) approach of industrial analysis to the evolution of the automobile industry and the strategies of its leading manufacturing firms between the late nineteenth century and the early twenty-first century. It regards a manufacturing site ("genba," such as a factory, development facility, etc.) and a product (and other economic artifacts, such as processes) as the two basic units of analysis. Both an industry and a firm can be seen as a collection of sites, as well as a collection of products. The CAP framework predicts that dynamic fits between the sites' organizational capabilities and the product/process architectures lead to sustainable competitive performance. Such key concepts as flows of value-carrying design information, productive/market/profit performance, design-based comparative advantage, integral/modular architectures, multiskilling, coordinative capability building, evolutionary capabilities, industry life cycle, and architectural evolution are discussed in a systematic and dynamic way.

Keywords: industrial evolution, automobile industry, competitive performance, lean manufacturing capability, integral/modular architecture

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1 The Field-Based Framework of Industries and Firms

1.1 Purpose and Scope

This Element explores the evolution of the automobile industry and the strategies of its leading manufacturing firms between the late nineteenth century and the early twenty-first century. We focus on manufacturers of passenger cars, such as Daimler/Benz, Ford, GM, VW, Toyota and others, and offer additional descriptions of truck makers, parts suppliers, automobile dealers, and other service providers when necessary.

Although most of today's big businesses, striving for continued growth, have diversified into multiple sectors (Chandler, 1962), the world's leading firms in automobile manufacturing are heavily dependent on this single industry, its total being large in global terms (nearly 100 million units and $3 trillion per year in the late 2010s, possibly reaching 100 million units some time in the 2020s). We therefore regard these manufacturers as nearly single-business firms and analyze their competitive performance, strategies, and operations. Our exploration mainly covers the period between the 1880s (birth of internal combustion engines) and the 2010s, with some predictions about the 2020s and beyond.

1.2 The Field-Based Approach for Analyzing Industries and Firms

The framework adopted here to analyze a manufacturing industry and its firms is essentially evolutionary and bottom-up. More specifically, we regard a *manufacturing site* (e.g., factory, development facility) and a *product* (and other economic artifacts, such as processes) as our two basic units of analysis, from which we start our investigation of the automobile industry and firms from the bottom-up.

Both an industry and a firm can be seen as a collection of sites, as well as a collection of products. So, this Element opens with an analysis of these two. We then deal with the next question, that is, which characteristics of sites and products are worth emphasizing? In describing the manufacturing sites and products of the auto industry, we pay special attention to their *design* and *flows*. Let us now sketch out this design-flow view of manufacturing (details are discussed in later sections).

1.3 Design-Flow View of Manufacturing

In our design-flow view of industries, *design* refers to information about the relations among the functional and structural parameters of an artifact, such as a car or a computer (Simon, 1969; Suh, 1990). As Figure 1 illustrates, a product (e.g., an automobile) – as well as all its related artifacts, such as production

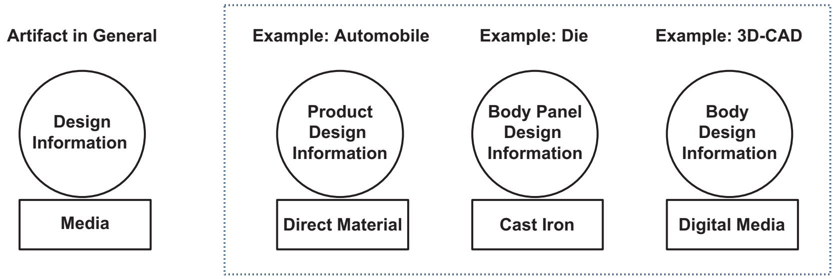

Figure 1 Productive resources as combination of value-carrying design information and its media.

equipment, jigs and dies, standard operating procedures (SOPs), workers' skills, numerical control programs, detailed engineering drawings, 3D-CAD models, prototypes, design sketches, mock-ups, product specifications, and product concept proposals – can be interpreted as a combination of design information and its media (e.g., direct materials, digital media, drafting papers), which may be called a productive resource (Penrose, 1959). We thus examine the automobile industry and firms starting from a design analysis of automobiles as products.

Then, there are *flows* of design information among productive resources. The firm's production, product development, procurement and sales activities all involve flows of design information, eventually reaching the customers or users of the product in question.

Design information is the source of value-added of a product, as well as its industry. Let us assume, for instance, that a coffee mug (its design information and medium) costs \$5 and that the unit cost of its direct material (i.e., medium) is \$1 per piece. Then, its value-added is \$4, which is nothing but the value of the design information added to the mug. Thus, a product's design information is the source of its value-added. The same logic holds true in the case of automobiles.

It follows from this analysis that the process of *manufacturing*, including production and development, can be broadly defined as *flows of value-carrying design information among productive resources* (*and ultimately to the customers*), as indicated in Figure 2. For instance, stamping operations to manufacture a car's body panels involve flows of design information from press dies to sheet steel. A car's product development includes flows of incomplete design information from engineering drawings to prototypes and their test results, as well as from body design (3D CAD) to die design (CAM) and physical dies. Hence, its production is nothing but transfer of design information from the process (e.g., die) to the product (e.g., body panel).

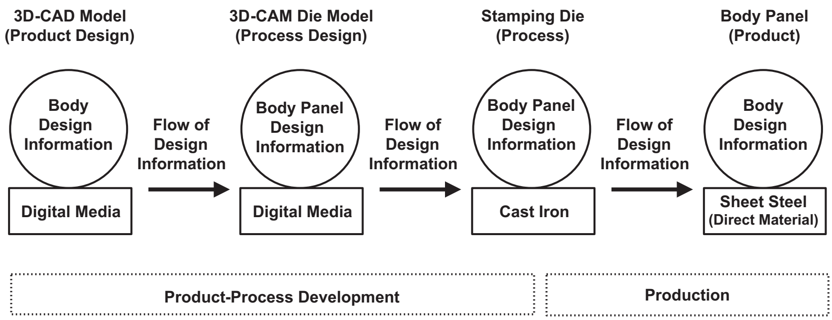

Figure 2 Manufacturing as flows of design information between productive resources (example of the automobile body).

Furthermore, to the extent that a complex artifact can be described hierarchically (Simon, 1969), we view an *industry* as total flows of value-carrying design information among *multiple hierarchies of productive resources* concerning a set of similar products, including the products' concepts, functional designs, structural designs, process designs, as well as their actual functions, structures, and processes in the physical space (Figure 3). As discussed later in the Element, these hierarchies and flows involve *transaction*, *competition,* and *complementation* among the productive resources of industries and firms.

Within this framework, a *manufacturing site*, or *genba* in Japanese, is nothing but a place, or a part of the industry, where value-carrying design information flows, or an organization of workers and other productive resources that govern or improve such flows. An industry can be seen as a set of manufacturing sites that deal with similar design information. Incidentally, this notion of "managing and improving flows of value-added in genba" is central to the so-called Toyota Production System (TPS).

Thus, in our bottom-up approach for analyzing the automobile industry and firms, our initial focus is on (1) the design characteristics of automobiles as products and (2) the flows of design information in automobile manufacturing sites. These two aspects are further discussed in Sections 2 and 3, respectively.

1.4 Product Architecture and Manufacturing Capability

Based on these preliminary observations, this Element proposes an *evolutionary framework* to analyze the automobile industry and firms that consists of (1) *organizational capability* of automobile manufacturing sites, (2) *product architecture* of the automobile, and (3) *competitive performance* of sites, firms and industries. These three components of our framework are all associated with

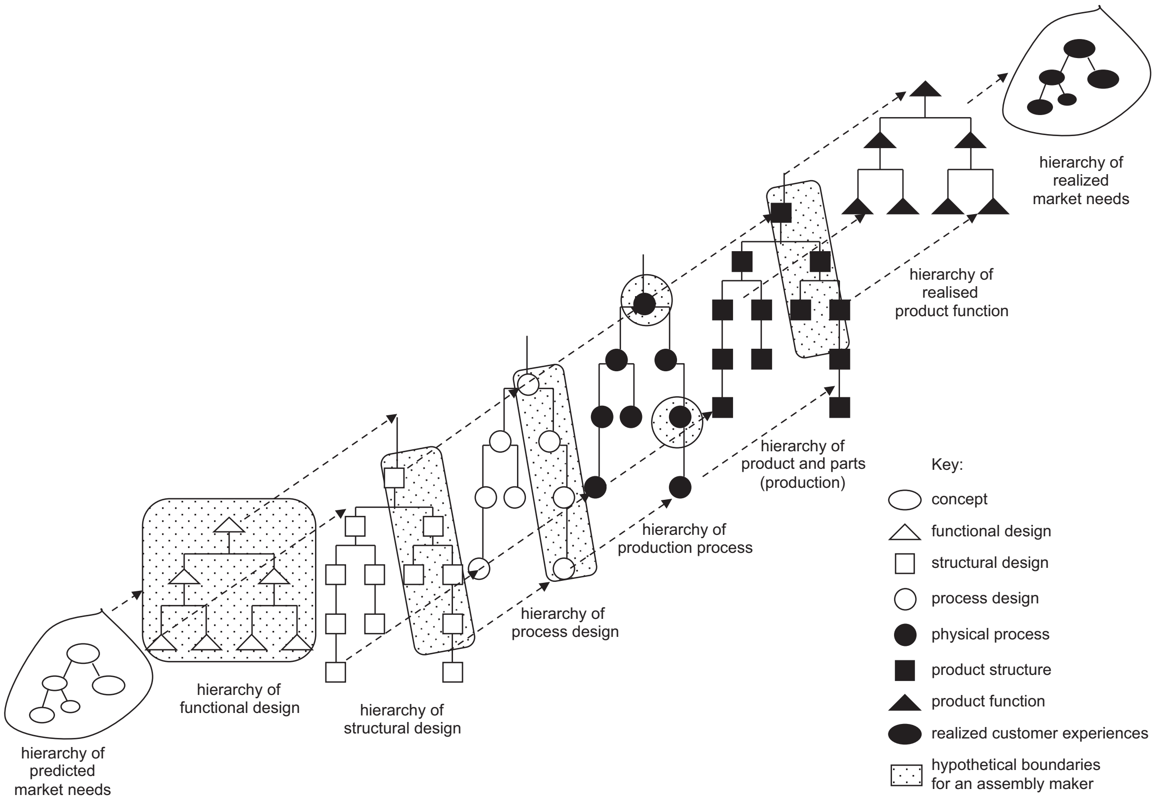

Figure 3 Industry as multiple hierarchies of design information.

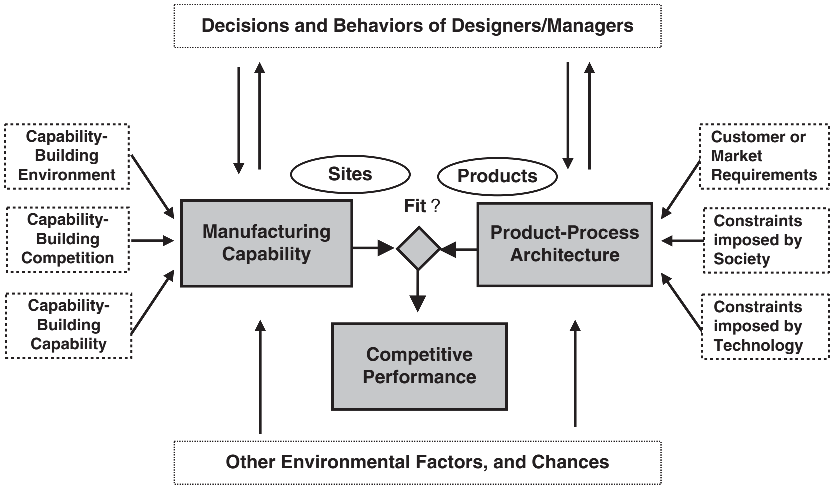

Figure 4 Design-flow view of industries: Capability, architecture, and competitiveness.

design information and its flows, which are the key concepts of our analysis (Figure 4).

Manufacturing capability: According to its definition in the routine-based view (e.g., Nelson & Winter, 1982), *manufacturing capability* is a system of organizational routines that govern the *flows* of design information to the customers both in factories and other sites. The Ford System, the modern mass-production system and TPS are prominent examples of manufacturing capabilities. TPS, for instance, is known as a manufacturing capability that consists of over 200 interrelated routines controlling the flows of value-carrying design information to the customers.

A certain type of manufacturing capability can evolve over time in a country characterized by a particular capability-building environment (see Figure 4). For example, the USA – a nation of immigrants – has tended to emphasize *division of labor*, or coordination-saving capability (e.g., standardization, modularization, specialization) whereby its firms make immediate use of incoming talent. Conversely, postwar Japan – a nation that experienced rapid economic growth and chronic labor shortage due to a lack of immigration influx – had no choice but to build collaborative (coordination-rich) capability to deal with this challenge, with long-term employment and teamwork involving multiskilled workers (Fujimoto, 1999, 2007a). Thus, the present framework assumes that history matters when it comes to the evolution of manufacturing capability.