

学位論文及び審査結果の要旨

横浜国立大学

氏名	MIHAIL MARINOV
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論文審査委員	主査 横浜国立大学 山倉 健嗣 教授 横浜国立大学 Heller Daniel 准教授 横浜国立大学 山岡 徹 教授 横浜国立大学 柴田 裕通 教授 横浜国立大学 河野 英子 教授

論文の要旨

1. Outline

In the last three decades a growing body of knowledge about product development and manufacturing in the automotive industry has emerged. One of the major contributions in this field has been done by Clark and Fujimoto (1991) whose work represents a lengthy and detailed study of product development in the world automotive industry. In their book they describe the different approaches to product development that can be found in different manufacturing companies around the world. Having done so, Clark and Fujimoto (1991) provide a convincing explanation of how and why the Japanese automakers have become performance leaders in the automotive industry and also give useful advice to those manufacturers who need to radically improve their competitiveness. This competitiveness continues today in some forms (Fujimoto and Nobeoka, 2006; Thomke, 2006; Higashi and Heller, 2012).

The major works in the field of automotive industry, like the ones mentioned above, are mainly concerned with two aspects of the transition from raw materials to products: product design and manufacturing. This approach may seem reasonable from the point of view that both product design and manufacturing have a specific output: product design provides the blueprints of the products that are to be manufactured, and manufacturing provides the products based on the blueprints drawn by product design. These specific outputs (blueprints and products) naturally make the performance (quality, cost, delivery, etc.) of both product design and manufacturing easy to quantify and measure.

Product and process historically have been in the center of academic and practitioner interest, however in recent years there has been a growing number of works that examine how the productivity of existing production lines can be improved and how new production lines can be introduced more

efficiently (Jonsson et al., 2004; Nakaoka et al., 2005). Both tasks, at least in Japanese companies, tend to be important responsibilities of manufacturing engineering (Shibata, 2009; Whitney et al., 2007; Koike, 2008). The transfer of manufacturing processes to overseas facilities of Japanese companies has been going on for some time, however in Japan, in recent years there appears to be an increasing focus on the transfer of manufacturing engineering processes to overseas facilities (Shibata, 2009; Heller et al., 2013).

The literature that elaborates on the different aspects of manufacturing engineering can be roughly divided into two periods whose boundary is situated approximately in the beginning of the 1990s. This is the time when Clark and Fujimoto (1991) and Womack et al. (1990) first published their works on product development and lean manufacturing respectively.

The first period begins in the late 1970s. During this period, the literature is predominantly concerned with the strategic aspect of manufacturing engineering. It is true that the literary works in this period do not explicitly refer to manufacturing engineering as such. Instead, Abernathy (1978) and (Hayes and Wheelwright, 1979a, 1979b) use the words "product" and "process", arguing that consistency between the product strategy and the process strategy is necessary for successful competition in the market, and pointing out that this consistency is of greater importance when the company produces a large variety of products. In other words, there is a strong link between the choice of products (product strategy) and the choice of production process to manufacture these products (process strategy).

Another important strategic aspect is that manufacturing engineering is in fact responsible for the development of manufacturing processes. In other words, the process strategy described in Hayes and Wheelwright (1979a, 1979b) is developed by manufacturing engineering. Of course, the core of the strategy, or its basic principles, are probably laid out at a higher managerial level, such as in technology strategy (Whitney, 1995), however manufacturing engineering is in charge of production line and production method development, i.e. elaborates the process strategy.

So, there are two strategic sides of manufacturing engineering. First, it provides the link between two strategies, namely product strategy and process strategy, which means that the link must be strategic too. Second, it is responsible for the development and implementation of the process strategy. Since there tend to be a multitude of product strategies and process strategies, even within the same industry (Boyer and Freyssenet, 2002) we may expect that different companies have different strategies for linking product with process.

The second period of the literature which is concerned with manufacturing engineering, begins after about a ten-year lag, in the end of the 1990s. During this period the main aspect that is elaborated on in the human resource management stream is the organizational and human resource side of manufacturing engineering. And from this organizational perspective, two research patterns are seen in the literature: one which examines the relationship between manufacturing engineering and its neighbouring phases in a new product development process, namely product development (upstream phase) and manufacturing (downstream phase), and another one which examines the internal structure of manufacturing

engineering, as well as the roles and responsibilities of the engineers who perform the different manufacturing engineering tasks.

From the literature review it can be concluded that, among others, there are two characteristics of a product development process that seem to affect the tasks of functions of manufacturing engineering:

1). How close is manufacturing engineering (a relatively downstream process) to product engineering (clearly an upstream process) or manufacturing (clearly a downstream process) organizationally and functionally, or said in another way, how dependent is manufacturing engineering on product engineering or manufacturing.

2). The level of product/process standardization. It must be considered in the context of the agents carrying out the tasks and functions, and the resource attributes involved in the manufacturing process, so it is clearly a *strategic* attribute of a product development process.

Therefore, based on the above, it is possible to build two hypotheses that seek to identify and potentially explain differences in manufacturing engineering in another business dimension, that of suppliers, more specifically first-tier and second-tier suppliers. The proposed hypotheses in this study is as follows. In suppliers of automotive components,

Hypothesis 1: There is a direct relationship between the level of product/process standardization and the level of dependence of the manufacturing engineering organization on upstream product development processes.

Hypothesis 2: There is an inverse relationship between the level of product/process standardization and the level of dependence of the manufacturing engineering organization on downstream product development processes.

The reason for seeking that relationship between the level of product standardization and the degree of dependence of manufacturing engineering organizations is that the manufacturing process of more standardized products is to a considerable extent determined at the product engineering phase, thus leaving fewer options for manufacturing engineering to influence product development in downstream stages. Less standardized products however, provide more options for manufacturing engineering to actively participate in product development, including the downstream stages, therefore an independent manufacturing engineering organization will be able to contribute more effectively to product development.

The characteristics of case study research show that hypothesis testing is a valid methodology for case study research. In addition, compared to exploratory and descriptive analysis and evaluation research, hypothesis testing is the more appropriate research strategy for this study because in the literature there is already a sufficient knowledge about manufacturing engineering, at least in Japan, and enough information that permits the building of a hypothesis.

2. Methodology

Based on the findings of Shibata (2009) and Koike (2008), this study employs a hypothesis testing with case study methodology, utilizing qualitative data obtained through in-depth interviews in two

Japanese suppliers of automotive components: Supplier A who is a second-tier supplier, and Supplier B who is a first-tier supplier and consequently larger than Supplier A.

Supplier A is a second-tier supplier. The main business of this supplier is the manufacturing of subassemblies (subcomponents) that are largely mechanical and used in a major automotive system. These subassemblies are assembled using a high level of automation with little employment of labour (at least in the Japanese facilities of this supplier).

Supplier B is a first-tier supplier. The main business of this supplier is the manufacturing of a major automotive system that consist of a number of subcomponents, one of which is the subcomponent manufactured by Supplier A. The assembly of this automotive system requires a considerable amount of (and according to the observation of the author, also intensive) labor, even in a high cost country as Japan. In addition, this automotive system is an example of what Clark and Fujimoto (1991) call black-box parts that require extensive co-development and integration (*suriawase*) between a supplier and an automaker. Supplier B also has a second-tier business (manufacture of components similar to those of Supplier A), however the first-tier business is significantly more than the second-tier business.

For the testing of the two hypotheses this study utilizes three variables: product/process standardization (explanatory variable); dependence of manufacturing engineering on product engineering (explained variable); dependence of manufacturing engineering on manufacturing engineering (explained variable)

There are two indicators that are used to measure product/process standardization (the explanatory variable) in this study: process automation and product variety. Also, there are two indicators that are used to measure the dependence of manufacturing engineering on product engineering or manufacturing engineering (the explained variables): co-location of manufacturing engineering with product engineering or manufacturing, and subordination of manufacturing engineering to product engineering or manufacturing.

Turning first to co-location, according to Hypothesis 1, a company whose products are characterized by high level of standardization whereby manufacturing engineering has to work in very close collaboration with product engineering because the high level of product standardization determines to a large degree how the product is manufactured and therefore restricts the options that are available to manufacturing engineering to intervene during the downstream stages of a new product development project, we should expect to find co-location of product engineering and manufacturing engineering. According to Hypothesis 2, if the inverse is true as well, meaning that in a company with low level of product standardization where manufacturing engineering is less dependent on product engineering, we should not expect to find co-location.

Regarding subordination, according to Hypothesis 1, a company whose products are characterized by high level of standardization whereby there is a greater need for product engineering to coordinate product development (engineering aspects, including manufacturing engineering) because the major product/process characteristics are determined in the early stages of a new product development project, we should expect to find that manufacturing engineering is subordinated to product development.

According to Hypothesis 2, if the inverse is true as well, meaning that in a company with low level of product standardization where the major process characteristics are determined in the later stages of a new product development project, we should not expect to find that manufacturing engineering is subordinated to product engineering.

3. Findings

The findings largely support the presence of a direct relationship between the level of product/process standardization and the dependence of manufacturing engineering on product engineering. Therefore Hypothesis 1 of this study can be considered supported. The findings also show partial support for an inverse relationship between the level of product/process standardization and the dependence of manufacturing engineering on manufacturing. Therefore Hypothesis 2 of this study can be considered partially supported.

The findings show that at Supplier A downstream manufacturing engineering is co-located with manufacturing, a result which in fact speaks against full support of Hypothesis 1. Co-location of downstream manufacturing engineering with manufacturing is however, as it can be seen from prior research on the subject (Shibata, 2009; Marinov and Heller, 2013), usual practice in all major geographic regions of the automotive industry, which implies that separating downstream manufacturing engineering from manufacturing is probably difficult, or not appropriate. Therefore, the result obtained by this study is not at odds with the usual practice in the industry

The reason why Hypothesis 2 is only partially supported is that upstream manufacturing engineering at Supplier B is not co-located and not subordinated to manufacturing. While the literature suggests that we can expect to find such co-location and subordination, however in practice such a case would be difficult to find as it would represent an extreme dependence of an upstream process (manufacturing engineering) on a downstream process (manufacturing). This would be contrary to the major flow of information (from upstream to downstream) during a new product development project and consequently difficult to implement.

Another possible explanation for Hypothesis 2 only being partially supported is that the small proportion of second-tier business of Supplier B is affecting the dependence of manufacturing engineering. According to the hypotheses, in a lower-tier supplier, we expect to find less dependence of manufacturing engineering on downstream processes like manufacturing. The findings in Supplier A (a second-tier supplier) support this prediction and show that the dependence of manufacturing engineering on manufacturing is not significant, and this may be true for Supplier B as well, given the fact that Supplier B also has second-tier business. According to the hypotheses in this study, manufacturing engineering at a lower-tier supplier that has a higher level of product/process standardization, is less dependent on manufacturing. By extension, this relationship may also apply for an upper-tier supplier that has lower-tier business.

The first major theoretical contribution of this study is insight into a factor that moderates the relationship of manufacturing engineering with product engineering and manufacturing. This factor is

the level of product/process standardization which is the explanatory variable in the two hypotheses of this study, and which until now was not associated with interactions between the different functions of new product development.

In this study the level of product/process standardization is identified as a factor that moderates the relationship of manufacturing engineering with product engineering and possibly with manufacturing. More specifically, the conclusion of this study is that when there is a high level of product/process standardization, manufacturing engineering is more dependent on product engineering than on manufacturing. In contrast, when there is a low level of product/process standardization, manufacturing engineering is more dependent on manufacturing than on product engineering, however support for that dependence is not as great. The dependence of manufacturing engineering is manifested by co-location and subordination to product engineering or manufacturing, i.e. bringing manufacturing engineering closer, physically and organizationally, to either product engineering or manufacturing

Thus, this study closes a gap between the strategic and the organizational aspects of new product development functions (product engineering, manufacturing engineering, manufacturing), which until now were studied mainly individually (unrelated to each other), or as a whole (a new product development project), underexamining the interactions between them.

Also, in the automotive industry, the mainstream of the literature on new product development, one of whose important functions is manufacturing engineering, is concerned with OEMs. This study however, provides insight into manufacturing engineering in Japanese automotive component suppliers, especially lower-tier, which constitutes the second major empirical contribution of this study.

審査結果の要旨

本論文は、**Manufacturing Engineering (ME)**に関する理論的・実証的論文であり、ミンツバークの戦略アプローチ、すなわちプランニングと実行の両方における意志決定の流れとしての戦略の視点から、日系の自動車部品一次サプライヤー1社と同サプライヤーの製品の構成部品を供給する二次サプライヤー1社を対象とする事例を調査し、2社それぞれの**ME**組織の社内的位置づけに関する実証研究を行ったものである。なお、ここで言う**ME**とは、日本語の「生産技術」と「製造技術」の両方を含む概念である。

従来の経営学研究では、**ME**は製品開発あるいは製造工程の一部として取り上げられてきた。この一連の研究では、**ME**に関わる組織能力がものづくり企業の競争力に大きく関与するサイマルテニアス・エンジニアリング（製品設計と工程設計の同時並行化）等に重要な役割と果たすことが指摘されてきた。この点において **ME** の戦略性が強調されたと解釈できるものの、**ME** よりも開発や製造に研究が集中した（e.g., Clark & Fujimoto, 1991 や Womack et al., 1990）。従って、最近までは**ME**の組織や業務等に関する研究がほとんどされてこなかった。

2000年代後半以降、日系自動車メーカーの長年に渡る競争力の原因追究や、日本企業の海外生産拠点の機能拡充における組織能力の移転の困難性を解明するため、**ME**に関する研究が徐々に増えてきた（中岡他, 2005 ; Whitney et al., 2007; 小池, 2008; ヘラー他, 2013）。とくに**ME**の任務と業務遂行において日本企業と欧米企業との大きな相違が指摘された（Shibata, 2009; Marinov & Heller, 2013）。

しかし、**ME**に対するこの新しい研究の流れは、従来の開発や製造を中心とする**ME**に関する研究とほぼ無関連に展開されてきた。本論文の第一の学術的貢献は、文献レビューにおいて、以上の**ME**に関する2つの研究の流れを融合し、今後の**ME**研究に新しい発展の可能性を示し

たことである。また、Abernathy (1979)や Hayes & Wheelwright (1979a, 1979b)等に基づいて ME 組織の社内的位置づけについて仮説を構築し検証したことも評価できる。

本論文の第二の学術的貢献は、比較的に関研究されてこなかった自動車部品の二次サプライヤーを含む事例研究を通じて、同じ製品特性を持つ部品を供給する日本企業においては、製品・工程戦略が ME 組織に影響を与えることを示したことである。具体的には、製品・工程戦略の重要な要因とされている標準化の度合いが、ME 組織の他部署（開発部門と工場）への依存度に影響することを示したのである。

本論文の一部は、『横浜国際社会科学研究』に研究ノートとして掲載されることが確定している他、信州大学イノベーション研究・支援センターの『イノベーション・マネジメント研究』（レフリー付き、ファースト・オーサー）に研究論文として掲載済みである。また、International Academy of Management and Business、組織学会、Gerpisa – Le Réseau International de l'Automobile 等で学会発表を行い、既に一定の外部評価を受けている。

以上のことから審査委員一同は本研究科の博士号審査基準（3）に照らして、Marinov 氏の学位請求論文「A Strategic Perspective on Manufacturing Engineering: Two Cases of Japanese Suppliers of Automotive Components」が博士（経営学）の学位を授与するものに相応しいと判断する。

注 論文及び審査結果の要旨欄に不足が生じる場合には、同欄の様式に準じ裏面又は別紙によること。