

Mapping the structural properties of production process and product mix

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Abstract

The description and classification of production capabilities, referring to the kind of product mix that can be produced in a given type of facility, is a fundamental task in analyzing production strategy and economics. In practice, however, the concepts of product structure and process structure have been hard to operationalize since there are no generally applied measurement scales or indices to capture the degree of standardization or customization of products, for instance, or to characterize the configuration and type of control of a production line. The objective here is to provide a systematic approach for analyzing production capabilities, or productabilities for short, by mapping the structural properties of production process and product mix with a set of quantitative indicators acknowledging the different levels of reference (actual operations, existing or planned resources, and strategic intentions) as well as the disciplinary perspectives of marketing and manufacturing management. The new mapping method is illustrated in the context of the product–process matrix by Hayes and Wheelwright which links the two dimensions of productability and their alignment to the performance-oriented measures of production capabilities, such as productivity of plants or profitability of products. The use of the mapping method is demonstrated with some illustrative numerical examples of productability analysis and a case study of an individual firm. Further development and testing of data collection in the context of industrial surveys and statistical studies are discussed.

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1. Introduction

The description and classification of production capabilities, referring to the kind of product mix

that can be produced in a given type of facility, is a fundamental task in analyzing production strategy and economics. In principle it seems easy to categorize any production unit as a flow line, an assembly line, or a job shop. Similarly the planned mix of products can be classified as commodities, a family of discrete products, or unique items. In practice, however, it might not be so straightforward to operationalize the concepts of product

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structure and process structure rigorously and generally enough for tracing changes in actual production of some given facilities for comparing production capabilities of any two firms or different industries, on one hand, and for testing the impact of the consistency product and process choices on firm performance, on the other hand. Hence this paper has two objectives. First, it provides a systematic approach for analyzing production capabilities of individual production units or production networks. We call the mapping of the structural properties of production process and product mix *the productability analysis* in contrast to other more performance-oriented measures of production capabilities, such as productivity of plants or profitability of products. Second, the new mapping method is linked to the well-known product–process matrix (Hayes and Wheelwright, 1979a) which has been extensively used over the last decades to study product–process alignment and firm performance. More specifically, we argue that prior to debating on the validity of the normative implications of the product–process matrix it should be assured that manufacturing units are properly positioned by measures relating to the two dimensions of productability.

We have chosen the product–process matrix as the platform for mapping productabilities and for evaluating product and process alignment for several reasons. Firstly, it is the most commonly used framework in the manufacturing strategy literature. Secondly, already Hayes and Wheelwright (1979b, p. 136) suggested that their classification can be used for managerial purposes including the following:

- To determine the appropriate mix of manufacturing facilities, to identify the key manufacturing objectives for each plant, and to monitor progress on those objectives at the corporate level.
- To review investment decisions for plant and equipment in terms of their consistency with product and process plans.
- To determine the direction and timing of major changes in a company's production processes.
- To evaluate product and market opportunities in light of the company's manufacturing capabilities.
- To select an appropriate process and product structure for entry into a new market.

Accordingly, the new mapping and assessment tool is intended to assist executives in strategic

positioning, comparisons and development of production capabilities.

Thirdly, since Hayes and Wheelwright (1979b) hypothesized the co-evolution of product structure and process structure, researchers seem to have focused heavily on analyzing the link between firm performance and the match between production line and product mix. However, the positioning of manufacturing plants into the matrix has been based on managerial perceptions of production capabilities or executional aspects such as capacity, speed, and quality with less concern for the structural properties of product mix or manufacturing operations. In most of the studies the empirical data on firm performance has been collected under operating conditions that are different, perhaps even drastically, from those intended at the time of manufacturing system design. This may lead to the inconsistency with the implications of the product–process matrix found when structural and infrastructural decisions are essential in developing of a certain manufacturing capabilities (Hallgren and Olhager, 2006; Hayes and Wheelwright, 1984). Thus, it is reasonable to discuss in some detail three questions concerning the operationalization of mapping the concepts of product structure and process structure: (1) Should a production unit be profiled on the basis of its actual operations, the resources employed, or perhaps on the basis of its strategic intentions? (2) Do the most commonly used definitions of product structure and process structure, such as product customization and process continuity, suffice for mapping of production units into the product–process matrix? (3) How reliable are the selected questions and qualitative measures used and how accurately would any representative of the company studied, or of a different company even in another industry, replicate the outcome? The following examples drawn from real-life cases illustrate the issues involved.

Example 1. A car manufacturer invested heavily in a flexible manufacturing system (FMS) to be able to produce a wide range of makes, just to see the customers to order only a few variants during the first years of operation, due to a recession. Does this mean that the automaker had relocated itself on the axis of product mix from the intended customized end of one-of-a-kind products towards mass products indicated by the operational records. Furthermore, how should the FMS line be positioned

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