

Formulating Growth Guidelines in the Innovation Process: The Case of Mechanical Engineering SMEs

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Abstract

In Japan and Germany, the mechanical engineering industry is a significant industrial sector, and the growth of small and medium-sized enterprises (SMEs), which constitute a large proportion of the number of firms and employees, has a considerable impact on a country's growth. Innovation is an effective approach for firms to achieve growth. In this study, we propose that the phase of formulating growth guidelines, which include three factors: growth objectives, scope, and directions for growth, should be established before the phase of implementing the innovation process. A new scope framework is constructed and a method for evaluating the consistency of the growth guidelines is presented. The method is applied to Japanese mechanical engineering SMEs that have achieved growth through innovation, and the applicability of the framework and the consistency of the growth guidelines are confirmed. This study provides an idea of growth guidelines that can be used to guide decision making in implementing the innovation process.

1. Introduction

The German mechanical engineering industry is the largest industrial sector [1]. The top four machinery exporting countries in the world are China, Germany, the U.S., and Japan, which together account for 45% of the world's machinery exports, and the three countries except the U.S. export more machinery than they import [2]. The mechanical engineering industry is highly competitive internationally in Germany, Japan, and China, where exports exceed imports. Mechanical engineering is expected to make academic and technical contributions to the creation of technological innovations, and its personnel are expected to play an active role in the industry [3].

The share of the manufacturing industry in the nominal GDP is approximately 20% in Japan and Germany [4], and the share of the mechanical engineering industry in the nominal production output of the manufacturing industry is 46% in Germany and 41% in Japan [5]. The high share of the mechanical engineering industry in GDP indicates that it is an important industrial sector in the country. The SMEs in both countries account for more than 99% of the total number of firms and generate approximately 60% of the total number of employees and approximately 50% of the total added value [6] and are the main driving force of the economy [7]. The creation of added value is known to be the cornerstone of innovation [8], and the generation of innovation and achievement of growth in mechanical engineering SMEs is expected to contribute to the growth of the country.

Innovation is an effective approach for firms to achieve growth. Innovation is a process and can be managed by controlling its factors [9]. By controlling the factors appropriately, it may be possible to increase the probability of creating innovations. Various models of innovation process are known, consisting of several stages [10], and each stage contains factors that should be controlled [11]. While previous researchers have

categorized the generations of innovation process models differently, Rothwell classifies the first generation as technology push and the second generation as market pull, positioning these models as linear models that sequentially progress through stages [10]. He further describes the third generation as a coupling model that is basically a sequential process but includes interactions and feedback loops between processes, and the fourth and later generations as a progression to an integrated model. A cyclical model that includes learning and re-innovation stages and improves the next innovation process through modification and refinement is also proposed [9], [12].

While the first-generation model assumes that the value to be provided to customers is self-evident, the second and later generations of models all start from the "discovering needs and generating value" stage. For example, the first stage of Tidd's model is "signal processing," which starts with finding potential signs of needs and technologies [9], and the first stage of Haruyama's model is "generating value," which starts with having foresight and using core technologies to generate value [12].

Then, the innovation process after the stage of "discovering needs and generating value" includes the strategic management process [13], [14] to provide the value to customers, markets, and society, and to gain competitive advantage. Business strategy in strategic management is considered as a guideline for decision making, and its main components are known as objectives, scope, and competitive advantage [15], [16]. Some SMEs develop their business strategy using the helpful SWOT-AHP analysis [17]. We position this guideline as a micro guideline contained within the innovation process, in contrast to the macro guideline discussed below.

When a firm tries to innovate, can it start from the first stage, "discovering needs and generating value," by trying to implement the innovation process from the ground up? We think not. In implementing the first stage, there are several factors that need to be controlled, and firms need to make specific choices about what activities to engage in or not to engage in with respect to these factors. The development of guidelines is required to facilitate decision making [18], and guidelines for firms to make decisions are considered essential. Therefore, before implementing the innovation process, it is necessary to decide what kind of growth the firm is aiming for based on its vision.

However, the innovation process in previous studies does not explicitly discuss the decision-making guidelines for firm growth prior to its implementation. In this study, we propose to insert the phase of formulating growth guidelines before the phase of implementing the innovation process. The growth guideline is a guideline for what kind of growth the firm is targeting to achieve its vision, and we position it as a macro guideline to be formulated before the phase of implementing the innovation process. This perspective is different from the micro perspective in the implementation phase of the innovation process, and the two are clearly distinguished.

We believe that it is especially important for firms to formulate growth guidelines for decision making when implementing the innovation process, i.e., the level of growth to be targeted, the scope of activities, and the directions for growth within the scope, as they move toward the goal of creating innovation. The three factors of the growth guidelines are presumed to be the growth objectives, the scope, and the directions for growth.

From a micro perspective, i.e., in business strategy, the competitive advantage of how to achieve the objectives is a key component [16]. On the other hand, from a macro perspective before the phase of implementing the innovation process, we believe that the directions of growth to be targeted is critical as a factor of growth guidelines. This is because, firms are required to implement the innovation process based on an understanding of what is necessary and what is lacking with respect to their objectives to generate innovation and growth, and different directions for growth will require different activities within the innovation process. Therefore, it is important for firms to thoroughly discuss in this phase whether the growth directions have potential to achieve the growth objectives.

Figure 1 shows the model of formulating growth guidelines, in which the phase of formulating growth guidelines consisting of the above three factors is inserted before the phase of implementing the innovation process. The purpose of this study is to answer the following questions: Are the expected levels of potential in the growth directions consistent with the levels of growth objectives, i.e., are the factors of the growth guidelines consistent?

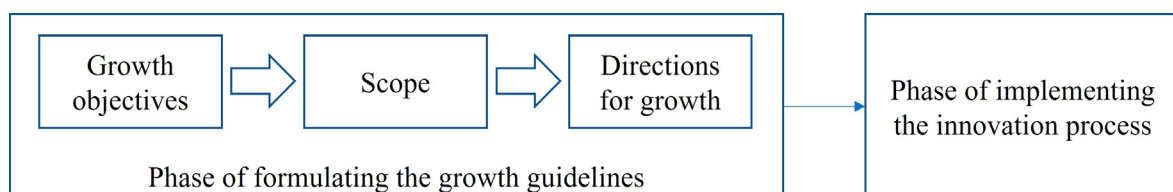


Fig. 1 The model of formulating the growth guidelines

In this study, we propose a scope framework that is a factor of growth guidelines. Then, we investigate a method for estimating the expected levels when setting the growth directions to be targeted in the scope framework, i.e., the performance of firms that can be achieved based on the growth directions. Once the performance is estimated, it can be compared with the growth objectives. We then discuss the applicability of the scope framework and the consistency of the growth guidelines - growth objectives, scope, and directions for growth - using Japanese manufacturing SMEs that have achieved growth as case studies.

2. Literature Review

As previous studies on the scope in which firms operate, a framework for defining the business scope [18] and a framework for defining the product scope in terms of technology and market [19] are well known. Ansoff shows a matrix that defines the business scope by dividing each of the two axes, product, and market, into two parts, present or new [19]. Johnson and Jones indicate a matrix that uses technology and market as two axes and divides both axes into three parts in terms of newness - no technological change (present technology) or improved technology or new technology, and no market change (present market) or strengthened market or new market - to define the product scope [20]. Buzell and Nourse define three categories of new products based on the degree of newness to the firm itself: product improvements, product line extensions, and distinct new products, and further distinguish distinct new products that are the first and second to be introduced to the market, regardless of the firm itself or its competitors, as pioneering new products [21].

The concept of the product life cycle (PLC) is well known as the life story of successful products that firms offer to the market [22]. The PLC generally consists of four stages, and although the names of these stages vary slightly among researchers, in this study, they are referred to as introduction, growth, maturity, and deadline. Although it is known that the PLC curves have different shapes [23], this study assumes a classical shape to discuss generality using the PLC concept, rather than differences in shape by product or industry. Three types of PLCs are known: industry life cycle, product line life cycle, and product model life cycle, and the product line and product model life cycles are the life cycles of the firm itself, while the industry life cycle is the life cycle at the market level, regardless of the firm itself or its competitors [24]. In this study, the PLC refers to the industry life cycle, unless otherwise noted, because we are discussing situations in which firms generate innovation in the marketplace.

3. Methodology

Figure 2 shows the three-step study flow in this research. First, a framework for the scope was constructed. Next, a method for estimating performance using the PLC concept was investigated based on the direction to be targeted within the scope. Then, using specific cases, we compared the level of growth objectives with the expected level of firm performance estimated by setting the scope and the directions for growth. In a series of steps, we examined the applicability of the scope framework and the consistency of the growth guidelines.

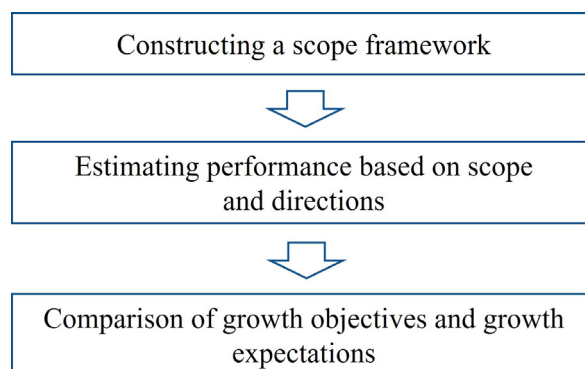


Fig. 2 3-step study flow

3.1 Constructing a Scope Framework

Since scope is a factor of decision guidelines as firms move toward the goal of generating innovation, we considered the following two perspectives important in constructing the scope framework. First, the scope is not defined in terms of products, but rather as a business scope that includes both market and product aspects. Second, the scope is not classified according to the newness to the firm itself, as shown in previous studies, but according to the newness to the market, regardless of the firm itself or its competitors. Based on these two perspectives, we investigated the scope matrix.

3.2 Estimating Performance Based on Scope and Directions

In this study, firm performance is expressed in terms of sales in the PLC. Figure 3 shows a classically shaped PLC [23]. The approximate level of sales can be estimated from two sources: the classic PLC curve with a single sales peak and its stage position. Specifically, when predicting the PLC curve - i.e., the sales peak - the firm's sales are estimated at the following levels: one-half of the peak level if the stage position is in the middle of the growth stage, and three-fourths of the peak level if it is at the end of the growth stage.

In estimating sales based on the targeted growth direction, we examined how to predict the PLC curve of the business defined by the scope and at what stage the targeted growth direction is positioned. For the latter, since the growth direction is set from each quadrant on the scope matrix constructed in the previous section, we investigated at what stage each quadrant is positioned by comparing the characteristics of the product, market, and business represented by each quadrant with the characteristics of each stage of the PLC. For the former, as for the prediction of PLC curves, various prediction techniques are known, such as customer/market research [25], and several quantitative statistical approaches are also proposed [26], [27]. Since the life cycle concept can be applied to both present and new products [22], it would be possible to select a prediction technique from previous studies that is appropriate for the product type. Therefore, in this study, the method of predicting the PLC curve follows the previous studies.

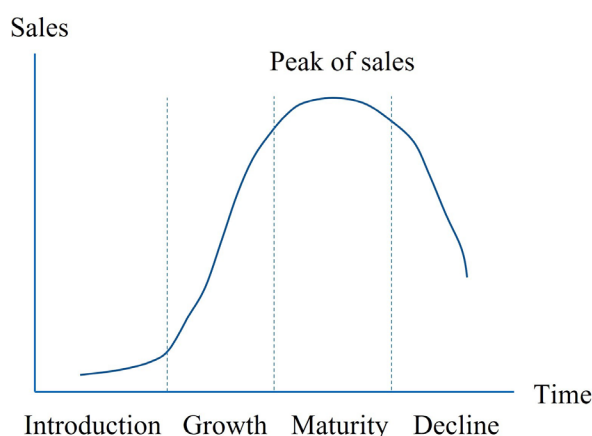


Fig. 3 Classical shaped product life cycle [23]

3.3 Comparison of Growth Objectives and Growth Expectations

We focus on a group of innovative manufacturing SMEs in the Kyushu region of Japan. Using SMEs that have generated innovation and achieved growth as case studies, we investigated whether the scope framework and performance estimation proposed in the previous section are applicable to SMEs and whether the level of growth objectives is consistent with the expected level of performance in SMEs. We first selected firms through theoretical sampling, then collected data from multiple data sources, and then conducted a comparative analysis based on these data, focusing on the following questions [28]: What were the growth guidelines (growth objectives, scope, and directions for growth) that were assumed before implementing the innovation process, and what was the expected level of performance based on the scope and directions for growth?

4. Results

The results were presented in sections for each step according to the study flow shown in Figure 2. Based on these results, the applicability of the scope framework and the consistency of the growth guidelines were discussed in the following sections.

4.1 Scope Framework

To construct the scope framework, the axes and their classifications were established. Two perspectives were considered: the axes should indicate the business scope, and the classification should be based on newness to the market. First, the axes of the scope framework were established as needs and products. Each quadrant was represented by a relationship between a need and a product that satisfies that need, indicating the scope of the business. Next, when classifying the axes, we added the idea of predictability or unpredictability, as well as present or new. Based on this idea, the product axis was classified into four parts: present products, products that can be predicted from present products, products that cannot be predicted from present products, and new products. These were divided into two groups, the first two and the latter two, and the product axis was

reclassified into two groups. One group consisted of present products and predictable products. Predictable products are those that do not currently exist but are likely to be launched in the future based on the external and internal environment. The other group was new products that cannot be predicted at this time. The classification of these two groups was not based on the newness to the firm itself, but on the newness to the market as a whole, regardless of the firm itself or its competitors. In the following, predictable products are referred to as updated products, that is, products that will be updated from present products in the future.

The needs axis was classified in the same way as the product axis. Current needs and needs that can be predicted from current needs were combined into one group. Since present needs are satisfied by present products, predictable needs are needs that are not satisfied by present products, but are likely to be satisfied in the future, based on the external and internal environment. These predictable needs can be satisfied by updated products. The other group was new needs that cannot be predicted at this time. As with the product axis, the classification of the needs axis was based not on the firm's perspective, but on the perspective of the market, including both the firm itself and its competitors. Since the market can be viewed in terms of needs and customers [19], the needs axis can be replaced by the market axis with almost the same meaning.

The scope framework derived from the axes and their classification described above is shown in Figure 4. In describing the characteristics of each quadrant of the scope framework - the needs-products matrix - we applied the concept of three levels of products [29], which represents the relationship between needs and products. This concept states that products must be considered at least at three levels, depending on the customer benefit: the first level is the core customer value of the product, the second level is the actual product, and the third level is the augmented product.

First, the third quadrant, located in the lower left of Figure 4, is a business area where present and predictable needs are satisfied by present and updated products, and is based on present needs-present products. Here, present products provide the core customer value that satisfies present needs. Updated products are updated at the level of actual and extended products to satisfy present and predictable needs, while including the core customer value provided by the present product. Since this business area is an extension of the present business, trends in needs and products are somewhat predictable. Borrowing the keyword from Ansoff's growth vector [19], we call this area extended market penetration. "Extended" means that it is based on the present business and is extended to a predictable area.

Next, the fourth quadrant, located in the lower right of Figure 4, is the business area where present and predictable needs are satisfied by new products. New products in the fourth quadrant are products that are new to the market, but their core customer value satisfies present needs. Therefore, the new product creates newness at the level of actual or augmented products. The needs of this business area are an extension of the present needs. Borrowing a keyword from the growth vector, we call this area the new product development at the level of actual and augmented products.

Then, the second quadrant is in the upper left of Figure 4 and is the business area where new needs are satisfied by present and updated products. Since the core customer value of the products in the second quadrant has already satisfied the present needs in the second quadrant, it is necessary to allocate the core customer value of the products that satisfy new needs from the level of actual and extended products in the present and updated products. The products in this business area are extensions of present products. We call this quadrant new needs development.

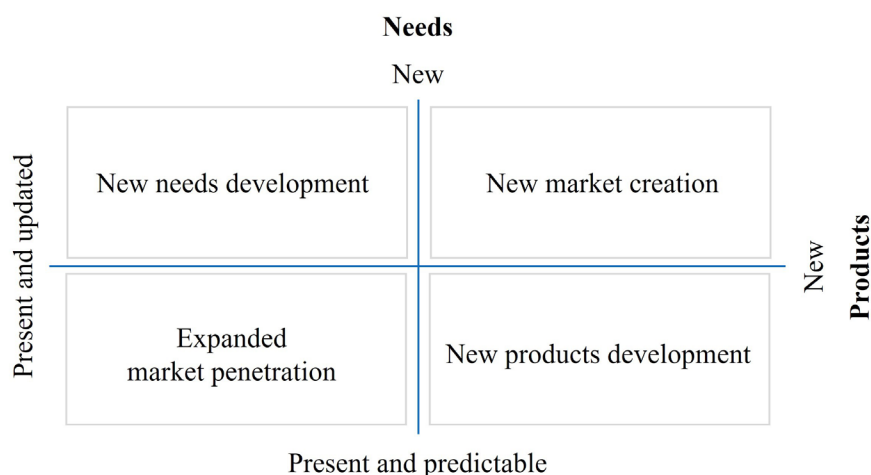


Fig. 4 Framework of scope: needs – products matrix

Finally, the first quadrant is in the upper right corner of Figure 4 and is the business area where new needs are satisfied by new products. New products in the first quadrant need to create new core customer value that

satisfies new needs, and this new customer value is different from the core customer value provided by products in the second through fourth quadrants. Since the needs and products in this business area are not an extension of the present business, forecasting them should require new activities beyond the present business area. We call this quadrant, which aims to simultaneously develop new needs and new products, new market creation.

Note that a product is everything that satisfies customer needs as a market offering [29] and is considered not only a product in the so-called narrow sense, but also a product in the broad sense that includes services and experiences.

4.2 Sales Estimates

To estimate sales based on the direction for growth, the stage of the PLC that corresponds to each quadrant of the matrix was identified by contrasting the characteristics of each quadrant of the needs-products matrix with the characteristics of each stage of the PLC when a quadrant in the scope framework was set as the direction for growth. Once the stages are identified, it is possible to estimate the approximate sales against the sales peak as the expected level of performance based on the targeted growth direction.

When the first quadrant is set as the direction for growth, the direction is the creation of new markets where new needs are satisfied by new products. This is exactly the creation of new PLCs. The introduction stage of PLCs is the period when new products are first launched in the market [22], and the stage corresponding to the first quadrant is the introduction stage of new PLCs. After that, we do not know whether growth will continue as the stage evolves or whether the firm will exit the market without having reached the growth stage, but the expected level of growth at this time is the peak of sales of the PLC.

When the third quadrant is set as the direction, in addition to satisfying present needs with present products, it aims to satisfy present and predictable needs with present and updated products. After a new PLC with new needs and new products is created, it replaces the present needs and present products in the introduction stage as the current PLC. In other words, on this basis, the present customers increase the frequency of using the present product and start using the updated product, and the updated product satisfies the predictable needs and attracts new customers. In this way, sales increase dramatically from the introduction stage, and a growth stage begins [22,29]. Based on this understanding, the stage that corresponds to the third quadrant is the introduction to growth stage, especially the first half of the growth stage. During this period, competitors, attracted by the opportunity, enter the market [29]. Competitors may enter with copies of present products or with updated products [22].

With the fourth quadrant as the direction, the goal is to satisfy present and predictable needs with new products that enhance the product value. To achieve this, new products with new value are created at the level of actual products and augmented products so that they can be differentiated from the competition. Then, present, and predictable needs are attracted, and sales are further increased. Since product and brand differentiation begins in the growth stage [22], the fourth quadrant mainly matches the growth stage, especially in the second half of the growth stage.

With the second quadrant set as the direction, the aim is to satisfy the new needs with the present and updated products. The core customer value provided by present and updated products satisfies the present needs and is generally considered incapable of satisfying the new needs. If some of the actual or augmented product value provided by the present and updated products matches the core customer value that satisfies the new needs, then new customers can be acquired, and sales can be further generated. Since entering new markets is one of the growth strategies to sustain rapid market growth [29], the third quadrant is mainly corresponding to the growth stage, especially in the second half of the growth stage.

In summary, we identified the PLC stages that best fit each quadrant of the matrix as follows.

- First quadrant: Introduction stage
- Second quadrant: Growth stage, especially in the second half of the growth stage
- Third quadrant: Introduction to growth stage, especially in the first half of the growth stage
- Fourth quadrant: Growth stage, especially in the second half of the growth stage

4.3 Analytical Results for SMEs

In this study, two SMEs, Firm A and Firm B, which manufacture mechanical engineering products with the largest market share in the domestic market, were selected from a group of manufacturing SMEs in different industries in Kyushu, Japan. We collected secondary data from firm histories, websites, and publicly available technology and patent information, as well as primary data from management interviews, including top management, and factory inspections. Based on the analysis of these collected data, subsections 4.3.1 and 4.3.2 described the business environment of Firm A and Firm B before the implementation of the innovation process. Table 1 summarizes how the growth guidelines - growth objectives, scope, and direction for growth - were set and how much the growth expectations of the estimated performance were. Subsection 4.3.3 compared the levels of growth objectives and expected levels of performance.

Table 1 Summary of analytical results for firm A and firm B

		Firm A	Firm B
Before implementing the innovation process	Growth objectives	Expanding sales and achieving No.1 market share	Creating a new product life cycle
	Growth guidelines	Large refrigerator trucks for transporting cold food in western Japan	Lines of small mowers for various needs for domestic and some overseas markets
	Scope	New products development	New market creation
	Directions for growth	Approximately one-half or more of the sales peak	Peak of sales at max.
	Growth expectations of the estimated performance		

4.3.1 Firm A

Firm A has been growing steadily since its establishment, and its major business is the large, refrigerated trucks business, which currently holds the largest market share in Japan. However, at the time, this business was competing with competitors with homogeneous products, and sales were flat to declining. To break out of this situation, the firm set the growth objectives as sales expansion one step ahead of the competition and also achieving the No.1 market share in sales. The scope of the present business was large, refrigerated trucks for transporting cold food in western Japan. The direction for growth was set as the new product development to differentiate from competitors' products - the fourth quadrant of the scope matrix. The performance, or sales, estimated from the scope and growth direction was in the growth stage of the PLC based on the results of the previous section, i.e., the expected sales level was approximately one-half or more of the sales peak.

4.3.2 Firm B

Firm B has achieved sustainable growth while continuing to create industry-first products based on its corporate spirit of creating useful products before anyone else, and is currently focusing on the small mower business, in which it has the largest market share in Japan. Repeatedly, the small mower business has pioneered new needs, created industry-first products, attracted new customers, and added new products to the product line life cycle. Following this trend, the growth objective was set to create a new product life cycle by developing new needs and new products. The scope of the existing business were product lines of small mowers for various mowing needs, for domestic and some overseas markets. The growth direction was set as creating new market - the first quadrant of the scope matrix. The estimated performance was the introduction stage based on the creation of a new PLC, and the expected sales level was the highest level of sales peak.

4.3.3 Comparison Results

From the summary of the analysis of Firm A and Firm B, we compared whether the levels of growth objectives and growth expectations were consistent. First, for Firm A, the estimated expectation was approximately one-half or more of the sales peak, which had no gap with the growth objective of No.1 in sales share. Second, for Firm B, the estimated growth expectation was the highest expectation of sales peak based on the creation of a new PLC, which did not differ from the growth objective of creating a PLC. Therefore, we showed that the growth guidelines and the growth expectations estimated from them were consistent for both Firm A and Firm B.

5. Discussions

We argue that before implementing the innovation process, firms need to decide from a macro perspective what kind of growth they want to achieve based on their vision, and that as they move toward the goal of creating innovation, it is important to set growth guidelines for decision making for each activity in the innovation process.

One subject of this study is to propose three factors of growth guidelines and to construct a scope framework, a needs-products matrix, which is one of the factors. In determining the axes and their classifications of the matrix, we focused on whether the products and needs are new to the competitors as well as to the firm itself. In the results of the previous section, we confirmed the applicability of the scope framework proposed in this study by analyzing two innovative Japanese SMEs.

When firms formulate growth guidelines as macro guidelines before executing the innovation process, one quadrant in the scope framework is set as the growth direction to be targeted. Based on this direction, firms understand what they need and what they lack, and proceed to the implementation phase of the innovation process based on these assumptions. Of course, depending on the assumptions, firm's activities within the innovation process will change. In this sense, we believe that setting this growth direction is extremely critical, and this scope framework can be useful.

The other subject is to propose a method to estimate performance from the growth direction and to judge whether the growth objectives are consistent or not. Performance is estimated by relating the growth direction to the PLC, which allows comparison with the growth guidelines. The scope framework perspective, which asks whether the needs and products are new to the firm and its competitors, plays a key role in the relationship between the growth direction and the PLC. The analysis of two SMEs confirmed that the performance estimation method proposed in this study was applicable and consistent with the growth guidelines.

The guidelines need to be consistent to guide decision making. We showed that the proposed growth guidelines could guide decision making in implementing the innovation process.

The theoretical contribution of this study is to point out the importance of formulating consistent growth guidelines to guide decision making before implementing the innovation process. The managerial contribution is to provide a framework within which firms can determine the scope and directions for growth, and a method for estimating performance.

We outline two challenges for future research. The first is to analyze a wider range of firms to better support this study. The second is to examine how to implement the innovation process after formulating growth objectives with the goal of generating innovation and achieving firm growth.

6. Conclusions

We proposed the insertion of the phase to formulate growth guidelines consisting of three factors - growth objective, scope, and growth directions - before implementing the innovation process. We developed a new scope framework and showed how to evaluate the consistency of the growth guidelines. Through the analysis of two Japanese mechanical engineering SMEs that have achieved innovation and firm growth, we found that the performance estimated based on the scope and directions for growth is consistent with the growth objectives. This result supports the usefulness of the scope framework for firms to determine growth directions and formulate growth guidelines. The growth guidelines can also be used to guide decision making in the implementation of the innovation process.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** Koji Masuda, Kojiro Fujiyama, Shigeyuki Haruyama; **data collection:** Koji Masuda, Kojiro Fujiyama; **draft manuscript preparation:** Koji Masuda; **review and supervision:** Shigeyuki Haruyama. All authors reviewed the results and approved the final version of the manuscript.

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