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Production competence revisited

a critique of the literature and a new measurement approach

Szász, Levente; Demeter, Krisztina; Boer, Harry

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Levente Szász Krisztina Demeter Harry Boer

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Production competence revisited – a critique of the literature and a new measurement approach

Levente Szász
Department of Economics and Business Administration in Hungarian Language, Babes-Bolyai University, Cluj Napoca, Romania
Krisztina Demeter
Department of Logistics and Supply Chain Management, Corvinus University of Budapest, Budapest, Hungary, and
Harry Boer
Center for Industrial Production, Aalborg University, Aalborg, Denmark

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Abstract

Purpose – The purpose of this paper is to seek remedy to two major flaws of the production competence literature, which concern: the way the production competence construct is operationalized and the way its effects on performance are measured.

Design/methodology/approach – The paper proposes to measure production competence as the two-dimensional operational level construct it actually is, and to use Slack's (1994) importance-performance matrix to study its business level performance effects. The three hypotheses developed are tested using a subsample of the International Manufacturing Strategy Survey database, which includes 465 manufacturing companies from 21 countries.

Findings – The study offers additional empirical support for production competence theory. Going beyond supporting existing theory, the results give more detailed insight by indicating that low operational performance on even one important competitive factor leads to lower business performance (order-losing effect); excessive investment in increasing operational performance on any less important competitive factor does not necessarily lead to higher business performance.

Practical implications – Using a large empirical dataset, the study shows that the importance-performance matrix is a useful tool for decision makers to assess and improve their company's manufacturing strategy: it indicates how to prioritize between improvement efforts to positively contribute to business performance.

Originality/value – The paper offers a novel approach to operationalize production competence. The importance-performance analysis approach adopted in this study avoids the two major drawbacks of previous production competence studies and offers an appropriate method to assess the impact of production competence on business performance.

Keywords Business performance, Survey, Importance-performance matrix, Competitive priorities, Production competence

Paper type Research paper

1. Introduction

Since the seminal work of Skinner (1969), many researchers have studied the contribution of manufacturing strategy to business performance (e.g. Swamidass and Newell, 1987; Kim and Arnold, 1993; Demeter, 2003; Da Silveira, 2005; Amoako-Gyampah and Acquaah, 2008). The practically relevant reason behind this interest is that a manufacturing strategy may only be "valuable" for a company if it enhances the company's business performance. Production competence is one of the manufacturing strategy constructs proposed to explain the relationship between manufacturing strategy

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and (business) performance. Definitions of production competence include the degree to which manufacturing supports a company's business strategy (Vickery, 1991), the degree of fit between competitive priorities and manufacturing strength (Kim and Arnold, 1993), and the degree to which manufacturing performance supports the strategic priorities of a company (Vickery *et al.*, 1993, 1994).

This paper focuses on two problems, which concern the measurement of the production competence concept and its performance effects, respectively, and proposes an alternative and essentially more correct way to research these two constructs. First, previous studies use a single fit index to operationalize production competence, which treats individual competitive priorities identically, irrespective of their importance for customers or the company's performance relative to competitors, and makes the evaluation of individual performance effects impossible. We propose Slack's (1994) importance-performance matrix as an essentially better approach to assess production competence. Each individual competitive priority can be positioned in one of the four different zones of that matrix, based on the importance customers attach to, and the company's performance on, the competitive priority considered. Second, most authors assess the operational performance effects of production competence, which makes their analyses tautological. Instead, business performance measures must be used to test the validity of the production competence concept.

This paper is structured as follows. First, based on a review of the manufacturing strategy and production competence literature, the two problems outlined above are identified and discussed. Next, the research framework and hypotheses are presented and accounted for. Subsequently, the research design is introduced, including the operationalization of the hypotheses and the data collection, validation and analytical methods used to investigate the hypotheses. After a presentation of the analytical results, the findings are discussed. Finally, the main theoretical contributions and managerial implications are outlined, followed by a discussion of the limitations of the study and suggestions for further research.

2. Literature review

2.1 Manufacturing strategy operationalization

The manufacturing strategy construct has been operationalized in several different ways. The two most influential approaches focus on decisions on manufacturing tasks and practices, respectively.

The manufacturing tasks approach uses competitive priorities to operationalize manufacturing strategy. The competitive priorities traditionally include the four dimensions of cost, quality, delivery and flexibility (e.g. Hayes and Wheelwright, 1984; Fine and Hax, 1985). More recently, additional priorities have been proposed, such as after-sales services (Miller and Roth, 1994; Wise and Baumgartner, 1999), innovation capabilities (Leong *et al.*, 1990) and environmental performance (De Burgos Jiménez and Céspedes Lorente, 2001; Johansson and Winroth, 2010). Using 1987 Manufacturing Futures Survey data, Miller and Roth (1994) consider 11 competitive capabilities or, what Bozarth and McDermott (1998) correctly[1] call, competitive priorities, to develop a taxonomy of manufacturing strategies. Referring to that taxonomy as "one of the most influential frameworks in the manufacturing strategy literature", Frohlich and Dixon (2001) replicate Miller and Roth's study using 1994 Manufacturing Futures and 1998 International Manufacturing Strategy Survey (IMSS) data. More recently, Grant *et al.* (2013) also replicate Miller and Roth using a sample of 199 Irish companies and the same set of 11 competitive priorities. Based on 1992, 1996 and 2001 IMSS data, Cagliano

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et al. (2005) study the stability of manufacturing strategies, operationalized using ten competitive priorities. Also other authors, e.g. Ward *et al.* (1995), Ward and Duray (2000), Christiansen *et al.* (2003), Kathuria (2000) and Youndt *et al.* (1996), operationalize manufacturing strategy in terms of competitive priorities.

Major authors in the manufacturing practices approach are Skinner (1969), who proposes five areas in which trade-off decisions must be made, Hayes and Wheelwright (1984), who distinguish two categories, structure and infrastructure, with four subcategories each, and Hill (1985), who proposes two overall categories, namely process choice and infrastructure – each with a range of subareas. These practices provide the manufacturing capabilities needed for a company to pursue its manufacturing tasks.

The two approaches are complementary (see also Voss, 1995, 2005) in the sense that, irrespective of the categorization of manufacturing practices adopted, it must be ensured that the decisions made are (Hayes and Pisano, 1994; Miller and Roth, 1994; Ruffini *et al.*, 2000; Brown and Blackmon, 2005):

- Internally consistent (Hayes and Wheelwright) – the decisions made must align properly (Skinner) and be examined in view of their contribution to the manufacturing tasks (Skinner).
- Externally consistent (Hayes and Wheelwright) – the decisions made must provide the capacities and capabilities that are needed for a company to qualify for, and win orders in, the marketplace (Hill) and, through that, support the company's corporate strategy (Skinner, Hill).

The essence of production competence theory is that fit between manufacturing competitive priorities and manufacturing capabilities affects business performance positively. In all production competence research, capabilities are measured indirectly:

- As practices – i.e. drivers or enablers of capabilities – e.g. Choe *et al.* (1997), Narasimhan and Jayaram (1998), Dangayach and Deshmukh (2004), and Schmenner and Vastag (2006).
- As performance on operational criteria corresponding to competitive priorities – i.e. capabilities are considered to manifest themselves in performance.

This paper focuses on the latter category. The central tenet of that body of theory is that it is not so much a company's manufacturing performance or its manufacturing strategic priorities, but rather the fit between the importance of, and the performance related to, the company's strategic priorities that has a positive effect on the company's business performance. In popular terms: a company performing poorly on criteria valued by its customers will perform poorly in the market place and, thus, financially as well.

2.2 Review of the production competence literature

Cleveland *et al.* (1989), who introduced the concept, define production competence as "the preparedness, skill, or capability that enables manufacturers to prosecute a product-market specific business strategy" (p. 657), and "measure" it by "assessing the manufacturer's strengths and weaknesses [in nine key performance areas] in relation to the business plan [measured as rank order of key performance areas]" (p. 658). Based on six case studies of companies representing considerable differences in business strategy, process choice and industry type, the authors find that "[…] there is probably a numerical relationship between production competence and business performance" (p. 668).

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In later publications, several problems in Cleveland *et al.*'s work have been addressed. First, the small sample size creates obvious problems related to, amongst others, validity and generalizability. Related to this, the authors cannot say much about the possible effects of internal and external contingencies. Then, the authors' operationalization of manufacturing performance does indeed contain performance measures but also (characteristics of) a manufacturing practice (process technology). Furthermore, their business performance construct partly overlaps with, i.e. includes indicators of, manufacturing performance. Finally, Cleveland *et al.*'s conceptualization of production competence does not consider the "match or fit of the firm's business strategy to its external, competitive environment" (Vickery, 1991, p. 642). The essence of the latter concern is that, if this fit is not assured, production competence may actually harm business performance.

Vickery (1991) was the first to challenge Cleveland *et al.*'s (1989) work. The purpose of her note is to correct the way Cleveland *et al.* measured production competence and business performance. Furthermore, she proposes a model of the relationship between business strategy, production competence and business performance in which explicit attention is drawn to the fit between a company's business strategy and its external environment.

In order to test these considerations, Vickery and her colleagues use a sample of 65 companies belonging to the furniture industry. Vickery *et al.* (1993) find that production competence has a statistically significant effect on return-on-assets (ROA), market share, and growth rate. Using the same sample, Vickery *et al.* (1994) confirm the convergent and discriminant validity of a construct they call strategic production competence, and show it is positively related to business performance.

Using data from the 1990 Manufacturing Futures Survey, Kim and Arnold (1993) analyze two models of production competence. Both models calculate the sum of the mathematical product of the importance of, and strength in, fifteen competitive capabilities, which are measured using production performance indicators, such as price, low defects, and fast and on-time delivery. Model I considers all indicators; model II only the important ones. Model II shows statistically significant relationships between production competence, and return on assets and return on sales, respectively; the effects on market share and sales growth, the other business performance indicators considered, are insignificant. Model I does not show any significant effects of production competence on business performance, which "implies that, in defining and measuring manufacturing competence, emphasis (or weight) should be given to the capabilities whose competitive importances are relatively high" (Kim and Arnold (1993), p. 20). Furthermore, these authors consider the impact of industry type, and find that "the significance of manufacturing competence in explaining various business performance is considerably different between the two industrial sectors" (Kim and Arnold (1993), p. 22) considered, namely the machinery and electronics sectors.

Safizadeh *et al.* (2000, p. 114) define production competence as a weighted average measure of differential importance weights for capabilities multiplied by their corresponding performances. Based on the results of an empirical study of 142 manufacturing plants, they conclude that the relationship between production competence and operations performance depends on manufacturing process choice and may only hold in the case of batch processes.

Devaraj *et al.* (2001) investigate how the fit between manufacturing objectives (competitive priorities) and generic manufacturing strategies (common patterns of

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organizing production aimed at achieving manufacturing objectives) affects performance outcomes. Using data from the World Class Manufacturing study collected in 164 companies in the electronics, machinery and suppliers to the automobile/trucks industries they find a positive relationship between proper fit and performance.

Avella and Vázquez-Bustelo (2010) revisit the theory of production competence to offer additional empirical evidence regarding the contribution of production competence to business performance. The main contribution of their article is that they define and validate production competence as a multidimensional, second-order construct. The five underlying factors of production competence consist of the four "traditional" manufacturing dimensions (cost, flexibility, quality, and delivery competence), to which the authors add a relatively new dimension, namely environmental competence. Additionally, they use two different measurement approaches to quantify the fit between the strategic importance of, and performance on, manufacturing competitive factors. Both approaches suggest that production competence has a positive effect on sales turnover, return on assets, and growth in sales turnover and return on assets, respectively.

Schoenherr and Narasimhan (2012) also adopt a multidimensional view of production competence and use two measurement approaches similar to Avella and Vázquez-Bustelo (2010). They employ regression analysis on a large-scale, international dataset to contribute to the generalizability of the theory of production competence. However, in assessing the impact of production competence on the performance of the plant they use immediate outcome measures (i.e. plant productivity and plant responsiveness), which are operational rather than business performance measures.

2.3 Summary and critique of the production competence literature

Based on our review of the production competence literature, we draw the following conclusions.

First, after the seminal article from Cleveland *et al.* (1989), the production competence concept has gradually been corrected (Vickery, 1991) and refined (e.g. Kim and Arnold, 1993; Vickery *et al.*, 1993, 1994; Safizadeh *et al.*, 2000; Devaraj *et al.*, 2001; Avella and Vázquez-Bustelo, 2010; Schoenherr and Narasimhan, 2012). Although there are exceptions (e.g. Choe *et al.*, 1997; Narasimhan and Jayaram, 1998; Dangayach and Deshmukh, 2004; Schmenner and Vastag, 2006), production competence is usually operationalized as the fit between the importance of, and actual performance on, manufacturing related competitive priorities.

Second, the literature fairly consistently shows that production competence affects performance positively. However, production competence theory seems to suffer from the same weakness as operations management practices theory: despite its growing importance, there is still little application of contingency theory. In the production competence literature indications can be found for the possible influence of industrial sector (e.g. Kim and Arnold, 1993), business strategy (Vickery *et al.*, 1994), or process choice (Safizadeh *et al.*, 2000). Other possibly important contingencies such as national context and culture, company size, or strategic context in the wide sense of the word (Sousa and Voss, 2008) have not so far been addressed.

Third, production competence theory generally builds on the assumption that a company's competitive priorities accurately reflect its business strategy or, even

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more, market/customer expectations. As Kim and Arnold (1993, p. 8) put it: "our model […] starts with the *assumption* that there exists a sound business strategy" (our emphasis). Furthermore, rather than defining competence with market/customer requirements in mind, importance and performance are usually assessed relative to competitors. Coates and McDermott (2002, p. 436), for example, define competence as "a bundle of aptitudes, skills, and technologies that the firm performs better than its competitors […]". The focus on competitors and the marginalization of market requirements is also problematized by Vickery (1991), Kim and Arnold (1993) and Dröge *et al.* (1994). As "markets are the common denominator of functional strategies" (Hill, 1997, p. 258), including manufacturing strategy, omitting the needs of target markets can lead to inconsistent strategy formulation (cf. Hayes and Wheelwright's (1984) external consistency demand) and, in effect, to lower business performance. Quoting Hill (2000, p. xiii), Da Silveira (2005, p. 665) puts it as follows: "[…] if the basic link between […] manufacturing strategy and the market is not strategically sound, then – by definition – the business will suffer". Consequently, to amend production competence theory, "the relationship among environment, strategy, and competitive priority importance deserves further study" (Dröge *et al.*, 1994, p. 684).

While these problems show that there is still much to be done to advance the theory of production competence (see the Conclusion section for suggestions), the remainder of this article focuses on problems related to the measurement of the production competence concept and its performance effects.

Problems related to the measurement of production competence. Production competence is based on a complex interrelationship between the importance of, and the performance on, competitive priorities. Most studies use a rather simplistic approach to the operationalization of this concept by simply combining importance and performance measures into one single measure. However, this is problematic.

Let us first consider the method used by Vickery (1991) and Vickery *et al.* (1993, 1994), which was essentially accepted by most later researchers (see Table I). Vickery and her colleagues measure the importance of competitive factors on a seven-point Likert scale ranging from 1 to 7. Performance is measured against competitors, also on a seven-point Likert scale but this one ranges from −3 to +3. Production competence is quantified by totaling the mathematical products of importance and performance scores on several competitive factors. According to this method, a performance matching the industry average (0) on a crucially important (7) and an unimportant (1) factor would contribute the same amount to the overall production competence score ($0 \times 7 = 0 \times 1 = 0$), which is certainly not appropriate.

Dröge *et al.* (1994), too, measure importance and performance on seven-point Likert scales, both of which range from 1 to 7. In that case, however, as 1×7 equals 7×1, the incorrect conclusion would be that outstanding performance (7) on an unimportant factor (1) is equivalent to having worst-in-industry performance (1) on a strategically crucial criterion (7). Safizadeh *et al.* (2000) adopt the same procedure using five-point Likert scales. While Dröge *et al.* (1994, p. 685) admit that "this does not accurately reflect the theoretical meaning of the competence construct", they consider that the advantage of incorporating importance and performance measures into a single formula outweighs the disadvantages presented above.

Avella and Vázquez-Bustelo (2010) suggest that production competence can be measured in terms of five underlying dimensions, related to cost, quality, flexibility,

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Table I. Key constructs in production competence theory and their operationalizations

Authors	Production competence: Definition	Production competence: Operationalization	Performance effects: Operationalization
Cleveland *et al.* (1989)	The combined effects of a manufacturer's strengths and weaknesses in certain key performance areas	Importance rank (1 … 9) × S/W of competitive area (−1, 0, +1)	Combination of business and operational performance
Vickery (1991)	The degree to which manufacturing supports the company's business strategy	Importance rank (1 … 9) × S/W of competitive area (−1, 0, +1)	Pretax return on assets, domestic market share, growth rate
Kim and Arnold (1993)	The degree of fit between competitive priorities and manufacturing strength	Two models: 1. Relative importance (−1 … +1) × Relative strength (−1 … +1) 2. Weighted importance (−1 … +1) × Relative strength (−1 […] +1)	Return on assets, profit ratio, sales growth rate, market share
Vickery *et al.* (1993, 1994)	The degree to which manufacturing performance supports the strategic priorities of the company	Importance (1 … 7) × Performance (−3 … +3)	Sales, profitability and growth
Safizadeh *et al.* (2000)	Not (explicitly) defined	Importance score (probably 1 … 5) × Performance score (probably 1 … 5)	Only operations performance measures
Devaraj *et al.* (2001)	Not defined	Consistency (fit) between intended and realized objectives	Only operations performance measures
Avella and Vázquez-Bustelo (2010)	Not (explicitly) defined; described as a multidimensional, second-order construct	Two models: 1. Importance (1 … 5) × Performance (−2 … +2) 2. 5 - |Importance (1 … 5) - Performance (1 … 5)|	Return on assets, sales (both relative to competitors and growth previous two years)
Schoenherr and Narasimhan (2012)	The fit between production/operations management capabilities and production/operations management priorities	Two models: 1. Importance (0 … 100) × Performance (1 … 7) 2. 1 – Euclidian distance between importance and performance	Only operations performance measures

delivery and environmental protection, and "propose the construct of production competence as a factor comprising competence along [these dimensions], considering either […]" (p. 561):

- PC1: an adaptation of the Vickery *et al.* (1993) (improved) version of the Cleveland *et al.* (1989) index, or
- PC2: an adaptation of the González-Benito (2007) index.

Essentially, these authors propose to build in an extra layer. Rather than calculating production competence as the product of the importance of, and performance

on, some mix of operational indicators they suggest that production competence is a result of competences in the areas of cost, quality, flexibility, delivery and environmental protection, each of which is measured as the sum total of importance × performance on cost, quality, flexibility, delivery and environmental protection indicators, respectively. This means that Dröge *et al.*'s (1994) admitted disadvantages actually remain.

Additionally, assessing production competence with a single measure implicitly assumes that low performance on an important competitive factor can be counterbalanced by high performance on other factors. This assumption goes against the order-losing sensitivity (Hill, 1985) of important factors, where underperforming on any important factor disqualifies the company from competing in the marketplace, regardless of the performance on other competitive factors.

Thus, in this paper a different approach is proposed, which accepts the true nature of production competence as a two-dimensional concept, and uses Slack's (1994) importance-performance matrix to study its performance effects. The advantage of the matrix lies in its zoning, which allows the effects of different degrees of fit/misfit on each competitive factor to be assessed. In the next section this approach is described in detail.

Problems related to the measurement of and findings reported on performance effects. The second problem concerns the performance effects investigated. Several of the articles mentioned above investigate the relationship between production competence and performance using operational, together with (Cleveland *et al.*, 1989), or instead of (e.g. Safizadeh *et al.*, 2000; Devaraj *et al.*, 2001; Schoenherr and Narasimhan, 2012), business performance measures (see Table I).

This is a methodological flaw, which undermines the validity of production competence theory: using operational performance indicators to measure the performance effects of production competence, which is measured in operational-level terms as well, is tautological and basically leads to theory saying that improved operational performance in important areas leads to improved operational performance.

Articles that do measure business performance effects report mixed findings. Vickery (1991) reports positive effects on return on assets, market share and growth rate. For one of their two models, Kim and Arnold (1993) find positive effects on return on assets and profit ratio, but not on growth rate and market share. According to the other model, production competence does not have any business performance effects. Avella and Vázquez-Bustelo (2010) identify positive effects on sales turnover, return on assets, sales turnover growth and return on assets growth.

In conclusion, we argue that two elements are needed when dealing with the production competence concept: the way production competence is operationalized should reflect its true, two-dimensional, nature; and in assessing the performance effects of production competence, indicators of business performance should be considered.

Thus, considering, in addition, the mixed findings on the association between production competence and business performance, the remainder of this article studies production competence as a two-dimensional construct, adopts a correct approach towards measuring performance effects, namely in terms of business performance, and tries to shed light on mixed reports concerning the business performance effects of production competence.

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3. Research framework and hypotheses

Figure 1 shows the research framework adopted in this study, which is similar to the model adopted in most production competence studies. The difference is in the way "fit" is operationalized.

Rather than combining importance and performance measures in one factor, we adopt the (two-dimensional) importance-performance analysis (IPA) approach, which was first introduced by Martilla and James (1977) in the marketing literature. Since its introduction, the IPA approach has been widely used, mainly in marketing, quality management, and service management research, usually with a focus on customer satisfaction issues (Bacon, 2003; Tontini and Picolo, 2010). IPA applications in the manufacturing and operations management literature are scarce. An exception is Slack's (1994) article, which proposes a modified importance-performance matrix to prioritize improvement programs related to different manufacturing competitive factors. Figure 2 shows a modified[2] version of Slack's (1994) matrix, where the two variables – importance of, and performance on, competitive factors– are measured on the horizontal and vertical axis, respectively.

In order to assess the "goodness" of production competence, Slack (1994) defines four zones for the fit/misfit between the importance of and performance on competitive factors:

(1) The "urgent action" zone (delimited by the curve CD) refers to competitive factors that are deemed very important for customers (i.e. most probably order winners). However, the company's performance on these factors lags behind that of its main competitors.

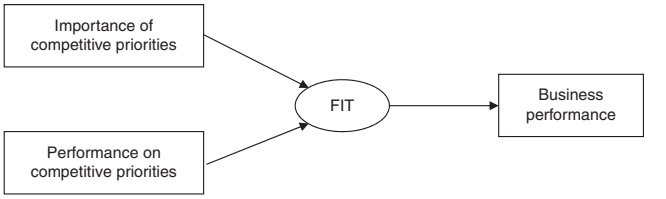

Figure 1.
Research framework

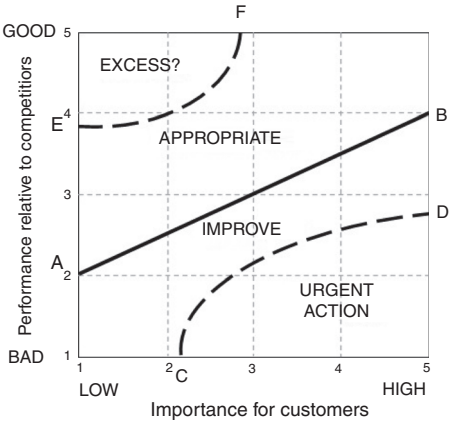

Figure 2.
The importance-performance matrix

(2) In the "improve" zone (delimited by the curve CD and the diagonal AB), the gap between importance and performance is smaller but still exists. For important factors, the company's performance is equal to or slightly above the industry average, which is hardly enough to win orders. For less important factors, performance is below industry average. Improvement of operational performance on these factors is still needed.

(3) The "appropriate" zone (delimited by the curve EF and the diagonal AB) is the ideal zone. For the most important factors, performance is higher than that of competitors, while for less important factors, performance is equal to or only slightly below industry average.

(4) In the "excess?" zone (delimited by curve EF), the company delivers an outstanding performance on factors that are considered less important. The question mark is used to suggest that too many resources may be used to achieve better performance than needed.

In comparison with the methods used in previous studies (see Table I), Slack's (1994) approach is more appropriate for describing the complex nature of the relationship between importance and performance measures, particularly because it solves the measurement problems of production competence identified in the literature analysis section, and positions each individual competitive factor in one of the four zones of the matrix based on its degree of fit/misfit. Kim and Arnold (1993), for example, also use a matrix to grasp the notion of production competence. However, they do not define zones and only consider the diagonal of the matrix, which – unlike the diagonal of the importance-performance matrix – connects the lower left corner with the upper right corner of the matrix. While this approach implies that relatively weak performance on less important factors (lower left corner) is ideal (Kim and Arnold, 1993, p. 14), the zoning of the importance-performance matrix indicates that even for less important factors, company performance "[…] need(s) improving, but probably not as a first priority" (Slack, 1994, p. 68).

The objective of this article is not so much to test, but rather to empirically show the usefulness of, the importance-performance matrix in strategic manufacturing decision-making, by linking a company's position in the matrix to the company's business performance. We formulate our research hypotheses based on the zoning of the importance-performance matrix:

H1. Companies with one or more competitive factors positioned in the "urgent action" zone deliver lower business performance than companies that have no competitive factor in that zone.

This hypothesis goes back to Hill's (1985) idea that underperforming on criteria that are important for a company to qualify for, or even win orders in, the market place, will harm the company's competitiveness and, in effect, its business performance. A company that performs poorer than its competitors on one or more criteria highly valued by customers does not win orders. And if the company performs poor on one or more qualifying criteria it may even lose orders – cf. Hill's (1985, p. 51) order-losing sensitivity notion. In both cases, business performance will suffer.

The negative impact of performing low on important factors is also reflected in several production competence studies (e.g. Vickery *et al.*, 1993; Dröge *et al.*, 1994; Avella and Vázquez-Bustelo, 2010). However, as these studies measure production

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competence by aggregating all competitive factors into one index, assessing the effect of underperformance on individual factors is impossible. The approach proposed in this article allows just doing that:

H2. Companies having one or more competitive factors in the "excess?" zone of the matrix do not achieve higher business performance than other companies.

The second hypothesis argues that investments aimed at increasing operational performance on less important factors do not contribute to current production competence or, in effect, higher business performance. The hypothesis reflects the nature of the "excess?" zone, namely performance that "is much better than would seem to be warranted" (Slack, 1994, p. 68). However, performance in this zone could reflect what Slack and Lewis (2011, p. 56) call "delights", i.e. "aspects of performance that customers have not yet been made aware of, or that are so novel that no one else is aware of them". They do not currently have a beneficial effect on the competitiveness and business performance of the company, but may become order winners in the future:

H3. Companies that are positioned in the "appropriate" zone of the matrix achieve higher business performance than companies located in the "improve" zone of the matrix.

The last hypothesis suggests that "shifting" competitive factors from the "improve" zone toward the "appropriate" zone by increasing their operational performance should lead to higher business performance. This hypothesis actually tests the core proposition of production competence and, indeed, manufacturing strategy theory, namely that companies performing less well than their competitors on factors (highly) valued by customers (i.e. companies falling into the "improve" zone), achieve lower levels of business performance than these competitors (which would then fall into the "appropriate" zone).

4. Research methodology

Data from the fifth round of the International Manufacturing Strategy Survey (IMSS V) is used to investigate the hypotheses. The IMSS V database includes information about 725 manufacturing companies belonging to the ISIC Rev. 4, Division 25-30 (manufacture of fabricated metal products, machinery and equipment). The IMSS is performed by an international network of researchers focusing on manufacturing strategies, practices and performance of organizations from all around the world. Data is collected on manufacturing plant level. The respondents are production/operation managers or individuals in similar positions. The fifth round of the survey was carried out during the year 2009 in 19 countries. The current version of the database includes responses from 21 countries and uses data from two additional countries collected during the first half of 2010. In this research only those plants are included that submitted complete data on all the variables presented below (altogether 465 plants). The sample composition by country is presented in Table II.

The IMSS V questionnaire enquired about 12 competitive priorities – see Table III. This list reflects previous operationalizations (e.g. Kim and Arnold, 1993; Vickery *et al.*, 1993, 1994; Miller and Roth, 1994; Ward *et al.*, 1995; Youndt *et al.*, 1996; Kathuria, 2000; Safizadeh *et al.*, 2000; Ward and Duray, 2000; Frohlich and Dixon, 2001; Christiansen *et al.*, 2003; Cagliano *et al.*, 2005) and includes items related to innovativeness (e.g. Leong *et al.*, 1990), after-sales service (e.g. Kim and Arnold, 1993; Miller and Roth,

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No.	Country	No. of plants	Percentage of total	No.	Country	No. of plants	Percentage of total
1.	Belgium	18	3.9	12.	Korea	37	8.0
2.	Brazil	25	5.4	13.	Mexico	15	3.2
3.	Canada	9	1.9	14.	Netherlands	27	5.8
4.	China	42	9.0	15.	Portugal	8	1.7
5.	Denmark	11	2.4	16.	Romania	15	3.2
6.	Estonia	17	3.7	17.	Spain	24	5.2
7.	Germany	20	4.3	18.	Switzerland	24	5.2
8.	Hungary	44	9.5	19.	Taiwan	29	6.2
9.	Ireland	3	0.6	20.	UK	16	3.4
10.	Italy	32	6.9	21.	USA	34	7.3
11.	Japan	15	3.2	Total		465	100.0

Table II. Sample composition by country

Importance measures (competitive priorities)	Performance measures (manufacturing performance)
Lower selling prices	Unit manufacturing cost
	Procurement costs
	Manufacturing overhead costs
Superior product design and quality	Product quality and reliability
Superior conformance to customer specifications	Manufacturing conformance
More dependable deliveries	Delivery reliability
Faster deliveries	Delivery speed
	Manufacturing lead time
Superior customer service	Customer service and support
Wider product range	Product customization ability
	Mix flexibility
Offer new products more frequently	Time to market
Offer products that are more innovative	Product innovativeness
Greater order size flexibility	Volume flexibility
Environmentally sound products and processes	Environmental performance
Committed social responsibility	Social reputation

Table III. Aligning importance and performance measures

1994; Wise and Baumgartner, 1999), and environmental (De Burgos Jiménez and Céspedes Lorente, 2001; Johansson and Winroth, 2010; Avella and Vázquez-Bustelo, 2010) as well as corporate social responsibility (e.g. Newman and Hanna, 1996; Klassen, 2001; Klassen and Vereecke, 2012), in addition to the four "traditional" components, cost, quality, delivery, and flexibility (e.g. Hayes and Wheelwright, 1984; Ward *et al.*, 1995; Ahmad and Schroeder, 2011a). The respondents were asked to indicate the importance of these factors to win orders from major customers on a five-point scale (1 = not important, 5 = very important).

The respondents also had to assess on a five-point scale how their current performance in 16 manufacturing-related areas (see Table III) compares with main competitor(s) (1 = much worse, 3 = equal, 5 = much better). All these performance indicators have been reported in previous articles (e.g. Kim and Arnold, 1993; Vickery *et al.*, 1993, 1994; Safizadeh *et al.*, 2000; Christiansen *et al.*, 2003; Cagliano *et al.*, 2005; De Burgos Jiménez and Céspedes Lorente, 2001; Devaraj *et al.*, 2001; Avella and Vázquez-Bustelo, 2010; Ahmad and Schroeder, 2011b; Schoenherr and Narasimhan, 2012).

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Importance and performance questions were developed separately based on literature on competitive priorities and manufacturing performance, respectively. However, in order to be able to plot these two aspects in the same matrix, the manufacturing performance measures included in the questionnaire had to be grouped according to the 12 identified competitive priorities, as shown in Table III. Where this action involved the creation of factors by combining two (performance indicators associated with faster deliveries and wider product range) or three (performance indicators associated with lower selling prices) individual performance indicators, Cronbach's alpha was used to assess the reliability of the measures. All three indicators exceeded the usual threshold values of 0.6-0.7 used in literature (0.758, 0.719 and 0.642).

Business performance was measured using four indicators: sales, market share, return on sales (ROS) and return on investment (ROI). All production competence publications that study business performance as an independent variable (e.g. Vickery, 1991; Kim and Arnold, 1993; Vickery *et al.*, 1993, 1994; Avella and Vázquez-Bustelo, 2010) but also other manufacturing strategy publications such as Hill (1985), Swamidass and Newell (1987), Dröge *et al.* (1994), Ward and Duray (2000), Papke-Shields and Malhotra (2001), Lau (2002), Demeter (2003), Da Silveira (2005), Dror and Barad (2006), and González-Benito (2007) (propose to) operationalize business performance using at least one, and in many cases two or three, of these indicators. Following the most common method employed in the literature, the respondents were asked to rate their current performance relative to their main competitors on a five-point scale (1 = much worse, 3 = equal, 5 = much better).

All questionnaire items are presented in Appendix 1. Geometrical analysis (see next section) was applied to quantify the position of each competitive factor in the importance-performance matrix. In testing the hypotheses, variance analysis (ANOVA) was used to determine significant differences in terms of the selected business performance measures between the zones of the matrix. To strengthen the validity of the results, for each ANOVA a Levene's test of homogeneity of variances was performed. The Welch and the Brown-Forsythe tests of equality of means were used to assure the validity of the analysis. Both tests confirmed the ANOVA results.

5. Analysis and findings

To investigate the first research hypothesis, the 465 manufacturing companies, which had complete data for both the importance of, and the performance on, all competitive factors, were grouped into two categories:

- "Urgent action" needed: companies with at least one competitive priority in the "urgent action" zone of the importance-performance matrix (a total of 191 companies). As indicated previously, Slack's (1994) delimitation of the zones was modified using a five-point scale. Thus, for example, if a company had at least one competitive priority rated as important (e.g. receiving four points on the five-point scale, a possible order winner), but its performance lagged behind competitors (e.g. receiving two points), it was included in the "urgent action" needed group (note that on Figure 2 point (4,2) falls inside the area delimited by curve CD).
- No "urgent action" needed: manufacturing companies with no competitive factor in the "urgent action" zone of the matrix (a total of 274 companies). These companies are either in the "improve", the "appropriate" or the "excess?" zone.

For the two categories described above, variance analysis was applied to determine significant differences in the selected business performance indicators.

The results, which are summarized in Table IV, indicate that *H1* is accepted. Companies with *at least one* competitive factor in the "urgent action" zone have significantly lower business performance on the four indicators considered than companies that have competitive factors exclusively outside the "urgent action" zone (cf. the order-losing effect; Hill, 1985).

To test the second research hypothesis (*H2*), first all manufacturing companies were removed that had at least one competitive factor in the "urgent action" zone of the matrix. With this step, the distorting (order-losing) effect of the "urgent action" zone was eliminated. The remaining 274 companies were then grouped into the following two categories:

- "Excess?" performance: manufacturing companies with at least one competitive priority in the "excess?" zone of the importance-performance matrix (a total of 91 companies).
- No "excess?" performance: manufacturing companies without any competitive factor in the "excess?" zone of the importance-performance matrix (a total of 183 companies).

A logic similar to that applied in the previous case was used to classify companies into the two groups described above. A company with at least one factor positioned in, for example, point (1,4) in Figure 1 – i.e., a factor rated not important for customers but with higher performance than that of the company's main competitors – was included in the "excess?" performance category. Variance analysis was applied to determine significant differences between the two categories described above, in terms of the selected business performance indicators. The results are summarized in Table V.

From a pure statistical point of view, the results of the analysis confirm *H2*. Although manufacturing companies with at least one competitive priority in the "excess?" zone of the matrix harvest higher market and financial benefits, the differences with companies outside that zone are not significant. Yet, it is remarkable that "excess?" companies

Table IV. Business performance of the "urgent action" needed ($n = 191$) and no "urgent action" needed ($n = 274$) companies

	"Urgent action" needed	No "urgent action" needed	*F*-value	Sig.
Sales	3.06	3.50	$F(1, 428) = 27.412$	0.000*
Market share	3.10	3.47	$F(1, 423) = 18.810$	0.000*
ROS	2.96	3.39	$F(1, 397) = 28.169$	0.000*
ROI	3.01	3.33	$F(1, 400) = 18.350$	0.000*

Note: *The mean difference is significant at the 0.05 level

Table V. Business performance of the "excess?" ($n = 91$) and no "excess?"($n = 183$) performance companies

	"Excess?" performance	No "excess?" performance	*F*-value	Sig.
Sales	3.61	3.45	$F(1, 251) = 2.228$	0.137
Market share	3.59	3.41	$F(1, 247) = 2.673$	0.103
ROS	3.49	3.34	$F(1, 232) = 1.988$	0.160
ROI	3.47	3.27	$F(1, 234) = 3.690$	0.056

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achieve consistently higher business performance. The question is if this could be due to these companies performing better on other criteria as well. In order to check for this option, we removed all competitive factors falling into the "excess?" zone. It appeared that, on average, the companies in the "excess?" group have more competitive factors above the diagonal of the matrix than the non-"excess?" companies (ANOVA, $F(1, 272) = 14.794$, $p = 0.000$). The mean distance of factors relative to the diagonal is 0.3002 for the "excess?" performance group and only 0.1145 for the no "excess?" performance group (for the calculation of mean distances, see Appendix 2). This suggests that, at least to some extent, the differences in business performance indicators might be explained by the fact that companies having factors in the "excess?" zone have already improved their performance on other competitive factors as well.

To test the third research hypothesis (*H3*), manufacturing companies that had at least one competitive factor in the "urgent action" or "excess?" zone of the matrix were filtered out. Then, for the remaining 183 companies, the following two categories were developed:

- Overall "appropriate": the average position of all competitive factors falls in the "appropriate" zone of the importance-performance matrix (a total of 109 companies).
- Overall "improve": the average position of all competitive factors falls in the "improve" zone of the matrix (a total 74 of companies).

To determine the average position of all competitive factors for a company, the distance of each competitive factor from the diagonal of the matrix (line AB in Figure 1) had to be determined. To calculate these distances, geometrical analysis was applied (see Appendix 2), based on which the overall "appropriate" and overall "improve" categories were developed. For these two categories, variance analysis was applied to determine significant differences in business performance indicators. The results are summarized in Table VI.

The results of the analysis indicate that *H3* is also valid. The diagonal of the importance-performance matrix, which separates the "appropriate" and "improve" zones of the matrix, also separates better and worse business performance. This confirms our expectation that companies that put effort into improving their performance on competitive factors that are positioned in the "improve" zone of the matrix will most probably enhance their business performance relative to main competitors in terms of sales, market share, return on sales and return on investments.

6. Discussion and conclusion

The analysis of the empirical data presented above supports the general connection between manufacturing strategy and business performance, measured through the lens of production competence, i.e. the "goodness of fit" between the importance of, and

Table VI. Business performance of the overall "appropriate" ($n = 109$) and "improve" ($n = 74$) companies

	Overall "appropriate"	Overall "improve"	*F*-value	Sig.
Sales	3.65	3.18	$F(1, 162) = 13.535$	0.000*
Market share	3.63	3.13	$F(1, 159) = 15.759$	0.000*
ROS	3.55	3.07	$F(1, 153) = 13.956$	0.000*
ROI	3.45	3.03	$F(1, 155) = 12.554$	0.000*

Note: *The mean difference is significant at the 0.05 level

performance on, competitive priorities: the better that fit, the stronger a company's production competence, the better its business performance. In effect, improving performance on important, and even less important, manufacturing competitive factors according to the logic of the importance-performance matrix can significantly contribute to an increase in the company's business performance.

6.1 Theoretical contributions

In addition to offering general support for the thinking behind existing theory of production competence, this article makes three important theoretical contributions.

First, the study refines the approach used by previous studies to measure the fit between importance and performance (e.g. Vickery, 1991; Dröge *et al.*, 1994; Safizadeh *et al.*, 2000). Recognizing the two-dimensional nature of production competence it offers a better way to operationalize the production competence concept and, especially, grasp the effects of misfit between the two dimensions, importance and performance. Using one aggregate variable, which is the widely accepted approach in production competence research and is essentially based on importance × performance, makes it impossible to assess whether a score of 5 is the result of 1×5 (overperformance) or 5×1 (underperformance). As the analysis of *H2* (the "excess?" zone) shows, significant overperformance on relatively less critical operational indicators has no business performance effects and only, most likely, internal performance, e.g. efficiency, effects. Significant underperformance on relatively important indicators, in contrast, has a damaging effect on market and financial performance, as confirmed by the analysis of *H1* (the "urgent action" zone). And, as the analysis of *H3* (the "appropriate" vs "improve" zones) shows, even slight underperformance on strategic priorities has negative effects on business performance.

Second, the importance-performance analysis approach first proposed by Martilla and James (1977) and translated to the field of operations management by Slack (1994), in the form of the importance-performance matrix, proves to be particularly useful to analyze and develop insight into the business performance effects of good and poor production competence. The matrix was previously used in case study based articles (Slack, 1994; Prochno and Correa, 1995). To the best of our knowledge, this paper represents the first application of the matrix using a large data set to investigate the relationship between production competence and business performance. While it is not the purpose of the present study to rigorously test the zoning of the importance-performance matrix, the analyses of the three hypotheses presented in this article, all of which accept the boundaries between the four zones proposed by Slack (1994) as given, suggest that the matrix is actually valid and can be effectively used to understand and relate production competence to business performance outcomes.

Finally, the present study supports the critique (Vickery, 1991) on (some of the) existing production competence theory (e.g. Cleveland *et al.*, 1989; Safizadeh *et al.*, 2000; Devaraj *et al.*, 2001; Schoenherr and Narasimhan, 2012), namely that the association between production competence and performance is assessed using operational measures together with or instead of business performance measures. As argued earlier on in this article, this is a methodological flaw, which basically leads to tautological theory saying that improved operational performance in important areas leads to improved operational performance. Furthermore, as indicated by the empirical analysis of *H2*, increasing operational performance on less important competitive factors does not necessarily lead to an increase in business performance. Consequently, this result suggests that the relationship between operational and business

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performance is not as direct or linear as assumed in several previous production competence publications – operational and business performance should be handled strictly separately (Choe *et al.*, 1997; Narasimhan and Jayaram, 1998; Schmenner and Vastag, 2006).

6.2 Managerial implications

The present research shows that the importance-performance matrix is a simple and practical tool for decision makers to assess and, if necessary or desired, improve their company's manufacturing strategy and business performance. The study provides solid evidence that if improvement priorities are determined based on the zones of the matrix, as suggested by Slack (1994), decision makers should expect significant changes in the business performance of their company. These business performance implications are detailed below.

First, the "urgent action" zone of the matrix must be avoided, i.e. competitive factors in this zone are the ones for which improvement is most critical. Companies with at least one competitive factor in the "urgent action" zone perform significantly poorer on each of the four business performance indicators considered in this paper than companies without any competitive factor in the "urgent action" zone.

Second, after avoiding the "urgent action" zone of the matrix, decision makers should aim to improve performance on those factors that are positioned in the "improve" zone of the matrix. Improving performance on important competitive factors from below to above the diagonal of the matrix leads to a significant increase in business performance.

Third, investing too many resources in a competitive factor that is considered less important by customers does not necessarily lead to higher business performance. If the importance of such a factor is not expected to increase in the future, managers should try to reallocate resources invested in the "excess?" zone of the matrix to improving factors from the "urgent action" and "improve" zones, where the negative impact on business performance indicators is evident and must be eliminated. However, the question mark in the name of the "excess?" zone is justifiable. Increasing performance on less important factors might also contribute to some extent to business performance. However, this impact is far weaker, on average, than the negative effect of the "urgent action" and "improve" zones. Based on this finding, two practical recommendations can be formulated: investment in the "excess?" zone should only be made after dealing with the "urgent action" and "improve" zones; and decision makers should expect a much lower (if any) immediate contribution to business performance from investment in the "excess?" zone than from investments in the "urgent action" and "improve" zones.

6.3 Limitations and further research

The present article offers a perspective on, and insight into, the relationship between manufacturing strategy, conceptualized through the lens of production competence theory, and business performance, but has several limitations that should be addressed in future research.

Generalizability. A large international dataset of manufacturing plants was used, which certainly adds to the generalizability of the findings. However, the database is restricted to a relatively narrow set of assembly industries (ISIC Rev. 4, div. 25-30). Further research is needed to check the generalizability of the findings beyond these industries.

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Performance on individual priorities. The study does not analyze each competitive priority individually. Individual competitive priorities (e.g. cost or quality) might have different impacts on business performance. It would therefore be useful to "dissect" the general relationships found in this study, investigate competitive factors individually, and study which factors are more likely to fall into the critical zones of the matrix and whether they differ in their impact on business performance.

Interaction effects. Due to the same limitation, it is not possible to say anything about the possible interaction among the competitive factors. A longitudinal analysis could be used to investigate how the improvement of a certain competitive factor affects performance on other factors (Grössler, 2010; Rosenzweig and Easton, 2010), and what their joint effect is on business performance. It is particularly interesting to address this question from the perspectives of two contradicting theories: the trade-off (Hayes and Wheelwright, 1984; Boyer and Lewis, 2002) and the cumulative capabilities (Ferdows and De Meyer, 1990; Rosenzweig and Roth, 2004), respectively.

Long-term effects. Production competence theory does not consider the long-term effects of manufacturing improvement (Azzone and Rangone, 1996), and this article is not different in that respect. Investigating long-term dynamics of competitive factors could also shed light on why some companies invest in less important factors. We presume that companies move part of their value proposition into the "excess?" zone of the importance-performance matrix hoping or even expecting that, as customer preferences and markets evolve, the factors supporting that become order winners in the future. Accomplishing superior performance on these factors could then be the key to securing a future competitive advantage against main competitors. However, this thought needs further empirical investigation.

The influence of context. As concluded in the literature review underpinning this article, production competence theory, like operations management practices theory (Sousa and Voss, 2008) and also operations strategy theory (Demeter and Boer, 2011), is relatively a-contextual. In this respect, the findings and recommendations presented in this article should be taken with some caution, too. It should not come as a surprise that industrial sector (cf. Kim and Arnold, 1993), process choice (cf. Safizadeh *et al.*, 2000) and also for example company size (cf. Cagliano *et al.*, 2001), affect the set and the relative importance of the competitive priorities pursued by a company and/or moderate the business performance effects of production competence. There is some evidence, reported in Sousa and Voss (2008), of the importance of these and other factors for operations management. However, further research is needed to investigate this proposition.

Direct measurement of customer requirements. Production competence theory builds on the assumption that the importance of, and a company's performance on, competitive factors affect the company's business performance. In this research, like in many production competence studies, competitive factor is operationalized as competitive priority, and it is assumed that a company's competitive priorities accurately reflect market/customer expectations. However, if a prioritized area is irrelevant in the eyes of the customer, the company will fail to grasp the benefits of its efforts (Hill, 1997) and, sooner or later, cease to exist. It would thus be important to measure the importance of competitive factors directly, i.e. in terms of market/customer demands. How to do that is a methodological problem that remains to be solved.

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Notes

1. The Manufacturing Futures Survey asked respondents to indicate the relative importance attributed to each capability that the manufacturing company chose to emphasize in appealing to customers and competing in the marketplace.
2. The five-point scale in Figure 2 is consistent with the measurement applied in the questionnaire used in the present research. Slack's original nine-point scales were proportionally converted to five-point scales, and the same approach was used to determine the boundaries of the zones.

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Appendix 1

1. Consider the importance of the following attributes to win orders from your major customers.

	Importance in the last three years				
	Not important				Very important
Lower *selling prices*	1	2	3	4	5
Superior *product design and quality*	1	2	3	4	5
Superior *conformance to customer specifications*	1	2	3	4	5
More *dependable deliveries*	1	2	3	4	5
Faster deliveries	1	2	3	4	5
Superior *customer service* (after-sales and/or technical support)	1	2	3	4	5
Wider *product range*	1	2	3	4	5
Offer *new products more frequently*	1	2	3	4	5
Offer *products that are more innovative*	1	2	3	4	5
Greater *order size flexibility*	1	2	3	4	5
Environmentally sound products and processes	1	2	3	4	5
Committed *social responsibility*	1	2	3	4	5

2. How does your current operational performance compare with main competitor(s)[a]*?*

	Relative to our main competitor(s), our performance is				
	Much worse		Equal		Much better
Manufacturing conformance	1	2	3	4	5
Product quality and reliability	1	2	3	4	5
Product customization ability	1	2	3	4	5
Volume flexibility	1	2	3	4	5
Mix flexibility	1	2	3	4	5
Time to market	1	2	3	4	5
Product innovativeness	1	2	3	4	5
Customer service and support	1	2	3	4	5
Delivery speed	1	2	3	4	5
Delivery reliability	1	2	3	4	5
Unit manufacturing cost	1	2	3	4	5
Procurement costs	1	2	3	4	5
Manufacturing lead time	1	2	3	4	5
Manufacturing overhead costs	1	2	3	4	5
Environmental performance	1	2	3	4	5
Social reputation	1	2	3	4	5

3. What is the current business unit performance? For market share indicate average in market(s) served by the business unit.

	Relative to our main competitor(s), our performance is:				
	Much worse		Equal		Much better
Sales	1	2	3	4	5
Market share	1	2	3	4	5
Return on sales (ROS)[b]	1	2	3	4	5
Return on investment (ROI)[c]	1	2	3	4	5

Notes: [a]Consider the average performance of the group of competitors that are the direct benchmark for the plant; [b]ROS = Earnings before interests and taxes/Sales; [c]ROI = Earnings before interests and taxes / Total assets

Table AI.

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Appendix 2

For geometrical calculations, a coordinate system was set up, in which the lower left corner of the matrix represents point (1,1), while the upper right corner represents point (5,5). To determine the average position of a company relative to the diagonal AB of the matrix, first the distance between each competitive factor (point) and the diagonal has to be determined – see Figure A1.

As a first step, the equation of the diagonal has to be determined using the straight-line formula (1) for a line passing through points (x_1, y_1) and (x_2, y_2):

$$d: \frac{x-x_1}{x_2-x_1} = \frac{y-y_1}{y_2-y_1} \tag{A1}$$

Selecting points A(1,2) and B(5,4) located on the diagonal of the matrix, Equation (A1) is used to determine the equation of the diagonal:

$$AB: \; x-2y+3=0 \tag{A2}$$

Second, slope m_{AB} of the diagonal has to be determined using the formula below:

$$m_{AB} = \frac{y_2-y_1}{x_2-x_1} = \frac{4-2}{5-1} = \frac{1}{2} \tag{A3}$$

With these data, distance of competitive factors relative to the diagonal of the matrix can be calculated. The general formula for the distance of a point $M_0(x_0,y_0)$ from a straight line determined by the equation $ax+by+c=0$ is shown in Equation (A4):

$$\text{Dist} = \frac{|ax_0+by_0+c|}{\sqrt{a^2+b^2}} \tag{A4}$$

Using Equation (A4) and Equation (A2), the distance of any point $M_O(x_O,y_O)$ from the diagonal AB of the matrix is determined by Equation (A5):

$$\text{Dist}_{M_0} = \frac{|x_0-2y_0+3|}{\sqrt{5}} \tag{A5}$$

However, to determine if a point $M_0(x_0,y_0)$ is located above or below the diagonal, the slope of the line passing through points A(1,2) and any particular $M_0(x_0,y_0)$ has to also be calculated. If this value is greater than the slope m_{AB} of the diagonal, it indicates that point M_0 is located above the diagonal, while if the value is less than slope m_{AB}, then point M_0 is located below the diagonal. In the case of equality, point M_0 is located exactly on the diagonal.

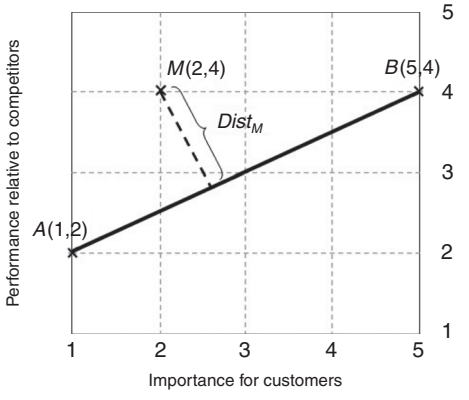

Figure A1. Determining positions relative to the diagonal of the matrix

Slope s of the straight line passing through points $A(1,2)$ and $M_0(x_0,y_0)$ is determined as follows:

$$s = \frac{y_0 - 2}{x_0 - 1} \tag{A6}$$

If $s > 1/2$, point $M_0(x_0,y_0)$ is located above the diagonal and receives a positive value for the distance from the diagonal. If $s < 1/2$, point $M_0(x_0,y_0)$ is located below the diagonal, and the distance measure has to be multiplied by -1, to obtain a negative value.

To illustrate the process described above, let us calculate the distance of point $M(2,4)$ from the diagonal AB of the matrix. First, we determine the slope s_M of the straight line passing through points $A(1,2)$ and $M(x_M, y_M)$:

$$s_M = \frac{y_M - Y_A}{x_M - x_A} = \frac{4-2}{2-1} = \frac{2}{1} > \frac{1}{2}$$

Since slope s_M is greater than the slope of the diagonal, the distance measure calculated below will be positive because point M is located above the diagonal. Using Equation (A5), we determine the distance of point $M(2,4)$ from the diagonal AB of the matrix:

$$Dist_M = \frac{|x_M - 2y_M + 3|}{\sqrt{5}} = \frac{|-3|}{\sqrt{5}} = 1.342$$

If point M was located below the diagonal, the above-calculated distance measure would have been multiplied by -1. Distances of competitive factors have to be averaged to obtain the average position of a company relative to the diagonal of the matrix.

About the authors

Levente Szász, PhD, is an Assistant Professor of Operations, Logistics and Supply Chain Management at the Faculty of Economics and Business Administration of the Babeş-Bolyai University in Cluj-Napoca, Romania. Assistant Professor Levente Szász is the corresponding author and can be contacted at: levente.szasz@econ.ubbcluj.ro

Krisztina Demeter, PhD, is an Associate Professor of Operations and Supply Chain Management at the Faculty of Business Administration of the Corvinus University of Budapest, Hungary.

Harry Boer, PhD, is Professor of Strategy and Organization at the Center for Industrial Production of the Aalborg University in Aalborg, Denmark. Since 2011 he is Honorary Fellow of the European Operations Management Association (EurOMA).

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