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Effective purchasing reallocation to suppliers: insights from productivity dynamics and real options theory

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ABSTRACT

Continuous supplier selection, evaluation and reselection are among buying firms' key processes to improve their overall performance. This paper aims at increasing knowledge on effective and dynamic supplier evaluation and management by answering the following research question: Do performance decomposition technique and real option theory represent appropriate mechanisms to understand structural change in supply chain and subsequent performance improvements? By taking insights from productivity dynamics in economics literature and real options theory from strategic investment context, we apply a method to measure buying firm's overall supply chain performance through reallocation of purchases among exiting, surviving, and entering suppliers based on their past performance. The method is tested and illustrated with the case of a Finnish contractor and its 535 suppliers in 269 construction projects during 2013–2016. This study provides new insights into the dynamic business relationships of a large buyer in an uncertain environment where supply chain performance is improved through continuous changes in the supplier network. The novelty of this study lies in adopting concepts from productivity decomposition literature in microeconomics in the context of supplier selection and management to quantify the overall performance development of all suppliers, and break it down to the performance components of exiting, surviving, and entering suppliers as well as reallocation of purchases among survivors. Furthermore, real options theory helps in interpreting the entering, surviving, and exiting supplier groups as real options exercised, maintained, and abandoned, respectively.

1. Introduction

In many industries, supplier selection and evaluation are key to improving a buying firm's performance and competitive position (e.g., Barney 2012). Several studies highlight the importance of appropriate supplier selection during the initial stage and multitudinous positive effects of supplier evaluation, such as enhancing suppliers' commitment (Prahinski and Fan 2007), encouraging them to compete with each other (Krause et al., 2000), analyzing product and service problems for potential solutions, and providing appropriate information to decision makers (Akyuz and Erkan 2010). In summary, previous research emphasizes that supplier evaluation is a key initial action in building competent supplier development (SD) initiatives (e.g., Krause et al., 2000; Lima-Junior and Carpinetti 2016).

At the buying firm level, the crucial question is how continuous supplier selection, evaluation and reselection processes contribute to improved overall supply chain performance. We argue that the question of improving overall performance through supplier portfolio management is analogous to the dynamics of productivity growth at the industry level. Market competition forces inefficient firms out of business through bankruptcy or mergers, leading to efficient allocation of resources to more competitive firms. In the 1990s, works by Baily et al. (1992), Griliches and Regev (1995), and Olley and Pakes (1996) developed the first systematic productivity decompositions that allow one to break down the aggregate productivity growth of a sector into components that capture the productivity growth of surviving firms and the contributions of entry and exit firms as well as the reallocation of resources among the surviving firms. Today, this structural change has been recognized as a key driver of productivity growth in many industries worldwide (see, e.g., Aghion et al., 2004; Syverson 2011; Bartelsman et al., 2013). Firm entry is conventionally understood as newly established startups while exit is generally understood as bankruptcy. In the context of supply chains, we argue that entry and exit is not limited to the market's competitive firms and that entry to and exit from the

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supply chain may result from managerial decisions, in the spirit of the real options thinking.

Just as research on the dynamics of productivity can provide concepts and measures to analyze overall performance through suppliers' contributions, real options theory (ROT) (see, e.g., Dixit and Pindyck 1994; McGrath et al., 2004; Trigeorgis and Reuer 2017) from strategic management literature may help in modeling how purchasing managers behave when they choose to buy more from some suppliers and scale down or even stop buying from other suppliers. It is typical in many industries, such as in engineering and construction projects with varying technologies, mixes of suppliers, and operating environments (Noorizadeh et al., 2019), that a single supplier's contribution to buyer performance is hard to estimate accurately. For such uncertain environments, ROT provides an idea of how to be more flexible with commitment decisions as well as guidance for "tak[ing] a variety of actions (scale up or down, abandon, change direction, or delay) until more information is available, rather than mak[ing] a full commitment to a given path at the outset of the project or initiative" (McGrath et al., 2004). Even if ROT has been applied in many contexts, such as investments in risky projects, its potential for explaining and guiding the managerial behavior behind supplier evaluation and selection has been neglected in a real-world setting.

Therefore, by taking insights from productivity dynamics in economics literature and real options from strategic investment contexts, this paper aims at increasing knowledge on effective and dynamic supplier evaluation and management by answering to the following research question: *Do performance decomposition technique and real option theory represent appropriate mechanisms to understand structural change in supply chain and subsequent performance improvements?* While productivity dynamics and ROT concepts are from two different research streams, we examine suitability of their joint applications in the supply chain management domain. In other words, our study seeks to explore whether findings from suppliers' performance decompositions can empirically complement ROT approach in explaining the structural change in the supplier portfolio over time. The novelty of this study is to adopt and apply ideas and concepts from industrial organization literature in microeconomics to the context of supplier selection and management. More specifically, we apply productivity decomposition by Melitz and Polanec (2015) to quantify the overall performance development of all suppliers, breaking it down to the performance components of exiting, surviving, and entering suppliers as well as reallocation of orders among survivors. Decomposing supplier performance can contribute to empirical evidence and managerial insights measuring the effectiveness and relative importance of developing existing suppliers, recruiting new suppliers, and getting rid of unreliable suppliers.

This multi-disciplinary study applies insights from the productivity dynamics and ROT approaches in a novel context to improve the buyer's purchasing practice and supply chain performance. In doing so, this paper contributes to the research on supplier evaluation and development, productivity dynamics, and real options theory from three different perspectives. First, this study investigates supplier performance and structural change in supplier portfolio over time, addressing the lack of longitudinal supplier evaluation (e.g., Autry and Golicic, 2010; Wetzstein et al., 2016; Gosling et al., 2019). We use a unique and rich dataset obtained from one of the worlds' largest international construction companies operating in Finland. Second, building on prior studies in the realm of productivity dynamics (e.g., Baily et al., 1992; Olley and Pakes 1996; Melitz and Polanec 2015), this study formally decompose the company's overall supply chain performance and its development to the contributions of the exiting, surviving, and entering supplier groups. We provide detailed analyses of suppliers' performance and the structural change in the construction company's supply chain portfolio. Third, we theoretically link productivity dynamics to the ROT literature (e.g., Dixit and Pindyck, 1994; McGrath et al., 2004; Trigeorgis and Reuer 2017), extending the boundaries and applications of these concepts to supplier evaluation and development contexts. We use our empirical data to illustrate how ROT provides concepts for buying companies to identify and choose among variety of actions regarding to scale up, scale down or abandon of purchases from a supplier, thus contributing to the overall productivity of the supply chain.

The rest of this paper is organized as follows. In the second section, we first explain the importance of supplier evaluation as managerial practice, and how it can help a buying firm and suppliers in boosting their businesses. After that, we review the literature on systematic productivity decomposition and discuss its adoption in the supplier management context. In the same section, we briefly elaborate on ROT and show how it provides useful concepts and managerial insights on purchasing reallocations from suppliers in order to improve overall performance. We summarize the theory section by presenting the method for dynamic supplier evaluation and management. We then test the method and present our results using supplier performance data from an international construction company. The dataset consists of 535 suppliers with 3688 evaluation records in 269 construction projects spanning from 2013 to 2016 and the corresponding purchasing value from suppliers by the construction company during those years. We next discuss the theoretical and empirical contributions of the research. Finally, we end the paper with conclusions and recommendations for future studies.

2. Supplier's performance dynamics and firm's purchasing reallocation

2.1. Supplier evaluation as a managerial practice

Research and practice communities commonly accept the key role of suppliers in a buying firm's performance and competitive position (e.g., Barney 2012). The importance of supplier evaluation and selection is discussed extensively in previous studies (see, e.g., Ho et al., 2010; Wetzstein et al., 2016). Buying firms can use evaluation after initial supplier selection to distinguish suppliers with good performance from those with poor performance with the buying firm. Evaluation results can help purchasing managers when placing future orders from most reliable suppliers. Additionally, evaluations can be of great value in identifying suppliers who are unwilling to change their behaviors, which in turn can facilitate decisions to terminate relationships with unsatisfactory suppliers. Consequently, supplier evaluation can greatly enhance suppliers' commitment to change their behavior (Prahinski and Fan 2007).

Furthermore, supplier evaluation can foster an environment wherein suppliers are encouraged to compete and attain higher performance (Krause et al., 2000). For instance, if the buyer has currently engaged multiple suppliers, supplier evaluation, through peer recognition and other reward mechanisms, can increase their efforts to be in a superior position relative to their counterparts. In addition, supplier evaluation can help to improve transparency and promote clear communication and cooperation between the buyer and supplier (Gunasekaran and Kobu 2007); evaluation further helps to avoid the perception among suppliers that price and internal politics are main factors behind purchasing decisions (Purdy et al., 1994). Akyuz and Erkan (2010) also list other advantages, such as assessment of success history, analyzing product/service problems in greater detail to find potential solutions, and providing appropriate data and information for decision makers.

Prior studies also highlight that regular supplier evaluation and feedback can be mutually beneficial to the buying firm and suppliers (e.

g., Prahinski and Benton 2004). For example, the buyer can monitor and detect aspects of supplier performance that should be improved (Hahn et al., 1990). Additionally, leveraging received performance feedback and comments can empower suppliers in their relationships with current and prospective buyers. Supplier evaluations can also be used in marketing; Jalkala and Salminen (2010) outlined the advantages of customer references as a marketing asset—a supplier can utilize the performance reviews from previous customers as references in an attempt to win business with new customers.

The above-mentioned benefits shed light on the important role of supplier evaluation in enhancing effective supply chain management practice. In construction supply chains, there have been attempts to address potential needs for supplier evaluation. For instance, Autry and Golicic (2010) analyzed suppliers' performance in a longitudinal study of buyer–supplier relationships within the domain of highway construction. In examining relationship–performance spirals, they found that the strength or weakness of the collaboration between the buyer and supplier affects supplier performance and that a long-term relationship can result in better project time and budget management. Gosling et al. (2015) investigated suppliers' key performance indicators (KPIs) to illustrate the impact of supplier development initiatives on KPIs. In another study, Gosling et al. (2019) show that the long-term supplier-buyer partnership, supported by SD, can enhance a supplier's learning and performance for more desirable outcomes. Noorizadeh et al. (2019) also discussed the challenges of performance evaluation where a supplier's working environment changes from one construction project to another.

Nonetheless, after investigating supplier performance both in general and in the construction business in particular, we believe that there are important unexplored areas. Association between supplier performance and a buyer's purchasing allocation is one of the important but less examined research topics in literature. There is wide empirical support for the notion that a firm's performance affects its survival rate (e.g., Syverson 2004; Asplund and Nocke 2006). As such, over time, analyses of supplier performance and their influence on the continuity or discontinuity of a relationship with a buying company can generate meaningful managerial insights. Consequently, we underline the need for promising methods that can connect supplier selection and evaluation to the overall supply chain performance of a buying company. We build on productivity decomposition and ROT literature, as two well-established research disciplines, to address this problem. We subsequently elaborate on each approach in turn.

2.2. Theoretical background of performance decomposition

According to the Schumpeterian notion of creative destruction, market competition forces inefficient firms out of business through bankruptcy or mergers, leading to more efficient allocation of resources to more competitive firms. The dynamics of structural change emerged as a central theme in economics in the 1990s thanks to influential works such as Baily et al. (1992), Griliches and Regev (1995), and Olley and Pakes (1996). These studies developed the first systematic productivity decompositions that break down the aggregate productivity growth of a sector into components that capture the surviving firms' productivity growth and contributions due to the entry and exit of firms and the reallocation of resources among surviving firms. Prior research emphasizes the role of structural change as a key driver of productivity growth in different industries (see, e.g., Aghion et al., 2004; Syverson 2011; Bartelsman et al., 2013; Fonseca et al., 2018). According to this view, understanding how firms' performance changes over time and whether such changes have a negative or positive effect on industry's productivity growth is a major area of interest. This research stream argues that competition influences market share (re)allocation among firms due to the fact that structural change in industries happens through: (i) the exit of lower-productivity firms, (ii) the entry of higher-productivity firms, and (iii) the reallocation of resources among surviving firms.

To understand the dynamics of productivity growth within the United States (U.S.) telecommunication industry, Olley and Pakes (1996) show that the productivity growth of the surviving firm is relatively modest, but the productivity of the industry is fueled by the entry of new, efficient firms and exit of inefficient ones. Syverson (2004) investigated the performance of ready-mixed concrete suppliers in the U.S. market and highlights that consumer access to high-performance suppliers makes the survival of less productive suppliers unprofitable. In another study, Asplund and Nocke (2006) discuss the exit and entry of hair salons into the Swedish market; their analysis suggests that while efficient salons survive, the market pushes out less efficient hair salons.

Firm entry is conventionally understood as newly established start-ups and firm exit is generally understood as bankruptcy. The study by Bernard et al. (2010) challenges this view by showing empirically that multi-product firms frequently switch from one line of production to another in the U.S. manufacturing industry. In this paper, we argue that entry and exit is not limited to competitive firms in the market. In the context of the supply chain, entry to and exit from the supply chain may result from managerial decisions that can potentially be attributed to ROT. The novelty of this study is to adopt and apply ideas and concepts from industrial organization literature in microeconomics to the context of supplier portfolio management. There is a large literature on the impact of structural change on productivity, going back to Baily et al. (1992) and Olley and Pakes (1996). In the same vein, our study employs insights from Melitz and Polanec (2015) as one of the latest contributions in this stream, which is built on the top of the earlier studies. More specifically, we apply productivity decomposition by Melitz and Polanec (2015) to quantify the overall performance development of all suppliers, breaking it down to the performance components of exiting, surviving, and entering suppliers as well as the reallocation of purchasing volumes among survivors.

2.3. Purchasing from suppliers as a real option

Research on performance decomposition provides concepts and measures to analyze overall supply chain performance through the suppliers' contribution. However, this research does not provide practical mechanisms about buying firms' actions to dynamically improve performance through supplier selection and evaluation. Therefore, ROT (see, e.g., Dixit and Pindyck 1994; McGrath et al., 2004; Trigeorgis and Reuer 2017) from strategic management literature could help in modeling how purchasing managers behave when choosing to buy more from certain suppliers and scale down or even to stop buying from other suppliers. The central aim of ROT is to support decision making under uncertain conditions (McGrath et al., 2004) by making small initial investment as a right, but not an obligation, to facilitate making further investment in the future (Trigeorgis and Reuer 2017). The idea is to obtain better knowledge and understanding from an option over time. If the outcome is beneficial, ROT encourages management teams to continue by expanding investment; conversely, ROT discourages continuity of investment and encourages the abandonment of the option in the case that the outcome is detrimental. To realize the benefits of real options, a firm must be flexible with its investment decisions.

The realization that ROT can guide organizations with their strategic decision making (Barnett, 2008) has garnered considerable attention

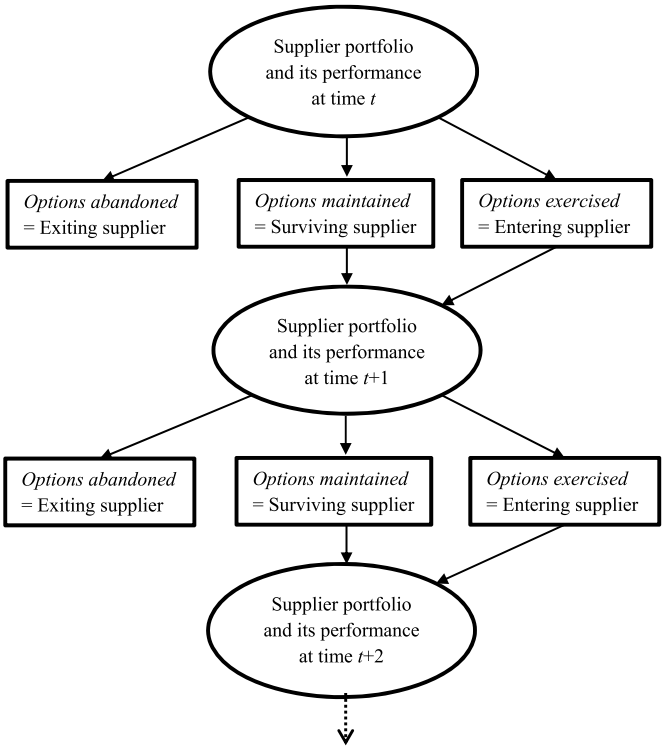

Fig. 1. A method to adopt real option thinking and performance decomposition into supplier selection and evaluation (modified from Barnett 2008).

from different research disciplines. Examples include customer lifetime-value analysis (Haenlein et al., 2006), technology selection for renewable energy generation (Kumbaroğlu et al., 2008), and choosing international market entry strategies (Ahi et al., 2017). For more ROT application areas, see Trigeorgis and Tsekrekos (2018). However, although much attention in literature has been focused on understanding the benefits of ROT in strategic and uncertain decision making, little is known about its advantages for improving supplier-buyer relationships and effective purchasing in the context of supply chains (e.g., Hult et al., 2010). In this study we demonstrate how ROT can theoretically be applied to the purchasing behavior of the buying company. In maintaining flexibility in its decision making, the buying company can, after analyzing supplier performance, decide to continue or discontinue purchasing from suppliers. This can greatly support firms with the flexibility to start purchasing from new suppliers while allowing them to improve or terminate collaboration with existing suppliers. This line of thought conforms with the ROT terminologies of exercising, maintaining, or abandoning real options (Barnett 2008) in strategic decision making under uncertainty.

Fig. 1 illustrates a firm's purchasing process from suppliers as real options over time connected to productivity dynamics. This figure is borrowed from Barnett (2008) and is modified according to the context of the current study. We also equate the three defined supplier categories of *entering*, *surviving*, and *exiting* suppliers to *exercised*, *maintained*, and *abandoned* options. This framework demonstrates ROT as an appealing theoretical lens to implement an effective purchasing strategy and supplier-buyer relationship.

In summary, despite the importance of ROT to strategic investment decisions over time, in general, far too little attention has been paid to its applications within SD literature and, in particular, within the construction supply chain. Prior literature highlights the role of buyers in adopting effective SD strategies in order to achieve the highest possible outcome relative to dedicated development investments (e.g., Noorizadeh et al., 2018) given that different theoretical and analytical approaches are proposed in SD literature (see Chen et al., 2016; Glock et al., 2017). However, it seems that the current literature fails to pinpoint ROT's potential in enhancing SD efforts. Therefore, identifying ROT as a superior mechanism of resource allocation for overall performance improvement can offer valuable insights to decision makers. Firms can invest in SD and later monitor and evaluate supplier performance. Obtaining supplier evaluation feedback after the implementation of the development program supports firms with decision making regarding the expansion or limitation of further investment in, or the divestment from respective supplier groups. At the supplier portfolio level, performance decomposition analysis can be used to evaluate whether developments and decisions have been successful. In the next section, we illustrate the utilized empirical data structure and the performance decomposition formulation.

Table 1
Supplier evaluation criteria.

Safety:
Attitude to occupational safety (AOS)
Cleanliness, order and environmental consideration (COE)
Compliance with safety instructions (CSI)
Activity in promoting safety (APS)
Co-operation, reliability and administrative procedure:
Supervisor expertise and availability (SEA)
Compliance with agreed timetables (CAT)
Additional claims in relation to the contract (ACC)
Billing and payment terms in accordance with the contract (BPC)
Quality:
Compliance with the agreement (CA)
Quality of the product and/or service (QPS)
Development activity (style of collaboration, way of working) (DA)
Corrective actions regarding possible comments and complaints by the buyer (CACC)

3. Data and research method

3.1. Data source

In the empirical part of the study, we test and illustrate the applied method with the longitudinal supplier performance and purchasing data of a Finnish construction company. We initially extract a number of evaluations feedback given by the company for each supplier during a given year (i.e., 2013–2016) within different construction projects. We later aggregate the obtained purchasing amounts of each supplier to account for total purchasing value during a given year. We then match our two separate datasets of *performance score* (evaluation feedback) and *purchasing value* using supplier name and standard industrial classification code. This rich dataset enables us to analyze how the company exercises, maintains, and abandons the options for its suppliers and allows us to conduct performance decomposition analysis in order to reveal whether the company's supplier development practices are effective. We provide further details on our dataset in the Appendix (Table A1).

Due to the nature of construction projects (e.g., unforeseen, location-based, unique) limited efforts are made to enhance supplier evaluation in the construction sector. However, even with such limitations, the case firm has decided to develop a platform that can help its site managers and purchasing department to systematically evaluate suppliers who participated in certain projects. Table 1 presents the list of supplier evaluation variables among three main categories: safety; co-operation, reliability and administrative procedure; and quality.

In each project, the evaluation is conducted via a site manager or the management team after supplier accomplishes its assigned tasks. The

evaluation system asks the superintendent by email to complete an electronic evaluation form one week after the planned end of the supplier's delivery.

Suppliers receive evaluation feedback regarding the above-mentioned criteria, representing their performance in the projects in question. Evaluation scores range from 1 to 5, where 1 represents the worst and 5 indicates the best performance in each criterion. The higher rating for each evaluation measure results in better overall supplier performance. Using the online assessment platform across projects from different cities in Finland, evaluation results are reported to the firm's Finnish headquarters in Helsinki. In yearly development meetings with the supplier, the supplier management team discusses the given evaluations feedback in order to find ways to improve performance. It is also important to mention that the yearly average of supplier performance is mostly based on multiple, rather than single, projects.

In this study, we utilize suppliers' evaluations[1] and their associated purchasing value between 2013 and 2016 by the construction firm. In total, 3688 evaluations within 269 unique construction projects across various cities in Finland were recorded. The overall purchasing value from suppliers across corresponding projects that received evaluation feedback is over €770 million. However, not all the attended suppliers received feedback from the firm, thus the total number of suppliers that participated in these projects is higher than the number used in our study.

For suppliers that have more than one evaluation in a year, we averaged all evaluations that yield to one evaluation for that year. This averaging also improves consistency of supplier evaluation that is affected by subjectivity of site managers or changing supplier operating environment moving from one project to another. Having explained the data of our study, we next conduct some basic analysis of the data before we move to the detailed performance decomposition method.

Fig. 2 plots the average performance score of suppliers considering 12 evaluation criteria between 2013 and 2016. Over these years, the highest performance scores are achieved in BPC (Billing and payment terms in accordance with the contract). This indicates that suppliers are careful with issuing invoices for the firm in order to receive their money at the earliest by facilitating invoice payment by the firm. In 2013, BPC was closely followed by CA (Compliance with the agreement) and CACC (Corrective actions). At the other side of the spectrum, APS (Activity in promoting safety), AOS (Attitude to occupational safety) and CSI (Compliance with safety instructions) represented the lowest performance areas among the evaluated criteria. Based on discussion of the results with the company's supply chain management team, this may indicate that the firm has high expectations of suppliers regarding safety-related actions and that they need to display further efforts in order to convince projects managers to assign them higher performance scores. Realizing the importance of safety for the company, it seems that supplier efforts greatly increased the performance score for the APS variable in 2016. The figure also illustrates that supplier performance improved in most of the criteria from year 2013–2016. CAT (Compliance with agreed timetables) represents well that improvement trend. On the other hand, in nine of the 12 criteria the highest scores were achieved in 2015 and the overall performance slightly decreased in 2016.

3.2. Performance decomposition among exiting, surviving, and entering suppliers

We next move to a more technical presentation of performance decomposition in the supplier selection and evaluation context. There are N_t suppliers in period t. The performance of supplier i in period t is denoted by p_{it} and the overall performance of all suppliers by P_t, respectively. Following Olley and Pakes (1996), we measure P_t as the share-weighted average of firm-level performance measures, formally,

$$P_t = \sum_{i=1}^{N_t} s_{it} p_{it}, \tag{1}$$

where $s_{it} \geq 0$ $(\sum_{i=1}^{n} s_{it} = 1)$ is the share of purchases of supplier i during the period t. Following Olley and Pakes (1996), equation (1) can be rewritten as:

$$P_t = \sum_{i=1}^{N_t} \left(\bar{s}_t + \Delta s_{it}\right)\left(\bar{p}_t + \Delta p_{it}\right), \tag{2}$$

where $\bar{p}$ and $\bar{s}$ denote the averages of supplier performance and the share of orders, respectively, and $\Delta s_{it} = s_{it} - \bar{s}$ and $\Delta p_{it} = p_{it} - \bar{p}$ denote the differences from the mean. Since the shares must sum to one, $N_t \bar{s} = 1$, and hence equation (2) can be equivalently rewritten as:

$$P_t = \bar{p}_t + \sum_{i=1}^{N_t} \Delta s_{it} \Delta p_{it}. \tag{3}$$

The right-hand side of equation (3) breaks down the overall supplier performance to two components: the first is the unweighted mean performance of all suppliers and the second represents the allocation of orders across suppliers. Note that the second component can be equivalently stated as:

$$\sum_{i=1}^{N_t} \Delta s_{it} \Delta p_{it} = \mathrm{cov}(s_{it}, p_{it}), \tag{4}$$

which underlines the fact that if orders are reallocated from low-performance suppliers to high-performance suppliers, the covariance of market share and productivity increases, which implies a positive contribution to the overall performance of suppliers. Therefore, changes in component (4) over time reflect supplier development and effective management of the supplier portfolio.

A notable limitation of the above decomposition is that it does not explicitly consider the entry and exit of suppliers. In economics, Melitz and Polanec (2015) extend the Olley and Pakes (1996) decomposition to include the impacts of entry and exit, applying insights from Baily et al. (1992), Griliches and Regev (1995), and Foster et al. (2001). Following Melitz and Polanec (2015), we partition the suppliers into three mutually exclusive groups in period t: surviving firms (S), new entrants (E), and exiting firms (X). Using this three-way grouping, we can break down the change in overall performance of suppliers from period t-1 to t as follows:

$$P_t - P_{t-1} = \left(P_{S,t} - P_{S,t-1}\right) + s_{E,t}\left(P_{E,t} - P_{S,t}\right) + s_{X,t-1}\left(P_{S,t-1} - P_{X,t-1}\right), \tag{5}$$

where the first component on the right-hand side is the performance change of surviving suppliers, the second component measures the contribution from the entry of new suppliers, and the third component measures the contribution of exiting suppliers. Note that the contributions of entry and exit are measured based on the performance differential relative to the surviving firms. This is a distinctive feature of the Melitz and Polanec (2015) decomposition compared with the previous decompositions by Griliches and Regev (1995) and Foster et al. (2001).

An appealing feature of the Melitz and Polanec (2015) decomposition is that the component of surviving suppliers can be further broken down into two components by applying the Olley and Pakes (1996) decomposition. More specifically,

$$\begin{aligned} P_t - P_{t-1} = &\left(\bar{p}_{S,t} - \bar{p}_{S,t-1}\right) + \left[\sum_{i \in S} \mathrm{cov}(s_{it}, p_{it}) - \sum_{i \in S} \mathrm{cov}\left(s_{i,t-1}, p_{i,t-1}\right)\right] \\ &+ s_{E,t}\left(P_{E,t} - P_{S,t}\right) + s_{X,t-1}\left(P_{S,t-1} - P_{X,t-1}\right), \end{aligned} \tag{6}$$

where the first component is the change in mean performance of sur-

[1] In this study, the term supplier refers to all types of material and service providers.

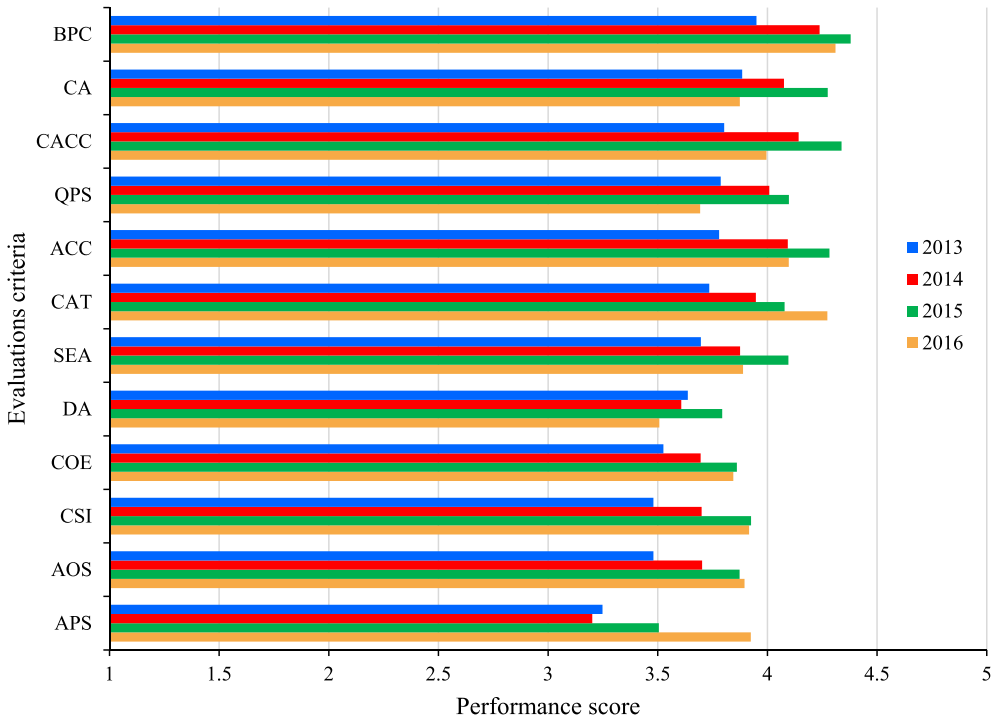

Fig. 2. Average suppliers' performance scores at different evaluation criteria (sample size: 2013 = 236, 2014 = 292, 2015 = 258, 2016 = 349).

viving suppliers, the second component captures re-allocation of purchases among surviving suppliers (i.e., scaling up or down), the third component is the entry effect, and the last term is the exit effect. Overall performance improvement of suppliers is the sum of these four components. This decomposition highlights not only the fact that the entry and exit of suppliers can help to improve performance, but also that the reallocation of orders among surviving suppliers is a potentially important source of performance improvement. Having presented the applied performance decomposition technique, we next discuss the conducted analyses and the derived results.

4. Results

4.1. Categorizing suppliers into three groups

We now turn to categorize suppliers into three groups of exiting, surviving, and entering. Previous studies examine how firms' productivity dynamics contribute to exit, survival or entry rate in their operating markets (e.g., Olley and Pakes 1996; Syverson 2004; Asplund and Nocke 2006; Melitz and Polanec 2015). Equipped with this knowledge, in order to understand whether there exist similar types of resource allocation patterns in our case, we explore how the construction company decides on purchasing allocation across its suppliers over time.

Table 2 presents the way suppliers are categorized in this study. The underlying logic to form the groups is based on availability of supplier evaluation data and the recorded purchasing volumes. We have first divided the four-year data into the two periods: period *t*-1 covering purchases and supplier evaluations in years 2013 and 2014, and period *t* covering years 2015 and 2016. Taking evaluation and purchasing data jointly into account, we classify suppliers into three groups: exiting[2] (if a supplier observed only in period *t*-1; n = 97), surviving (if a supplier observed in both periods; n = 118), and entering (if a supplier observed only in period *t*; n = 176). Dividing suppliers into these categories allows us to analyze the contribution of each category on the company's supply chain via suppliers' performance decomposition. The detailed overview of how we categorized the suppliers is provided in the Appendix (Table A2).

Table 2
Categorization of suppliers.

Period	*t*-1		*t*	
Category	2013	2014	2015	2016
Exiting	✓	✓		
	✓			
Entering			✓	✓
				✓
Surviving	✓	✓	✓	✓
		✓	✓	✓

√ = Available purchasing data as well as evaluation data.

It is worth to note that our supplier grouping is different than how most of the earlier studies categorize firms in the productivity dynamics literature. That is, our supplier grouping into exiting, surviving, and entering only reflects their relationship with the construction company and not suppliers' entire revenues or transitions within operating markets. For suppliers being in the exiting and entering group only mean that the company has stopped or started purchasing from them, respectively. Given these, an exiting supplier may continue its business with other purchasers and an entering supplier has possibly been working with other purchasers in the market before joining the case company's supplier network. In the same vein, a supplier in the case company's surviving group might be exited from other purchaser's supply chain or the supplier may be recently joined to another construction firm's supplier network as an entrant. Stated differently,

[2] Although for eight suppliers purchasing is recorded in 2013, we used their only available evaluation feedback from 2015 and assigned them into the exiting group.

suppliers' relationships with other buyers are not considered in placing them into the surviving group. Thus, the categorization of suppliers in this study are based on their relationships with the case company and our constructed groupings cannot be generalized to whole operating markets of suppliers.

After building supplier categories, first we conduct statistical analysis to investigate the association between supplier performance and the supplier categories. After that, we compare the amount of purchasing from different groups. These would provide valuable insights about differences across and among the supplier categories for our further analysis of performance decomposition. To discover if there are significant differences among exiting, surviving, and entering supplier groups, considering qualitative nature of our supplier evaluation dataset, we use Kruskal-Wallis H test.[3] For doing so, null and alternative hypotheses are defined as follows:

$H_0 = \theta_{\text{surviving}} = \theta_{\text{exiting}} = \theta_{\text{entering}}$

H_A=At least one of the supplier categories' performance is distributed differently.

4.2. Significance tests on performance differences between the suppliers' groups

Table 3 presents the average performance scores and purchasing values of the three supplier categories. Rather obviously, the surviving group has the highest financial transaction value with the construction firm. Interestingly, entering suppliers have on average the highest performance scores. The exiting supplier group experiences the lowest performance score and the lowest order volume compared to other two groups. What is striking in the results is a substantial gap in purchasing volume between surviving group relative to the exiting and entering suppliers.

It is important to understand that different factors can contribute to the surviving group gaining a larger purchasing share. For one, according to our supplier-buyer transaction records, the company has more working history with surviving group compared to other two groups. This supports high frequency of placing orders to surviving suppliers. However, we also observed single suppliers from exiting or entering groups that obtained higher purchasing value than some surviving suppliers. Type of offering and consumption quantity of the supplied products and services from these groups usually explain these observations. For example, consumption of concrete products is huge in Finnish construction industry and per most of the projects. This increases allocated purchasing volume to such suppliers, within the surviving group, significantly.

Despite of surviving group's high business share with the company, the entering group could achieve performance score slightly above surviving one. As noted by Autry and Golicic (2010), new suppliers try harder to prove themselves and attain good performance outcomes in order to support their business relationship continuity with the contractor. In fact, suppliers' high performance score plays an important role in promoting their short-term contract to a long-term one with the construction company. On the other side, the lower performance by the surviving group may represent Villena et al.'s (2011) idea of the dark side of long-term supplier-buyer relationship. According to their view, taking the buyer's purchasing as granted might demotivate supplier to put extra effort for continuous performance improvement.

One may ask whether a supplier's size affects the purchasing level from each supplier category. Although this kind of connection might exist, in this study, we did not investigate the sizes of suppliers within the different groups. As mentioned above, for a supplier being in one specific category does not mean that its obtained purchasing volume is higher or lower than other groups. For example, within our dataset, we observed a supplier with overall purchasing only of 14,699 euro from the surviving group and another one with more than five million euro from the exiting group. Furthermore, orders of supplied items in various projects could be assigned to different suppliers, regardless of them being from exiting, surviving or entering categories.

Table 4 provides the results of Kruskal-Wallis H test to compare possible statistical differences in performance among exiting, surviving, and entering supplier categories (the first row in Table 4). A comparison of the three groups reveals that there are statistically significant differences across the supplier categories (Chi-Square = 32.336, p-value <0.05). Given that, we reject the null hypothesis because of a meaningful difference that exists between the performance of one or more of the three supplier categories.

In the next stage, to explore where the differences lie among the three groups, we run a post hoc test. To do so, we apply Kruskal-Wallis H test for pairwise comparisons of supplier groups. Table 4 shows that the performance difference between the exiting and entering suppliers has statistically highest significance followed by the difference between the surviving and exiting suppliers. The difference between the surviving and entering groups has the lowest statistical significance. In summary, our results indicate that there are statistically significant differences among the suppliers performance dependent on the category they are located.

In closer inspection of Tables 3 and 4, the exiting supplier group obtained the lowest average performance score compared to other two groups. As such, it seems that the construction firm responses to the exiting group's performance shortfall by deciding not to scale up its purchasing. This is clear from the lowest amount of purchasing allocated by the firm to exiting group. This ultimately resulted in the firm decision to terminate purchasing relationship with such suppliers (i.e., abandon options). On the other hand, suppliers of surviving group could achieve a better performance score relative to the exiting group. This indicates that surviving suppliers were able to meet the performance requirements and, in turn received larger and ongoing purchasing orders from the firm. This continuity of purchasing can boost the quality of the collaboration with suppliers of surviving group (i.e., maintain options). In addition, constant firm's endeavor to improve its supply chain can be manifested in obtained performance score by entering suppliers. The results show that entering group could obtain even higher performance score than surviving one. From purchasing aspect, entering supplier also occupies superior position relative to exiting group. The attempt to replace low-performance suppliers with alternative high-performance ones (i.e., exercise options) is a clear action that is taken by the firm

Table 3
Average performance score and purchasing volume at different supplier groups.

Group	Average performance score	Average purchasing value (€)
Exiting	3.56	462,230
Surviving	3.90	3,953,697
Entering	3.96	638,550

Sample size: exiting = 97, surviving = 118, entering = 176.

Table 4
Differences in supplier performance by group.

Comparison	Chi-Square	Degree of freedom	P-value
Exiting, surviving, and entering	32.336	2	0.000
Exiting and entering	26.133	1	0.000
Exiting and surviving	17.229	1	0.000
Surviving and entering	7.067	1	0.008

Sample size: exiting = 97, surviving = 118, entering = 176.

[3] The Kruskal-Wallis H test is performed with a significance level of 5%.

to enhance its supply chain competitiveness. In overall, discovering this unintentional practice of ROT logic by the case firm is another appealing aspect of this empirical study.

4.3. Multinomial logistic regression on the suppliers' classifications

With respect to suppliers' classifications, we provide further analysis using multinomial logistic regression. It helps to realize whether, based on the evaluation feedback and purchasing volume data, suppliers could be grouped into different profiles than our defined classifications. In the following analysis, we consider surviving group as a base. That is, we like to understand how similar suppliers from exiting and entering groups are to surviving group. This can help to recognize suppliers that are exited but they could continue their relationship with the company considering their similarity of evaluation and purchasing data to surviving and entering groups. On the other hand, the model can suggest suppliers from entering group that are more likely, at least in medium or long-term, to join surviving group and those that may end up in exiting group.

To run the multinomial logistic regression, we combined 12 evaluation data with one purchasing data at each year. Given that, our imported dataset to the model consists a large number of data rows: surviving group 443 ($\times$ 13 = 5759 data points), exiting group 117 ($\times$ 13 = 1521 data points), and entering group 218 ($\times$ 13 = 2834 data points). Regarding the model fitting information, the likelihood ratio test with Chi-Square = 255.078 and *p-value* <0.001 indicates a very good model fit. This illustrates that evaluation measures and purchasing volume clearly played an important role in supplier categorizations in the model. Pseudo R-Square (McFadden) also shows that 0.306 of variances are explained. Thus, the obtained results from the test demonstrate the high explanatory power of the applied method. According to our data records and findings from Table 3, there might be several possible explanations for these results. First, in all of the evaluation measures exiting suppliers obtained lowest performance score compared to surviving and entering groups. At the same time, this category obtained the minimum purchasing volume compared to other two groups. Second, entering suppliers show better performance than exiting and surviving groups in seven out of 12 criteria. Having achieved such position in evaluation measures can justify receiving higher purchasing order relative to exiting group. Finally, considering surviving category as a base that two other categories are compared with, it could attain the highest scores in five evaluation criteria besides to obtaining the largest purchasing volume. In general, therefore, it seems that when exiting and entering groups are compared with surviving groups connections exist between their supplier evaluation and purchasing data.

Table 5 provides predictions of multinomial logistic regression regarding supplier categories. The highest success rate (81.8%) is obtained by the entering group. This is followed by the surviving (61.9%) and exiting (57.7%) supplier groups. The success rates imply the level of accuracy between the observed and the predicted groups for suppliers. For example, out of 118 suppliers, that we have basically identified for surviving category, the model estimates that 10 and 35 suppliers could be assigned to exiting and entering groups, respectively. This mismatch can be explained by several factors. For instance, a bottleneck supplier with immense power in the relationship with the buyer could be categorized into the surviving group even if its purchasing and performance data would not justify that. Similarly, 31 exiting suppliers were predicted to be in the entering group indicating that these suppliers have more common characteristics, regarding the evaluations and purchasing data, with entering suppliers than their own group. This can be explained in two ways. First, due to a natural variety of construction projects, the offerings of these suppliers may not be any more needed in the buying firm's new projects leading to categorizing this supplier as exiting regardless of its previous purchasing and performance data. Second, 22 entering suppliers have achieved performance and/or purchasing records that are close to those of exiting suppliers. In simple terms, some entering suppliers are likely to fall into the exiting group even the company has just started purchasing from them. Similar to the surviving group, the criticality of the offered items by poor-performing entering suppliers and the lack of access to more competent suppliers may justify the buyer's purchasing from these suppliers, hoping to improve their performance through the SD efforts.

On the other hand, from SD standpoint, it can be important to further investigate the observed surviving and entering suppliers that the multinomial logistic regression model predicts to the exiting category. The firm can commit more SD resources to improve performance of these suppliers. Maybe they provide rare or strategic materials/services for the firm, and SD investments are necessary to enhance their performance and support continuity of relationship with them.

We could not assign some suppliers into any of the exiting, surviving, and entering groups. These suppliers were not qualified to be in any of the groups because of missing and incompatible data.

Table 5
Classification of suppliers based on multinomial logistic regression.

	Predicted supplier categorize			
Observed supplier categorize	Surviving	Exiting	Entering	Success %
Exiting	10	**56**	31	57.7%
Surviving	**73**	10	35	61.9%
Entering	10	22	**144**	81.8%

Sample size: exiting = 97, surviving = 118, entering = 176.

4.4. Performance decomposition

Turning now to supply chain performance decomposition, Table 6 reports the number of suppliers, their associated purchasing volumes and the obtained average performance scores from the construction company in years 2013–2016. Since the composition of suppliers is constantly changing, in Table 6 the suppliers have been classified into four subsets: I) *All suppliers*; II) *Surviving suppliers* observed in the previous year and the next year (IIa and IIb); III) *Entering suppliers* that were not present in the previous year but are observed in the next year; and IV) *Existing suppliers* that are not observed in the next year. Note that the size of group I=IIa + III=IIb + IV. Likewise, summing the number of suppliers in group IIa with IV (from the previous year) yields the total number of suppliers (group I) in the previous year.

When all suppliers are considered, it is clear from Table 6 that the purchasing amount has a growing trend, increasing from 172 million

Table 6
Number of suppliers, purchasing allocations and average performance score across 2013–2016.

	2013	2014	2015	2016
I) Overall suppliers	236	292	258	349
- Total purchasing volume (M€)	171.74	149.54	189.21	257.45
- Average performance score	3.67	3.86	4.03	3.93
IIa) Surviving suppliers from previous year	–	134	148	178
- Total purchasing volume (M€)	–	103.48	139.61	177.59
- Average performance score	–	3.86	4.01	3.97
IIb) Surviving suppliers to next year	134	148	178	–
- Total purchasing volume (M€)	141.16	120.23	167.91	–
- Average performance score	3.74	3.87	3.98	–
III) Entering suppliers	–	158	110	171
- Total purchasing volume (M€)	–	46.05	49.60	79.86
- Average performance score	–	3.85	4.09	3.90
IV) Exiting suppliers	102	144	80	–
- Total purchasing volume (M€)	30.58	29.31	21.30	–
- Average performance score	3.57	3.84	4.18	–

euro in 2013 to 257 million euro in 2016. In other words, the total purchasing volume of the company increased by 67%. During the same period, the company has contracted a growing number of suppliers from 236 in 2013 to 349, three years later. This indicates that number of suppliers increased, almost similar to purchasing volume, by 68%. As such, the average purchasing volume per suppliers has remained almost unchanged during the four years. Meanwhile, the trend of suppliers' performance score also is upward in general, shifting from 3.67 in 2013 to 4.03 in 2015 and with a slight decrease in 2016 to 3.93. In light of these findings, it is interesting to examine how the composition of suppliers has changed over these years, which leads us to consider group II in Table 6.

The group II of survivors consists of those suppliers that were observed in the data during the previous year. For example, 134 suppliers observed in year 2014 (57%) continued to receive purchasing orders in 2015. Note that the average purchasing volume allocated for these suppliers is larger than the average value of all suppliers in group I. The average performance of the surviving suppliers is very close to that of all suppliers. Therefore, a positive performance contribution of new suppliers can help to increase the overall performance of the supplier pool. We hence consider the entering suppliers of group III.

What is striking about group III is the large numbers of new suppliers that entered the company's supplier portfolio during 2014–2016. A closer inspection of group III shows that this group represented almost half of all suppliers during these years. On the other hand, although purchasing data indicate that new suppliers' share of orders is smaller than that of group II, the purchases allocated to new suppliers was growing over the years. The trend of new suppliers' performance score at different years is also very similar to that of groups I and II.

Besides to entering suppliers, there are considerable number of suppliers that are no longer observed in the following year (group IV). The share of exiting suppliers varies from 30% to almost 50% of all suppliers, moving from 2013 to 2015. Two interesting trends emerge regarding associated purchasing volume and performance score over these years in group IV. First, the average purchasing volume per supplier decreased by 9%. Second, contrary to the purchasing direction, the average performance score shows upward trend, improving from 3.57 (2013) to 3.84 (2014) and then to 4.18 (2015). To provide further explanations about suppliers of group IV, recall conditions of falling into exiting and entering supplier groups from Table 2; exiting group if a supplier presence confirmed from 2013 to 2014 and entering group if a supplier presence confirmed from 2015 to 2016. According to our detailed data investigation, out of 102 (2013) and 144 (2014) exiting suppliers in IV, more than 75% and about 14% are observed in 2014 and 2015, respectively. On the other hand, out of 144 (2014) and 80 (2015) suppliers, almost 29% (in 2015) and about 53% (in 2016) could join to the entering supplier category. What is interesting about these findings is that in 2013 the lowest and in 2015 the highest average performance scores are recorded for group IV. Therefore, based on the aforementioned findings, we expect to see that such structural changes influence the supply chain performance of the client company.

Having explained year-by-year structural changes in our supplier evaluation and purchasing data across 2013–2016, next we present such composition changes based on the exiting, surviving, and entering supplier categorizes. To do so, we measure the company's overall supplier performance as the weighted average of all suppliers, using the size of purchasing orders (euro) as weights for suppliers' performance scores. We decompose the weighted average to the components of exiting, surviving, and entering supplier categorizes. After that, we examine the reallocation effect within the surviving group based on the covariance of performance score and purchasing orders. Therefore, conducting these analyses can help us to realize how structural change has occurred in the company's supply chain over time.

Table 7
Average supply chain performance growth and its components (%).

Component	2013–2016
Surviving suppliers	13.79
+ Exit contribution	3.93
+ Entry contribution	−5.06
+ Reallocation effect	0.03
= Total supply chain performance growth	12.69

Applying insights from Melitz and Polanec (2015), performance change of the surviving group is measured as $\bar{p}_{S,t} - \bar{p}_{S,\,t-1}$. The impact of reallocation of orders among surviving suppliers also is measured as $\sum_{i\in s} cov\,(s_{it},\, p_{it}) - \sum_{i\in s} cov\,(s_{i,t-1},\, p_{i,t-1})$, where s_{it} is the share of supplier i of all purchases in year t. This difference of covariances indicates whether the larger/smaller purchasing share devoted to high-performing surviving suppliers or not. For the entering group, the contribution is measured by $s_{E,t}\left(P_{E,t} - P_{S,t}\right)$ Similarly for the exiting group, the contribution is calculated by $s_{X,t-1}\left(P_{S,t-1} - P_{X,t-1}\right)$. As mentioned earlier in Table 2, we present performance contribution of surviving, exiting, and entering groups by aggregating the four-year time period into two sub-periods: period t-1 (2013–2014) and period t (2015–2016).

Table 7 presents the performance contribution of each supplier category from period t-1 to t. The overall performance of all suppliers increased by almost 12.7 percent during this time period, which is good news for the client company. The most important source of performance improvement is attributed to the group of surviving suppliers, which improved performance by staggering 13.79 percent during this period. However, reallocation of orders among surviving suppliers provided only marginal effect on overall performance. Another notable source of performance improvement of 3.9 percent is due to exit of suppliers with low performance. In contrast, entry of new suppliers contributed to 5 percent decrease in the overall performance of the supplier pool. These results suggest that the development of surviving suppliers has been very successful and that excluding weak suppliers has also positively contributed to overall performance. Reallocating orders to the best performing survivors could provide possibilities for further performance improvement. In particular, the selection of new suppliers might call for more careful attention.

We next investigate in more detail the contributions of entering and exiting groups to supply chain performance. Considering the overall performance, during this period, the exiting group's performance is lower than surviving group ($P_{X,t-1}$=3.55; $P_{S,t-1}$ = 3.78). This indicates that the lower performance of exiting suppliers has played a role in discontinuity of placing purchasing order from this group. Therefore, considering advantages of structural change in the company's purchasing allocation, the exiting group have positively contributed to the supply chain performance. This can be interpreted via assigning further purchasing volume to surviving suppliers at period t. According to our data analysis, 254.22 M€ purchasing is recorded for surviving group at period t while the corresponding purchasing amount at period t-1 is 212.32 M€. On the other hand, exiting suppliers facilitate the entry of new suppliers by freeing resources from the former group and shifting them to the later one. The above statistics clearly show benefits of exiting group to the company's current supplier portfolio.

In Table 8 we further decompose performance and market share of surviving group versus exiting group at period t-1 and surviving group versus entering group at period t. What stands out from this table is that

Table 8
Performance decomposition of surviving group vs. exiting and entering groups.

Period	Surviving $P_{s,\,t-1}$	$s_{s,\,t-1}$	Exiting $P_{x,\,t-1}$	$s_{x,\,t-1}$	Surviving and exiting P_{t-1}
t-1 (2013-2014)	3.777428	0.825644	3.552121	0.174356	3.738144
	Surviving $P_{s,t}$	$s_{s,t}$	Entering $P_{E,t}$	$s_{E,t}$	Surviving and entering P_t
t (2015-2016)	3.982658	0.693443	3.817512	0.306557	3.932031

sum of performance change for surviving + entering (period *t*) is higher than surviving + exiting (period *t*-1). This is achieved through performance and market share shift across these two time periods. Comparing the data of these two periods reveal interesting findings. Regarding the performance, from period *t*-1 to *t*, it can be seen that $P_{S,t}>P_{S,t-1}$ $P_{E,t}>P_{X,t-1}$. As we discussed above, exit of suppliers with lower performance and entry of suppliers with higher performance pushes the surviving supplier performance up at period *t*. As such, it might be rational to believe that the improved performance of surviving group stems from entry effect of new suppliers at this period. Because surviving suppliers have to compete with entering group to keep their current market share and then strive to increase it if possible.

In contrast to augmented performance by surviving group at period *t*, however, its market share is deteriorated relative to *t*-1. During these periods, the sequence of allocated market shares is $s_{S,t-1}> s_{S,t} > s_{E,t} > s_{X,t-1}$. Two points should be noted here. First, while the surviving group has better performance at period *t*, its market share decreased relative to period *t*-1. Second, the entering group could attain higher performance and higher market share compared to exiting one. Based on the findings, we suggest that supply chain performance could be further improved by slightly decreasing purchases from entering suppliers and allocating these purchases to surviving suppliers. These results clearly show trend of structural changes and performance growth within the company's supply chain.

5. Discussion

Throughout this paper, we have benefited from different theories and analytical tools for longitudinal study of the supplier portfolio management by the case construction company. Initially, we categorize suppliers into exiting, surviving, and entering groups based on their purchasing transactions and performance records in our dataset. For doing so, we follow the literature of industrial organization that investigates productivity growth within different sectors. This research stream builds on Schumpeterian notion of creative destruction to argue that firm's performance has a pivotal role in their obtained market share. In other words, existing market competition influences resource (re)allocation among firms. However, while estimating the performance impact of structural change in supply chain can provide insightful information for purchasing decision makers, we are not aware of such discussions to enhance supplier portfolio management in the literature. Therefore, we decompose our case company's supply chain performance among the exiting, surviving, and entering supplier groups helping to realize the contribution of each category. Our analyses show that the company's supply chain experiences structural change via sharp decrease (exit) in number of suppliers. The same pattern is evident from the enormous number of new suppliers that join (enter) the supply chain at each year. Meanwhile, there are suppliers that could continue (survive) their collaboration with the company over 2013–2016. Our empirical decompositions and the obtained findings illustrate that the structural change play a positive role in the supply chain performance growth.

On the other hand, although previous productivity decomposition studies mainly concentrated on modeling and formulation of their analysis, in this study we theoretically link productivity decomposition to ROT. Our research argues that ROT as a strategic and rational decision-making logic (e.g., Dixit and Pindyck 1994; McGrath 1999) can be helpful in purchasing decision from suppliers. That is, to reduce uncertainty of working with suppliers, their performance feedback can be analyzed and then decided accordingly. We present connection between supplier performance over time and staging purchasing using ROT. As such, we posit that the buyer company can place initial low-volume purchase from a supplier and then learn from its working relationship with that supplier. After that, based on supplier performance, the buyer decides to continue with more purchases or discontinue its relationship without further purchasing. Previous research on supply chain management highlights the involved uncertainty in purchasing (e.g., Heckmann et al., 2015). Due to nature of construction projects that contains high uncertainty, our research contends that ROT can explain exercising, maintaining, and abandoning supplier groups helping to reduce uncertainty across a company's supply chain. Longitudinal supplier analysis is the key for a proper ROT understanding.

However, supplier evaluation based on a panel dataset is rare in the supply chain literature. The current study adds new knowledge to supplier evaluation research by further analysis of supplier performance dynamics. Besides the applied decompositions, our longitudinal supplier evaluation findings indicate that there is an association between supplier performance and their assignment to exiting, surviving, and entering groups. Using the unweighted average performance, among these three supplier categories, the entering and exiting ones have achieved the highest and lowest performance scores, respectively. It was not a great surprise that there are meaningful differences across and between supplier groups according to our statistical tests. This shows that supplier performance plays important role in the buyer's decision-making regarding continuity/discontinuity of relationship with supplier. Interestingly, our evidence on the different supplier groups are consistent with the logic of the structural change and ROT approaches. That is, the exiting supplier category, with the lowest attained purchasing volume and performance score, is equivalent to abandoned options. The surviving group, which achieved highest purchasing and better performance than the exiting one, represents maintained options. The entering group, which could obtain higher purchasing than exiting suppliers and slightly better performance score than surviving group, as exercised options. However, these results have partially affected when using weighted average performance and dividing supplier categorizes into two periods of *t*-1 and *t*. More specifically, we found that the

entering group's overall performance is lower than the surviving group at time t (when entering occurs). Despite such adjustments in the results, we believe that the main novelty of this study remains in joint discussion of ROT and productivity decomposition in supply chain management context. In general, our research findings illustrate that supplier performance is associated with structural change in the buying company's supply chain performance growth. This is evident from the buyer's willingness to increase/decrease/stop placing purchasing orders from different supplier groups. Thus, our findings build on studies such as Olley and Pakes (1996), Syverson (2004) Asplund and Nocke (2006) that a firm performance contributes to its exit, survival or entry from operating market. Our results can therefore contribute new knowledge to the linkages among structural change and performance growth, ROT, and supplier evaluation.

Furthermore, to show whether suppliers performance of exiting, surviving, and entering groups statistically differ from each other, we used Kruskal-Wallis H test. According to the obtained results, there is statistically significant differences among supplier categories. Pairwise comparisons of groups also illustrate that exiting group has the statistically highest differences with entering and surviving groups. These findings indicate that, besides to higher average (unweighted average) performance gap of exiting group with entering and then surviving group, there are large variations on distribution of performance within exiting group compared with entering and surviving ones. As such, we further performed multinomial logistic regression analysis to enhance our understanding of supplier categories.

As our applied multinomial logistic regression suggested, there are meaningful associations among predicted versus observed exiting, surviving, and entering supplier categories. This means that the model could predict accuracy of more than 80 percentage for entering group and around 60 percentage for exiting and surviving groups relative to observed groups. In other words, the model estimates patterns of performance score and purchasing amount for suppliers within each category. Yet, there are suppliers that the model recommends one of the other two groups than their current group. Thus, although supplier's performance is important in the company's decision making regarding its supplier portfolio management, it seems that other factors, such as necessity and rarity of the supplier's offering or natural variety of the buying firm's projects, also play roles in the company's purchasing behavior.

Emphasizing that supplier evaluation is crucially important for enhancing the competitive advantage of supply chain, most of the existing studies use small sample size for their analysis. Such datasets can limit the border understanding of possible patterns in suppliers' data and buyer's behavior. Given that, we have empirically investigated a large number of suppliers for performance evaluation. However, regarding our supplier performance analysis, several measurement concerns are of note. First, complexity and working conditions of supplier's operations can differ within the project compared to other involved suppliers and across the projects. Second, in supplier evaluation process, perceived supplier's performance by a project manager may be affected based on quality of overall suppliers' performance. That is, if one supplier performs very well and achieve highest score, most likely that supplier acts as a reference point in assessing other existing suppliers in that project. Third, having mostly different supervising managers across the projects, their perception regarding supplier evaluation grading may differ from each other. In this setting, a supplier may obtain a high score in one project and with the same performance level may achieve a lower score in another project because of variation in projects managers. Finally, another important concern is reproducibility of the obtained data from supplier evaluation. To validate the generated data, if one asks from projects managers to do test-retest procedure, what would be the possibility of the getting exactly the same rating for each criterion, in a second or third re-evaluation.

However, in light of these challenges, the firm constantly tries to improve the application of its supplier evaluation system. In doing so, they benefit from external academicians and internal technical staff. Annual meetings of the firm's purchasing and supplier management departments from different operating markets provide valuable opportunity to share and discuss the current supplier evaluation framework and its challenges.

6. Conclusions

This study contributes to the extant literature on long-term supplier-buyer relationship analysis. Drawing on literature on supplier evaluation, productivity dynamics, and ROT, we examine the buying firm's overall supply chain performance and purchasing (re)allocation among exiting, surviving, and entering supplier categories. We empirically test how suppliers' performance is associated with positioning them into exiting, surviving, and entering groups. We further decompose overall supplier performance across these three supplier groups. This helps to realize contribution of each group to the company's supply chain performance. Reviewing the previous supplier evaluation and supply chain management studies indicate that they mainly focus on surviving suppliers, and therefore the role of structural change remains unexplored. However, the current study is one of the first attempts to systematically analyze the contribution of structural change on supply chain performance growth. Accordingly, revisiting our initially posited research question, based on the derived results, we argue that utilizing performance decomposition and ROT approaches enables to specify and quantify mechanisms that affect structural changes and subsequent performance developments in the buyer's supply chain portfolio.

There are several avenues worth exploring in the future research. First, despite of differences in materials and services provided by suppliers, firms often apply identical measures to assess suppliers' performance within the projects. Grouping suppliers based on similarity in offered items and then comparing their performance might be one solution which requires further investigation. Second, considering complexity and changing environment of projects, assigning optimal weights to evaluation measures at different projects can be another improvement area for the future research. Third, to enhance the reliability of obtained supplier performance score, it would be valuable to incorporate some objective measures to the current subjective evaluation criteria. As an example of the objective evaluation measure one may consider deviation between estimated and actual time of task accomplishment within the construction project (e.g., hour, day).

Fourth, in this study we could not consider variables outside of the case construction company's influence when placing suppliers into the surviving group. Besides to surviving suppliers' performance and associated purchasing records, there might be other factors that contribute to continuity of their relationship with the company. Examples of such influencing factors are: a supplier that enjoys its monopolistic position in a certain market; a client (i.e., a project owner) interest to use a particular supplier despite its poor performance with the contractor; and a supplier with a long-term contract with the case company as a main purchaser. On the other hand, a favored supplier may not anymore offer services for the buyer due to reasons such as finding more attractive customers or facing a bankruptcy. We could not also identify the history of the surviving suppliers' relationship with the buyer before the study period. Therefore, some of them might have just started as entering suppliers in the beginning of the study period. A longer time horizon and deeper analysis of supplier's role in buyer's business would enable more nuanced analysis of the structural changes in supply chain.

Finally, in our view, the discussed framework regarding suppliers evaluation, their classification to exiting, surviving and entering category, and how they are linked to ROT, are generic enough to be applied to supply chains in other sectors, such as other project businesses, manufacturing and retail trade. Regarding the generalizability of the findings of this study, customer relationship management can be another potential area for further investigation. While customer value analysis (e.g., Zhang et al., 2015) is a well-established research stream within the marketing context, dividing the seller's customers into exiting, surviving, and entering groups can be insightful. Over time, this can help to decompose seller's overall purchasing performance into exiting, surviving, and entering customer groups and then, for example, investigate on effective allocation of marketing resource among different categories following the logic of ROT.

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Appendix

Below we provide supplementary figures and tables for our study. Table A1 provides descriptive statistics regarding supplier evaluation feedback and purchasing value from suppliers during our study period. Three points are of note considering our dataset preparation. First, suppliers with missing data in more than six criteria (half of the variables) are removed. For supplier with missing values in six or less than six criteria, missing values are replaced with average performance of the supplier in all criteria. Second, if supplier has changed its name or merged with another one, we treat them as an identical supplier in our dataset. Third, while our purchasing value dataset is based on order amount, for some suppliers, in 2016, we use invoice amount. Order and invoice amounts are related to how purchasing is managed in construction projects. Table A2 also shows that how suppliers are categorized into surviving, exiting and entering groups. Suppliers' data from the second and the third columns of the table are reviewed in order to define years that should be considered for suppliers' categorization. In the same table, those suppliers that are not fit into our defined categories' specifications considering the evaluation and purchasing years are removed from further analysis.

Figures A1 and A2 plot empirical cumulative distribution functions of exiting, surviving, and entering groups regarding performance and purchasing aspects, respectively. Figure A1 represents variation in performance score inside the supplier categories and compared to each other. Figure A2 also depicts that there are clear trends regarding increasing of purchasing from suppliers by the construction firm moving from exiting to entering and then to surviving supplier groups.

Table A1
Descriptive statistics of suppliers' evaluations and received purchasing value at different years.

	No. of suppliers	Mean	Median	Minimum	Maximum
Evaluations feedback[a]					
2013	236	3.67	3.75	1.08	5
2014	292	3.86	3.89	1.58	5
2015	258	4.04	4.08	2.13	5
2016	349	3.94	4	1.40	5
Purchasing value (€)					
2013	236	727,705	266,116	49	21,977,671
2014	292	512,109	188,087	57	7,133,537
2015	258	733,359	220,182	2450	13,549,871
2016	349	737,668	177,233	31	16,822,746

[a] Average of 12 criteria is considered.

Table A2
Suppliers' categorization into surviving, exiting, and entering groups.

Category	Year of purchase	Year of evaluation feedback	Considered year of purchase and evaluation feedback
Surviving	2013, 2014, 2015, 2016	2013, 2014, 2015, 2016	2013, 2014, 2015, 2016
	2014, 2015, 2016	2014, 2015, 2016	2014, 2015, 2016
Exiting	2013, 2014	2013, 2014	2013, 2014
	2013	2013	2013
	2013	2015	2013 and 2015
	2013	2013,2014	2013 (Likert average of 2013 and 2014)
	2013, 2014, 2016	2013, 2014	2013, 2014
	2013, 2014, 2016	2013	2013
	2010, 2011, 2012, 2013	2013	2013[a]
Entering	2015, 2016	2015, 2016	2015, 2016
	2016	2016	2016
	2013, 2015, 2016	2016	2016
	2014, 2015, 2016	2016	2016
	2013, 2015, 2016	2015, 2016	2015, 2016
	2014, 2015, 2016	2015, 2016	2015, 2016
	2013, 2014, 2015, 2016	2015, 2016	2015, 2016

[a] These suppliers have purchasing records from earlier years (i.e., 2010, 2011, 2012). However, due to availability of evaluation data from 2013 onwards, in this study, we took year 2013 as a base for purchasing and performance analysis of entire suppliers.

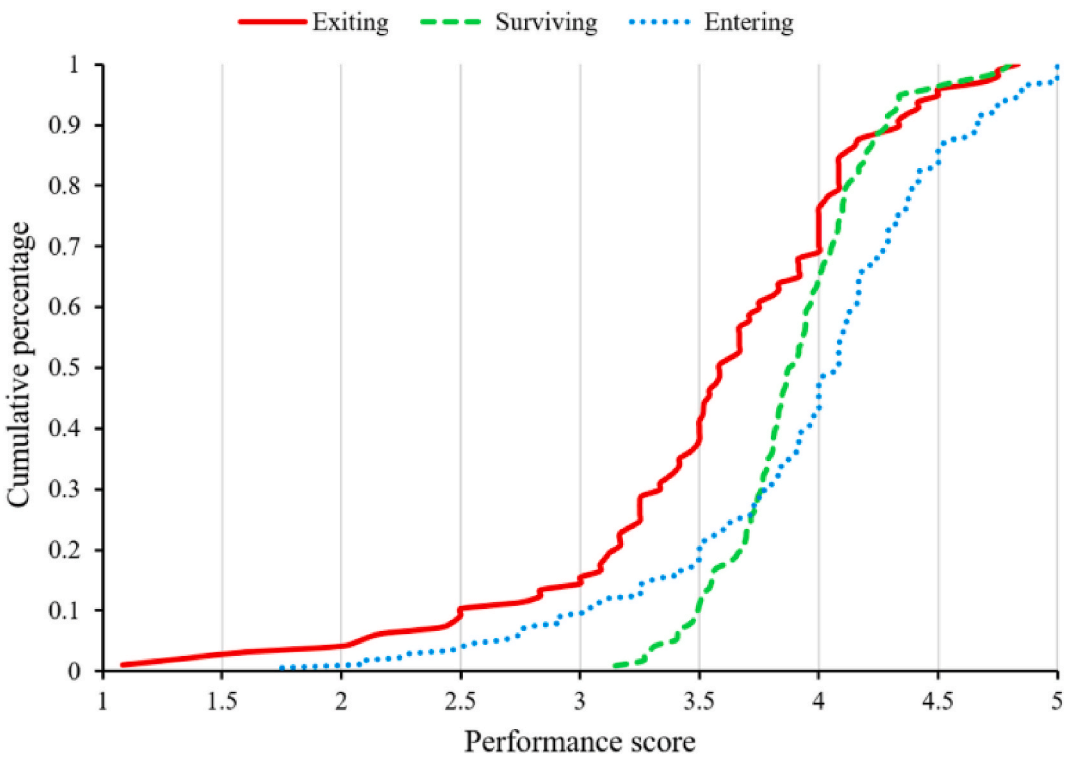

Fig. A1. Suppliers' performance within the groups (sample size; exiting = 97, surviving = 118, entering = 176).

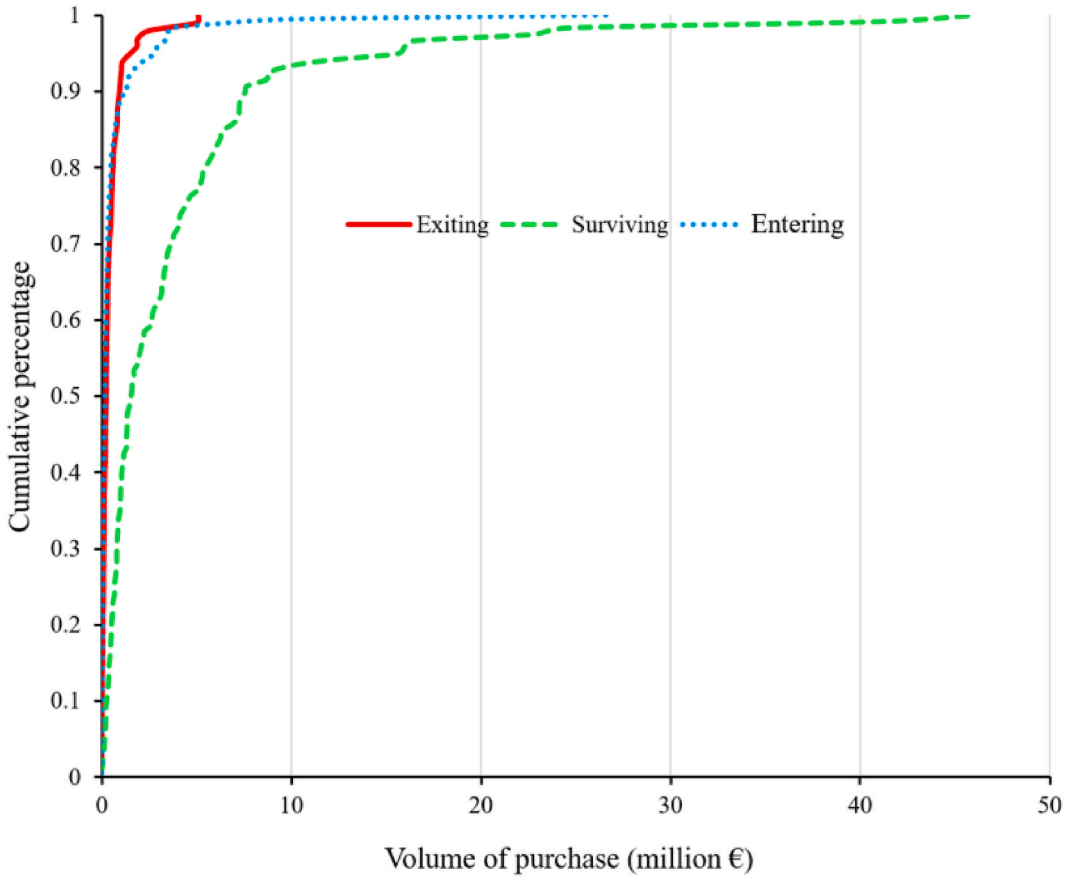

Fig. A2. Amounts of purchase (€) from different supplier groups (sample size: exiting = 97, surviving = 118, entering = 176).

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