Exploiting the potential of manufacturing network embeddedness: an OM perspective

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Abstract

Purpose – This paper provides guidance in setting the level of autonomy (i.e. parental control) of plants in a network to enhance operational performance. In particular, the effect of autonomy on performance is analysed directly and indirectly through internal manufacturing network integration and external supply chain integration as two dimensions of manufacturing network embeddedness.
Design/methodology/approach – The analysis is based on data from 441 manufacturing plants in 17 countries. Data were gathered during the sixth International Manufacturing Strategy Survey. Five main constructs were obtained after carrying out a confirmatory factor analysis: plant autonomy, internal manufacturing network integration, external supply chain integration, efficiency and effectiveness. Direct and indirect relationships among the constructs are tested through a structural equation model.
Findings – Higher levels of autonomy correlate with higher effectiveness and similar efficiency. However, lower autonomy leads to higher levels of manufacturing network and supply chain integration, which enhance performance. Although not statistically significant, the analysis of the total effects reveals a mildly positive effect of autonomy on effectiveness and negative effect on efficiency, which requires further investigation.

Research limitations/implications – Further research could include headquarters' perspectives or additional determinants (e.g. business strategy objectives).
Practical implications – Managers should set autonomy levels strategically: higher for effectiveness and lower for efficiency. However, lower autonomy can also strengthen internal manufacturing network integration and external supply chain integration, thus improving operational performance.
Originality/value – The concept of manufacturing network embeddedness highlights the importance of considering external supply chain and internal manufacturing network integration in the same framework, as both dimensions can affect operational performance.

Keywords – plant autonomy, internal/external integration, manufacturing network embeddedness, operational performance

Paper type Research paper

Introduction

In recent decades, many medium and large manufacturing companies have gone from producing at single sites to having multiple production plants spread around the globe. Among other advantages, multiple plants allow companies to gain access to new skills or low-cost resources (Ferdows, 1997b). This potential has been recognised and manufacturing networks have received increasing attention among researchers and practitioners alike (Cheng *et al*., 2011; Rudberg and West, 2008). Still, the coordination of plants in the network to improve performance has yet to be fully explored (Cheng et al., 2015).

One of the central coordination mechanisms is the level of autonomy given by headquarters to the plants. Generally, autonomy is defined as the extent of freedom of a subsidiary manager to make decisions at the strategic and operational level (McDonald et al., 2008; O'Donnell, 2000; Young and Tavares, 2004).

Several studies reveal that autonomy is an important coordination mechanism (Gammelgaard *et al*., 2012; Gomez and Werner, 2004; Young and Tavares, 2004). Although most studies report a positive relationship between subsidiary autonomy and performance (Kawai and Strange, 2014), some research indicates that the level of autonomy can be too high, leading to isolation of the subsidiary in the network, thus negatively influencing performance (Keupp et al., 2011; Monteiro et al., 2008). These mixed results concerning the relationship between autonomy and performance may be due to additional factors. For instance, some authors (e.g. Kawai and Strange, 2014;

Keupp et al., 2011) argue that different levels of embeddedness can affect the autonomy–performance relationship.

The level of embeddedness corresponds to the level of collaboration and exchange of knowledge of a subsidiary with internal partners (i.e. other subsidiaries within the company-wide network) and external partners (i.e. suppliers and customers), and it has been widely advocated as a performance-enhancing factor (Kawai and Strange, 2014). The concept of embeddedness, as applied in the international business literature, combines notions of how to benefit simultaneously from collaboration with external partners and from being part of a company with internationally dispersed subsidiaries (Holm et al., 2005).

However, only a few studies in the international business literature have examined the level of autonomy, embeddedness and performance as part of a single analysis (Birkinshaw et al., 2005; Gammelgaard et al., 2012; McDonald et al., 2008). This gap becomes even more evident when considering the impacts of these factors on the operational level (i.e. operational performance). We are not aware of any large-scale study in Operations Management whereby the impact of decisions regarding autonomy and embeddedness on operational performance is analysed. However, understanding the relationships among these dimensions is important for understanding how to coordinate the manufacturing network successfully.

As a consequence, this paper examines how a manufacturing network coordination mechanism (i.e. autonomy) impacts operational performance directly and indirectly through manufacturing network embeddedness. In particular, the study considers manufacturing network embeddedness by means of two distinct constructs: integration in the internal manufacturing network and in the external supply chain, respectively. In contrast to the international business literature, which studies subsidiaries with a variety of functions, we focus specifically on manufacturing networks. These networks are composed of manufacturing plants and have primarily operations-related objectives. Consequently, the aim of our research is to answer the following research question: *How does autonomy and manufacturing network embeddedness influence operational performance?*

Thus, the focus is on plants that are part of an intra-company manufacturing network and that are connected to external suppliers and customers (Figure 1).

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The paper is organised as follows. First, the theoretical background and the research hypotheses is developed. Next, the method is presented, including the operationalisation of autonomy, integration and performance from an Operations Management perspective. After that, the results of the analysis are presented and discussed. Finally, the contributions of the paper are summarised, and the limitations and future developments are highlighted.

Theoretical background and hypotheses

Many studies have demonstrated the importance of understanding business networks (e.g. Andersson and Forsgren, 2000; Birkinshaw *et al*., 2005; Forsgren and Holm, 2010). Business networks are composed of subsidiaries that enfold different functions (e.g. R&D, manufacturing, sales) and these subsidiaries can have different levels of autonomy with regards to operational and strategic decisions (Birkinshaw and Morrison, 1995; Kawai and Strange, 2014; O'Donnell, 2000). Moreover, each subsidiary can have relationships with external partners (i.e. suppliers and customers) and internal partners (i.e. other subsidiaries of the same legal company) and these relationships can differ in terms of histories, qualities, and extent of collaborative activities (Andersson and Forsgren, 2000).

Manufacturing networks, which are composed of manufacturing plants and have primarily operations-related objectives, are a specific class of business network. Despite the differences between general business networks and manufacturing networks, autonomy and internal and external collaborative activities are also important for manufacturing plants. In particular, this paper focuses on how these factors affect operational performance.

Studies on networks, especially in the international business area, consider financial/market performance (e.g. return on investment, growth) or strategic performance (e.g. innovation, competence development). This study aims to provide insights into the underlying mechanism of manufacturing network embeddedness and how the level of autonomy and relationships with internal and external partners support a manufacturing plant in improving efficiency and effectiveness. Consequently, this study does not employ measures of performance such as innovation or growth in sales, which would not directly measure operational improvements in efficiency and effectiveness of a plant but are mainly influenced by R&D activities. On the contrary, the paper focuses on operational performance as defined by Flynn et al. (2010), Vereecke et al. (2006) and Szász et al. (2016). In line with the studies in the strategic management literature (starting from Porter, 1985), we refer to two classes of operational performance: efficiency (cost and lead-time) and effectiveness (quality, delivery, flexibility). These categories are also found in the OM literature (e.g. Beamon, 1999; Jeong and Phillips, 2001; Szász et al., 2016).

Another note regarding the performance indicators used in this study is about the use of objective vs subjective measures. Objective measures are not widely employed in the literature, as industries can differ significantly (Van der Vaart and Van Donk, 2008). Subjective measures are much more frequently adopted in quantitative studies comparing business results to competitors (e.g., Kalchschmidt et al., 2010) or in improvement terms (e.g., Caniato et al., 2013). Given the ultimate goal of showing how to exploit the potential of the manufacturing network, a performance improvement measure was chosen. In this way, the analysis can show managers dealing with manufacturing networks how they can improve performance levels by acting on other key variables (autonomy, internal manufacturing network and external supply chain integration).

The remainder of this section first introduces the two dimensions of external supply chain integration and internal manufacturing network integration and describes their relationship to performance. Then, the association between autonomy and performance is described. Finally, following the argumentation of the business network theory, the paper discusses how the level of autonomy of a plant is associated with the extent of integration into the internal manufacturing network and into the external supply chain.

External supply chain integration (SCI)

The term "integration" is defined as "the unified control of a number of successive or similar economic or especially industrial processes formerly carried on independently" (Webster's, 1966). Translated into operations management terminology, integration refers to the extent to which separate parties work together in a cooperative manner (O'Leary-Kelly and Flores, 2002).

Within the supply chain literature, the role of integration and its influence on performance is a central theme (Van der Vaart and Van Donk, 2008). Integration describes processes that are aligned to ensure a high level of customer value (Pagell, 2004). More specifically, external supply chain integration refers to the degree to which a subsidiary executes collaborative and synchronised processes with its key suppliers and customers (Chen and Paulraj, 2004; Stank et al., 2001; Zhao et al., 2011). From this line of argument, the following definition for external supply chain integration for this specific research project is derived:

"External supply chain integration (SCI) is a process of interaction and collaboration in which a specific manufacturing plant and its supply chain partners (i.e. suppliers and customers) work together, share information and make joint decisions to achieve results not achievable by the plant alone."

A large body of studies associates SCI with better performance. Among others, Schoenherr and Swink (2012), Flynn et al. (2010) and Van der Vaart and Van Donk (2008) provide overviews and discussions of the dimensions of SCI and its relationship with performance improvement.

Schoenherr and Swink (2012) highlight the fact that many researchers justify this improvement using a resource-based view of firms (RBV) (e.g. Chen et al., 2009; Das et al., 2006; Devaraj et al., 2007). In particular, these authors argue that routines and competences stemming from collaborative relations are unique resources that cannot be easily replicated (Holweg and Pil, 2008) and that they help to improve operational performance (Das et al., 2006; Swink et al., 2007). Applying these theoretical foundations, efforts undertaken to build up relational competences through external SCI practices are likely related to improvements in operational performance. For example, the effort undertaken to achieve a higher level of integration is likely to be positively related to higher operational efficiency through quicker identification and communication of challenges, joint problem solving efforts and deeper understanding of each organisation's processes (Schoenherr and Swink, 2012). Similarly, information-sharing activities improve operational effectiveness (e.g. delivery speed, reliability and flexibility) by providing accurate and up-to-date demand and supply information (e.g. information about production plans and forecasts) (Lee *et al*., 2004). The international business literature also finds a positive effect of SCI on performance. Within these studies, performance is often represented by learning and innovation (Andersson et al., 2001; Frost, 2001; McDonald et al., 2008) or the development of useful resources and assets (Andersson et al., 2002; Frost et al., 2002). Herein, different performance measures than the ones described above are applied in the analysis of plant activities and hence, the influence of operational performance. Thus, in alignment with the RBV argumentation, a positive relationship between SCI and operational performance is formulated:

H1: For plants in a manufacturing network, a higher level of external supply chain integration (SCI) is associated with a higher level of operational performance.

While many studies have already confirmed this hypothesis, this analysis occurs within the context of manufacturing networks, and hence, its theoretical contribution should be seen in relation to the overall set of hypotheses developed in the remainder of this section.

Internal manufacturing network integration (MNI)

In manufacturing networks, the underlying goal of internal integration is to coordinate and exchange knowledge among plants belonging to the same company-wide manufacturing network in order to improve performance (Kogut, 1990; Podolny and Page, 1998; Shi and Gregory, 1998). This type of integration occurs only between plants of the same manufacturing network and should not be confused with *supply chain internal integration*, which refers to collaborative processes and practices between different *functions of the same plant* (Morash and Clinton, 1998; Pagell, 2004; Williams *et al*., 2013) and hence can occur even in stand-alone plants. This paper refers only to multinational network integration (MNI) to represent collaborative activities among plants within the same intra-company network and does not consider integration between functions of the same plant.

Accordingly, the following definition is used in this paper:

> "Internal manufacturing network integration is a process of interaction and collaboration in which a specific manufacturing plant and other plants of the same company work together, share information and make joint decisions to achieve results not achievable by the plant alone."

Different studies have analysed the relationship between MNI and performance. For example, Chew et al. (1990) demonstrate that the transfer of innovation to other plants in a network enhances the performance of the manufacturing network as a whole. From the focus of a single plant integrated into a wider intra-company manufacturing network, Vereecke *et al*. (2006) demonstrate that different plant types, which are derived from knowledge flows, do not present differences in performance. However, with reference to the international business literature, a higher MNI is often associated with higher performance. For example, MNI can create opportunities for a subsidiary to learn from other subsidiaries (Bartlett and Ghoshal, 1989; Gupta and Govindarajan, 2000), positively influencing the subsidiary's performance (Venaik et al., 2005). It is also argued that a higher number of direct exchanges with other subsidiaries is important for a subsidiary's development potential (Forsgren *et al*., 2007; Ghoshal and Bartlett, 2005).

Considering the notion of the RBV, manufacturing plants can build up unique competences through interaction with other plants within the same company and use these competences to improve performance. One of the main reasons multinationals exist is the possibility that their subsidiaries can jointly create and use technological assets across national boundaries (Dunning, 1993). Hence, the transfer of knowledge through integrated networks and the ability to absorb that knowledge through the exchange of employees or other collaborative activities may improve the plants' operational efficiency and effectiveness.

Though very few studies have analysed the effect of inter-plant integration on operational performance in a manufacturing network context, given the positive impacts of collaborative activities on the other types of performance discussed above (e.g. learning, development), it can be hypothesised that operational performance can also be achieved through a higher level of MNI; therefore:

H2: For plants in a manufacturing network, a higher level of internal manufacturing network integration (MNI) is associated with a higher level of operational performance.

Several studies focus solely on external integration, i.e. with suppliers and customers (e.g. Cao and Zhang, 2011; Holweg and Pil, 2008) or internal manufacturing network integration (Szàsz et al., 2016). However, many researchers argue that integration covers internal as well as external collaboration activities (see Flynn et al. (2010) for a literature review). In particular, some studies provide examples of how knowledge gained through collaboration between plants of an internal manufacturing network with respect to process improvements may also be transferred to suppliers and customers and vice versa (Childerhouse and Towill, 2011; Miltenburg, 2009). As a consequence, we expect that MNI and SCI are two distinct constructs, but mutually related:

H3: For plants in a manufacturing network, a higher level of internal manufacturing network integration (MNI) is positively correlated with a higher level external supply chain integration (SCI).

Manufacturing plant autonomy

One central goal of global production managers or headquarters is to motivate plant managers to share knowledge and information and to turn it into improvements in effectiveness and efficiency. To do so, global production managers can implement different coordination mechanisms. Several coordination mechanisms, such as the level of standardisation, centralisation, autonomy, and degree of cooperation and competition have been discussed in the literature (Deflorin *et al*., 2015). Decisions about the level of autonomy appear to influence decisions related to standardisation, thereby defining the degree of competition and cooperation in a manufacturing network. Consequently, autonomy is the cornerstone for other coordination mechanisms and is emphasised in this paper.

Many studies approach autonomy from two perspectives: operational and strategic (Birkinshaw and Morrison, 1995; Kawai and Strange, 2014; O'Donnell, 2000). Strategic autonomy corresponds with the power to make decisions in the adoption and development of production systems or policies in R&D or marketing (Birkinshaw and Morrison, 1995; Davis and Meyer, 2004). Operational autonomy includes tacit decisions and the management of day-to-day operations (McDonald *et al*., 2008). Autonomy given to a subsidiary has often been analysed as the counterpart of centralised parental control (e.g., O'Donnell, 2000; Young and Tavares, 2004), and the balance between autonomy and parental control is one of the most challenging tasks for practitioners (Van Dut, 2013). Thus, autonomy is also defined as the distribution of decision-making power between a local unit and an outside unit controlling it, i.e. headquarters (Birkinshaw *et al*., 2004; McDonald *et al*., 2008). Transferred to this paper, this results in the following definition:

> "Manufacturing plant autonomy is the degree to which a plant in a manufacturing network has strategic and operational decision-making authority."

One of the theoretical perspectives applied by researchers analysing autonomy is business network theory (Andersson *et al*., 2005; Forsgren and Holm, 2010). This perspective implies that headquarters is a relative outsider of the local business context and hence cannot successfully coordinate the activities carried out by the subsidiaries (Van Dut, 2013). Several studies show that higher subsidiary autonomy positively influences subsidiary performance (see Kawai and Strange, 2014 for an overview). For example, researchers demonstrate that autonomy fosters organisational learning and knowledge creation and diffusion (Luo, 2003; McDonald *et al*., 2008; Young and Tavares, 2004). Furthermore, autonomy improves performance outcomes in terms of cost (McDonald et al., 2008), flexibility (Doyle, 1990), and innovation (Ghoshal and Bartlett, 1988; McDonald *et al*., 2008; Tavares and Pearce, 2002). Others, however, challenge these findings and argue that autonomy may negatively influence performance as it prevents subsidiaries from identifying specialised resources within the network (Birkinshaw and Hood, 1998; Keupp *et al*., 2011).

Some of the studies described above use different autonomy and performance measures than the ones applied in this study, which focuses on the manufacturing network context. This study follows the idea of the business network theory and builds upon previous research results showing that, for example, autonomy improves cost and flexibility (Doyle, 1990; McDonald *et al*., 2008). Hence, similar findings related to autonomy and operational performance are expected:

H4: A higher level of manufacturing plant autonomy is associated with a higher level of operational performance.

Furthermore, the literature demonstrates that autonomy is also related to MNI and SCI (Monteiro *et al*., 2008; Noorderhaven and Harzing, 2009; Vereecke *et al*., 2006). For instance, Noorderhaven and Harzing (2009) argue that subsidiary autonomy leads to isolation, implying that the level of MNI is lower. Very autonomous subsidiaries have been found to be less motivated to interact with other plants (Andersson and Forsgren, 1996; Birkinshaw *et al*., 1998; Phelps and Fuller, 2000; Taggart, 1997) and to send or receive knowledge (Monteiro *et al*., 2008; Noorderhaven and Harzing, 2009; Vereecke *et al*., 2006). Furthermore, a plant's freedom to set its own strategy could lead to considerable strategic differences, and this diversity can reduce the perceived benefit of exchanging knowledge with other plants (Scherrer-Rathje and Deflorin, 2015). Hence, it is assumed that a higher level of autonomy leads to a lower level of MNI in terms of collaboration, joint decision making and information sharing. In conclusion:

H5: A higher level of manufacturing plant autonomy is associated with a lower level of internal manufacturing network integration (MNI).

On the contrary, higher subsidiary autonomy — and thus lower parental control — helps subsidiary managers focus on external business relationships (Andersson and Forsgren, 1996; Birkinshaw *et al*., 2005; Gammelgaard *et al*., 2012). Knowledge about how to get involved and exploit the specific business environment (i.e. suppliers and customers) often resides at the subsidiary (Andersson *et al*., 2005; Ciabuschi *et al*., 2011). The theoretical perspective summarising this argumentation is again the business network theory, according to which headquarters does not have superior knowledge compared to subsidiaries. Following this line of reasoning, headquarters provide autonomy in order to enable the plant to respond to local conditions and fully exploit its supply-side and customer-side market knowledge (Miltenburg, 2009). In addition, if resources are constrained, autonomy facilitates innovations because subsidiaries take advantage of existing relationships with external partners (Gammelgaard *et al*., 2012). Thus, a manufacturing plant with the freedom to exploit existing business relationships with suppliers and customers is more likely to engage intensively with supply chain partners and, it follows, to be highly integrated. Hence, the following hypothesis:

H6*: A higher level of autonomy is associated with a higher level of external supply chain integration (SCI).*

In conclusion, Figure 2 provides a summary of the research framework and related hypotheses. The two concepts of MNI and SCI are considered in parallel as two distinct aspects of manufacturing network embeddedness. Moreover, the hypotheses have a competing structure: if the power of autonomy to increase performance directly (H4) and indirectly (H6+H1) through SCI is lower than its negative effect through MNI (H5+H2), then the total effect is negative. So, while all the hypotheses may hold true, path analysis is performed to assess the power of the estimates and, ultimately, the total effect of autonomy on performance. In conclusion, hypotheses 5 and 6 are in line with Ambos et al. (2011), who found that the majority of studies associate a high level of MNI with a low level of autonomy and a high level of SCI with a high level of autonomy. Consequently, according to the presented theoretical framework, global production managers from headquarters try to set the level of autonomy in order to strengthen performance, but they face a trade-off: the chosen level of autonomy strengthens either MNI or SCI but not both. This paper attempts to shed light on this trade-off from an Operations Management point of view.

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Methodology

The hypotheses are tested using the 2013–2014 International Manufacturing Strategy Survey dataset (www.manufacturingstrategy.net). This project, originally launched by the London Business School and Chalmers University of Technology, studies manufacturing strategies within the assembly industry (ISIC 25-30 classification) through a common questionnaire administered simultaneously in many countries by local research groups (Lindberg *et al.*, 1998). The main research goal of the project is to investigate the relationships among strategic priorities, manufacturing practices, improvement programmes, performance and contingent variables.

Companies are usually selected from local databases and operations, production or the plant manager is contacted regarding their willingness to participate in the research. If the respondent agrees, they receive the questionnaire. If necessary, they receive a reminder several weeks later. Returned questionnaires are controlled for missing data, which is handled on a case-by-case basis, usually by contacting the company again. Finally, all data are grouped into a unique database, which is further controlled by the project coordinator and distributed to all partners.

The first section of the questionnaire relates to the business unit (gathering general information, such as company size, industry, production network configuration, competitive strategy and business performance); other sections refer to the plant (focusing on manufacturing strategies, practices and performance). Although the structure of the questionnaire has remained the same with every edition, some questions have been updated or removed, and new questions have been added by the design team, which is composed of a pool of international researchers in order to avoid researchers' country biases (Van de Vijver and Leung, 1997). In particular, for the purposes of this study, specific questions were asked about the level of autonomy, the degree of internal and external integration and operational performance.

From the original sample of more than 900 answers, 441 usable answers were drawn from companies from different countries. In particular, companies missing essential information (such as the ISIC code and company size), companies with less than 50 employees, stand-alone companies (i.e. not part of a manufacturing network) and companies not providing information for all of the items utilised in this study were excluded. Finally, all countries not providing at least 15 cases in line with other studies using the same dataset were dropped (Gimenez *et al*., 2012). Table 1 presents the distribution of the sample in terms of country, industry and company size.

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Autonomy is measured using two items. The respondent provides a score from 1 to 5 for the degree of autonomy in planning and taking strategic decisions (the scale is reversed, so that a higher value corresponds to higher autonomy). In alignment with the literature and with respect to the present operations management context, autonomy was measured at the strategic and operational levels (Birkinshaw and Morrison, 1995; O'Donnell, 2000). *Strategic autonomy* measures the degree of a plant's autonomy in defining its own competitive strategy (Buckley and Ghauri, 2004; O'Donnell, 2000; Taggart and Hood, 1999). *Operational autonomy* was based on Maritan *et al*. (2004), which found that the level of autonomy in planning is particularly significant in explaining differences among plant roles, while the same does not hold for the level of autonomy in production and control. Consequently, *operational autonomy* was measured as the degree of freedom of the plant manager to decide on production planning.

Internal *manufacturing network integration* (MNI) refers to direct exchanges between subsidiaries, which may involve information sharing, cross-functional teams, joint planning or working together (Cheng *et al*., 2011; Meijboom and Vos, 1997). The exchange involves the integration of data and information systems (Williams *et al*., 2013) in order to reach better performance at the network level (Gupta and Govindarajan, 1991; Henderson, 2003).

Based on the provided literature, MNI is assessed using means of four items that measure, on a 1–5 Likert scale (1: none, 5: high), the effort expended over the last three years in implementing related action programmes. These items include:

- Improve information sharing for coordinating the flow of goods between the respondent's plant and other plants of the network (e.g. through exchange of information on inventories, deliveries, production plants, etc.) (Rudberg and Olhager, 2003)
- Improve joint decision making to define production plans and allocate production in collaboration with other plants in the network (e.g. through shared procedures, shared forecasts) (Colotla *et al*., 2003; Jansen *et al*., 2005)
- Improve innovation sharing/joint innovation with other plants (through knowledge dissemination and exchange of employees inside the network) (Ghoshal and Bartlett, 1988; Rabbiosi, 2011; Vereecke *et al*., 2006)
- Improve the use of technology to support communication with other plants of the network (e.g. ERP integration, shared databases, social networks) (Gupta and Govindarajan, 2000)

External *supply chain integration* (SCI) is measured using six items (three on the supplier side and three on the customer side) measuring, on a 1–5 Likert scale (1: none, 5: high), the effort expended over the last three years in implementing related action programmes. In line with the literature (e.g. Droge *et al*., 2012; Germain and Iyer, 2006), these items include customer-side and supplier-side items. One item is included for each of the most common integration areas in terms of attitude and practices (Van der Vaart and Van Donk, 2008): developing collaboration approaches with suppliers (Handfield *et al*., 2006; Spekman, 1988), information exchange (Ellinger et al., 2000) and joint decision-making. Appendix 1 provides a detailed description of the items composing these three constructs. Given the purpose of understanding the role of external integration as a whole concept, external SCI is used as a unique second-order construct measured by supplier and customer integration (Byrne and Stewart, 2006; Danese *et al*., 2013). This procedure is also supported from the statistical point of view, as supplier integration and customer integration constructs show a significant correlation (.576, p = 0.000), in line with other studies (Wiengarten *et al*., 2014; Wong *et al*., 2011).

Finally, *operational performance* improvement is assessed by considering a set of questions that asks, “how has your manufacturing performance changed over the past three years”, where scores range from 1 (decreased by 5% or worse) to 5 (strongly increased by 25% or better). In line with the literature, the following areas of performance and related items were considered: efficiency (unit manufacturing cost, ordering costs, manufacturing lead time – each one measured by one item) and effectiveness (quality, delivery, flexibility – each one measured by two items each).

Using all of the items mentioned above, a confirmatory factor analysis was performed. As already mentioned, two of the five constructs are measured as second-order constructs in the following way:

- SCI: measured by supplier integration (three items) and customer integration (three items)
- Effectiveness: measured by quality, flexibility and delivery (two items each)

Table 2 gives the detailed results.

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The analysis presents good fit indices (χ^2/df = 1.702; NFI = 0.932; CFI = 0.971; RMSEA = 0.040) according to the suggestions provided by the literature (CMIN/DF < 2-5; NFI > 0.90; CFI > 0.90; RMSEA < 0.05) (Byrne and Stewart, 2006; Hair *et al*., 1998; Sharma, 1996). The model also passes the discriminant validity test using Fornell and Larcker (1981) procedure, i.e. checking that the square root of average composite reliability of each construct is always larger than the correlation with the other constructs (Table 3).

A path analysis using a structural equation model is used to verify the research hypotheses. This approach allows simultaneous assessment of direct and indirect effects given that the model has multiple tiers (autonomy, integration, performance).

The preliminary analyses tested the effect of the following control variables. First, company size was considered (calculated as the logarithm of the number of employees). Company size is one of the most common control variables used in management studies (McDonald *et al*., 2008); for instance, Hedlund (1979) found that autonomy increased with subsidiary size. Moreover, size can affect the resources and power available in the company to implement SCI (Mentzer *et al*., 2001). Next, gross national income (GNI) per capita of the country where the plant is located was considered. This is a proxy for the level of development of a country, which, for example, can affect its level of integration with suppliers and customers (e.g. Wiengarten *et al*., 2014) or its performance due to cyclical fluctuations of the local economy. Moreover, this variable can be correlated to the level of autonomy, i.e. plants in developed countries are expected to have higher autonomy (Christmann *et al*., 2000). Furthermore, IMSS is a multi-country project, and thus it is useful to have a control variable at the country level that is not a country dummy, which would fragment the sample (Danese and Kalchschmidt, 2011). Consequently, GNI per capita has been frequently used in papers using the same dataset used here (e.g. Gualandris *et al*., 2014; Jonsson *et al*., 2011). Furthermore, geographical scope of the subsidiary was measured using a Likert-type scale variable ranging from 1 ("your plant serves only a specified surrounding geographic area/market") to 5 ("your plant serves the entire world/global market"). This variable can affect the level of autonomy (i.e. the narrower the scope, the higher the level of autonomy), the level of SCI (i.e. the more global the scope, the more difficult to integrate with other members of the supply chain, especially customers) and the effectiveness of performance (i.e. the more global the scope the more difficult to ensure delivery speed and reliability). Similar considerations on the role of this variable can be found in other studies (Birkinshaw and Morrison, 1995; Rugman and Bennett, 1982; Rugman and Poynter, 1983; White and Poynter, 1984).

The analysis also considered intra-network purchases measured as a percentage of inputs (goods and services) sourced by the plant from other plants in the manufacturing network compared to inputs sourced from external suppliers. This variable can help differentiate plants in more process-oriented networks from those that are more market-oriented (Rudberg and Olhager, 2003; Shi and Gregory, 1998).

Finally, the analysis considered the level of responsibility related to product and process development. According to the literature (Ferdows, 1997a; Ferdows et al., 2016; Vereecke and Van Dierdonck, 2002), plants can be characterised by different levels of responsibility with regards to R&D processes, which can be related to higher autonomy and integration within and outside of the network to source for innovation-related knowledge that does not lie in the plant (Hajmohammad *et al*., 2012; Wu, 2013).

Intra-network purchases and the level of responsibility for product and process development correlate with autonomy but do not affect the dependent variables in the model (i.e. MNI, SCI, efficiency and effectiveness). Regarding the other control variables, only GNI per capita of the country was found to have a significant effect on the dependent variables. Thus, GNI per capita was the only control variable left in the model correlated with autonomy and connected directly with SCI, MNI, effectiveness and efficiency.

Finally, in line with H3, we added a correlation term between MNI and SCI. In order to ensure that the correlation was the right modelling approach, we checked first that MNI was not an enabler (i.e., necessary condition) for SCI and vice versa, but no evidence of this relationship was found (Dul, 2015). Next, it was checked whether SCI and MNI belong to the same construct due to common method bias or problems for the respondent to distinguish between the two constructs. In particular, a single *integration* construct was created wherein MNI is an additional first-order construct of SCI (the other two first-order constructs are customer and supplier integration). In this case, the confirmatory factor analysis and the final model have a lower fit compared to the initial models with the correlation. Beside the standard measures of fit (NFI, CFI, RMSEA), the AIC (Akaike Information Criterion), which is used to compare non-nested models, suggests that the original models where MNI and SCI are two separate constructs have a better fit (see Appendix 2). Furthermore, all the results obtained with the integrated model remain aligned with the original model, but with a lower level of detail. In conclusion, the data suggest that SCI and MNI are two separate constructs, but with a reciprocal influence. In order to model this relationship correctly, a correlation term was left between MNI and SCI. Figure 3 shows the final model.

TAKE IN FIGURE 3

Before discussing the results, it is important to remember that although the questionnaire is designed to minimise common method bias (by ensuring anonymity, clarity and brevity of questions and the spread of the questions throughout the questionnaire), the Harman's one single-factor test was run (Podsakoff *et al.*, 2003) to verify that common method bias is not an issue here. In particular, considering only one factor for all the variables provides a model with a very bad fit (χ^2/df = 12.307; RMSEA

= 0.160; NFI = 0.465; CFI = 0.484). Moreover, as pointed out by Wiengarten *et al.* (2014), the respondents in the IMSS sample self-report as average performers (average return on sales compared to competitors of 3 in a scale from 1 to 5), thus showing a reduced propensity for social desirability.

Results

To test the results, a path analysis was performed using a structural equation model based on the one reported in Figure 3. The overall model shows good fit indices (χ^2/df = 2.076; NFI = 0.911; CFI = 0.95; RMSEA = 0.049) according to the recommendations provided by the literature (CMIN/DF < 2–5; NFI > 0.90; CFI > 0.90; RMSEA < 0.05) (Byrne and Stewart, 2006; Hair *et al.*, 1998). In line with the earlier CFA, the measurement model looks reliable (AVE > 0.5 and CR > 0.7 for all constructs).

Table 4 shows the results for the structural model.

TAKE IN TABLE 4

Apart from the effect of GNI, used as a control variable, the relationship between SCI and performance is analysed starting from the bottom of Table 4. SCI appears to be strongly and positively associated with both effectiveness (0.304, p = 0.005) and efficiency (0.360, p = 0.002), leading to a full acceptance of H1. On the contrary, MNI shows a significant relationship only with effectiveness (0.199, p = 0.048), but not with efficiency, thus only partially confirming H2. H3 is confirmed, as the correlation between SCI and MNI is significant. Next, autonomy is positively related to effectiveness (0.148, p = 0.029), but not to efficiency, thus only partially confirming H4. Finally, autonomy is negatively related to MNI (−0.294, p < 0.001), confirming H5, but also to SCI (−0.168, p < 0.001), thus leading to a rejection of H6.

Table 5 provides a summary of the research hypotheses and Figure 4 shows the model with only the significant relationships reported. The results are confirmed even in the model with MNI and SCI integrated in the same construct (figure in Appendix 2).

TAKE IN TABLE 5

Given the chain of significant relationships from autonomy, through MNI and SCI, to performance, it is worth analysing the total effect of autonomy on performance. The total effect of autonomy through MNI and SCI on effectiveness is 0.019 (0.038 unstandardised). The total effect of autonomy on efficiency is −0.042 (−0.066 unstandardised). However, these effects are not significant. Appendix 2 reports a comparison of these results with the total effects calculated after integrating SCI and MNI in a single construct. The results are very similar to those initially obtained.

TAKE IN FIGURE 4

Discussion

The results described herein show that SCI improves operational performance (H1), in agreement with the majority of the studies in the field (e.g. Anderson and Parker, 2002; Flynn *et al*., 2010; Schoenherr and Swink, 2012; Van der Vaart and Van Donk, 2008). In particular, the findings, based on a sample of 441 manufacturing firms that belong to a manufacturing network, show that SCI improves efficiency and effectiveness to a very similar extent.

Departing from this baseline hypothesis (SCI improves performance), two components of a manufacturing network were introduced: autonomy and MNI. The latter (MNI) corresponds to the interplay among different plants; the results showed that MNI is related to higher effectiveness but not to higher efficiency (H2). Hence, MNI may be an enabler for learning from other subsidiaries (Bartlett and Ghoshal, 1989; Gupta and Govindarajan, 2000) and a support for plant managers to develop unique resources and improvements, but only when related to effectiveness performance (i.e. quality, delivery, flexibility). On the other side, improvement of efficiency relates to initiatives other than MNI, such as collaboration with supply chain partners. The exchange between plants is not necessarily focused around the production of one joint product; each plant of the same internal manufacturing network may produce a different product using different processes, hence reducing the effect of efficiency-related collaborations within the network.

However, the positive and significant correlation between MNI and SCI (H3) suggests that MNI and SCI support each other in a co-creation process. A plant can learn from other plants and transfer this knowledge to supplier and customers and vice versa (Ambos et al., 2011; Ambos et al., 2006; Childerhouse and Towill, 2011). In conclusion, while efficiency seems to be enhanced only by SCI, SCI may be supported by MNI. Therefore, plants that are part of a multinational network may have an advantage in developing collaborative relationships with supply chain members (and therefore achieving better performance) thanks to the knowledge acquired from the internal network. Consequently, these findings strengthen the perception that the overall manufacturing network embeddedness of a plant in its internal and external networks strengthens its performance achievements.

To obtain insight into how the level of autonomy influences the level of integration of the plant, the study also analysed the effect of autonomy on MNI (H5) and SCI (H6). As discussed in the literature review, the literature reveals a positive link between autonomy and SCI (Ciabuschi *et al.*, 2011) and a negative link between autonomy and MNI (e.g., Gammelgaard *et al.*, 2012; Noorderhaven and Harzing, 2009). Contrasting this, the results here show that if the level of autonomy is higher, MNI and SCI are reduced at the same time. This result can be explained through headquarters-centred theory (Forsgren and Holm, 2010; Van Dut, 2013). From this perspective, headquarters is understood as the centre of the network, which coordinates the other units of the network (i.e. plants). Hence, headquarters has the ability to determine and allocate resources to the appropriate plants in the network and can identify complementarities between plants. For example, if a plant needs to develop specific capabilities, headquarters can identify another plant that is able to provide knowledge and support this development.

Hence, these results show that, by restricting a plants' autonomy, headquarters supports manufacturing plants in developing their MNI and SCI. Therefore, based on the results, the study concludes that a low level of autonomy is positively related to SCI and MNI.

Finally, to understand the effect of autonomy on performance, the whole model must be considered. In line with the literature, the data showed that autonomy has a positive direct effect on performance, and especially on effectiveness. This finding taken alone supports the idea that higher autonomy is beneficial for the plant, in line with the business network theory, which emphasises the role of the subsidiaries in exploiting the local business environment (Andersson et al., 2005; Forsgren and Holm, 2010).

However, because of the indirect effects of autonomy through MNI and SCI, the total effect of autonomy on performance is actually very limited and, in the case of efficiency, it is negative. The fact that the total effect of autonomy on performance is not significant, shows that an isolated focus on the autonomy-performance relationship neglects important impacts deriving from the level of autonomy through internal and external manufacturing network integration. Moreover, these results can be seen in relation to the recently published study of Kawai and Strange (2014), despite the differences in the studied performance indicators. Kawai and Strange (2014) argue that the autonomy-performance relationship may be influenced by additional factors. Specifically, our results indicate that in order to understand the effect of autonomy on performance, manufacturing network embeddedness (i.e. SCI and MNI) has to be taken into account.

Also of importance, no evidence was found in the data of a trade-off between autonomy, MNI and SCI, as reflected in the hypotheses (i.e. if autonomy and SCI are high, MNI is low and vice versa). Interestingly, the findings here show a different trade-off, between efficiency and effectiveness. Although not statistically significant, the analysis suggests that companies aiming at improving efficiency should benefit from lower autonomy (due to higher SCI). On the contrary, companies aiming at improving effectiveness benefit from higher autonomy, though to a very limited extent if they do not simultaneously sustain MNI and SCI through proper investments. Consequently, by acting only on autonomy it is not possible to reach high efficiency and effectiveness simultaneously.

Conclusion

This paper presents an examination of 441 plants located in 17 different countries by gathering specific insights into the influence of autonomy in manufacturing networks on operational performance through manufacturing network embeddedness, here defined by the following two constructs: external supply chain integration (SCI) and internal manufacturing network integration (MNI).

The findings reveal that autonomy (or parental control) should be managed very carefully given its complex effect on plant integration and performance. In particular, the hypothesised trade-off based on the relationships *high autonomy → low MNI → low performance* and *high autonomy → high SCI → high performance* was not confirmed by the results. On the contrary, a higher level of autonomy relates to very limited effects in efficiency and effectiveness. This lack of effect is caused by MNI and SCI, which enhance performance, but which are reduced by higher autonomy. Thus, higher autonomy can lead to a reduced adoption of MNI and SCI practices and thereby a deterioration of operational performance in the long run. Moreover, the study demonstrates that it is important to consider MNI and SCI within the same model, as they are two dimensions of manufacturing network embeddedness related to both autonomy and performance.

Theoretical and managerial contribution

From a theoretical perspective, the study supports prior research using the resource-based view of firms (Chen *et al.*, 2009; Das *et al.*, 2006; Devaraj *et al.*, 2007). Assuming that manufacturing network embeddedness fosters competences that are not easily replicated, the results indicate that manufacturing network embeddedness can be a source of competitive advantage.

In addition, the results and their comparison to the literature indicate that manufacturing plants must be considered differently than other subsidiaries. Production plants do not necessarily have high R&D or marketing competences and, therefore, they may be dependent on the rest of the network for such activities and benefit from lower autonomy. In line with this, the analysis of the control variables showed that higher competences in product/process development are related to higher autonomy. However, while higher autonomy is generally associated with better subsidiary performance and integration in the local business environment, the results presented here suggest that, instead, a higher level of plant autonomy leads to fewer collaboration activities and thus lower efficiency. Thus, if headquarters restricts the level of autonomy of the plants, centrally orchestrating the strategic and operational decisions, then the level of plant integration is higher. In contrast to the business network theory, which emphasises the importance of subsidiary autonomy, these findings highlight the pivotal role and contribution of headquarters, in line with headquarters-centred perspectives (Forsgren and Holm, 2010; Van Dut, 2013).

Finally, this study contributes to operations management literature and, in particular, to supply chain management literature. The results show that for a plant in a manufacturing network, supply chain integration (SCI) features a complex interplay with autonomy, MNI and performance.

From a managerial perspective, the analysis reveals that increased parental control can strengthen manufacturing network embeddedness. The literature overview by Ambos et al. (2011) points out that most studies report a high autonomy–high SCI–low MNI relationship. The findings presented here help to shift the attention from this conflict to the concept of manufacturing network embeddedness. In fact, these results show that plant managers should accept a lower level of autonomy when this aids integration and learning from the internal and external networks. These results also suggest that MNI and SCI are associated, and hence, collaboration activities on either side of the integration support the other side.

Based on these results, the level of autonomy should be set according to the strategy of the plant. When efficiency is the main objective, lower autonomy is beneficial. On the contrary, higher autonomy can lead to improvements in effectiveness. However, higher autonomy carries the risk of weakening the manufacturing network embeddedness and reducing operational performance.

Furthermore, analysis of the control variables showed that the share of inputs sourced from other plants in the network is negatively correlated to autonomy. This highlights that for headquarters, it is easier to reduce the level of autonomy and therefore increase the integration of plants that exchange significant amounts of goods with other plants in the network. On the contrary, plants with little or no exchange of goods inside the network will require more effort and attention from headquarters when it comes to reducing their autonomy.

Limitations and further research

The results presented here should be considered in light of several assumptions and limitations of the study.

First, the unit of analysis used here is the manufacturing plant, with a focus on its performance improvements. Hence, it was not tested whether networks that have a higher level of embeddedness (MNI and SCI) perform better than networks with a lower level of embeddedness. Thus, future research may collect data from global plant managers in order to understand the differences on the network level.

Another interesting expansion relates to the MNI–performance relationship. Ambos et al. (2006) point out that knowledge inflows are not equally beneficial to all subsidiaries. The differences between the performance outcome of MNI and SCI could be found in the underlying type of knowledge. Supply chain partners often have the same prior knowledge stock (e.g. knowledge related to products), which helps them to absorb and translate knowledge into performance improvements (Gupta and Govindarajan, 2000). However, the knowledge stock of plants in the same manufacturing network may differ significantly as they may produce different kinds of products; hence, there may be no pre-existing knowledge base (Gupta and Govindarajan, 2000; Song, 2014). Therefore, in line with our results, the capability to absorb knowledge from collaborations within the internal network and transfer it to performance improvements is less developed than the capability to absorb and transfer knowledge from external supply chain partners. Hence, including the concept of absorptive capacity and prior related stock of knowledge of the knowledge recipient and the internal and external supply chain partners would be an interesting advance on this study.

Furthermore, given the time frame of this study (data were collected in 2013), the economic crisis could have played a role. Under this regime of market difficulty, a higher level of control might have helped multinational companies optimise their resources (the “thriftiness ability” discussed in Shi and Gregory, 1998). Nevertheless, excess control extended for many years can strangle the ability of a company to access local markets through supplier and customer interactions, consequently hindering the ability of the company to provide knowledge to the rest of the network (Young and Tavares, 2004). Therefore, the positive effect of low autonomy may be contingent on economic cycles and may hamper performance in the long run. Even though this study considered multiple countries with different economic cycles, hence supporting the generalisability of the results, future studies could try to replicate these results in different economic conditions.

Furthermore, while a linear relationship between autonomy and performance was hypothesised, this relationship could be shaped differently, e.g. reverse U-shape

(Chiesa, 1999; Taggart and Hood, 1999). In this case, the optimal level of autonomy would be moderate, whereas too little or too much would be disadvantageous.

Finally, a two-item scale was employed for autonomy, measuring its key dimensions of strategic and operational autonomy. Future studies could use richer measures of autonomy or investigate the impact of its single dimensions.

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Appendix 1: items of the questionnaire

Autonomy

How do you coordinate with other plants in the network? (the scale was reversed):

- A1: This plant is autonomous in defining the production plan (1) or Production plans are coordinated by another plant or an international division (5)
- A2: You can make your own strategic decisions (1) or The strategy is set by another plant in the network or an international division (5)

Internal manufacturing network integration

Indicate the effort put in the last 3 years into implementing, and the current level of implementation of, action programs related to:

- IB1: Improve information sharing for the coordination of the flow of goods between your plant and other plants of the network (e.g. through exchange information on inventories, deliveries, production plans, etc.)
- IB2: Improve joint decision making to define production plans and allocate production in collaboration with other plants in the network (e.g. through shared procedures, shared forecasts)
- IB3: Improve innovation sharing / joint innovation with other plants (through knowledge dissemination and exchange of employees inside the network)
- IB4: Improve the use of technology to support communication with other plants of the network (e.g. ERP integration, shared databases, social networks)

External supply chain integration

Indicate the effort put in the last 3 years into implementing, and the current level of implementation of, action programs related to:

- EB1: sharing information with key suppliers (about sales forecast, production plans, order tracking and tracing, delivery status, stock level)
- EB2: Developing collaborative approaches with key suppliers (e.g. supplier development, risk/revenue sharing, long-term agreements)
- EB3: Joint decision making with key suppliers (about product design/modifications, process design/modifications, quality improvement and cost control)
- EB1: sharing information with key customers (about sales forecast, production plans, order tracking and tracing, delivery status, stock level)
- EB2: Developing collaborative approaches with key customers (e.g., risk/revenue sharing, long-term agreements)
- EB3: Joint decision making with key customers (about product design/modifications, process design/modifications, quality improvement and cost control)

Operational performance

How has your manufacturing performance changed over the last three years?

	Decrease (- 5% or worse)	stayed about the same (-5%/+5%)	slightly increased (+5- +15%)	increased (+15-25%)	Strongly increased (+25% or better)
Conformance quality	1	2	3	4	5
Product quality and reliability	1	2	3	4	5
Volume flexibility	1	2	3	4	5
Mix flexibility	1	2	3	4	5
Delivery speed	1	2	3	4	5

	Increased (+ 5% or worse)	stayed about the same (+5%/-5%)	slightly decreased (-5/-15%)	decreased (-15/-25%)	strongly decreased (-25% or more)
Unit manufacturing cost	1	2	3	4	5
Ordering costs	1	2	3	4	5
Manufacturing lead time	1	2	3	4	5

Appendix 2: Comparison with model with MNI and SCI integrated in a single construct

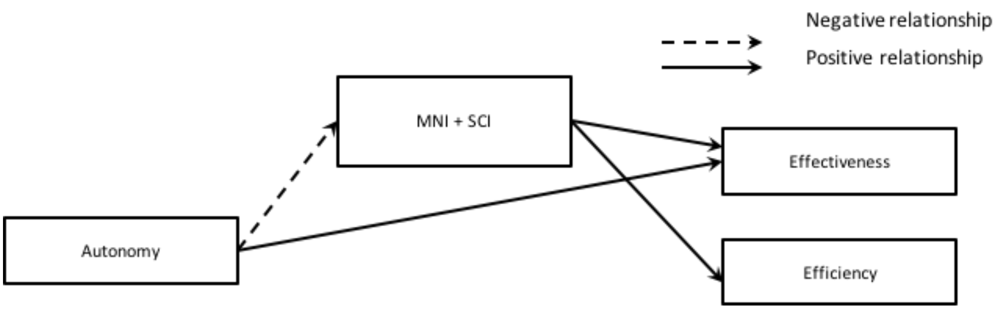
Comparison of Confirmatory Factor Analyses

	χ^2	df	χ^2/df	NFI	CFI	RMSEA	AIC
CFA with SCI and MNI correlated (current)	296.070	174	1.702	.932	.971	.040	452
CFA with SCI and MNI integrated	314.493	177	1.777	.928	.967	.042	464

Comparison of Final Models

	CMIN	DF	χ^2/df	NFI	CFI	RMSEA	AIC
Final Model with SCI and MNI correlated	396.556	191	2.076	.911	.950	.049	564
Final Model with SCI and MNI integrated	420.406	195	2.156	.905	.946	.051	580

The resulting model when MNI and SCI are merged in a single construct. Only significant relationships are reported.



Comparison of the Total Effect of Autonomy on Performance

	Standardised Total Effect (unstandardised in brackets)	
	Autonomy → Efficiency	Autonomy → Effectiveness
Final Model with SCI and MNI separated	−0.042 (−0.066)	0.019 (0.038)
Final Model with SCI and MNI integrated	−0.035 (−0.050)	0.027 (0.049)

Figures

Figure 1: Manufacturing network embeddedness: the combination of supply chain and manufacturing network integration

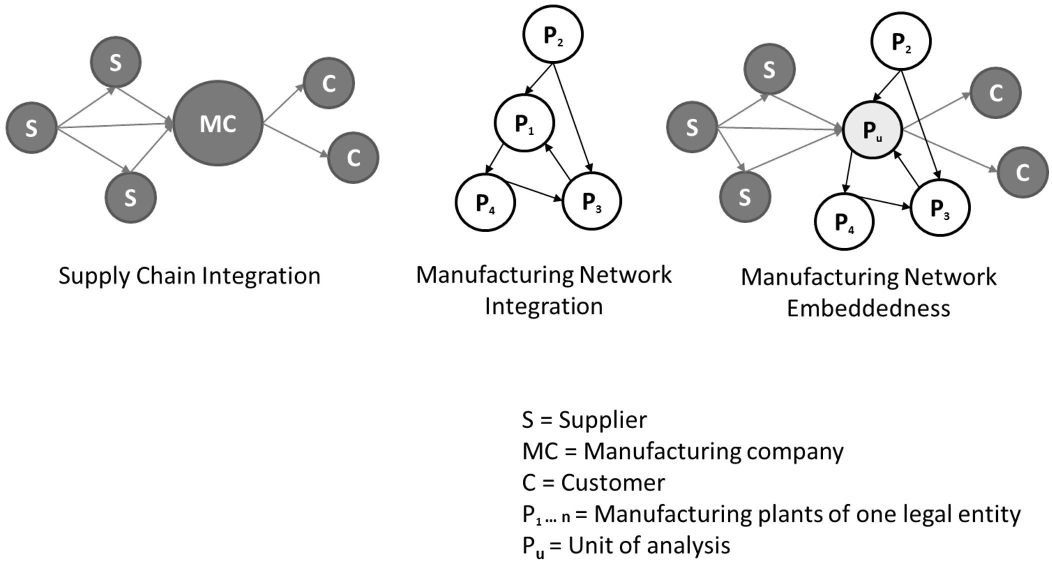


Figure 2: Research framework and the hypotheses

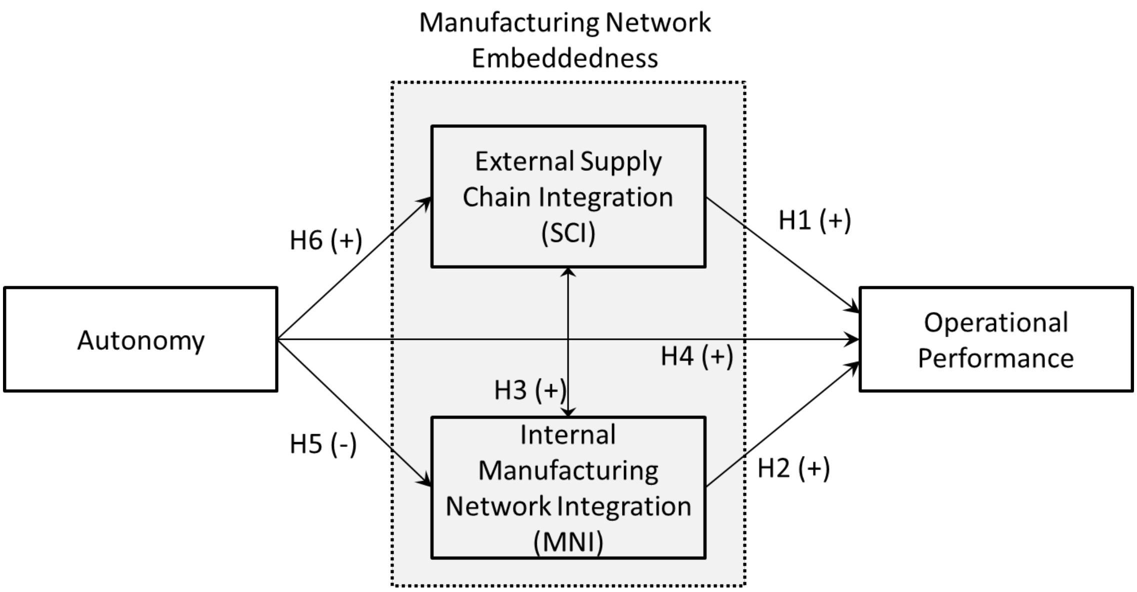


Figure 3 – Structural equation model employed in this study (GNI per capita is omitted)

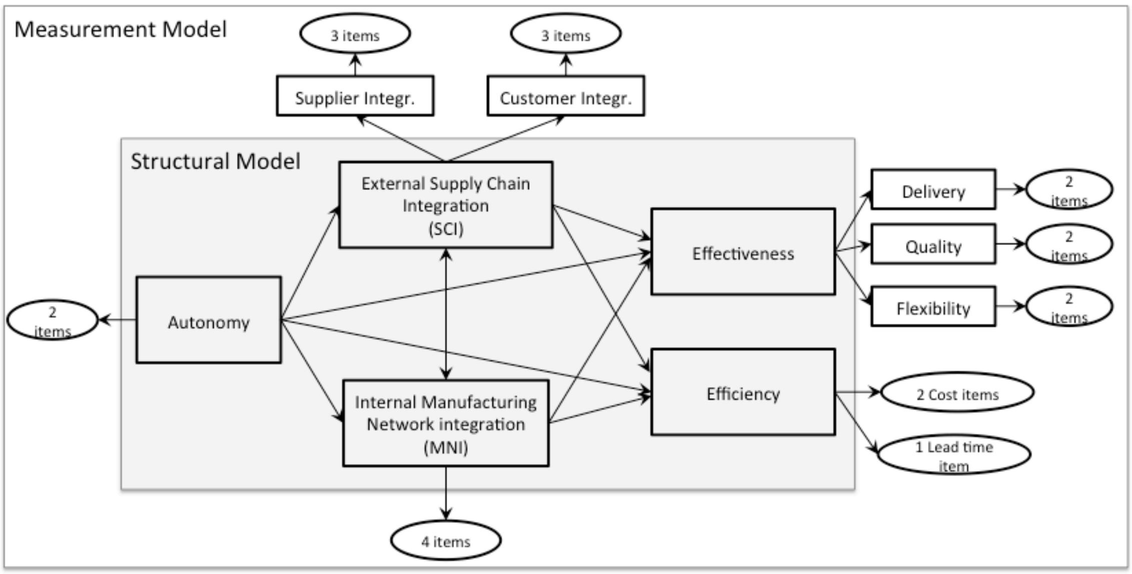
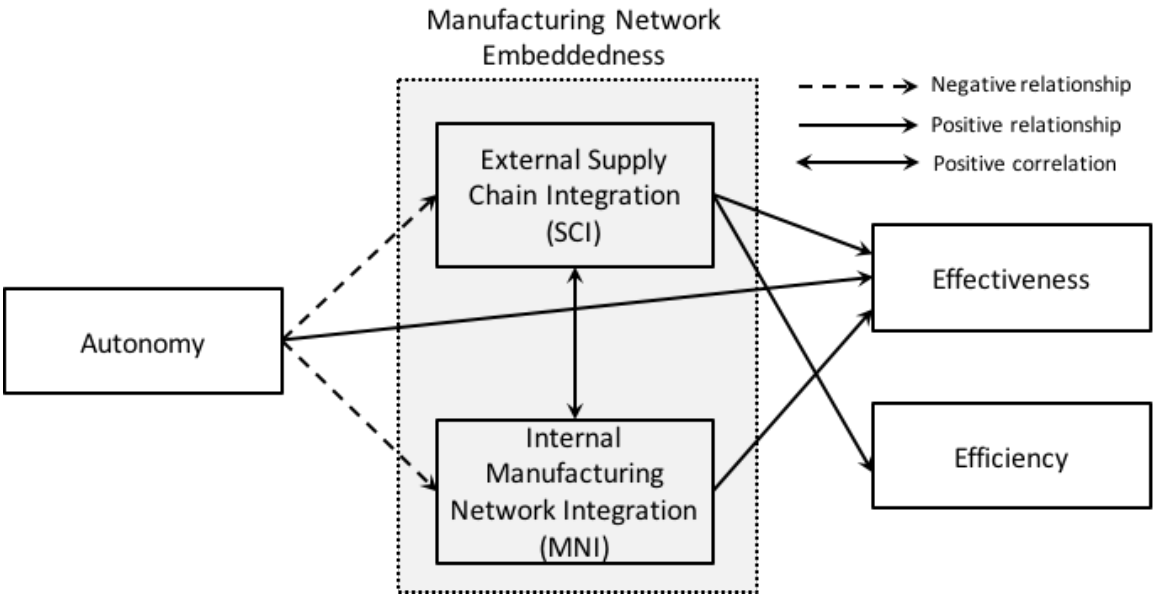


Figure 4 – The resulting model (only significant relationships are reported)


Manufacturing Network Embeddedness
Negative relationship
Positive relationship
Positive correlation
External Supply Chain Integration (SCI)
Autonomy
Effectiveness
Efficiency
Internal Manufacturing Network Integration (MNI)

Tables

Table 1 – Distribution of the sample by country, industry and size

Country	Frequency	Percent
Belgium	18	4.1
Brazil	22	5.0
China	46	10.4
Denmark	21	4.8
Hungary	29	6.6
India	41	9.3
Italy	26	5.9
Japan	53	12.0
Netherlands	28	6.3
Norway	20	4.5
Portugal	22	5.0
Romania	16	3.6
Spain	15	3.4
Sweden	23	5.2
Switzerland	16	3.6
Taiwan	20	4.5
USA	25	5.7
Total	**441**	**100.0**

ISIC Code	Frequency	Percent
25	123	27.9
26	62	14.1
27	75	17.0
28	99	22.4
29	59	13.4
30	23	5.2
Total	**441**	**100.0**

Employees	Frequency	Percent
Small (30-250)	148	33.6
Medium (250-500)	76	17.2
Large (500+)	217	49.2
Total	**441**	**100.0**

ISIC Codes
25: Manufacture of fabricated metal products, except machinery and equipment; 26: Manufacture of computer, electronic and optical products; 27: Manufacture of electrical equipment; 28: Manufacture of machinery and equipment not elsewhere classified; 29: Manufacture of motor vehicles, trailers and semi-trailers; 30: Manufacture of other transport equipment

Table 2 – Confirmatory factor analysis including Average Variance Explained (AVE) and Composite Reliability (CR)

Variable	Std. Loadings	Factor	AVE	CR
Autonomy in planning	0.840	Autonomy	55%	0.71
Autonomy in strategic decisions	0.633			
Delivery	0.795	Effectiveness*	60%	0.82
Quality	0.797			
Flexibility	0.729			
Unit manufacturing cost	0.815	Efficiency	52%	0.76
Ordering costs	0.724			
Manufacturing lead time	0.613			
Supplier Integration	0.830	SCI**	69%	0.82
Customer Integration	0.837			
Information sharing	0.751	MNI	59%	0.85
Joint decision making	0.797			
Innovation sharing	0.727			
Use of technology	0.779			
**Effectiveness second order items*				
Conformance quality	0.838	Quality	72%	0.84
Product quality and reliability	0.860			
Volume flexibility	0.832	Flexibility	62%	0.76
Mix flexibility	0.734			
Delivery speed	0.835	Delivery	75%	0.86
Delivery reliability	0.898			
***External SCI second order items*				
Sharing information w/ suppliers	0.773	Supplier Integration	64%	0.84
Collaboration w/ suppliers	0.862			
Joint decision making w/ suppliers	0.770			
Sharing information w/ customers	0.773	Customer Integration	65%	0.85
Collaboration w/ customers	0.862			
Joint decision making w/ customers	0.770			

Table 3 - Discriminant validity analysis of first-order constructs (bold values are squared-root of AVE, others are correlations)

	SCI	**Effectiveness**	**MNI**	**Efficiency**	**Autonomy**
SCI	**0.834**	0.413	0.703	0.240	-0.179
Effectiveness	0.413	**0.774**	0.389	0.525	0.033
MNI	0.703	0.389	**0.769**	0.186	-0.304
Efficiency	0.240	0.525	0.186	**0.722**	-0.073
Autonomy	-0.179	0.033	-0.304	-0.073	**0.744**

Table 4 – Path coefficients of the structural model.

			Std. Estimate	Estimate	S.E.	C.R.	p
GNI 2013	→	MNI	-0.073	0.000	0.000	-1.450	0.147
GNI 2013	→	SCI	-0.270***	0.000	0.000	-4.919	< 0.001
GNI 2013	→	Effectiveness	-0.155***	0.000	0.000	-2.765	0.006
GNI 2013	→	Efficiency	0.171***	0.000	0.000	2.969	0.003
Autonomy	→	MNI	-0.294***	-0.198	0.053	-3.736	< 0.001
Autonomy	→	SCI	-0.168**	-0.102	0.042	-2.467	0.014
Autonomy	→	Effectiveness	0.148**	0.075	0.034	2.181	0.029
Autonomy	→	Efficiency	-0.022	-0.014	0.040	-0.349	0.727
MNI	→	Effectiveness	0.199**	0.150	0.076	1.974	0.048
MNI	→	Efficiency	-0.054	-0.051	0.098	-0.519	0.604
SCI	→	Effectiveness	0.304***	0.253	0.090	2.804	0.005
SCI	→	Efficiency	0.360***	0.373	0.117	3.174	0.002
SCI	←→	MNI	0.706***	0.418	0.050	8.433	<0.001
** p < 0.05 *** p < 0.01							

Table 5 – Summary of the results in comparison to the research hypotheses

H1	*For plants in a manufacturing network, a higher level of external supply chain integration is associated with a higher level of operational performance.*	Confirmed
H2	*For plants in a manufacturing network, a higher level of internal manufacturing network integration is associated with a higher level of operational performance.*	Partially confirmed
H3	*For plants in a manufacturing network, a higher level of internal manufacturing network integration (MNI) is positively correlated with a higher level external supply chain integration (SCI).*	Confirmed
H4	*A higher level of manufacturing plant autonomy is associated with a higher level of operational performance.*	Partially confirmed
H5	*A higher level of manufacturing plant autonomy is associated with a lower level of internal manufacturing network integration.*	Confirmed
H6	*A higher level of autonomy is associated with a higher level of external supply chain integration.*	Rejected