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Backshoring strategy and the adoption of Industry 4.0: Evidence from Europe

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ABSTRACT

An analysis of the competitive priorities that may lead backshoring companies to adopt new technologies is developed and tested using secondary data from 495 relocation initiatives to Europe. Findings suggest that backshoring is associated with the adoption of Industry 4.0 when the firm's priorities are high quality and the reduction of costs tied to non-conformance. Backshoring initiatives prioritizing the reduction of direct costs or responsiveness are not significantly tied to Industry 4.0 adoption. The analysis further highlights that the adoption of new technology by firms that compete on quality is more likely when they are involved in product innovation.

1. Introduction

In the last decade, the relocation of manufacturing back to Europe and the US has become a subject of interest for both academia and policy (Foerstl, Kirchoff, & Bals, 2016; Fratocchi, Di Mauro, Barbieri, Nassimbeni, & Zanoni, 2014; Gray, Esenduran, Rungtusanatham, & Skowronski, 2017; Johansson, Olhager, Heikkilä, & Stentoft, 2018; Kinkel & Maloca, 2009). Although a variety of labels have been proposed, the term reshoring (Ellram, Tate, & Petersen, 2013; Gray, Skowronsky, Esenduran, & Rungtudanatham, 2013) has been used by many authors to encompass relocations nearer to the home country of the firm (nearshoring) or within the home country (backshoring). Reshoring has been described as a reversal of an offshoring initiative, irrespective "of who is performing the manufacturing activities in question" (Gray et al., 2013, p. 28). To illustrate, the term backshoring encompasses relocations from either offshore wholly owned facilities or from offshore suppliers to either own home facilities or home suppliers (Fratocchi et al., 2016; Stentoft, Olhager, Heikkilä, & Thoms, 2016; Wan, Orzes, Sartor, Di Mauro, & Nassimbeni, 2018). While the majority of reshoring initiatives reported in the literature concern relocations from countries characterized by low cost of labor, thus reflecting offshoring motivated predominantly by cost and efficiency considerations (da Silveira, 2014; Johansson & Olhager, 2018b), the term reshoring does not disqualify other geographical origins, including countries with high cost of labor.

Academic interest on reshoring has mostly been centered on the motives underscoring this type of relocation, as illustrated by several recent review articles (Bals, Kirchoff, & Foerstl, 2016; Di Mauro, Fratocchi, Orzes, & Sartor, 2018; Foerstl et al., 2016; Fratocchi et al., 2016; Stentoft et al., 2016; Wiesmann, Snoei, Hilletofth, & Eriksson, 2017). Operational and strategic challenges in offshore locations ranging from shrinking labor cost advantages in countries such as China, rising freight costs (Simchi-Levi, Peruvankal, Mulani, Read, & Ferreira, 2012), unsatisfactory product quality offshore (Ancarani, Di Mauro, Fratocchi, Orzes, & Sartor, 2015), and growing demand for production flexibility and customer responsiveness (Moradlou, Backhouse, & Ranganathan, 2017) have been pinpointed as being at the root of reshoring. At the same time that some of the locational advantages of producing offshore shrink, new opportunities arise in the home country, encompassing the value attached by customers to "made in" products (Grappi, Romani, & Bagozzi, 2018; Grappi, Romani, & Bagozzi, 2015), the lower cost of energy in the US (Simchi-Levi et al., 2012), and government support for reshoring (Joubioux & Vanpoucke, 2016).

Although the importance of identifying reshoring drivers is undeniable, the focus on the reshoring motives has not been matched by equal attention towards the understanding of the structural choices reshoring firms' adopt following the domestic relocation. The last few years have witnessed an emergent interest in the relations between reshoring and recent technological advancements in manufacturing. Specifically, the rise of the so called Industry 4.0 paradigm has been heralded as potentially beneficial for reshoring initiatives (Arlbjørn & Mikkelsen, 2014; Bals et al., 2016; Bailey & De Propris, 2014). In fact, progress and falling costs in advanced automation and digitalization allow reducing firms' reliance on labor, in addition to improving

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product manufacturability, and reducing time and waste in production processes (Fitzgerald, Kruschwitz, Bonnet, & Welch, 2014; McAfee, Brynjolfsson, & Davenport, 2012; Sirkin, Zinser, & Rose, 2015). While the literature has started to explore the advantages of these new technologies for reshoring firms (Kaivo-Oja, Knudsen, & Lauraéus, 2018; Moradlou & Tate, 2018; Müller, Dotzauer, & Voigt, 2017), so far little attention has been paid to the exploration of the antecedents of new manufacturing technology adoption by reshoring firms (Ancarani & Di Mauro, 2018a).

An established literature stream has acknowledged that the technological choices of the firm find significant antecedents in the firm's competitive priorities in terms of cost, quality, flexibility and delivery (Boyer & Lewis, 2002; Zahra & Covin, 1993). At the same time, competitive priorities have been considered as key antecedents of location initiatives, both for offshoring (da Silveira, 2014), and reshoring (Di Mauro et al., 2018; Robinson & Hsieh, 2016). Taken together, these findings suggest that the decision to innovate manufacturing technology as part of the relocation may be driven by the competitive priorities underlying reshoring.

In order to explore this contention, this study offers an empirical assessment of the extent to which relocations back to the home country of the firm (backshoring) are associated with the adoption of Industry 4.0 technologies in manufacturing, and tests whether the likelihood of adoption differs according to the competitive priorities underlying backshoring.

The paper follows Ellram et al. (2013), Fratocchi et al. (2014), Gray et al. (2013), and Stentoft, Mikkelsen, Jensen, and Rajkumar (2018) by defining backshoring as the relocation of value chain activities, irrespective of the governance structure both offshore and inshore. Further, offshoring will be intended as any relocation to a host country other than the firm's home country.

The research positions itself at the intersection among three streams of academic literature: the analysis of manufacturing backshoring (Fratocchi et al., 2016; Stentoft et al., 2016; Wiesmann et al., 2017), the study of the technology-competitive priorities linkages (Parthasarthy & Sethi, 1993; Zahra & Covin, 1993), and the investigation of the association between technological factors and location of activities within global value chains (Hannibal & Knight, 2018; Strange & Zucchella, 2017).

The study contributes to develop the academic discourse on how the competitive priorities that drive backshoring initiatives and the opportunities created by Industry 4.0 combine in explaining the technological structural choices following the relocation of production in Europe. From a managerial viewpoint, the study contributes to better inform backshoring decisions, by offering recommendations to firms planning to repatriate production on the potential advantages of upgrading their technology endowment (Ketokivi, Turkulainen, Seppälä, Rouvinen, & Ali-Yrkkö, 2017). Results can also be useful to inspire and inform policies that effectively support backshoring through more focused and tailored actions that include attention to technological gaps and needs of firms (Spring, Hughes, Mason, & McCaffrey, 2017).

The paper is organized into the following sections: Section 2 discusses theoretical underpinnings and summarizes the literature findings from the different streams of literature. Section 3 elaborates on the expected advantages of Industry 4.0 for backshoring firms according to their competitive priority. The data set and empirical analysis are introduced in Section 4. Sections 5 and 6 provide a discussion of empirical results and of their implications, while Section 7 concludes with limitations and future research directions.

2. Literature background

2.1. Theoretical support for backshoring

Transaction Cost Economics (TCE) and Resource Based View (RBV) (Foerstl et al., 2016; Fratocchi et al., 2016) provide key insights for understanding manufacturing relocations, by linking location choices to the efficiency of the control and coordination structures, and to the search for long-term competitive advantage (McIvor, 2013). Both theories have been applied to evaluate the conditions for disintegrating, mobilizing, or re-integrating specific value chain activities from a geographical point of view.

In the perspective of TCE, value chain activities requiring low monitoring costs, and loose coordination with other company functions and stages of the value chain can be performed offshore (Ketokivi et al., 2017; Mudambi, 2008). Therefore, offshoring is attractive mainly for those production activities involving routinary tasks or modularity. In this instances, offshore locations that offer low labor costs advantages and economies of scale may become attractive, while not impacting transaction costs significantly.

According to RBV, the decision on which value chain activities may be performed offshore depends on their impact upon the long-term capabilities of the organization, in order to avoid that over time key capabilities are relinquished (McIvor, 2013). In this perspective, firms will try to combine the comparative advantages of different geographic locations with their own resources and competencies (Mudambi & Venzin, 2010). Firms retain control inshore over the components or processes of the value chain through which they can create and appropriate the most value (Jensen, Larsen, & Pedersen, 2013), while offshoring to own subsidiaries or to offshore suppliers less value adding activities (Mudambi, 2008).

A reversal of the arguments that justify offshoring can explain backshoring. A TCE-consistent geographical re-concentration of the manufacturing value chain in the home country may stem from an increase in coordination and control costs that firms face offshore with respect to the home country. Higher transaction costs may be caused by rising market volatility, specificity of operations, or frequency of transactions within the value chain (Williamson, 1981). The greater degree of customization, differentiation, and product innovation currently required by many markets (Bailey & De Propris, 2014; Bals et al., 2016) may all conjure to increase the specificity of production activities, therefore requiring geographical proximity to markets and greater coordination within the value chain (e.g. between production and R&D).

Conversely, in the perspective of RBV, backshoring may follow from the importance of innovation and firm and network-level capabilities. Back in 2012, Pisano and Shih pointed to the need to consider production as part of the firm's innovation system, and to nurture innovation capabilities by co-locating production and R&D. Backshoring also offers opportunities to exploit competencies geographically held in the home country, such as technological knowledge residing in local industrial clusters (Di Mauro et al., 2018) and labor skills that lead to higher product quality (Ancarani et al., 2015). Finally, relocation to the home country may also guarantee a more effective protection of intellectual property rights with respect to some offshore locations (Tate, Ellram, Schoenherr, & Petersen, 2014; Wiesmann et al., 2017).

2.2. Evidence on factors explaining backshoring

Given the extensive list of motivations underscoring backshoring initiatives identified in the academic literature (see for instance Fratocchi et al., 2016), the effort of recent contributions has been directed towards bundling motivations into factors or groups that are empirically or theoretically grounded (Table 1). Theory grounded factors driving backshoring build mainly on TCE and RBV (Foerstl et al., 2016; Fratocchi et al., 2016), Dunning's eclectic paradigm (Ancarani et al., 2015), and the global value chain/global network production concepts (Vanchan, Mulhall, & Bryson, 2018). In terms of methodology, contributions can be distinguished into purely conceptual (Foerstl et al., 2016), literature reviews (Benstead, Stevenson, & Hendry, 2017; Pal, Harper, & Vellesalu, 2018; Stentoft et al., 2016; Wiesmann et al., 2017), and empirical contributions in which the bundling is either theory-

Table 1
Key factors driving backshoring.

Authors	Research strategy	Key factors identified		Process of identification of backshoring factors
Ancarani et al. (2015)	Empirical analysis of secondary data on 249 cases in US and Europe	• Efficiency seeking • Resource seeking	• Market seeking • Strategic assets seeking	Theory based: OLI
Benstead et al. (2017)	Literature review + single case study in UK	• Risk • Uncertainty and ease of doing business • Cost-related	• Infrastructure-related • Competitive priorities	Literature based
Di Mauro et al. (2018)	Multiple case studies	• Cost based	• Value based	Literature based
Ellram et al. (2013)	Survey with 319 cases in US	• Input/product • Cost • Labor • Logistics	• Supply chain interruption risk • Strategic access • Country risk • Government trade policies	Empirically driven through Exploratory factor analysis
Engström et al. (2018)	Case studies	• Global environment • Host country • Home country	• Supply chain • Firm-specific	Literature based
Foerstl et al. (2016)	Conceptual	• Transactional	• Human and behavioral	Theory based: TCE and OBB
Fratocchi et al. (2016)	Conceptual + Empirical analysis of secondary data on 377 cases in US and Europe	• Cost based	• Value based	Theory based: TCE, RBV, OLI
Johansson et al. (2018)	Survey with 160 cases in Denmark, Finland, and Sweden	• Quality	• Development, market proximity, cost, and external influence and trade policy	Empirically driven through Exploratory factor analysis
Srai and Ané (2016)	Survey with 94 cases in France and UK	• Quality improvement and brand image enhancement • Changes in country factor costs • Reconfiguration and restructured cost	• Responsiveness and resource efficiency • Risk management and dependability • Institution • Enhanced innovation	Literature based
Pal et al. (2018)	Literature review + Delphi study	• Cost • Quality, service and innovation	• Delivery and flexibility • Relationship related • Environmental related	Literature based
Stentoft et al. (2016)	Literature review	• Cost • Quality • Time and Flexibility • Access to skill and knowledge	• Risks • Market • Incentives and Corrections	Literature based
Vanchan et al. (2018)	Empirical analysis of secondary data of 255 US companies and 14 cases in UK	• Push	• Pull	Theory based: GVC/GPN
Wiesmann et al. (2017)	Literature review	• Global competitive dynamics • Host country • Home country	• Supply chain • Firm-specific	Literature based
Zhai et al. (2016)	Empirical analysis of secondary data on 139 cases in US	• Cost • Product • Competence	• Operations • Institutions	Empirically driven

based or data-driven.

Among the empirical contributions, several use secondary data concerning firms headquartered either in the US or Europe (Ancarani et al., 2015; Fratocchi et al., 2016; Vanchan et al., 2018; Zhai, Sun, & Zhang, 2016). Three articles are based on survey data, concerning either the US (Ellram et al., 2013) or Europe (Johansson et al., 2018; Srai & Ané, 2016). In particular, Ellram et al. (2013) and Johansson et al. (2018) use exploratory factor analysis to aggregate motivations into factors, rather than classify drivers on an ex ante base. Other methodologies are infrequently used to identify motivations, and are rather adopted to illustrate the relevance of the factors previously identified in the literature. This applies to case studies (Benstead et al., 2017; Di Mauro et al., 2018; Engström, Sollander, Hilletofth, & Eriksson, 2018) and Delphi studies (Pal et al., 2018).

It is noteworthy that bundles of motivations have been interpreted not only as reflecting modifications in the location advantages of offshore manufacturing (e.g., Ancarani et al., 2015; Ellram et al., 2013; Vanchan et al., 2018; Wiesmann et al., 2017) but also as indicating backshoring competitive priorities (Fratocchi et al., 2016; Johansson et al., 2018; Stentoft et al., 2016). Growing international competition, increasing market volatility, demand for highly customized products and shortened product life cycles have created challenges for manufacturing, and backshoring has been seen as part of the realignment of the business strategy to changed market and external conditions (Bals et al., 2016; Benstead et al., 2017; Di Mauro et al., 2018). For instance, Stentoft et al. (2016) bundle motivations according to the four classical competitive priorities (cost, quality, flexibility and delivery), while Johansson et al. (2018) and Johansson and Olhager (2018b) indicate that offshoring is dominated by a cost perspective, while quality, flexibility, and delivery are frequently associated with backshoring. Finally, while not referring to competitive priorities, Di Mauro et al. (2018) and Fratocchi et al. (2016) stress the strategic content by separating cost and efficiency oriented from customer value-oriented backshoring.

2.3. Backshoring and advances in manufacturing technologies

The label Industry 4.0 (Kagermann, 2015) identifies a systematic high-tech strategy, encompassing the integration of robotics, internet of things, big data analytics, digitalization, and advanced manufacturing technologies such as additive manufacturing/3D printing (Gress & Kalafsky, 2015; Hofmann & Rüsch, 2017). These technologies are expected to lead to higher levels of operational efficiency and productivity by providing IT-enabled customization of manufactured products, and to make the production chain automatic and flexible, by tracking parts and products, and facilitating communication among parts, products, and machines (Lu, 2017; Roblek, Meško, & Krapež, 2016). Although robots and digital tools have already been inside companies for many years, what has changed recently is the acceleration of both the capabilities enabled by these technologies, as well as the pace of adoption, due to the higher maturity of IT and lower costs of hardware and software (Fraunhofer ISI, 2015).

Scholars in International Business have recently argued that the advent of Industry 4.0 technologies is expected to alter location advantages and the geography of production and global value chains (Hannibal & Knight, 2018; Strange & Zucchella, 2017), although it is still left to speculation whether firms will use these technologies to support their international network of operations or will re-concentrate production in advanced economies. In the same vein, scholars in supply chain management have suggested a correlation between Industry 4.0 and manufacturing location decisions. In particular, backshoring firms are expected to adopt new technologies when the technology intensity and the complexity of the supply chain are high (Foerstl et al., 2016), and when there are high risks of loss of control over offshore manufacturing processes (Bals et al., 2016) and of intellectual property violations (Kaivo-Oja et al., 2018). While these contributions suggest a correlation, given the relative newness of both Industry 4.0 and backshoring, it is still left to conjecture whether technology is actually the driver or the reflection of backshoring (Martinsuo & Chaoji, 2017).

3. Model development

3.1. Backshoring, competitive priorities and Industry 4.0

In the operations management literature, there is widespread agreement that the competitive priorities in manufacturing can be expressed by four key capabilities: cost, quality, delivery, and flexibility (Größler & Grübner, 2006; Leong, Snyder, & Ward, 1990; Ward & Duray, 2000; Ward, McCreery, Ritzman, & Sharma, 1998), although other classifications have been proposed (see Sansone, Hilletofth, & Eriksson, 2017 for a literature review). Competitive priorities underscore manufacturing strategy (Frohlich & Dixon, 2001) and signal the strategic emphasis on developing certain manufacturing structures and infrastructures that may strengthen the firm's position in the marketplace (Boyer & Lewis, 2002). Therefore, they will inform structural decisions regarding capacity, facilities, vertical integration, sourcing and technology (Wheelwright, 1984). With respect to technology, past research (Parthasarthy & Sethi, 1993; Zahra & Covin, 1993) suggests that a fit between technology and competitive priorities is required for performance to accrue, especially under conditions of evolving manufacturing technology.

Competitive priorities are also key to relocation initiatives, as they lead to identify the activities over which the firm needs to build competitive advantage (Hamel & Prahalad, 1990) and retain control (Buckley & Casson, 1976), thus informing the decision on whether an activity should be performed at home or offshore (Mudambi, 2008). As argued in Section 2.2, motivations underlying a relocation initiative have often been considered as indicators of competitive priorities. In fact, due to bounded rationality, challenges motivating the location decision will be perceived as such only when they intersect the firm competitive priorities (Manning, 2014; Ocasio, 1997). For instance, da Silveira (2014) shows that offshore initiatives are significantly related to cost and delivery motivations/priorities (see also Davis & Naghavi, 2011 and Manning, Massini, & Lewin, 2008).

In the case of backshoring, the literature has identified bundles of motivations that can be reconciled with the existence of different competitive priorities underlying the relocation (Stentoft et al., 2016). Elaborating on previous literature on manufacturing strategy discussed above, we contend that different competitive priorities may require different technological choices once firms relocate back home. In essence, the adoption of Industry 4.0 following backshoring will be contingent on whether firms compete on cost, quality, delivery or flexibility.

When competing based on cost, the relocation back home generally occurs in response to challenges that reduce offshore cost advantages, and which firms cannot "tolerate or mitigate" (Manning, 2014), such as rising costs of labor, logistics, rework and, more in general, an increase in landed costs. The cost priority implies that backshoring firms must retain economies of scale, high capacity utilization, and competitive pricing. For firms returning from offshore locations characterized by lower cost of labor with respect to the home country. Industry 4.0 technologies allow substituting labor for capital and can act as an "equalizer" of location costs. In addition to reducing the labor input needed for production, they further decrease production unit costs by reducing the percentage of rework and returns (Bals et al., 2016). The case for an association between the cost focus and new manufacturing technology is also strengthened by past research showing that cost-focused firms tend to be process innovators (Adner & Levinthal, 2001; Zahra & Covin, 1993). Therefore, a cost priority is expected to be associated with the adoption of new production technologies.

Quality as a competitive priority is associated with a focus on brand image and product performance. Backshoring by quality-focused firms has often been described as aimed at increasing brand recognition through the "made in" effect (Ancarani et al., 2015; Grappi et al., 2015). Next, some industry-specific competences (e.g. in apparel, food processing, leather industries) that are highly valued by customers are only imperfectly available offshore while they are available in the home country (Di Mauro et al., 2018). Finally, manufacturers of high quality products may opt for backshoring because the creation of greater value at the production stage engenders the exploitation of the cross-functional linkages in terms of information exchange and collaboration (Ketokivi et al., 2017; Mudambi, 2008), and for close monitoring of production quality.

Given these motivations, the value generated by highly specialized human capital and the premium price associated with the "made in" product label is likely to weaken incentives to invest in advanced technologies (Zahra & Covin, 1993). Further, recent research on some Industry 4.0 technologies (e.g. additive manufacturing, Laplume, Petersen, & Pearce, 2016) highlights the low diffusion and uncertain future applicability in some industries for which "Made in" is a crucial backshoring motivation, such as leather and textile (Robinson & Hsieh, 2016). However, the experience of German manufacturers suggests that intelligent automation within the production system may lead to significant improvements in product quality by means of smart maintenance and quality control (Brettel, Friederichsen, Keller, & Rosenberg, 2014). According to Rüßmann et al. (2015), high quality industries, such as pharmaceuticals and semiconductors, will be among those that will benefit the most from the use of data analytics driven improvements able to reduce error rates. Overall, the above arguments provide mixed a priori support for the link between Industry 4.0 technologies and backshoring initiatives with quality priority.

When flexibility is the competitive priority, companies seek product variety and product customization provided in a cost-effective manner (Garrido-Vega, Jimenez, & Morita, 2015; Parker, 2000; Parthasarthy & Sethi, 1993; Tracey, Vonderembse, & Lim, 1999). Flexibility goals intersect backshoring, given that the growing demand for differentiation and customization of products requires that the production unit delivers each product in smaller batches (Simchi-Levi et al., 2012), therefore either increasing transport costs from offshore, or forcing the company to keep extra inventory in case of long lead times (Zhou & Wan, 2017). Previous research on the relation between flexibility and process innovation relying on automation and IT has returned ambiguous findings. Traditionally, automation was synonym to standardization, considered to be at odds with product variety and volume mix. However, in the past twenty years, advanced manufacturing has made the traditional cost-variety trade-off less stringent (Fogliatto, da Silveira, & Borenstein, 2012; Kotha & Swamidass, 2000) and, in this direction, Industry 4.0 technologies are expected to support flexible production by allowing small-batch production at low costs (Lu, 2017). In particular,

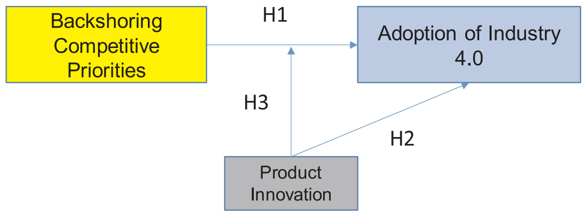

Fig. 1. Hypothesized model.

robots and machine to machine communication will provide this flexibility by making autonomous decisions (Rüßmann et al., 2015). Arguments against a positive association between flexibility and Industry 4.0 are indirectly provided by Pine (1993), according to whom customers' willingness to pay a premium price for customized products largely depends on the higher performance quality of the product. In turn, this quality is assured by a dynamic network of relatively autonomous operating units, requiring multi-skilled employees, who need to develop new capabilities through learning processes (Fang, Li, & Lu, 2016). When firms try to implement mass customization relying on automation, the result is to weaken the skills of the workers and to reduce learning opportunities.

When delivery is the competitive priority, emphasis is placed on providing customer service by either delivery reliability or delivery speed. The emphasis on fast and reliable delivery can motivate backshoring because proximity to customer can generate greater responsiveness by allowing the postponement of final design and manufacturing (Yang, Burns, & Backhouse, 2004). Indeed, Kinkel and Maloca (2009) find that delivery ability is one of the most frequent motives for backshoring to Germany, Moradlou et al. (2017) describe lack of responsiveness as the premier driver of backshoring to the UK, while Johansson and Olhager (2018a) describe market proximity as one of the key factors explaining the relocation of production plants to Sweden. In this light, some Industry 4.0 technologies, such as additive manufacturing can improve postponement (Fratocchi, 2017; Moradlou & Tate, 2018; Yang et al., 2004). Although these arguments favor the association between delivery-driven backshoring and Industry 4.0, geographical proximity to markets solves per se the delivery challenge by reducing lead times, therefore weakening the pressure to invest in new technology.

To sum up, given the relations between the competitive priorities underscoring the individual backshoring initiatives and Industry 4.0 technology as discussed above, it seems plausible to expect heterogeneity in technology adoption across firms with different competitive priorities. Therefore, the following general hypothesis is offered:

H1. The adoption of Industry 4.0 technologies following backshoring will significantly vary across firms with different competitive priorities.

3.2. *The role of product innovation*

Several advanced manufacturing and design processes within Industry 4.0 are considered functional to improve new product development and producibility decisions (Laplume et al., 2016; Lu, 2017; Rehnberg & Ponte, 2017). Indeed, past research has recognized that product and process innovation are often complementary to each other (Damanpour & Gopalakrishnan, 2001; Martínez-Ros & Labeaga, 2009; Pisano, 1997; Reichstein & Salter, 2006).

Backshoring has been linked to more efficient and effective new product development. In particular, Ketokivi et al. (2017) stress the advantages of co-locating R&D and production in case of strong interdependencies between the two functions, arising for instance from engineering-to-order production, need for joint problem solving, and non-modular designs. Di Mauro et al. (2018) provide case study evidence of firms for which backshoring allows better managing the complexities of production-development coupling. Johansson et al. (2018) find that proximity to R&D and access to skills and knowledge is a relevant backshoring driver for Scandinavian firms. In turn, the set of motives tied to product innovation are significantly linked to benefits in terms of product and process quality, speed of delivery, and flexibility. Given the above discussion, backshoring firms involved in product innovation are expected to be more likely to adopt Industry 4.0 technologies, leading to the following hypothesis:

H2. The adoption of Industry 4.0 technologies by backshoring firms is positively related to product innovation.

At the same time, product innovation interacts with competitive priorities, being often observed in conjunction with quality and flexibility (Oke, 2013; Parker, 2000). Further, Reichstein and Salter (2006) provide evidence that both flexibility and quality are associated with process innovation when coupled with product innovation. Taken together, these findings suggest that the relation between competitive priority and Industry 4.0 is expected to be positively moderated by involvement in product innovation:

H3. The relation between the backshoring competitive priority and the adoption of Industry 4.0 technologies is positively moderated by product innovation.

Fig. 1 summarizes the hypothesized model, in which a relation is envisaged between competitive priorities and the adoption of new production technologies following backshoring. This relation is assumed to be moderated by product innovation.

4. Empirical analysis

4.1. *Sample characteristics*

In order to test our model, a database of 495 backshoring initiatives undertaken by firms headquartered in Europe was created by drawing information from secondary sources (newspapers and magazines, press releases, companies' websites, and white papers from consulting companies). Secondary data as opposed to primary data have been considered useful because they reduce researcher and respondent bias, allow the collection of larger samples, and facilitate replication (Calantone & Vickery, 2010; Harris, 2001; Rabinovich & Cheon, 2011), while a drawback is represented by reduced construct validity. Written records such as newspapers and magazines are considered useful when no other sources are available (Cowton, 1998; Franzosi, 1987; Mazzola & Perrone, 2013), and have been used both in International Business and in Operations Management (Rabinovich & Cheon, 2011; Roth, Cattani, & Froehle, 2008; Yang, Wang, & Su, 2006). With specific reference to international business studies, Judd, Smith, and Kidder (1991) consider press sources suitable for longitudinal and multi-country studies. Yang et al. (2006) found that 20 empirical articles published in six leading international business journals from 1992 to 2003 adopted samples based on newspapers articles. Empirical research on backshoring has often made use of secondary data (Ancarani et al., 2015; Moore, Rothenberg, & Moser, 2018; Vanchan et al., 2018; Zhai et al., 2016 among others).

The database used in this study was created through the following steps: first, firms that had been involved in backshoring were identified using two databases, the UniClub More Reshoring (Fratocchi et al., 2016) and the Eurofound Monitor of Reshoring (https://reshoring.eurofound.europa.eu/). Second, two members of the research team independently carried out content analysis on the original press sources reporting the backshoring initiatives, and collected all the information required for the purpose of the present analysis (Kolbe & Burnett, 1991). In case of different interpretations, the third researcher was involved, and the source was reviewed again until agreement was reached. When multiple sources were available, the information was compared and, in case of inconsistencies, the case was eliminated from

Table 2
Sample description (n = 495).

Variable	Description	Proportion
Industry		
Automotive		12%
Electronics		13%
Food & Beverages		5%
Furniture		4%
Machinery and metal parts		19%
Clothing & Textile & Footwear		21%
Firm's characteristics		
Small companies	Companies with less than 50 employees	19%
Medium companies	Companies having between 50 and 249 employees	23%
Large companies	Companies with at least 250 employees	58%
Insourcing backshoring	Companies adopting an insourcing governance mode following reshoring	81%
Global reorganization	The reshoring initiative is part of a larger reconfiguration of the firm's operations network	24%
Motivations		
Customer proximity	Advantages of relocating production closer to market	21%
Lead time	Long delivery time to final markets	20%
Made in	Customers' pressure for goods to be produced in the home country	17%
Defective products	Need to reduce rate of defective products	17%
Total landed costs	Increase in the total landed costs from producing/sourcing in offshore location	17%
Logistic costs	Increase in transport and inventory costs from offshore location	15%
Production flexibility	Need to increase volume and mix flexibility	11%
Labor costs	Increase in labor costs in offshore location	10%
Offshore control complexity	Complexity of controlling and coordinating offshore subsidiaries and/or suppliers	6%
Quality	Unsatisfactory product quality in the offshore location	5%
IPR protection	Problems in protecting intellectual property offshore	3%
Innovation		
Industry 4.0	Adoption of Industry 4.0 technology following reshoring	14%
Product innovation	New product development associated with reshoring	12%
Contextual variables		
Host China	Reshored operations were previously located in China	37%
Support for relocation	Private or governmental support to relocate domestically	8%

the database. The unit of analysis was the single backshoring initiative. Backshoring of value chain activities other than production was not considered.

The coding of backshoring motivations applied for the purpose of the study was the one used by the European Reshoring Monitor, which comprises forty-two motivations, in turn drawn from the backshoring literature (Fratocchi et al., 2016). The sources were also probed for information on new technology adoption as a consequence of backshoring, by using keywords such as Industry 4.0, robotics, automation, additive manufacturing, 3DP, smart manufacturing, digitalization, advanced manufacturing, etc. Cases were classified as being characterized by product innovation if the sources indicated product innovation as a key determinant of business success (Zahra & Covin, 1993).

The resulting database includes information on firm's size, industry, home country, offshore country, year of backshoring, governance mode (insourcing versus outsourcing) both offshore and inshore, main motives for backshoring, adoption of Industry 4.0 technologies and involvement in product innovation following the backshoring initiative. Table 2 summarizes the characteristics of the sample and provides a description of the variables used in the empirical analysis. The table provides frequencies only for those backshoring motivations that were present in at least 1% of the cases (the motivations for each initiative are not mutually exclusive). The table shows that large firms prevail among backshoring companies (58%). A significant proportion of firms repatriate from China (37%), while the backshoring countries are Italy (26%), UK (18%), France (14%), Germany (12%), Scandinavian countries (11%), Netherlands (4%), Spain (4%), and other European countries (11%). Interestingly, 21% of backshoring initiatives are part of a wider re-configuration of the firm's network of operations.

Overall, 14% of backshoring initiatives explicitly cite advanced robotics and/or additive manufacturing, while other technologies labelled Industry 4.0 (e.g. IoT, digitalization) are not mentioned explicitly in the original sources. However, because Industry 4.0 technologies are often complementary to each other, we cannot exclude their adoption (De Backer, DeStefano, Menon, & Suh, 2018). The proportion of firms adopting Industry 4.0 in our sample is in line with the survey carried out by the Boston Consulting Group in 2016 on manufacturing companies in Europe and the US (19% in Germany and 16% in the US).

4.2. Aggregations of backshoring motives

Competitive priorities were measured using the offshore challenges that motivated backshoring, as listed in Table 2. An exploratory factor analysis was performed in order to derive empirically grounded aggregations of backshoring motives (Ellram et al., 2013; Johansson et al., 2018). Hinkin (1998)'s suggestions for appropriate steps for exploratory factor analysis were followed. First, principal component analysis was used to extract factors, and Kaiser criterion was applied to select factors with eigenvalues above one. Five factors satisfying this condition were identified, explaining 64% of variance, a percentage considered acceptable (Hinkin, 1998). Next, varimax rotation was applied to the data. Tabachnick and Fidell (2014) recommend dropping items with loadings smaller than 0.32 (representing 10% of the shared variance), while Field (2013) recommends suppressing factor loadings less than 0.3. Cross loadings for all items were checked to ensure that any individual item did not load on multiple factors. A common recommendation is to suppress items that load on one factor less than twice as strongly with respect to other factors (Hinkin, 1998). These steps led to discard the item "total landed costs", while all the other items exhibited loadings above 0.6 and unambiguously mapped onto one factor. Communalities in the final solution were also calculated, with the aim to assess the proportion of factor variance explained by each item. All items had a communality score higher than 0.5, so no item had to be removed (Table 3).

Out of the resulting five factors, Factor 2 (labelled Direct costs) captures challenges deriving from direct costs offshore (Labor costs and

Table 3
Exploratory factor analysis.

	F1 Responsiveness	F2 Direct Costs	F3 Quality	F4 Brand Recognition	F5 Costs of non-conformance	Uniqueness
Customer Proximity	**0.7261**	−0.0998	0.0219	0.1237	0.0344	*0.4459*
Production Flexibility	**0.7211**	0.0681	−0.0726	0.068	−0.1739	*0.4352*
Lead Time	**0.6412**	0.1576	0.2077	−0.2404	0.2852	*0.3818*
Logistic Costs	0.1809	**0.7163**	−0.2262	−0.0718	0.1823	*0.3646*
Labour Costs	−0.0662	**0.8399**	0.1375	0.0439	−0.0862	*0.262*
Quality	0.1114	−0.0501	**0.7225**	0.1844	−0.0573	*0.4258*
Offshore Control Complexity	−0.0317	0.0596	**0.7285**	−0.1917	0.1941	*0.3904*
Made in	0.0116	0.0171	−0.2415	**0.7153**	0.2538	*0.3651*
IPR protection	0.0249	−0.0098	0.1847	**0.7593**	−0.1546	*0.3647*
Defective products	0.0098	0.0098	0.0589	0.0259	**0.905**	*0.1767*
% Variance explained	15	13	13	12	11	64

Logistics costs) and is fully consistent with a cost priority. Two more factors (3 and 4) are consistent with a quality priority. Specifically, Factor 3 (labelled Quality) encompasses the items Quality and Offshore control complexity, while Factor 4 (labelled Brand recognition) captures the aspects of quality that make products recognizable and unique in the eyes of customers (Made in, IPR protection). Factor 5 (labelled Costs of non-conformance) captures the costs stemming from a high proportion of defective products and can be considered to be consistent with both a cost priority and a quality priority (Frohlich & Dixon, 2001; Miller & Roth, 1994). Finally, Factor 1 bundles the items Production flexibility, Customer proximity and Lead time, therefore reflecting a joint focus on flexibility and delivery.

4.3. Logit model

A logit model is adopted to test hypotheses H1–H3 described in Fig. 1. The binary dependent variable is the adoption of Industry 4.0 technologies following backshoring. Fig. 2 illustrates the measurement model. Two models are estimated (Table 4): Model 1 allows testing H1–H2, whereas Model 2 includes interactions terms of backshoring factors with product innovation, in order to test the moderation hypothesis H3.

Control variables include industry and firm specific variables (right hand side of Fig. 2). Specifically, industry-related variables are captured by dummy variables for two sectors typically involved in automation, namely *automotive* and *electronics* with the addition of *textile, clothing, and footwear* as an aggregation of industries frequently involved in backshoring. Firm-specific variables include the ownership mode following backshoring (*insourcing* backshoring), firm size (whether the firm is a SME, obtained as the sum of *Small* and *Medium* in Table 2). Further, the fact that the backshoring initiative is part of a wider global reorganization of operations (*Global reorganization*) is controlled for, while the backshoring year is added to the equation in order to capture the maturity of the technologies adopted. Finally, contextual locational factors are included, namely private (e.g. from large buyers) or government support for domestic relocation (*Support for relocation*) and China as the offshore host country (*Host China*).

Goodness of fit measures are shown at the end of Table 4, suggesting a satisfactory fit (Kennedy, 2003). Variance inflation factors (VIF) exhibited values below the conservative cutoff value of three, therefore leading to exclude multi-collinearity problems.

Results show that the factor labelled "Costs of non-conformance" is significantly and positively related to new technology adoption ($p = 0.000$), while the factor capturing direct costs of offshoring is not statistically significantly. "Brand recognition" is not significantly related, while "Quality" is significantly and positively related to technology adoption ($p = 0.000$). The "Responsiveness" factor is never significant. These findings lend support to the hypothesis H1 that the

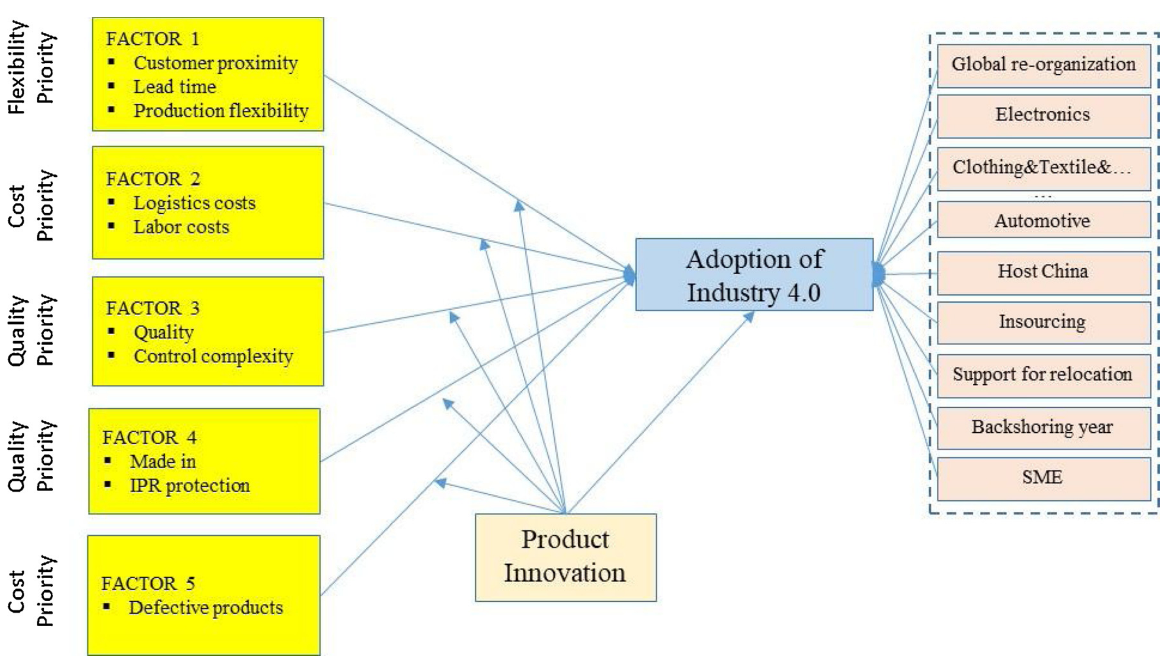

Fig. 2. Measurement model.

Table 4
Logit model (dependent variable: adoption of Industry 4.0).

Independent. Variables	MODEL 1			MODEL 2		
	Coeff	St.err	Sig.	Coeff	St.err	Sig.
Factor 1 – Responsiveness	0.129	0.147		0.224	0.170	
Factor 2 – Direct costs	−0.061	0.158		0.052	0.176	
Factor3 – Quality	0.442	0.124	***	0.329	0.163	**
Factor 4 – Brand recognition	−0.358	0.197	*	−0.177	0.288	
Factor 5 – Costs of non-conformance	0.544	0.149	***	0.529	0.167	***
Automotive	−1.053	0.620	*	−1.176	0.646	*
Clothing & Textile & Footwear	−0.807	0.489	*	−0.902	0.525	*
Electronics	0.456	0.422		0.271	0.449	
Host China	−0.707	0.363	*	−0.725	0.376	*
Insourcing backshoring	1.579	0.535	***	1.965	0.631	***
Backshoring year	0.806	0.180	***	0.853	0.190	***
SME	−0.019	0.328		−0.171	0.345	
Global reorganization	−1.036	0.461	**	−1.044	0.472	**
Support for relocation	0.007	0.563		0.010	0.567	
Product Innovation	1.966	0.400	***	1.787	0.468	***
Factor 1* Product Innovation				−0.255	0.323	
Factor 2* Product Innovation				−0.238	0.457	
Factor 3* Product Innovation				0.697	0.354	**
Factor 4* Product Innovation				−0.550	0.480	
Factor 5* Product Innovation				0.563	0.433	
Constant	−3.331	0.599	***	−3.537	0.673	***
GOODNESS OF FIT MEASURES						
McFadden pseudo R2	0.267			0.286		
LR chi2 (p > chi2)	106.57			114.41		
Percentage correctly predicted (p ≥ 0.5)	87.47%			87.07%		
Area under ROC curve	0.853			0.865		
Observations	495			495		

*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.10$.

likelihood of adoption of new production technologies varies with the competitive priority supporting backshoring.

The coefficient for product innovation is always statistically significant and positive (p = 0.000), thus confirming H2. Model 2 shows that only the interaction between Product innovation and Quality is positive and statistically significant (p = 0.049). In order to assess the overall impact of the Quality factor, we use the graphical moderation analysis introduced by Aitken and West (1991) (Fig. 3). The figure shows that, when the firm follows a quality strategy, the probability of adoption of Industry 4.0 increases from 2% to 33% if the firm is involved in product innovation. This finding lends partial support to H3.

Turning to the control variables, Industry 4.0 is not associated with the industry, with support for relocation, and with the firm size. The coefficient for global re-organization is negative and significant (p = 0.024), while the year of backshoring (p = 0.000) and insourcing backshoring (p = 0.003) both exhibit positive and significant coefficients.

5. Discussion

5.1. Diffusion of Industry 4.0 among backshoring firms

The data collected suggest that the diffusion of Industry 4.0 among companies backshoring to Europe is not widespread (14%), though comparable with percentages observed in recent manufacturing surveys (Boston Consulting Group, 2016). Overall, these results suggest that backshoring has predominantly occurred without resorting to labor saving technologies. A first explanation consistent with the RBV is that, in order to adopt new manufacturing technologies, backshoring companies need to possess the necessary technological capabilities or reshuffle their resource base in order to acquire the relevant Industry 4.0 skills. In addition, technological updating is undoubtedly costly, and backshoring firms may already be burdened by the costs of domestic relocation and of the restructuring of their value and supply chains.

Within Industry 4.0, advanced automation and additive manufacturing were the only technologies explicitly mentioned. This finding may hint that backshoring firms are more frequently drawn towards technologies that respond to challenges specifically tied to production and prototyping, rather than towards the advantages of intra- and cross-firm digital integration. Finally, adoption of new technologies has increased in recent years as a result of the maturity of the technologies, leading to expect an acceleration of adoption in the years to come.

5.2. Competitive priorities and Industry 4.0

The empirical model has explored whether backshoring firms with different competitive priorities adopt Industry 4.0 technologies following relocation at home. In the literature, both technology adoption (Zahra & Covin, 1993) and backshoring (Bals et al., 2016; Benito, 2015; Fratocchi et al., 2016) have been viewed as purposeful and strategy-driven, and therefore the likelihood of the adoption of new technologies was assumed to vary with the competitive priority underlying backshoring.

The literature on Industry 4.0 has pinpointed its positive impacts in terms of cost reduction, quality control and improvement, faster development and time to market (Brettel et al., 2014; Lu, 2017), while the backshoring literature, though limited, has mainly viewed Industry 4.0 as a cost equalizer between low cost and high cost countries (Arlbjørn & Mikkelsen, 2014) and as being functional to postponement (Moradlou & Tate, 2018).

Results from our empirical analysis on a large sample of firms backshoring to Europe suggest that Industry 4.0 is more frequently associated with two factors, the first relating to the costs of rework and

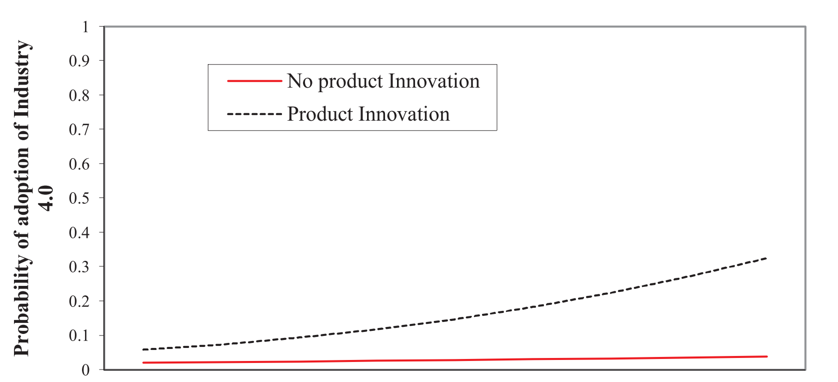

Fig. 3. Moderation analysis – Product innovation on Quality.

returns from the customer (Cost of non-conformance), the second concerning firms with a quality priority, intended as high product performance (Quality). The "Cost of non-conformance" factor points to the relevancy of hidden costs of producing offshore. Rework and returns generate costs, as they require additional time, material and labor. These costs, which would be saved if the job was undertaken appropriately the first time, are mostly hidden, because they are not generally recorded in the firm's accounting system (Schiffauerova & Thomson, 2006). In the same direction, in 2008 McKinsey estimated that, while labor savings from offshore production in countries such as China still accrued, these savings were offset by hidden costs (Goel, Moussavi, & Srivatsan, 2008). When relocating domestically, these companies need to rapidly solve the issue of the high rate of defective products. Robotics, combined with sensors and simulations, serves the purpose. Defective products will decrease through the lower usage of humans, while the need for quality inspections will be limited by spotting errors through the exploitation of real-time data (Rüßmann et al., 2015), resulting in higher labor and total factor productivity (De Backer et al., 2018).

The adoption of Industry 4.0 is significantly related also to one of the factors capturing quality priority, which highlights the importance of high product quality and effective control across the value chain. When product quality is a key determinant of the competitive success of the firm, close control is required towards offshore activities, in addition to their coordination with domestic processes. Control complexity stems from knowledge transfer, training of offshore personnel, or the monitoring of performance of offshore units, regardless of whether they are internal or external (Larsen, Manning, & Pedersen, 2013; Theyel, Hofmann, & Gregory, 2018). Analysis of the data reveals that these characteristics pertain mostly to firms in automotive and electronics, i.e. industries often requiring high precision and a high degree of quality control. In these industries, the adoption of automated processes leads to dramatic improvements of quality standards. For instance, systems based on robotic vision technologies are being used to improve product quality in several automotive companies (Bogue, 2013), but their introduction increases accuracy and precision also in other industries where quality is crucial, such as food production (De Backer et al., 2018). In addition, in industries such as electronics, metal parts and food processing, robotics contributes to overcome the problem of labor skills no longer available in Europe due to extensive offshoring (Kinkel, 2014; Reymen et al., 2015; Wiesmann et al., 2017).

Consistent with hypothesis H2, results show that product innovation and manufacturing technology renewal are complementary (Damanpour & Gopalakrishnan, 2001), suggesting that backshoring firms find new technologies useful especially to support product development. Further, when the quality priority is coupled with new product development, the adoption of new manufacturing technologies is amplified, since technologies such as additive manufacturing may allow timely prototyping and speed up time to market (Laplume et al., 2016).

The remaining three factors (Direct Costs, Brand recognition and Responsiveness) are not significantly related to Industry 4.0. The finding that rising direct costs offshore (labor and logistics) is not significantly associated with Industry 4.0 is seemingly counterintuitive, since one would expect the cost focus to lead backshoring firms to seek labor savings through automation. However, it should be acknowledged that several cost focused industries frequently involved in backshoring may not be able to automate. In fact, backshoring motivated by shrinking labor cost differentials significantly concerns labor-intensive productions such as textile and clothing (28%), which are slower to adopt robotics because of the low capital-labor substitutability. Worth of notice, 54% of the firms repatriating because of rising labor costs are SMEs, which have limited access to capital and lack competences (ICT, data management) crucial for the adoption of advanced technologies (Sommer, 2015). Finally, when the cause of backshoring is rising transport costs from Asia and minimum batch sizes, the relocation per se removes the cause of higher costs and may not require further investment in cost-cutting technologies.

The Brand recognition factor is associated with backshoring driven by the search for brand equity tied to the "Made in" label (Ancarani et al., 2015; Grappi et al., 2015) and more reliable patent protection (Bailey & De Propris, 2014). As already argued in seminal papers (Zahra & Covin, 1993), the premium price tied to ownership and control of these resources exceeds the return that could be generated by investment in new technologies, therefore weakening incentives to automate or upgrade manufacturing technologies. Further, at least for industries such as apparel and leather, the applicability of robotics and additive manufacturing is still limited because of low capital-labor substitutability.

Moradlou and Tate (2018) have pointed out the potential benefits of technologies such as additive manufacturing for backshoring motivated by the need for greater customer responsiveness, although they observe a low rate of diffusion. In the same direction, our study suggests that backshoring priorities in terms of greater production flexibility and customer proximity (Responsiveness factor) are not associated with new technology adoption. Data inspection reveals that several of the companies claiming this priority belong to the fabricated metal products industry, in which the diffusion of additive manufacturing is still limited (Laplume et al., 2016). For these firms, domestic relocation is tied not so much to benefits of the proximity to the headquarters of the company, but rather to supply chain issues, such as the need for closer collaboration with buyers and for the provision of better customer services (Wiesmann et al., 2017), which do not necessarily call for technology upgrading.

5.3. The impact of other variables

Consistent with previous literature, the concept of backshoring used in this paper has encompassed both insourcing and outsourcing backshoring (Fratocchi et al., 2014; Gray et al., 2013; Wan et al., 2018). The empirical models control for the impact of the governance decision on technology adoption and show that Industry 4.0 is significantly associated with a backshoring insource mode. Current research (Wan et al., 2018) points to vertical integration (from offshore outsourcing to domestic insourcing) as a strategy to overcome monitoring and control issues. In the same vein, our results suggest that in house investment in robotics allows solving issues arising from asset specificity, such as quality and performance monitoring of suppliers. In addition to transaction cost considerations, backshoring firms often return to home countries where the supplier base has dwindled, therefore mandating the substitution of technology for labor. Finally, worth of notice is the significant and negative association of Industry 4.0 with a global reorganization of production facilities. We conjecture that these re-organizations may capture backshoring oriented to exploiting untapped production capacity at home generated by the economic crisis that limits the firm's investment capacity.

6. Managerial and policy implications

Although lack of information on post-backshoring performance does not allow assigning prescriptive value to the findings of this paper, results can provide useful insights for managers evaluating prospective backshoring decisions and for policy makers intending to revitalize manufacturing in Europe. First, by showing that to date backshoring has largely taken place without investment in new technologies, results suggest that many of the challenges that firms faced offshore can be addressed by the mere relocation to the home country. This is certainly true for firms repatriating because of the "Made in" effect and in order to better protect intellectual property, but also for firms seeking shorter lead times and proximity to customers. Conversely, the new generation of technologies appear to be providing opportunities to increase productivity and to address product quality issues. In these instances, new technologies allow combining advantages in terms of lower labor usage, quality control and replacement of vanished labor skills. Though quantitative results do not offer direct evidence of this link, the reading of several of the press sources suggests that backshoring manufacturers felt the need to resort to investment in technology when work skills and the pre-offshore supply base had dwindled. In addition, new technologies can answer the need for curbing control costs across the value chain, therefore pointing to benefits for backshoring productions exhibiting high interdependencies and co-specialization. Results also point out to the significant linkage between backshoring and product and process innovation, suggesting that backshoring firms are adopting Industry 4.0 to improve design and strengthen the product-development linkage (Ketokivi et al., 2017).

Results also bear implications for European policy makers who have included the revitalization of domestic manufacturing among their priorities. In spite of this stated goal, only the UK has adopted an explicit policy supporting backshoring, while in other countries repatriations have been a bottom up phenomenon, led by firms' manufacturing strategy rather than by industrial policy (Spring et al., 2017). At the same time, several European countries (including Germany, France, Italy, UK) are providing public support for the adoption of Industry 4.0 in order to make domestic manufacturing competitive (Bortolini, Ferrari, Gamberi, Pilati, & Faccio, 2017). Findings from our sample suggest that to date backshoring adopting Industry 4.0 is not concentrated in a single country, and hence tied to ad hoc policy actions, but rather equally spread all over Europe. Similarly, we do not find any significant effect of the variable capturing either private or public support for relocation on the adoption of technology.

Although results suggest a marginal effect to date, policy makers may carve an important role in reconciling manufacturing competitiveness while simultaneously attracting manufacturing back from offshore locations. First, while some of the current Industry 4.0 policies are aimed at reducing the fixed costs of technology adoption, efforts should also be directed towards developing the necessary digital competencies for the successful exploitation of these technologies (Ancarani & Di Mauro, 2018b). Next, given the Industry 4.0, product innovation, and backshoring linkages identified in this research, the creation and reinforcement of innovation ecosystems may represent a lever to re-attract manufacturing currently in offshore locations and to provide the basis for future technological development (Pisano & Shih, 2012). Indeed, the positive moderation effect of product innovation suggests that the higher the degree of product quality of manufacturing and the greater process complexity and need for coordination, the greater the benefits of co-location of production and development. Policy action may concern not only own innovation efforts but also promote bridges with other organizations within innovation networks such as community colleges, research centers or spatial aggregations of knowledge intensive manufacturing (Spring et al., 2017). In this direction, previous research on backshoring has pointed to the advantages of co-locating within an industrial district as locus of knowledge and product innovation (Baraldi, Ciabuschi, Lindahl, & Fratocchi, 2018; Di Mauro et al., 2018).

7. Limitations and conclusions

Which companies are more likely to adopt new technologies as part of their decision to backshore production? Is the adoption of Industry 4.0 linked to the competitive priorities underscoring the backshoring initiative? These questions, which are current in academic and policy debate, have been explored in this paper with reference to a sample of firms backshoring to Europe.

Given that research on the potential role of technology in the relocation of manufacturing to western countries and data collection are still at their early stages, several limitations of this study must be highlighted. First, because of the cross-section nature of the information, causality links could not be ascertained. Therefore, our results can only be taken to imply contextuality not causality. Next, the relatively low number of firms introducing new technologies has not allowed studying the linkages between backshoring and specific Industry 4.0 technologies. Further, although careful textual search has been applied in order to extract information from secondary sources, the use of newspaper articles entails heterogeneity in the details of the case description provided by the authors of the press sources. Therefore, first hand data on firms' priorities should be sought to complement and enrich information. Finally, as the pace of adoption of new technologies progresses, empirical research will be called to assess whether the adoption of Industry 4.0 technologies contributes to the performance of backshoring firms.

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