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Innovation in Micro Firms that Build Machine Tools: Effects of T-KIBS on Technological and Non-technological Innovations

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Abstract

Purpose – This study aims to evaluate the effects of KIBS on innovation outcomes in micro firms that build machine tools according to the categories of KIBS. **Theoretical framework** – This article not only contributes to the theory on the innovation process by reinforcing the arguments that micro firms can achieve innovations, but also to the idea that KIBS have a positive influence on technological and non-technological innovation in manufacturing firms. **Design/methodology/approach** – To achieve the objective of the study, the Mann-Whitney U Test was used as the analysis technique. A survey was carried out to collect data from 40 micro firms that build machine tools located in the Basque Country (Spain) and Emilia-Romagna (Italy). **Findings** – The results suggest that KIBS have positive effects on innovations in manufacturing firms. However, there are differences according to the categories of KIBS. For instance, T-KIBS favour technological innovation, while P-KIBS and C-KIBS affect non-technological innovation. In addition, ICT services also have a positive relationship with non-technological innovation. We conclude by highlighting the importance of T-KIBS to confront the challenges of Industry 4.0 and the need for further research to determine the role of KIBS in the context of the Fourth Industrial Revolution. **Practical & social implications of the research** – Micro firms need to enhance their absorptive capacity by increasing ICT and R&D investments, to confront the challenges of Industry 4.0, and given the fact that industry is beginning to incorporate more and more codified science-based knowledge. Perhaps hiring T-KIBS would be an appropriate decision for micro firms. **Originality/value** – This study contributes to the advancement of research involving different category of KIBS and their effects on manufacturing firms' innovation, especially in micro firms that build machine tools.

Keywords – KIBS, technological innovation, non-technological innovation, micro firms, machine tools.

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1 Introduction

Firms with fewer than 10 employees are often assumed to be marginal businesses with no innovative capacity, and information on the innovation or R&D activities of micro firms is rarely collected (Baumann & Kritikos, 2016; Fernandes-Crespo, Curado, Oliveira, & Muñoz-Pascual, 2021). Previous studies on innovation have usually focused on SMEs (small and medium-sized enterprises) and large companies, excluding micro firms. For example, for developed economies, Acs and Audretsch (1990), Crepon, Duguet and Mairesse (1998), Hervas-Oliver, Sempere-Ripoll and Boronat-Moll (2021) and, for developing and emerging economies, Alvarez and Crespi (2003), Chudnovsky, Lopez and Pupato (2006), and Seclen-Luna and Morales (2022), show that SMEs with more than 10 workers contribute considerably to innovation outcomes.

In this research, we analyse whether micro firms that build machine tools produce innovative outcomes (technological and non-technological innovations). International empirical evidence has shown that the machine tool industry is the backbone of modern manufacturing, the first engine of progress and the cornerstone of economic growth (CECIMO, 2011) and it is highly concentrated in a few companies, which tend to be grouped in highly specialized regions (Chen, 2009; Schricke, Zenker, & Stahlecker, 2012). Our study focuses on two European regions, namely the Basque Country (Spain) and Emilia-Romagna (Italy), due to both regions being characterized as having a high presence of micro firms that build machine tools. For example, 48% of machine tool builders are micro firms in the Basque Country (AFM, 2015) and 64% are in Emilia-Romagna (UCIMU, 2013).

In recent years, manufacturers have added high intensity R&D to their processes due to the challenges of the industry and the advances in manufacturing driven by the Fourth Industrial Revolution (Propris & Bailey, 2020). In this context, the machine tool industry is increasingly characterised by knowledge and R&D intensity (CECIMO, 2011; European Commission, 2012). Notwithstanding, the key competences of machine tool builders boil down to tacit engineering know-how. Hence, innovations are largely incremental and often arise from the machinery firms' persistent efforts to satisfy requests from customers (Lissoni, 2001). In other words, in these companies, innovation is usually based on interactions and relies on learning by doing, by using, and by interacting. In addition, innovation usually emerges from other specialized providers, such as R&D services and engineering services (Chen, 2009; Seclen-Luna, & Barrutia-Güenaga, 2018). Our study analyses to what extent the innovation outcomes (technological and non-technological innovation) of micro firms that build machine tools are affected by specialized providers.

Knowledge intensive business services (KIBS) are becoming a prominent way to create and implement both technological and non-technological innovations in manufacturing firms (Amara, Landry, & Doloreux, 2009; Rizzi, Campanini, & Costa, 2012). More recent studies explore differences across KIBS sectors (Rodríguez, Doloreux, & Shearmur, 2017; Vaillant, Lafuente, Horváth, & Vendrell-Herrero, 2021), concluding that KIBS have different effects on manufacturing firms' innovation; it is especially argued that T-KIBS are more important than other categories of KIBS. Thus, within this research stream, our contribution lies in understanding whether KIBS can influence the innovation outcomes of micro firms that build machine tools, which raises the following research questions: Do KIBS have a positive effect on innovation outcomes in micro firms that build machine tools? Are there differences in the effects that KIBS sectors have on the innovation outcomes of micro firms?

The empirical analysis uses the Mann-Whitney U Test and is based on a sample of 40 micro firms that build machine tools in the Basque Country and in Emilia-Romagna that are highly representative of a mature and concentrated industry in their respective countries (AFM, 2015; UCIMU, 2013; Rizzi et al., 2012; Valdaliso, 2020). The results indicate that T-KIBS are mainly related to technological innovation – product and process innovation (García-Quevedo, Mas-Verdú, & Montolio, 2013; Vaillant et al., 2021) – while P-KIBS, C-KIBS and T-KIBS are related to non-technological innovation – organizational and marketing innovation (Alvisi, 2012; Amara et al., 2009; Zhou & Wang, 2020), this latter category to a lesser extent. In any case, T-KIBS are key to boosting the innovation capacity of the micro firms in both regions, with the firms from Emilia-Romagna being more prone to internationalization than those from the Basque Country.

The structure of this paper is as follows. The second section presents the literature review and establishes the research hypotheses. The third section details the database and tests the hypotheses. The empirical results are provided in the fourth section. Lastly, the fifth section provides some brief conclusions, the limitations, and suggestions for future research.

2 Literature Review and Hypothesis Development

2.1 Innovation outcomes: technological and non-technological innovations

Innovation can be understood as a final product or process that makes it possible to combine technical, financial, productive, organizational, and commercial capabilities to create or improve a product. In terms of final product, the main innovation outcomes are product innovation, process innovation, organizational innovation, and marketing innovation (OECD & EUROSTAT, 2005). In other words, as firms possess heterogeneous innovative resources, they can adopt different innovation paths to configure their innovation portfolio based on four innovation strategies: product, process, organizational and marketing innovation (Gunday, Ulusoy, Kilic, & Alpkan, 2011). In the literature, innovation outcomes are also called innovation performance or innovation portfolio (Bustinza, Gomes, Vendrell-Herrero, & Baines, 2019; Seclen-Luna, Opazo-Basáez, Narvaiza, & Moya-Fernández, 2021).

Another way to understand innovation outcomes is through the distinction between technological and non-technological innovations (Geldes, Felzensztein, & Palacios-Fenech, 2017; Mothe & Nguyen, 2010). Technological innovations are defined as product and process innovations, whilst non-technological innovations are associated with organizational and marketing innovations (Mothe & Nguyen, 2010). Technological innovation consists of the application of technologies to different aspects of a company with the aim of producing a significant novelty effect. That is, technological innovations are only related to the development and application of new technologies and are based on the results of new technological developments, new combinations of existing technologies, or the use of other knowledge acquired by the company, e.g., science and technology (Freeman, 1976). On the other hand, non-technological innovation is a facilitator of product and process innovations, as the success of these more tangible and visible innovations largely depends on how the organizational structures and processes co-evolve with new technologies (Armbruster, Bikfalvi, Kinkel, & Lay, 2008). However, recent studies have found that different types of technological innovation have different effects on the performance of organizational innovation, implying that not all innovation capabilities can be integrated to build complex systems of interconnected assets (Hervas-Oliver & Sempere-Ripoll, 2015). In fact, these authors state that technological process innovations strengthen the impact of organizational innovation, whereas the introduction of technological product innovations diminishes it. Therefore, we must observe caution when analysing these relationships. In any case, Hervas-Oliver, Ripoll-Sempere and Boronat-Moll (2016) suggest that the integration of technology and organization creates higher-order complex innovation capabilities and positive complementarities that improve performance. That is, firms need to complement their limited technological innovation capacity with other non-technological or management innovations, with the aim of compensating for the rather weak internal capabilities usually found in SMEs in low-tech sectors and settings. Furthermore, Hervas-Oliver et al. (2021) affirm that the integration of internal and external sources of knowledge creates combinations of activities that build up a firm's innovation capabilities.

2.2 Knowledge-intensive business services (KIBS) and manufacturing firms

In general terms, KIBS are critical components of modern economies since they are problem-solvers for other organizations (Miles, Belousova, Chichkanov, & Krayushkina, 2021). That is, they develop tailored solutions for customers that require tailored solutions to complex and specific problems (Santos & Spring, 2015). KIBS are service organisations whose primary value propositions include knowledge-intensive inputs to the business processes of customer organisations (Miles, 2005). Thus, their specialization in the knowledge field constitutes the specific mode of production adopted by them (Hertog, 2000) and they can be innovative by themselves (Chichkanov, Miles, & Belousova, 2019; Teixeira & Santos, 2016). Also, they have grown rapidly in modern economies and have become integrated into many supply chains and business strategies (Miles et al., 2021).

More specifically, KIBS can be an important source of innovation (Muller & Doloreux, 2009) since they can compensate for or complement the innovation capabilities of their client companies (Ciriaci, Montresor, & Palma, 2015; Muller & Zenker, 2001). Likewise, they can act as innovation facilitators or knowledge intermediaries (Czarnitzki & Spielkamp, 2003; Hertog, 2000) since they support clients in the development of their innovation processes. More recent studies explore the relationship between KIBS and manufacturing firms with regards to different issues, such as: the factors that influence the purchasing decisions of a firm's customers (Kohtamäki & Partanen, 2016), the vertical integration in several industries (Antonietti, Ferrante, & Leoncini, 2014) where KIBS are an effective carrier of production-based R&D to manufacturing firms (Bustinza et al., 2019; Ciriaci et al., 2015; García-Quevedo, Mas-Verdú, & Montolio, 2013), the transfer of knowledge on firms' innovation and technology commercialisation processes (Zhou & Wang, 2020), supporting the emergence of circular oriented innovation (Pereira & Vence, 2021), internationalization (Shearmur, Doloreux, & Laperrière, 2015), as well as the co-location of KIBS (Brunow, Hammer, & McCann, 2020; Seclen-Luna & Moya-Fernández, 2020) and territorial servitization (Lafuente, Vaillant, & Vendrell-Herrero, 2019).

The literature has recognized that the evolutionary patterns for KIBS are significantly affected by the characteristics of the local manufacturing industry. Thus, by acquiring knowledge-intensive services needed to produce their final products, manufacturing firms also learn by interacting, and acquire technical knowledge and customised problem-solving experience, which may have a positive impact on their innovation capacity (Ciriaci et al., 2015). KIBS are especially important to compensate for the weakness of small size that often hampers the quest for innovation by small and medium-sized (SME) manufacturers, especially for micro firms that lack the internal resources and capabilities required for internal, advanced product development.

However, not all knowledge-intensive service provision plays the same role within the innovation process (Doloreux & Shearmur, 2012) or not all KIBS are equally innovative (Corrocher, Cusmano, & Morrison, 2009; Rodríguez & Camacho, 2010). Therefore, one should be cautious when generalizing about innovation in KIBS since they have different 'knowledge-bases' (Pina & Tether, 2016; Strambach, 2008). The literature traditionally distinguishes between two kinds of KIBS: professional-based KIBS (P-KIBS), which are often seen as intensive users of technology; and technology-based KIBS (T-KIBS), which use, develop, and transfer technology (Doloreux & Shearmur, 2012). The differences across the KIBS sub-sectors have not been broadly explored; thus, KIBS cannot be analysed as an undifferentiated group of establishments (Rodríguez, Doloreux, & Shearmur, 2017). In this sense, one of the most useful classifications of KIBS is the one proposed by Miles (2012) and which is currently used to understand in detail each industrial sector of KIBS (Miles et al., 2021): 1) traditional professional services (P-KIBS), which are composed of administration and institutional knowledge services, such as legal services (NACE M69.1), accounting services (NACE M69.2), business management (NACE M70.2), etc.; 2) scientific and technological knowledge services (T-KIBS), which are made up of computer-related services (NACE J63), R&D services (NACE M72), engineering services (NACE M71.12), technical testing services (NACE M71.2), among others; and 3) more creative and cultural knowledge services (C-KIBS), which include design services (NACE M74.1), market research services (NACE M71.11), and advertising services (NACE M73.1), etc.

As such, P-KIBS, T-KIBS and C-KIBS may influence the performance of a local industry in different ways. Fundamentally, the role and importance of KIBS may differ depending on the nature of the knowledge-intensive service supplied. For instance, P-KIBS are grounded on professional-based services and support activities that depend on personal expertise and tend to be less likely to transfer their knowledge to other local firms (Doloreux, Freel, & Shearmur, 2010). Furthermore, they are unlikely to stimulate the necessary flows of knowledge across a local value chain that can affect industrial performance (Amara, Deste, Landry, & Doloreux, 2016).

On the contrary, the positioning of T-KIBS within their clients' value chain is likely to be more connected to manufacturers' operations (Lafuente, Vaillant, & Vendrell-Herrero, 2017), enabling manufacturing firms to benefit from smart manufacturing technologies (Bustinza, Opazo-Basaez, & Tarba, 2021). At a regional level, T-KIBS have a potential resources-based relatedness in their 'knowledge space', allowing their local manufacturing sectors to diversify production more easily towards Industry 4.0 and embrace the 'Fourth Industrial Revolution' (Vaillant, Lafuente, Horváth, &

Vendrell-Herrero, 2021). In any case, authors suggest that industrial firms can benefit more from the relatively greater local presence of T-KIBS than P-KIBS. In addition to the abovementioned arguments, other authors state that manufacturers-KIBS interdependency depends on the role of the industry life cycle. Industries at early or maturing stages of their life cycle would rely on the explorative potential of KIBS, such as in R&D, marketing, or management (Elche, Consoli, & Sánchez-Barrioluengo, 2021). Thus, based on these arguments, we propose the following hypotheses:

H1a: P-KIBS are positively associated with the technological innovation of micro firms that build machine tools.

H1b: P-KIBS are positively associated with the non-technological innovation of micro firms that build machine tools.

H2a: T-KIBS are positively associated with the technological innovation of micro firms that build machine tools.

H2b: T-KIBS are positively associated with the non-technological innovation of micro firms that build machine tools.

H3a: C-KIBS are positively associated with the technological innovation of micro firms that build machine tools.

H3b: C-KIBS are positively associated with the non-technological innovation of micro firms that build machine tools.

Figure 1 presents the hypotheses formulated in a theoretical model. The next section covers the study methodology.

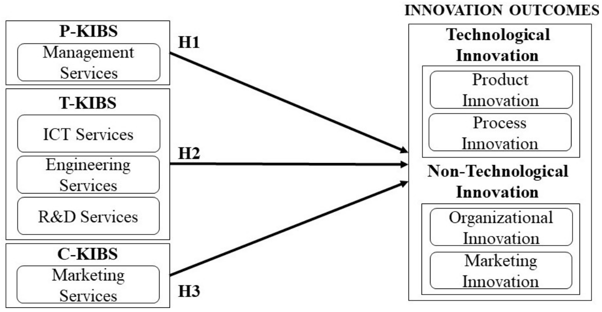

Figure 1. Theoretical model.

3 Data, Variables and Method

3.1 Data description

In Europe, the production of machine tools is led by Germany, followed by Italy, Switzerland, and Spain (CECIMO, 2015). In this context, we focus on Spain (Basque Country) and Italy (Emilia Romagna) due to both being leading countries (regions) in the machine tool industry in Europe. In particular, the first region accounts for 70% of machine tool production in Spain (AFM, 2015), and in the second, 90% of the companies in the machine tool industry are SMEs (UCIMU, 2013). Furthermore, another important reason for analysing these regions is because both have similar characteristics in terms of concentration of manufacturing specialization and KIBS, which can have different effects on the innovation outcomes of micro firms.

According to our research objective (to understand the effects of KIBS on the innovation of micro firms that build machine tools), we split the sample into two groups according to the region where the companies are located. The first group was made up of those micro firms from the Basque Country and the second group consisted of those micro firms from Emilia-Romagna. For the empirical illustration, a unique primary dataset drawn from a research project on the effects of KIBS on manufacturing firms was used. The process was entirely supervised by a team from the Faculty of Business and Economics at the University of the Basque Country (Spain) and the Faculty of Business and Economics at the University of Perugia (Italy). In the Basque Country, the information was collected from November 2011 to January of 2012, through direct face-to-face surveys, which consisted of completing a questionnaire through a tablet device, with 20 questions geared towards obtaining information on the innovation processes, relationship with KIBS, and business environment of the micro firms that build machine tools. This involved the participation of a qualified pollster and informants that were the firms' managers, who participated in the decision-making for the companies. However, in Emilia-Romagna, the surveys were conducted online by cooperating institutions, such as the Italian Confederation of Small and Medium Private Industry (CONFAPI), from February to May of 2012.

It is important to mention that each questionnaire included a cover letter explaining the purpose of the study. The incoming data only included observations for which a complete dataset of the analysed variables could be constructed. This process yielded a final sample of 40 companies: 25 from the Basque Country and 15 from Emilia Romana. This study is more census-type than sample-type, owing to the small size of the population, as we mentioned above, where in the Basque Country there are 60 builders of machine tools and 29 of them are micro firms (AFM, 2015) and in Emilia-Romagna there are 42 builders of machine tools and 27 of them are micro firms (UCIMU, 2013).

3.2 Description of variables

Based on the comprehensive questionnaires, two groups of variables could be observed. The first set of variables deals with innovation outcomes, while the second group of variables deals with KIBS. The dependent variable is the innovation outcomes. According to the Oslo Manual (OECD & EUROSTAT, 2005), the four main innovation outcomes are: product, process, organizational and marketing innovation. In this study, the respondents were asked to score on a five-point Likert scale (1 = no results and 5 = excellent results) the individual importance of innovation outcomes over the last three years. The division of the positive scale values (from ‘1’ to ‘5’) allows a sufficient degree of differentiation in the valuation of the analysed variables (Cheng & Shiu, 2015). It is important to mention that the informants’ responses are framed in their management experience and existing knowledge (Kunc & Morecroft, 2010), which in turn could influence how managers perceive innovation outcomes. Perception in this sense includes all the cognitively interpreted information that managers use to make decisions, as Mezias and Starbuck (2003) established.

Nevertheless, due to the low number of observations for some of the key variables prohibiting our analysis, we grouped them into two innovation outcome categories. In this respect, the first category comprises technological innovations (as the sum of product innovation and process innovation), and the second category comprises non-technological innovation (as the sum of organizational innovation and marketing innovation). In the literature on technological innovation, it is recognized that both product and process innovation are part of technological innovation (Freeman, 1976). Thus, in our research, we used as an indicator of technological innovation both the product and process innovation achieved by companies. In the field of innovation, there is a large body of research on the use of this conception of technological innovation (Flor & Oltra, 2004; Freeman, 1976; Mothe & Nguyen, 2010; Seclen-Luna & Morales, 2022). Other studies opt to measure technological innovation through the number of patents or patent citations, but they could be underestimating the innovation activity of firms because some of them are unwilling to register patents for fear of their new ideas being appropriated or they cannot afford the exposure and time involved in the patenting process. Thus, we used both product and process innovation together as technological innovation. Following the previous argument, we carried out a similar process for the case of non-technological innovation (Geldes et al., 2017; Mothe & Nguyen, 2010). In terms of analysing the scale’s internal consistency, the variable of technological innovation has a Cronbach’s alpha value of α = 0.792, and the variable of non-technological innovation has a Cronbach’s alpha value of α = 0.651, which indicate a considerable reliability level and are accepted for an exploratory investigation (Malhotra, Birks, & Wills, 2012).

On the other hand, in accordance with the literature on KIBS reviewed (Doloreux & Shearmur, 2012; Miles, 2012; Miles et al., 2021), we considered as independent variables the different kinds of KIBS that firms hire to achieve technological innovation outcomes (products and processes), and non-technological innovation outcomes (organizational and marketing). Thus, we grouped them in three categories: 1) traditional professional services (P-KIBS), which we called ‘management services’; 2) services with scientific and technological knowledge (T-KIBS), which are made up of computer-related services or ‘ICT services’, ‘R&D services’, and ‘engineering services’; and 3) services with more creative and cultural knowledge (C-KIBS), which include ‘marketing services’. Like in previous studies (e.g., Rodríguez & Camacho, 2010; Seclen-Luna & Barrutia-Güenaga, 2018), these five items are included in the questionnaire using a binary variable (0 = KIBS not incorporated and 1 = KIBS incorporated). In analysis terms, the scale’s internal consistency shows a Cronbach’s alpha value of α = 0.663, which indicates a considerable reliability level and is accepted for an exploratory investigation (Malhotra et al., 2012). Table 1 shows the definitions of the variables used in this study.

3.3 Method and tests

In accordance with our research objectives, we estimated the effects of KIBS on the innovativeness of the micro firms that build machine tools. The descriptive data and tests were computed using the R software. For the comparative statistical analysis we used the Mann-Whitney U test instead of the T-test because the assumption of normality in the data is not satisfied; but also, to test the hypotheses we analysed the relationships using this method due to it not being an overly complex method that does not requires big sample sizes.

4 Empirical Results

Our first statistical results indicate that micro firms that build machine tools are more likely to obtain technological innovation than non-technological innovation (Table 2). Also, engineering services and management services are the most hired by them, while R&D services are the least hired.

Although this information may be useful, we cannot see any differences between the two regions (Basque Country versus Emilia-Romagna). Thus, from the contextual point of view, we analysed innovation outcomes (technological and non-technological) in machine tool builders according to their regions, using the Mann-Whitney U test, and we found that the innovation outcomes differ slightly between the micro firms that build machine tools from the Basque Country and those from Emilia-Romagna. As shown in Table 3, the two-sided asymptotic significance of the Mann-Whitney U statistics is greater than 0.10, so it is safe to say that the differences are due to chance variations, which implies that there are no differences between the manufacturers (Schricke, Zenker, & Stahlecker, 2012) in terms of product, process, and organizational innovation.

However, the data in Table 3 also show that there are differences regarding marketing innovation ($p = 0.015$). One possible explanation for this is that an overseas orientation could influence this result (Shearmur et al., 2015). For instance, the machine tool builders from the Basque Country allocated 74% of their production to the domestic market in 2012, while the builders from Emilia-Romagna allocated only 52% of their production to the

Table 1
Definition of variables

Variable	Definition	Scales
Innovation Outcomes	Level of importance in carrying out innovation (product, process, organizational and marketing) over the last three years	Ordinal
KIBS	Firm reported that they hired KIBS to support their innovation processes	Dichotomous
Foreign Markets	A value of 1 indicates that the firm reported exporting its products. 0 otherwise.	Dichotomous
Firm Size	Number of workers	Logarithm
Firm Age	Time from foundation of the firm	Logarithm
Region	A value of 1 indicates that the firm is from the Basque Country and 0 means it is from Emilia Romagna	Dichotomous

Table 2
Summary statistics

Variable	Min	Max	Mean	SD
Technological Innovation	2	10	4.90	2.2736
Non-technological Innovation	2	6	3.15	1.2920
Management Services	0	1	0.52	0.5057
ICT Services	0	1	0.37	0.4903
Engineering Services	0	1	0.55	0.5038
R&D Services	0	1	0.30	0.4641
Marketing Services	0	1	0.35	0.4830
Firm Size	1	9	7.07	2.2914
Firm Age	5	76	23.52	16.6687

Table 3
Comparative statistics

Variable	Region	Min	Max	Mean	Median	SD	Mann-Whitney U Test	P Value
Product Innovation	Basque Country	1	5	2.44	3.00	1.325	185.500	0.953
	Emilia Romagna	1	5	2.47	3.00	1.125		
Process Innovation	Basque Country	1	5	2.36	3.00	1.350	169.500	0.598
	Emilia Romagna	1	5	2.60	3.00	1.121		
Organizational Innovation	Basque Country	1	3	1.32	1.00	0.557	144.000	0.150
	Emilia Romagna	1	2	1.53	2.00	0.516		
Marketing Innovation	Basque Country	1	4	1.48	1.00	0.963	111.500	0.015
	Emilia Romagna	1	3	2.20	3.00	0.941		

domestic market. Thus, in the Emilia-Romagna region there is a tendency for internationalization (Rizzi et al., 2012). Therefore, our results suggest that there are no essential differences in innovation outcomes for machine tool builders from both regions, except in marketing innovation.

On the other hand, Table 4 and Table 5 show the results of the full Mann-Whitney U test analysis. In the first, technological innovation is estimated according to the total sample and the region of the companies. Similarly, in the second, non-technological innovation is estimated, respectively. It is important to note that the Mann-Whitney U test results are consistent with the T-test and even with the OLS estimation – that is, the results are qualitatively similar.

In Table 4, the three categories of KIBS are estimated separately, that is, P-KIBS, T-KIBS and C-KIBS. We observed that the micro firms that build machine tools that incorporate ICT services, engineering services and R&D services in their innovation processes have positive effects on technological innovation (product and process innovation). Particularly, a higher effect is seen from ICT services and engineering services compared to R&D services. These results support **H2a** and show that T-KIBS and technological innovation are positively related for micro firms that build machine tools. Thus, this finding suggests that T-KIBS boost technological innovation (Bustinza et al., 2019 & 2021; Ciriaci et al., 2015; García-Quevedo et al., 2013; Vaillant et al., 2021). In other words, the micro firms that build machine tools hired T-KIBS to improve their products and processes, and increase their knowledge (CECIMO, 2011; European Commission, 2012). Conversely, other services such as management services and marketing services, as well as the firm's region, are not significant. Therefore, our results suggest that industrial firms can benefit more from the relatively greater local presence of T-KIBS than P-KIBS, as found in recent studies (e.g., Vaillant et al., 2021).

In Table 5, we estimated P-KIBS, T-KIBS and C-KIBS separately with respect to non-technological innovation. We observed whether micro firms that build machine tools that incorporate management services, ICT services and marketing services in their innovation processes have positive effects on non-technological innovation (organizational and marketing innovation). A higher effect is seen for marketing services compared to ICT services. These results support **H1b, H3b** and **partially H2b**. Hence, our results show that P-KIBS, T-KIBS (ICT services), C-KIBS and non-technological innovation are positively related for micro firms that build machine tools. Thus, this finding suggests that almost all kinds of KIBS boost non-technological innovation (Ciriaci et al., 2015; Rodríguez & Camacho, 2010; Seclen-Luna & Barrutia-Güenaga, 2018).

Conversely, other services such as engineering services and R&D services are not significant. This finding suggests that it is mainly P-KIBS and C-KIBS that boost non-technological innovation (Alvisi, 2012; Amara et al., 2009; Corrocher et al., 2009; Zhou & Wang, 2020). In addition, these relationships can be different depending on the region, being more significant in the Emilia-Romagna region than in the Basque Country. All in all, it is noteworthy that non-technological innovation is oriented towards the domestic market (Rizzi et al., 2012; Valdaliso, 2020).

In any case, all these results coincide with previous studies such as those of Chen (2009), Ciriaci et al. (2015) and Seclen-Luna and Barrutia-Güenaga (2018), who

Table 4
Test for technological innovation

Variables	Group	Min	Max	Mean	Median	SD	N	Mann-Whitney U Test	P Value
Management Services	No	2	8	4.79	6	2.53	19	203.5	0.9216
	Yes	2	10	5.00	6	2.07	21		
ICT Services	No	2	10	4.16	4	2.43	25	86	0.0034
	Yes	3	8	6.13	6	1.30	15		
Engineering Services	No	2	10	3.22	4	2.43	25	86	0.0034
	Yes	3	8	6.27	6	1.30	15		
R&D Services	No	2	10	4.32	4	2.47	28	87	0.0140
	Yes	5	8	6.25	6	0.75	12		
Marketing Services	No	2	10	4.65	5	2.59	26	147.5	0.3171
	Yes	2	7	5.36	6	1.50	14		
Region	Basque Country	2	10	4.80	6	2.60	25	175.000	0.7279
	Emilia-Romagna	2	7	5.07	6	1.67	15		

Table 5
Test for non-technological innovation

Variables	Group	Min	Max	Mean	Median	SD	n	Mann-Whitney U Test	P Value
Management Services	No	2	6	2.53	2	1.07	19	91.5	0.0019
	Yes	2	6	3.71	4	1.23	21		
ICT Services	No	2	6	2.76	2	1.23	25	96	0.0067
	Yes	2	5	3.80	4	1.15	15		
Engineering Services	No	2	6	3.11	2.5	1.41	18	187	0.7606
	Yes	2	5	3.18	3	1.22	22		
R&D Services	No	2	6	3.00	2	1.31	28	128	0.2134
	Yes	2	5	3.50	4	1.24	12		
Marketing Services	No	2	5	2.58	2	0.90	26	59	0.0002
	Yes	2	6	4.21	4	1.25	14		
Region	Basque Country	2	6	2.80	2	1.29	25	103	0.0123
	Emilia-Romagna	2	5	3.73	4	1.10	15		

stated that specialized providers can improve innovations in the machine tool industry. Nonetheless, despite the micro firms that build machine tools not contracting ICT services very frequently, all of the findings show that KIBS specialized in ICT are the only category that positively affects both technological and non-technological innovation. Therefore, in relative terms, this kind of KIBS could be of great importance for innovation outcomes in micro firms. This is particularly true in the context of the Fourth Industrial Revolution (Bustinza et al., 2021; Propris & Bailey, 2020; Vaillant et al., 2021).

5 Conclusions

5.1 Theoretical implications

This article not only contributes to the theory by reinforcing the arguments that micro firms can achieve innovation outcomes (Baumann & Kritikos, 2016; Fernandes-Crespo et al., 2021), but also that KIBS have a positive influence on their innovation outcomes (Ciriaci et al., 2015; Doloreux & Shearmur, 2012; Seclen-Luna & Barrutia-Güenaga, 2018; Hervas-Oliver et al., 2021). Furthermore, this study presents evidence on the heterogeneous nature of the KIBS sector for the innovation outcomes of micro firms that build machine tools. Thus, there are differences between the types of KIBS and innovation outcomes (technological and non-technological). T-KIBS are mainly related to technological innovation – product and process innovation (Bustinza et al., 2019 & 2021; Ciriaci et al., 2015; García-Quevedo et al., 2013; Vaillant et al., 2021), while P-KIBS, C-KIBS and T-KIBS are related to non-technological innovation – organizational and marketing innovation (Alvisi, 2012; Amara et al., 2009; Corrocher et al., 2009; Zhou & Wang, 2020), the latter category to a lesser extent. Overall, the findings are consistent with previous work that emphasizes the heterogeneity of KIBS sectors as well as the relevance of taking into consideration these differences to understand how KIBS contribute to innovation in manufacturing firms. Therefore, our study adds arguments to understand the differences in KIBS sector effects (Doloreux & Shearmur, 2012; Miles et al., 2021; Rodríguez et al., 2017), highlighting the importance of T-KIBS (Vaillant et al., 2021).

5.2 Managerial and policy implications

This study contains two main implications. First, our findings suggest that the very small size of a manufacturer and its specialization in a domestic market niche (Rizzi et al., 2012; Valdaliso, 2020) gives it few incentives to internationalize and generate new knowledge. Therefore, micro firms need to enhance their absorptive capacity (Ciriaci et al., 2015; Chen, 2009) by increasing ICT and R&D investments (Baumann & Kritikos, 2016; Bustinza et al., 2019), given the fact that the industry is beginning to incorporate more and more codified science-based knowledge (CECIMO, 2011; European Commission, 2012), and it needs to undergo a renewal or transformation process (Zubiaurre, Sisti, & Retegi 2020) to confront the challenges of Industry 4.0 (Bustinza et al., 2021; Propris & Bailey, 2020; Vaillant et al., 2021). In this sense, micro firms should improve their R&D capabilities (García-Quevedo et al., 2013; Bustinza et al., 2019), and especially their ICT capacity (Vaillant et al., 2021). As we evidenced in this study, perhaps hiring T-KIBS would be an appropriate decision for micro firms. The second implication is that KIBS are very heterogeneous and there is a need to understand their effect on innovation processes or their clients (Doloreux & Shearmur, 2012; Miles et al., 2021; Rodríguez et al., 2017). Therefore, a detailed analysis of their innovation patterns could be useful for government efforts to promote industrial policies. In fact, it is important for regional and local governments to consider integrating KIBS into manufacturing clusters when designing industrial policies (Vendrell-Herrero & Wilson, 2017). This is especially important because these relationships can help to build a process of territorial servitization (Lafuente et al., 2019) that includes the machine tool industry (Valdaliso, 2020; Zubiaurre et al., 2020).

5.3 Limitations and future research

Although these results are useful due to their implications for business managers and policy makers, since they advance the knowledge about how an innovation portfolio should be managed by micro firms that build machine tools, this study has limitations that suggest the need for future research. Firstly, due to the fact that the empirical analysis is more census-type than sample-type, owing to the small size of the population, the results prevent an analysis at the industry level. Secondly, the data do not enable an evaluation of how manufacturing internalizes KIBS in its operations, especially for its internationalization process; further research on this issue would be valuable. Thirdly, the analysis carried out in this exploratory study is of a cross-sectional nature, and so it does not capture all the dynamics of the innovation process; further research on this issue would therefore also be valuable. Lastly, it would also be very worthwhile to carry out comparative studies among European regions (Ciriaci et al., 2015; Schricke et al., 2012; Vaillant et al., 2021) and even beyond European boundaries (Seclen-Luna & Moya-Fernández, 2020), which would help governments to improve their industrial policies. Thus, future research will need to corroborate the results in specific contexts in a long-term analysis, to determine some of the causal mechanisms.

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