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Assessment of industrial pre-determinants for territories with active product-service innovation ecosystems

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ABSTRACT

There has been growing interest in service-augmented products and the subsequent formation of product-service innovation (PSI) ecosystems. Hence, the objective of this paper is to empirically address an unexplored aspect of PSI ecosystems research by offering answers as to whether territories develop more performant PSI ecosystems in terms of manufacturing employment growth when they arise from an existing industrial base. Running a fixed-effects model on a sample of all 17 Spanish autonomous communities in the period from 2006 to 2012, the importance of territories having a strong incumbent manufacturing sector before developing PSI ecosystems is revealed. Specifically, it is found that PSI ecosystems will generate greater industrial employment growth in manufacturing-led territories. Our model and findings suggest various implications for scholars, managers, and policymakers alike.

1. Introduction

Digital transformation and the transition to a data-based economy is increasingly reshaping and expanding the boundaries of industry (Acs et al., 2022; Lafuente et al., 2022; Porter and Heppelmann, 2014). The adoption of service-augmented products is an increasingly popular strategy implemented by manufacturing businesses seeking superior competitiveness in reaction to the development of such a knowledge-based economy (Crozet and Milet, 2017; Lafuente et al., 2017; Lombardi et al., 2022). As such, product-service innovation (PSI) can be viewed as conduit mechanisms that contribute to the development of innovation capabilities and help manufacturers to make the transition. Related research has primarily focused on how manufacturing businesses develop advanced services in-house (Cusumano et al., 2015; Bustinza et al., 2019a, 2021). However, many manufacturing businesses do not have the capacity to achieve the potential benefits of PSIs internally (Horváth and Rabetino, 2019) or may find strategic benefits in the innovation-driven outcomes of different types of collaborative PSI strategies (e.g., outsourcing, strategic alliance) (Wyrwich, 2019; Vaillant et al., 2021).

Recent studies have therefore invoked increased inter-industry collaborations to stimulate servitization-based innovations in response to the digital transformation of the economy (e.g., Landry et al., 2013; Lafuente et al., 2017; Lafuente et al., 2022; Kapoor et al., 2021). These innovation processes imply the development of an external hybrid value chain, platforms and territorial collaborations, a process that is linked to the development of a product-service innovation (PSI) ecosystem (Lafuente et al., 2019; Vendrell-Herrero et al., 2020, 2021a). However, despite attempts to stimulate such systems, evidence has shown that the public administrations of many advanced economies are having a hard time replicating such processes despite their attempts to transition towards a digitally servitized economy (Matsuyama, 2009; OECD, 2017, 2021). Research into PSI ecosystems is developing quickly. However, for the moment, there is still a significant gap in terms of identifying the pre-determinant factors leading to the establishment of active PSI systems within a territory.

The objective of this paper is therefore to empirically address this unexplored aspect of PSI ecosystems research and attempt to find answers as to the pre-determinant industrial origins of such value-adding ecosystems. Specifically, the study seeks to test whether territories develop more performant PSI ecosystems in terms of manufacturing employment growth if they previously had a strong incumbent manufacturing sector.

Our study not only addresses the identified gap but also responds to

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the call for research offering empirical evidence of the role that active hybrid value-chain collaboration plays in re-defining value creation through the development of local product-service innovation ecosystems (Lafuente et al., 2019; Vendrell-Herrero et al., 2021b). It does so by examining the role that an established incumbent manufacturing sector plays in fostering disruptive value-adding PSI ecosystems that enhance employment creation. The related diversification trajectory premises underlying the evolutionary economic geography literature (Boschma and Frenken, 2018; Whittle and Kogler, 2020) offer some clues as to why a strong incumbent manufacturing sector may help to trigger the disruptive value-adding territorial servitization process linked with PSI ecosystems (De Propris and Storai, 2019; Lafuente et al., 2019). The rationale proposed herein is that regions with a strong incumbent manufacturing sector have built an established local capability set that gives them better access to the knowledge space and potential diversification trajectories that are compatible with the development of value-adding PSI ecosystems (Whittle and Kogler, 2020).

The study and its findings not only help to advance the theoretical premise of the PSI ecosystem and territorial servitization literature, but also offer insights as to how regional economies can access, adopt, and possibly develop the new competencies required to successfully compete in a knowledge-based digital economy. The results will help industrial strategy-makers to better understand the formation of PSI ecosystems, thus leading to improved innovation-based resilience and competitiveness among local industrial ecosystems (Bailey et al., 2020). This requires greater knowledge of the mechanisms that drive the formation of PSI ecosystems. Our findings contribute to this.

The remainder of the paper is divided into two main parts. The first section presents the problem statement motivating the study's main hypothesis, which is then theoretically developed in the following section. Section 3 describes the data and methodology. After a presentation of the results of the model, the implications of the empirical findings are discussed in the concluding remarks presented in section 6.

2. PSI ecosystems and hypothesis development

The digital transformation of the economy is having a profound impact on producers of manufactured goods (Ghosh et al., 2022). The emergence of smart, connected products is shifting the functionality of a discrete product towards the performance of the broader value system consisting of closely related product-service structures. Further still, products cease to be stand-alone goods, to instead become elements of wider interconnected systems of systems in which firms are interdependent actors that link an array of such PSI systems together (Aaldering and Song, 2021). Manufacturers therefore offer pieces of a larger package of connected equipment and related services that optimize overall results leading to 'products as a service' (Porter and Heppelmann, 2015). As such, manufacturers' value creation becomes "productless" (Opazo-Basáez et al., 2022). That is, the system that connects products is the core output, not the products themselves. Porter and Heppelmann (2014) offer the example of the tractor manufacturer that when connected and integrated within a larger farming optimization system, ceases to be a mere tractor manufacturer to instead become a deliverer of value within a farming performance facilitation system (Fig. 1).

With such PSI systems, the competitive boundaries of an industry widen to encompass a set of related products that together meet a broader underlying need (Bustinza et al., 2013). The function delivered by one PSI is optimized with other related products and services as well as data collection nodes. Therefore, the transition to greater PSI development also creates new best practices across the value chain (Tronvoll et al., 2020). But PSI systems go beyond simple transactional value-chain exchanges to include a rich and complex ecosystem of platform-based data collection, information processes, and knowledge interaction (Tian et al., 2021). In-fact, PSI ecosystems, together with private firms, often include territorially bonded public and social institutions that act as system enhancers and facilitators of information and knowledge flow (Hou and Shi, 2021).

Internal development of the entire technology stack for such connected value creation covering the whole PSI ecosystem requires significant investment in specialized skills, technologies, and infrastructure that is rarely found within any single manufacturing company (Jovanovic et al., 2019, 2021). Therefore, the transition of industrial regions to PSI ecosystems is often associated with increasing instances of hyperspecialization and external collaboration (Giustiziero et al., 2021; Lombardi et al., 2022). Participants in PSI ecosystems must decide which layers of technology will be developed and maintained in-house and which will be accessed through the firm's participation in an

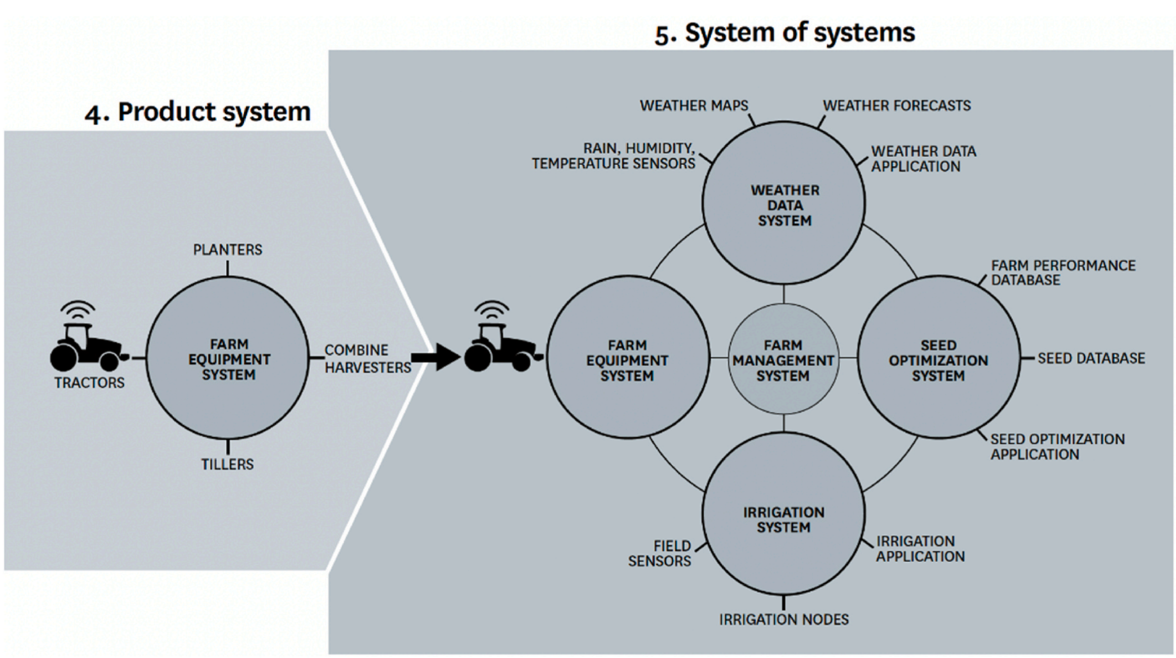

Fig. 1. PSI performance facilitation ecosystems – Example of Manufacturer's "productless" value creation
Derived from Porter and Hepplemenn (2014).

existing ecosystem. The manufacturer's competitiveness therefore depends on the cohesion and effectiveness of the entire PSI ecosystem, as it has become just one part of a much wider territorial value-generating network.

For territorial economies, the proper configuration of local value ecosystems based on a hybrid configuration of product and service providers has been found to stimulate knowledge flow and innovative capabilities (Vendrell-Herrero et al., 2021b). This synergetic process is called 'territorial servitization' (Lafuente et al., 2017; Vendrell-Herrero et al., 2020), the premises of which specifically propose that local innovative capabilities develop when tenacious incumbent manufacturers attract knowledge-intensive business service firms that in turn help to spur the renewed growth of new, innovative manufacturing start-ups (Lafuente et al., 2019). "Territorial servitization is the symbiotic relation between knowledge-intensive service sectors and manufacturing firms as an engine for enhanced territorial resilience, manufacturing renaissance and competitiveness, as well as regional development" (Lafuente et al., 2017, p. 20). The implications of developing PSI ecosystems means that although some components of the self-coordinating value system may be geographically disperse, for the most part they tend to be regionally connected (Parida and Jovanovic, 2022). And it is this regionally connected territorial servitization process that leads to the observed and documented local economic benefits, notably for manufacturing-based regions (Gomes et al., 2019; Horváth and Rabetino, 2019; Wyrwich, 2019; Lombardi et al., 2022).

The renaissance and growth of local manufacturing therefore requires the adoption of more service-augmented disruptive value-adding innovations (Lafuente et al., 2017). The competitiveness of manufacturing businesses increasingly relies on their ability to introduce services to their operations (Vandermerwe and Rada, 1988; Vandermerwe et al., 1989; Cusumano et al., 2015) and the potential for the local development of synergetic PSI ecosystems. Such PSI becomes a mechanism for the development of regional innovation by shifting the local industrial fabric from a production-based to a product-service based innovation ecosystem (Bustinza et al., 2019b, 2021). For incumbent manufacturers, this equates to upgrading innovative competencies so they can transition to the delivery of more disruptive and high-value added, customized solutions. As a result of the territorial servitization dynamics involved, PSI ecosystems are also associated with greater manufacturing growth and entrepreneurial activity (De Propris and Storai, 2019; Horváth and Rabetino, 2019).

The mechanics behind the territorial servitization process of PSI ecosystems have been extensively studied and defined (Bellandi and Santini, 2019; Lafuente et al., 2019). However, little has been published as to the pre-determinant factors that help to drive such a process (Gomes et al., 2019). The original theoretical premises of territorial servitization (Lafuente et al., 2017) suggest that the origin of the process lies in the presence of a strong incumbent regional manufacturing sector, which is found to attract knowledge-intensive business service firms that subsequently help to spur the renewed growth of new, innovative manufacturing start-ups. However, no empirical studies have sought to confirm whether having a strong manufacturing industry is a prerequisite for territorial servitization dynamics to take form. Alternative views could posit that value-adding territorial servitization processes within PSI ecosystems are also generated out of regional economies that were previously dominated by advanced services, or even territories that lacked any significant established manufacturing or knowledge-intensive business service industries.

However, theoretical indications suggest that the disruptive value-adding processes found in PSI ecosystems are more likely to have originated from within a strongly established regional manufacturing sector. This is because of the radical reconfiguration of the underlying capabilities of a regional economy that are needed to adapt its techno-economic structure in order for value-adding PSI ecosystems to form, and territorial servitization dynamics to take hold (Vaillant et al., 2021; Lombardi et al., 2022). It has been repeatedly found that the success rate of regions diversifying into unrelated knowledge-spaces is extremely low (Boschma and Frenken, 2010; Pinheiro et al., 2018). Empirical literature casts doubt on the potential development of territorial servitization benefits if promoted in isolation from the existing local manufacturing value chains and their endogenous capability endowments (Lafuente et al., 2017; Vaillant et al., 2021). Innovation stimulus, when not embedded in the local economic fabric, tends to develop limited local linkages and pursue industrial functions with little to no disruptive value-adding spillovers (Phelps, 2008). The benefits of PSI at the territorial level "… *can only be delivered with parallel indigenous innovation efforts … and conducive innovation ecosystems*" (Fu et al., 2011, p. 1210).

Based on the existing local knowledge space and capability set, and the related diversification trajectory of a region's industry (Whittle and Kogler, 2020; Vaillant et al., 2021), the evolutionary economic geography literature offers some clues as to how an established manufacturing base can impact the technological transformation of regions (Boschma and Frenken, 2018). From the evolutionary economic geography perspective, which is dominant in the regional studies literature, the guiding principles behind both the resource-based view (Penrose, 1959) and evolutionary theory (Nelson and Winter 1982) have highlighted how industrial regions develop skills, routines and specialisations over time that determine the possibilities of future diversification trajectories (Boschma and Frenken, 2010; Neffke et al., 2011). Local manufacturers therefore diversify their production in ways related to an existing set of knowledge and skills (Hidalgo et al., 2007), suggesting that incumbent capabilities at a regional level enable the development of new capabilities. Consequently, the accumulation and production of knowledge is embedded in region-specific patterns that have been developed over time (Rigby and Essletzbichler, 1997). Recent research on regional employment dynamics indicate that increases in occupational relatedness are positively related to employment growth (Hane-Weijman et al., 2022). The type of value-adding industrial transformation and resulting performance therefore varies according to the existing industrial competencies and productive knowledge space delivered by a strong, established manufacturing base (Lafuente et al., 2019; Wyrwich, 2019). As such, a regional economy is more likely to adopt territorial servitization processes and develop a value-adding PSI ecosystem if it has a pre-existing manufacturing skillset upon which to build (Whittle and Kogler, 2020).

It can therefore be deduced from this theoretical rationale that in comparison to other regions, one with a strong established incumbent manufacturing sector is more likely to improve its manufacturing employment levels, and do so to a greater extent, as a result of the value-adding PSI ecosystems that contribute to the potential competitiveness and growth of manufacturing regions. It is therefore hypothesized that:

H1. *Territories with a strong incumbent manufacturing sector (in t-2) and with a successfully implemented PSI ecosystem (in t-1) will exhibit the highest employment growth rates in manufacturing (t-1 → t).*

3. Data, variable definition and method

3.1. Data

The unit of analysis in this study is the region, and we consider data for the 17 Spanish regions (NUTS-2) for the period from 2006 through 2012. This period was deliberately chosen as it coincides with a major surge in regional PSI ecosystems in Spain (Aranguren et al., 2014), thus allowing the study to capture the post-trough formation of several regional PSI ecosystems and to observe the regional industrial fabric prior to these developments. The panel dataset used in this research was built from three separate sources. First, secondary data on regional macroeconomic and industrial performance figures compiled by the Spanish Institute of Statistics (INE) was used for all 17 Spanish autonomous regions for the six-year period from 2006 to 2012. These were combined with industry configuration variables extracted from the Eurostat database. Finally, to build the PSI ecosystem construct that helped to determine the regional presence of hybridized manufacturing and advanced service dynamics, results from the GEM-Spain annual adult population surveys for the years under study were utilised (Reynolds et al., 2005). All these have been developed using standardised uniform data gathering and surveying methods across all periods and territories to ensure comparability. Similar joint regional analyses have been implemented in several recent studies of industrial development in European regions (e.g., Content et al., 2019; Horváth and Rabetino, 2019; Vaillant et al., 2021).

3.2. Variables

The dependent variable—i.e., Employment—is manufacturers' average employment growth at regional level, measured as the percentage variation in employment between periods *t* and *t*-1. Fig. 2 maps this variable *vis-à-vis* the stock of manufacturing firms. From the map, it can be observed that regions with more manufacturing activity are not necessarily the ones exhibiting higher employment growth in manufacturing.

The key independent variable is related to regions' active PSI ecosystems. The first PSI ecosystem dummy variable identifies regions with both manufacturing and KIBS industries having a synchronized proportional output level above the national median values in period *t*-1. Although it does not capture cross-industry innovation outputs associated with synergetic territorial servitization processes, this dummy variable proxies such dynamics and the likely regional presence of an established PSI ecosystem. Second, for each region demonstrating a newly generated product-service industrial ecosystem in *t*-1, we evaluated its preceding (in *t*-2) industrial profile. We created three dummy variables that determine whether the PSI ecosystem (in *t*-1) arose from a manufacturing-dominated economic fabric (Manufacturing-led), a KIBS-dominated economic fabric (KIBS-led), or from an economic fabric that did not have a dominant manufacturing or advanced service sector (low KIBS/Manufacturing).

The study contains a number of control variables. The KIBS variable captures the rate of new KIBS businesses in the region, while the (logged) stock of manufacturing businesses measures the size and economic capacity of manufacturing industries (Lafuente et al., 2017). The proposed model also controls for market growth (GDP per capita expressed in 2012 constant euros) and unemployment (proportion of the economically active population without a job). Finally, a set of *t*-1 time dummies was included to account for the potential effects of trends over time. Summary statistics for the variables used in the study are presented in Table 1.

3.3. Method

To test the study hypothesis linking territories' average manufacturing employment to the development of manufacturing-led PSI ecosystems, we use the fixed-effects estimator (Wooldridge, 2008) to compute a vector of parameters described in the following equation:

$$\text{Employment change}_{it} = \beta_0 + \beta_1 \text{PSI Ecosystems}_{it-1} + \beta_2 \text{KIBS}_{it-1}$$
$$+\beta_3 \ln \text{Stock of manufacturers}_{it-1} + \beta_4 \ln \text{GDP per capita}_{it-1} \quad (1)$$
$$+\beta_5 \text{Unemployment}_{it-1} + \text{Time}_t + \eta_i + \varepsilon_{it}$$

In equation (1), β_0 is the constant term, β_j are parameter estimates for the *j*th independent variable, η_i is the time-invariant fixed effect that controls for unobserved heterogeneity across regions (*i*), and ε_{it} is the normally distributed error term that varies cross-regions and cross-time. Note that all independent variables are lagged at least one period (*t*-1) to avoid potential endogeneity problems linked to reverse causality (Wooldridge, 2008). In terms of the study hypothesis, we expect $\beta_1 > 0$

Table 1
Descriptive statistics for the study variables.

	Mean	Standard deviation	Q1	Q3
Employment change in manufacturing firms	0.5324	2.6768	−0.6400	0.4100
PSI Ecosystem (dummy) (*t*-1)	0.1140	0.3193	0.0000	0.0000
PSI Ecosystem: KIBS-led (between *t*-2 and *t*-1)	0.0351	0.1848	0.0000	0.0000
PSI Ecosystem: Manufacturing-led (between *t*-2 and *t*-1)	0.0439	0.2057	0.0000	0.0000
PSI Ecosystem: low KIBS/ manufacturing (between *t*-2 and *t*-1)	0.0351	0.1848	0.0000	0.0000
KIBS *t*-1	0.0829	0.0727	0.0198	0.1329
Stock of manufacturing firms *t*-1	11,613.44	11,793.84	3733.00	14,105.00
GDP per capita *t*-1	23,752.24	4493.38	20,500.00	27,272.70
Unemployment rate *t*-1	0.1683	0.0731	0.1130	0.2190

Sample size: 119 observations.

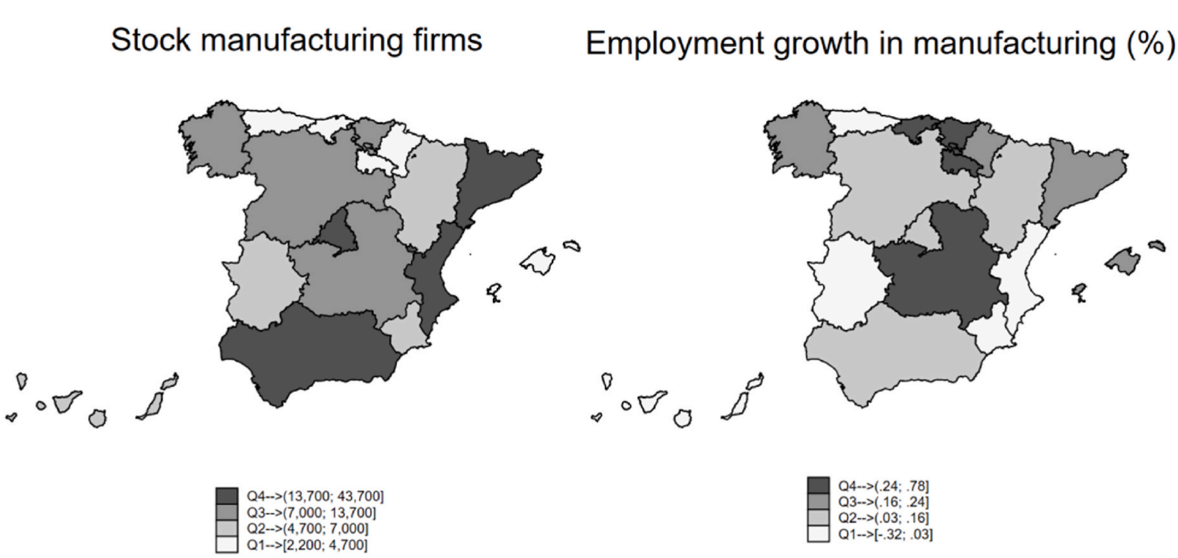

Fig. 2. Regional distribution of manufacturing and manufacturing employment growth - Spain.

for the manufacturing dominated PSI ecosystem category (i.e. Manufacturing-led) and $\beta_1 = 0$ for the other categories, which would confirm that regions with a strong manufacturing base that successfully initiate a regional PSI ecosystem present the highest average manufacturing employment growth (H1).

4. Results

This section presents the results of the empirical exercise. From a descriptive viewpoint, the observed improvement in average manufacturing employment in regions with an active PSI ecosystem is 34.4% greater than that found in regions lacking such a hybrid industrial ecosystem. This is an indication of the presence of territorial servitization dynamics within PSI ecosystems leading to the observed value-adding impact of these hybrid industrial ecosystems on the prosperity of the regional manufacturing sector.

More important for the purpose of this study is the observation that regions that successfully initiate a PSI ecosystem report an annual improvement in their average manufacturing employment levels of 80%. This result tends to indicate that regions initiating a PSI ecosystem were experiencing far greater manufacturing recuperation and growth than other Spanish regions (e.g., see Fig. 3 for a longitudinal comparison between regions with and without PSI systems). But if we look at the segmentation of Spanish regions according to their predominant industrial fabric prior to initiating their PSI ecosystems, there seems to be an important advantage of having a strong regional incumbent manufacturing sector for achieving the greatest potency of PSI ecosystems. The annual improvement in average manufacturing employment levels is 141.2% in regions where PSI ecosystems were preceded by a manufacturing-based industrial fabric. This compares to the mere 16% improvement reported for regions where the PSI ecosystem was characterized by a strong KIBs sector or by no clear production or service sector dominance.

The results of the fixed-effects regression in Table 2 offer a better understanding of the mechanisms explaining the formation of PSI ecosystems. They indicate that new PSI ecosystems help to spur the manufacturing employment growth of regions when such ecosystems are preceded by a manufacturing-dominated regional industrial fabric. PSI ecosystems that developed in regions that had a strong, advanced service fabric are not found to have any impact on manufacturing employment growth. The same holds for those PSI ecosystems built in regions with no clear industrial prevalence (manufacturing or KIBS industrial base), that is, the coefficient is not statistically significant. This would seem to agree with the theoretical basis of the territorial servitization premises whereby the starting point of such territorial value-adding processes for PSI ecosystems lies in the foundations of a resilient local manufacturing sector (Lafuente et al., 2017, 2019). This result also supports the study's hypothesis (H1) by providing empirical evidence that those *territories with a strong incumbent manufacturing sector (in t-2) and with a successfully implemented PSI ecosystem (in t-1) will exhibit the highest employment growth rates in manufacturing (t-1 → t).*

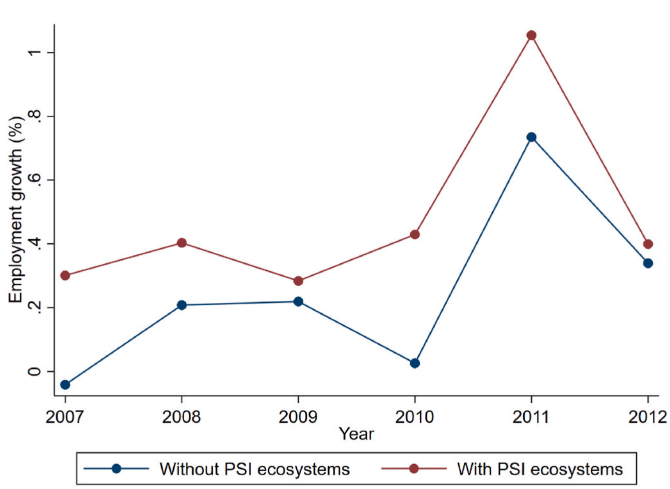

Fig. 3. Manufacturing employment growth in regions with and without active PSI systems (2007–2012).

Table 2
Manufacturing employment growth: Fixed-effects regression results.

	Model (1)	Model (2)
PSI Ecosystem (dummy) (*t*-1)	0.0141	
	(1.49)	
PSI Ecosystem: KIBS-led (between *t*-2 and *t*-1)		0.0157
		(0.78)
PSI Ecosystem: Manufacturing-led (between *t*-2 and *t*-1)		0.0224*
		(1.91)
PSI Ecosystem: low KIBS/manufacturing (between *t*-2 and *t*-1)		−0.0075
		(1.31)
KIBS *t*-1	0.1084*	0.1147*
	(1.69)	(1.79)
ln Stock of manufacturing firms *t*-1	0.1609*	0.1830**
	(1.81)	(2.44)
ln GDP per capita *t*-1	−0.1760	−0.1726
	(0.73)	(0.71)
Unemployment rate *t*-1	0.0015	0.0018
	(1.00)	(1.14)
Time dummies	Yes	Yes
Intercept	0.3136	0.0794
	(0.14)	(0.04)
F-test	4.18***	4.48***
R2 (within)	0.2066	0.2214
Observations	102	102

Absolute *t* statistic values based on robust standard errors are presented in parentheses. *, **, *** = significance at 10%, 5% and 1%, respectively.

The results also show that regions with a larger presence of KIBS firms likewise benefitted from greater manufacturing employment growth, as did regions with a greater stock of manufacturing firms. This latter result is important as it indicates that the positive influence of the establishment of PSI ecosystems for regional manufacturing employment does not only occur in catch-up regions but also in regions where the stock of manufacturing firms is already well established. This would seem to indicate that growth in manufacturing employment not only comes from the creation of new entrepreneurial ventures associated with the territorial servitization process, but also from the gains in competitiveness and growth of the existing incumbent manufacturers.

5. Implications and concluding remarks

The study presented in this paper sought to test whether territories develop more performant PSI ecosystems in terms of manufacturing employment growth if they previously had a strong incumbent manufacturing sector. This was done to thereby offer a better understanding of the mechanisms that explain the formation of PSI ecosystems through the assessment of the industrial pre-determinants of territories with such active product-service innovation ecosystems.

Theoretically, we know from the premises of the territorial servitization process that the presence of a resilient incumbent local manufacturing sector is likely to be a major initial building block for productive PSI ecosystems to take hold in a region (Lafuente et al., 2017, 2019). This is also coherent with the consolidated principles of evolutionary economic geography, dominant in regional studies literature (Boschma and Frenken, 2018). This latter view focuses on the importance of knowledge and innovation in regional evolution and path development, and the role of related variety in regional diversification. The presence of a strong incumbent industrial sector in a region therefore offers the innovation path and knowledge space necessary for territorial servitization processes to ignite and PSI ecosystems to take root more effectively.

Based on territorial servitization and evolutionary economic geography, both stemming from the resource-based view (Penrose, 1959) and evolutionary theory (Nelson and Winter 1982), the model proposed in our study suggest that the accumulation and production of knowledge and capabilities is embedded in region-specific patterns that have been developed over time (Rigby and Essletzbichler, 1997; Whittle and Kogler, 2020; Vaillant et al., 2021). In line with recent research on regional employment dynamics that indicate that increases in occupational relatedness are positively related to employment growth (Hane-Weijman et al., 2022), the study presented in this paper developed a model hypothesizing that territories with PSI ecosystems that have a strong incumbent manufacturing sector will exhibit the highest manufacturing employment growth rates.

This hypothesis was tested by running a fixed-effects model on a sample of all 17 Spanish autonomous communities during the period from 2006 to 2012. The results of this analysis delivered empirical evidence of the role that the coexistence of incumbent manufacturers and advanced service sectors plays in re-defining value creation through the development of active local PSI ecosystems. These processes were found to have their greatest impact on manufacturing employment growth in regions with an established incumbent manufacturing sector, empirically confirming what had theoretically been expected. These findings provide better evidence as to the origins of regional PSI ecosystems and the value-adding processes that they engender.

The academic implications of these empirical findings are clear, as they help to fill an obvious gap in the PSI ecosystem literature. Therefore, the study helps to advance the theoretical premise of territorial servitization research, giving some resolve to the debate as to whether value-adding PSI ecosystems were truly the outcome of territorial servitization processes (where advanced business service sectors come to complement existing incumbent manufacturers) (Lafuente et al., 2017; De Propris and Storai, 2019), or territorial hybridization (where PSI ecosystems could originate from more varied trajectories of either service or production intensive industrial fabrics) (Gomes et al., 2019), or even where no embedded local product or service sectors previously existed.

The practical implications are also highly relevant as the study's main finding would seem to indicate that sequencing is important in order for local PSI ecosystems to take hold. For the sake of gaining (or at least retaining) competitiveness, many local and regional administrations across OECD member countries have been encouraging their regional industries to implement product-service innovation and transition towards the key success factors of servitization that are required to compete in a knowledge-based digitally transformed economy (OECD, 2017, 2021). However, evidence has shown that many advanced economies are having a hard time generating sustainable competitive advantages despite their attempts to transition towards a digitally servitized economy (Matsuyama, 2009; Buckley et al., 2020). Demonstration of the importance of building PSI ecosystems upon the established knowledge and capabilities of existing regional incumbent manufacturers, rather than on the margins thereof, is essential for proper value-adding processes to develop, and greater manufacturing industry growth to arise as a result. When attempting to spur a new regional industrial fabric compatible with the PSI ecosystems, it may be tempting to believe that it is best to clear the drawing board and start from scratch by promoting the development of a brand-new generation of industrial ventures (Darko et al., 2021). However, the results of this study have evidenced that building upon a resilient incumbent manufacturing knowledgebase is likely to be the most effective way to achieve a successful transition towards industry 4.0 and digital transformation (Vaillant et al. 2021).

Of course, this study has several limitations that should be taken into consideration when interpreting and extrapolating its results. The proposed framework may guide future research but should also be subject to review as the body of research into PSI ecosystems grows.

The empirical study described herein is deliberately succinct and limited to answering a single research question. But further development will surely enrich the understanding around this important topic. Beyond the single hypothesis tested in this study, further research could expand and build on the initial empirical findings delivered here to help increase the body of knowledge surrounding PSI ecosystem formation and the establishment of productive territorial servitization dynamics.

Although time controls were added to the model, the temporal specificity of the study is likely to have played a role in its results. The study period was purposefully chosen because it included the formation of such a large number of initial PSI ecosystems following the severe economic slowdown that hit Spain. Without so many of these PSI transition events it would probably have been impossible to address the study's research objective with quantitative methodology. Without these exceptional circumstances, future research will probably be limited to case study analysis. It should also be noted that although Spain offered the possibility of studying 17 different regions for which a full set of data was available, the geographic specificity of the results must also be considered. Consequently, further research should be encouraged to replicate this study in other chronological and geographic scenarios. The use of longitudinal data made our results more robust, but the small sample size limited the empirical techniques that could be used to ensure the reliability of findings. In an ideal setting, the use of more extensive longitudinal data would be useful to enhance the generalizability of the findings of future studies. Similarly, as the digital transformation and what is now being called the fourth industrial revolution was barely in its infancy during the period under study, it would be interesting to observe the importance of the knowledge space of an incumbent manufacturing sector for regional value-adding PSI ecosystems to take hold during such important productive changes. Furthermore, our study assumed regional homogeneity in terms of industry lifecycle, a variable that seems decisive for understanding the success of the firm- and regional-level PSI implementation (e.g., Gomes et al., 2021; Vendrell-Herrero et al., 2022). In this regard, future studies should investigate whether the employment-enhancing effect of active PSI ecosystems depends on the industry lifecycle stage experimented within the region.

Our analysis has identified the potential presence of an active product-service industrial ecosystem through the simultaneous regional presence of above-average output levels of both manufacturing and knowledge-intensive service industries. It could be argued that this is only a proxy for the presence of synergetic territorial servitization processes and does not capture true cross-industry innovation output. Although capture of the innovation output of PSI ecosystems was beyond the scope of this study, it may be warranted in further research. Further studies should build on the current findings and seek to offer greater insights into how regional economies can access, adopt, and develop the new competencies required to establish high value-adding PSI ecosystems that contribute to local industrial competitiveness within a knowledge-based digital economy.

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