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Causal relations between knowledge-intensive business services and regional employment growth

Thomas Brenner[a], Marco Capasso[b], Matthias Duschl[c], Koen Frenken[d] and Tania Treibich[e]

ABSTRACT

Causal relations between knowledge-intensive business services and regional employment growth. *Regional Studies*. This paper studies the causal relations between regional employment growth in knowledge-intensive business services (KIBS) and overall regional employment growth using German labour-market data for 1999–2012. Adopting a recently developed technique, it uses a structural vector autoregressive model in which the causal directions between KIBS and other sectors are examined including various time lags. Results show that although regional growth has a negative short-term effect on KIBS, KIBS growth has a long-term positive effect on the whole regional economy. This confirms the claim that KIBS can play a key role in regional policies.

KEYWORDS

regional employment growth; growth spillovers; knowledge-intensive business services (KIBS); industrial dynamics; financial geography

摘要

知识密集商业服务和区域就业成长之间的因果关係。*Regional Studies*. 本文运用德国自1999年至2012年的劳动市场数据，研究知识密集商业服务（KIBS）的区域就业成长和总体区域就业成长之间的因果关係。本文採用晚进发展的技术，使用结构向量自迴归模型，其中KIBS和其他部门之间的因果方向受到检视，包括各种时间迟后。研究结果显示，尽管区域成长对KIBS具有短期的负面效应，KIBS成长对於整体区域经济则具有长期的正面效应。此一研究结果确认了KIBS能够在区域政策中扮演关键角色的主张。

关键词

区域就业成长; 成长外溢; 知识密集商业服务（KIBS）; 產业动态; 金融地理学

RÉSUMÉ

Les liens de causalité entre les services aux entreprises à haute intensité de connaissances et la croissance de l'emploi régional. *Regional Studies*. À partir des données sur le marché allemand du travail pour la période allant de 1999 jusqu'à 2012, ce présent article étudie les liens de causalité entre la croissance de l'emploi régional dans les services aux entreprises à haute intensité de connaissances (knowledge-intensive business services; KIBS) et la croissance globale de

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l'emploi régional. En employant une technique mise au point récemment, on se sert d'un modèle vectoriel autorégressif structurel dans lequel on examine les liens de causalité entre les KIBS et d'autres secteurs, y compris divers décalages. Les résultats laissent voir que la croissance des KIBS a un effet positif à long terme sur toute l'économie régionale, bien que la croissance régionale ait un effet négatif à court terme sur les KIBS. Ce constat confirme l'affirmation que les KIBS peuvent jouer un rôle primordial dans les politiques régionales.

MOTS-CLÉS
croissance de l'emploi régional; retombées de la croissance; services aux entreprises à haute intensité de connaissances (KIBS); dynamique industrielle; géographie financière

ZUSAMMENFASSUNG
Kausale Zusammenhänge zwischen wissensintensiven Unternehmensdienstleistungen und regionalem Beschäftigungswachstum. *Regional Studies*. In diesem Beitrag untersuchen wir die kausalen Zusammenhänge zwischen dem regionalen Beschäftigungswachstum in wissensintensiven Unternehmensdienstleistungen und dem gesamten regionalen Beschäftigungswachstum anhand von Daten des deutschen Arbeitsmarkts im Zeitraum von 1999 bis 2012. Unter Nutzung einer neu entwickelten Technik kommt ein strukturelles autoregressives Vektormodell zum Einsatz, in dem die kausalen Richtungen zwischen wissensintensiven Unternehmensdienstleistungen und anderen Sektoren einschließlich verschiedener Zeitverzögerungen untersucht werden. Aus den Ergebnissen geht hervor, dass sich das regionale Wachstum zwar kurzfristig negativ auf wissensintensive Unternehmensdienstleistungen, aber das Wachstum in wissensintensiven Unternehmensdienstleistungen langfristig positiv auf die gesamte regionale Wirtschaft auswirkt. Hierdurch bestätigt sich die These, dass wissensintensive Unternehmensdienstleistungen in der Regionalpolitik eine zentrale Rolle spielen können.

SCHLÜSSELWÖRTER
regionales Beschäftigungswachstum; Übertragungseffekte von Wachstum; wissensintensive Unternehmensdienstleistungen; Branchendynamik; Finanzgeografie

RESUMEN
Relaciones causales entre los servicios empresariales intensivos en conocimiento y el crecimiento de empleo regional. *Regional Studies*. En este artículo estudiamos las relaciones causales entre el crecimiento de empleo regional en servicios empresariales intensivos en conocimiento (SEIC) y el crecimiento general de empleo regional mediante datos del mercado laboral en Alemania para el periodo de 1999 a 2012. Adoptando una técnica desarrollada recientemente, utilizamos un modelo de vectores autorregresivos estructurales en el que examinamos las direcciones causales entre los SEIC y otros sectores, incluyendo los diferentes desfases temporales. Los resultados indican que aunque el crecimiento regional tiene un efecto negativo a corto plazo en los SEIC, el crecimiento de los SEIC tiene un efecto positivo a largo plazo en toda la economía regional. Esto confirma la afirmación de que los SEIC pueden desempeñar un papel importante en las políticas regionales.

PALABRAS CLAVES
crecimiento de empleo regional; efectos secundarios del crecimiento; servicios empresariales intensivos en conocimiento (SEIC); dinámicas industriales; geografía financiera

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INTRODUCTION

New global challenges call for more comprehensive research and innovation policies, relevant to all the sectors of the economy (Foray, David, & Hall, 2009). Increasingly, the emphasis lies on policies that foster an entrepreneurial process of discovery: entrepreneurs should be enabled to discover the research and innovation domains in which a region can hope to excel, by gathering localized information about the region's skills, materials, environmental conditions and market access conditions (Foray et al., 2009; McCann & Ortega-Argilés, 2015). Service innovation (coming from either service or manufacturing sectors) can boost entrepreneurial dynamism by closing the gap between scientific innovation and market requirements, and facilitating a cross-sectoral fertilization which ultimately contributes to growth and jobs (European Commission, 2012). Inherent difficulties in supporting novelty creation in the form of services rather than goods (Rubalcaba, Michel, Sundbo, Brown, & Reynoso, 2012) may explain why in the European Union only a few countries have implemented policies explicitly focused on the service sectors (European Commission, 2009). Yet it remains unclear whether selecting target sectors may contribute to overall economic growth, let alone which sectors should receive most attention from policy-makers. Additional empirical evidence on causal relations between sectoral employment growth dynamics is needed to address this issue.

Service sectors may occupy key positions in the network of inter-sectoral knowledge flows. Notably, knowledge-intensive business services (KIBS) are able to provide advanced technological knowledge directly to other industrial sectors, and indirectly to the whole economy (Castellacci, 2008). Business service industries can be defined as KIBS if they are private organizations that rely heavily on professional knowledge, and supply intermediate products and services that are knowledge based (Den Hertog, 2000). The process of 'knowledge re-engineering' operated by the KIBS when interacting with other enterprises, and in particular with small and medium ones, causes KIBS to be a 'relevant object' for both innovation and regional policies (Muller & Zenker, 2001). Still, the peculiarity of such process of knowledge creation has often prevented researchers from obtaining a precise evaluation of the innovative contribution of KIBS (Muller & Doloreux, 2009). Also for what concerns the impact of KIBS on growth (at either regional or national levels), there is no conclusive evidence in the literature (Rubalcaba & Kox, 2007). Because KIBS are attracted to places where they find demand and labour (Herstad & Ebersberger, 2014; Jacobs, Koster, & van Oort, 2014; Keeble & Nachum, 2002; Koch & Stahlecker, 2006), some authors argue that public policy should not be aimed directly at KIBS growth, but rather at fostering regional diversification and technological upgrading, which in turn would drive KIBS growth through a demand-pull process (Wernerheim & Sharpe, 2003).

Research is needed to investigate further the system-wide interactions of KIBS, and to assess how different typologies of KIBS and manufacturing segments interact (Corrocher & Cusmano, 2014). This study investigates the causal relations between regional employment growth in the KIBS sector and regional employment growth in the rest of the economy. By means of a recent development of the vector autoregression (VAR) approach, the causal effects of employment changes in KIBS and the rest of the economy on each other are examined, as well as the time lags at which these feedbacks take place. From such results, the causal impact of past exogenous shocks could indicate what would be the expected impact of a (future) policy shock. The analysis is conducted over 270 labour market regions in Germany, observed between 1999 and 2012.

The paper is structured as follows. The second section discusses the mechanisms linking the dynamics of the KIBS sector to the rest of the economy. The third section explains the methodology used, and the reasons for adopting it. The fourth section describes the data. The fifth section has the results. The sixth section concludes.

HYPOTHESES

Feedback effects between KIBS and the rest of the economy

Especially in the early stages after foundation, KIBS benefit from their proximity to suppliers and clients (Koch & Stahlecker, 2006) and, in general, both demand-side influences and localized 'collective learning' processes seem to determine the clustering of KIBS firms (Keeble & Nachum, 2002). Indeed, their activities are often associated with face-to-face interactions (McCann & Ortega-Argilés, 2015). Yet, the economy can benefit collectively from the knowledge produced by KIBS even in the absence of bilateral connections among them, as their knowledge is diffused throughout the economy (Jensen, Johnson, Lorenz, & Lundvall, 2007). As a consequence, the contribution of KIBS to the productivity of the other industrial sectors may well exceed the productivity gains as measured within the KIBS sector itself (Castaldi, 2009). Both the productivity gains and the knowledge diffusion processes take some time to materialize in employment gains. Hence, the effects discussed here are expected to be relevant for the interaction between growth in one part of the economy in one year and growth in the other part of the economy in the years thereafter. Therefore, the following hypotheses follow:

Hypothesis 1 (H1) (Knowledge diffusion): KIBS growth causes growth of the rest of the economy in the next or later years.

Hypothesis 2 (H2) (Demand-pull): Growth in the rest of the economy causes KIBS to grow in the next or later years.

KIBS, manufacturing and services

The impact of KIBS on the local economy goes well beyond its contribution through the growth effects of knowledge diffusion and productivity growth, which could be only observed after a certain delay. Indeed, another channel has been put forward by Moretti and Thulin (2013). Their results imply that a growth in high-skilled labour-intensive activities stimulates the local economy by creating demand, especially in the non-tradable sector (i.e., services locally produced and consumed).

It may be expected, from the same mechanism, that KIBS growth would also foster the demand for local services. Indeed, the magnitude of this 'local multiplier' is 'particularly large for employers with many well-educated workers and for employers in the high-technology sector' (Moretti & Thulin, 2013, p. 342). This leads to the following hypothesis:

Hypothesis 3 (H3) (Local multiplier): Growth in the KIBS sector causes growth of other services.

Besides such a link with other services, KIBS also co-evolve with other specific sectors. The first reason has to do with the role of KIBS in the development of (local) outsourcing of service activities (Fixler & Siegel, 1999; Heshmati, 2003; Miozzo & Grimshaw, 2005), sustaining the productivity growth in both the manufacturing and the service sectors (Fixler & Siegel, 1999). The externalization of business services has generally tightened the links and developed the knowledge exchanges between the manufacturing and services industries (Castellacci, 2008, p. 981).

What are the implications of such interdependence of activities on employment patterns? First, KIBS clients retain minimum 'in-house' capabilities allowing them to keep interacting with the external supplier in close

proximity, which requires the outsourcing to be done in the local context (Miozzo & Grimshaw, 2005). Thus, H1 and H2 would be all the more true in sectors where outsourcing is more prevalent: they should exert a demand-pull effect on KIBS, and the knowledge created by KIBS should spill more easily onto other firms due to outsourcing. Second, Heshmati (2003) mentions a much more immediate 'displacement effect'. If a firm (e.g., from manufacturing) outsources parts of its activity to local service firms (e.g., from KIBS), it can be expected that the employment in that firm decreases at exactly the same time as the employment in the service firms increases. Furthermore, the causality runs from the outsourcing process on one side, to the increase of employment in KIBS and the decrease of employment in the rest of the economy on the other side. In other words, the positive and the negative changes of employment are not caused by one another, instead both are caused by the outsourcing event. This causal structure differs from the other causal effects studied here, and implies a relationship. Hence, the following is expected:

Hypothesis 4 (H4) (Labour sharing): In the short-run, KIBS growth and growth in the rest of the economy are negatively related.

Since the main research question relates to the interrelations between the KIBS sector and the rest of the economy, KIBS' internal diversity may matter as well.

The different faces of KIBS

While financial aspects of economic geographies have been neglected for a long time because 'the prevailing notion was that financial markets are somehow separate from the real economy' (Lee, Clark, Pollard, & Leyshon, 2009, p. 726), more recent works have studied the geographical characteristics of financial activities (Coval & Moskowitz, 1999; Pike & Pollard, 2010).

Pike and Pollard (2010) have pushed for considering financial activities as an 'integral' element of economic geographies, adding that financial activities accentuate the volatility of the business cycle. Geography also matters when it comes to financial decisions because of investors' 'local bias' (Coval & Moskowitz, 1999). This is because proximity makes it is easier to acquire reliable information about equity sellers, beyond what can be found in firms' financial statements and credit records, yielding abnormal returns.[1] Also in the case of banking relationships, only close monitoring allows lenders to overcome small and young firms' opacity and lack of credit record, making these borrowers especially captive of local banks (Degryse & Ongena, 2005).

The importance of local banks to regional dynamics is all the more prevalent in decentralized financial systems such as in Germany (Klagge & Martin, 2005). Also, because of the prevalence of small and medium-sized firms (the 'Mittelstand') with poor access to external capital markets, local credit dominates the German financial system (Stolz & Wedow, 2011).

Due to the strong embeddedness of financial KIBS in the economy of German regions, the demand-pull mechanism highlighted by H2 could be reinforced in these sectors. The local responsiveness of the financial sector to regional growth would thus imply that regional growth in non-KIBS sectors would cause financial KIBS to grow faster than non-financial KIBS. This expectation is further supported by the fact that skills in the financial sector are rather different from skills in non-financial KIBS, with only the latter being related to the rest of the economy (Neffke & Henning, 2013). It follows that the labour-sharing mechanism defined by H4 would be much limited in the case of financial KIBS. Hence, with non-KIBS sectors growing, only few labour resources would be drained away from the financial sector, and many more would be drained away from non-financial KIBS.

This leads to the last hypothesis:

Hypothesis 5 (H5) (Financial versus non-financial KIBS): Growth in the rest of the economy causes financial KIBS to grow more than non-financial KIBS.

Summarizing the hypotheses, it could be expected in the short run either that KIBS growth leads to growth in services (H3: Local multiplier) or that the rest of the economy negatively impacts KIBS growth due to H4 (Labour sharing). Instead, with some delay, a positive feedback effect from KIBS to the rest of the economy (H1: Knowledge diffusion) and back (H2: Demand-pull) should be observed. Finally, differences in the impact of the rest of the economy on financial and non-financial KIBS (H5) may appear.

METHODS

There are two variables of interest in the benchmark model, before proceeding to further disaggregation: regional employment growth in KIBS, and regional employment growth in the rest of the economy (i.e., in all the other industrial sectors, considered altogether). The goal of this study is determining how changes in one variable of interest, like a policy action which suddenly changes the employment growth in KIBS or in the rest of the economy, influences the evolution over time of both variables. The two variables of interest are endogenous: they influence each other, although it is not clear to what extent nor over which time frame, as discussed in the previous section.

y_t is the vector containing the two variables of interest, as observed in year t. It is assumed that the whole regional economic system evolves in reaction to some exogenous events. These events are assumed to be drawn from a zero-mean probability distribution, and to be temporally uncorrelated; contemporaneous events are independent. In the literature on the VAR method these effects are called shocks and this language used in the methodological part, calling changes that are triggered from exogenous events shocks. ε_t is the vector of shocks impacting the variables of interest in year t.

Independently of the sign and size of the shocks, the development of the regional economic system is assumed to be described by the following VAR:

$$y_t = By_t + \Gamma_1 y_{t-1} + \cdots + \Gamma_p y_{t-p} + \varepsilon_t \quad (1)$$

where the number of lags p will be selected according to several information criteria, as explained in the next section. Equation (1) shows the dynamics of the regional economic system that is assumed 'structural' with respect to interventions on the shocks, and thus allows to predict the behaviour of the variables of interest following the exogenous events (Hurwicz, 1962). The economic system evolves according to a law connecting the current growth of KIBS and of the rest of the economy (the vector y_t on the left side of the equation) to its past values (the vectors $y_{t-1}, y_{t-2}, \ldots, y_{t-p}$) through the parameters Γ. Current growth of KIBS and of the rest of the economy is also connected to the current exogenous shocks ε_t, and to itself through the matrix parameter B. Indeed, there are contemporaneous relations among the variables of interest, by which a shock to one variable may affect another variable 'instantaneously' (within one time unit, i.e., within one year).

In order to identify the parameters in equation (1), the vector autoregression linear non-Gaussian acyclic model (VAR-LiNGAM) in Hyvärinen, Shimizu, and Hoyer (2008) and Moneta, Entner, Hoyer, and Coad (2013) is used. By adopting the VAR-LiNGAM, the structural model represented in equation (1) is integrated with the following three assumptions: the structural shocks ε are mutually independent; no more than one structural shock is Gaussian; and there is no contemporaneous feedback among the observable variables. This last assumption of 'acyclicality'[2] must be interpreted as follows: if, in the model, an exogenous shock to one variable is immediately able (within one time unit, that is within one year in this context) to affect a second variable, then it is not possible that an exogenous shock to the second variable is immediately able to affect the first variable. Notice that there is no need to define a priori the ordering of the variables in the described causal structure: the VAR-LiNGAM estimation will define, through a data-driven procedure, whether a shock to KIBS is able immediately to affect the rest of the economy, or the other way around.[3]

DATA AND VARIABLES

The data are obtained from the Institute for Employment Research (IAB) in Germany and include the full population of employees recorded in the German social security system (excluding self-employment and public officers). The data contain the number of employees in each of 270 labour market regions and each NACE industry (at four-digit level) for 30 June each year from 1999 to 2012. Since the NACE classification changed from 2007 to 2008 (Rev. 1 to Rev. 2), all data from 2008 onwards are reclassified into the NACE Rev. 1 classification. In order to avoid biases due to the classification change, all years from 2000 to 2012, except 2008, are included in the analysis (the analysis relates each year to the year before). Labour market regions are used because they represent functional units (see Broekel & Binder, 2007, for a theoretical discussion; and Buerger, Broekel, & Coad, 2012, for a previous use in a similar context). They result from the aggregation over the 413 German NUTS-3 districts, concerning commuting flows (Binder & Schwengler, 2006). Through this, each region contains a central city (few regions contain multiple centers) and its surrounding (living places of people working in the central city). This leads to some homogeneity in the functional structure of the regions, although they differ especially in size (from Sonneberg with a population of 58,000 to Berlin with a population of 3.37 million). It would be interesting to study whether the results of this study differ between agglomerations and more rural places, but this goes beyond the scope of this paper.

In order to define the KIBS sectors according to their NACE (Rev. 2) industry code, the empirical classification in Jacobs et al. (2014), in turn based on the theoretical considerations of Strambach (2008), is used. They are comprised of financial KIBS (industry codes 64.1, 64.2, 64.3, 64.9, 66.11 and 69.2) and non-financial KIBS (industry codes 62.01, 62.02, 70.1, 70.2, 73.1, 73.2, 72.1 and 72.2). To account for potential differences in their interaction with the regional economy, thus testing the last hypothesis (H5: Financial versus non-financial KIBS), financial KIBS and non-financial KIBS are considered separately.[4]

Analogously, the peculiar relations observed between KIBS and manufacturing sectors (e.g., Corrocher & Cusmano, 2014) bring to the estimation of two models having, as a second variable of interest opposed to KIBS, respectively manufacturing and service sectors. Indeed, as discussed in the second section, the local multiplier effect (H3) implies a particular relation between KIBS and other services. Services are defined as all sectors having the following two-digit NACE codes: 33, 45–82 and 90–96 (from these, the KIBS sectors are excluded to avoid double counting in the analysis below).[5]

Summing up, there are six sectoral groups divided into a set of three groups associated with KIBS (all KIBS, only financial KIBS and only non-financial KIBS), and a set

Table 1. Summary of the nine models.

	All KIBS	Financial KIBS	Non-financial KIBS
All the other (non-KIBS) sectors	Model 1	Model 2	Model 3
Manufacturing sectors	Model 4	Model 5	Model 6
Other (non-KIBS) service sectors	Model 7	Model 8	Model 9

Note: Column labels indicate the first group of sectors, i.e., the first element of y_t in equation (1); row labels indicate the second group of sectors, i.e., the second element of y_t in equation (1).

of three sectoral groups associated with the rest of the economy (all non-KIBS sectors, only manufacturing and only non-KIBS services). Nine models are estimated, each considering, as sectors of interest, only one group from the first (KIBS) set, and only one group from the second (rest of the economy) set. Said in terms of the notation in equation (1), there are always only two elements constituting the vector y_t. See Table 1 for a summary of each model in terms of its sector composition.

The variable of interest is the regional employment growth rates g_t, which is computed as log-differences of employment in the region and sector. The growth rates g_t are then rescaled in order to control for the negative relation between the levels of the region–industry employment and the variance of their growth rates (Duschl & Brenner, 2013) (see also the procedure in the supplemental data online). Henceforth, when referring simply to 'growth', it is meant 'rescaled growth'. The Laplace-like features of the empirical distribution of regional growth rates are confirmed, hinting that non-Gaussian shocks are driving the dynamics of the data, an important prerequisite for the estimation of the structural form of the models.[6]

There are other variables that influence the variables of interest, and are not influenced by them: they are assumed to be exogenous to the model, and controlled for in all specifications. Such control variables are measured only at the initial time of the dataset (later observation might invalidate the exogeneity assumption) and are: population density, share of KIBS employment over total employment and a dummy variable equal to 1 if the region belongs to the former East Germany (and 0 otherwise).

The selection of the number of lags p in the VAR is based on various statistics, like Akaike information, Hannan–Quinn or Schwarz criterion (Lütkepohl, 2001). Here, all criteria advocate a one-lag model, which is driven by the disproportionate loss of information that is not counterbalanced by additional explanatory power from the inclusion of further lags. The selection of lag length might statistically collide with the determination of the causal ordering (Demiralp & Hoover, 2003). Yet, further checks state that the latter stays robust when increasing the number of lags. No changes in the causal ordering are observed and the estimates remain very similar in a two-year lag model.

RESULTS

For each model, the results are presented in two forms. Tables 2–4 show the parameter estimates for the structural autoregressive form of the model, as in equation (1). Figures A1–A3 in the supplemental data online illustrate the evolution of the variables of interest over time, following a shock applied to one of them.

In the tables, each estimated coefficient must be interpreted as measuring the effect of the row variable on the column variable. The rows having the variables with the '(t)' suffix show the estimates of the instantaneous spillovers (i.e., the elements of the matrix parameter B of equation 1); those having variables with the '$(t-1)$' suffix show the estimates of the spillovers occurring after one year (i.e., the spillovers Γ_1).

The evolution of the variables of interest over time is traced by computing the cumulative sum of the impulse response function:

$$\Psi_l^a = \sum_{j=0}^{l} \Psi_j \tag{2}$$

Table 2. VARLiNGAM estimates of the parameters of the structural autoregression (equation 1) when modelling KIBS growth versus growth in all the other sectors.

Model 1: All KIBS versus all other (non-KIBS) sectors				
Dependent variable	**All KIBS (t)**		**All other (non-KIBS) sectors (t)**	
All KIBS (t)	–		–	
All other (non-KIBS) sectors (t)	–0.258*	(0.139)	–	
All KIBS ($t-1$)	0.015	(0.015)	0.024***	(0.005)
All other (non-KIBS) sectors ($t-1$)	0.381***	(0.079)	0.391***	(0.027)
Model 2: Financial KIBS versus all other (non-KIBS) sectors				
Dependent variable	**Financial KIBS (t)**		**All other (non-KIBS) sectors (t)**	
Financial KIBS (t)	–		–	
All other (non-KIBS) sectors (t)	0.130***	(0.050)	–	
Financial KIBS (t – 1)	0.078***	(0.021)	0.027***	(0.007)
All other (non-KIBS) sectors (t – 1)	0.181***	(0.046)	0.395***	(0.028)
Model 3: Non-financial KIBS versus all other (non-KIBS) sectors				
Dependent variable	**Non-financial KIBS (t)**		**All other (non-KIBS) sectors (t)**	
Non-financial KIBS (t)	–		–	
All other (non-KIBS) sectors (t)	–1.133***	(0.350)	–	
Non-financial KIBS ($t-1$)	0.014	(0.012)	0.009***	(0.002)
All other (non-KIBS) sectors ($t-1$)	0.763***	(0.189)	0.391***	(0.028)

Note: *10% significance; **5% significance; ***1% significance; bootstrapped standard errors are shown in parentheses.

Table 3. VARLiNGAM estimates of the parameters of the structural autoregression (equation 1) when modelling KIBS growth versus growth in the manufacturing sectors.

Model 4: All KIBS versus manufacturing				
Dependent variable	**All KIBS (*t*)**		**Manufacturing (*t*)**	
All KIBS (*t*)	–		–	
Manufacturing (*t*)	–0.298***	(0.094)	–	
All KIBS (*t* – 1)	0.011	(0.021)	0.009	(0.011)
Manufacturing (*t* – 1)	0.056	(0.042)	0.247***	(0.027)
Model 5: Financial KIBS versus manufacturing				
Dependent variable	**Financial KIBS (*t*)**		**Manufacturing (*t*)**	
Financial KIBS (*t*)	–		–	
Manufacturing (*t*)	–0.086	(0.084)	–	
Financial KIBS (*t* – 1)	0.099***	(0.022)	0.008	(0.016)
Manufacturing (*t* – 1)	0.026	(0.028)	0.249***	(0.027)
Model 6: Non-financial KIBS versus manufacturing				
Dependent variable	**Non-financial KIBS (*t*)**		**Manufacturing (*t*)**	
Non-financial KIBS (*t*)	–		–	
Manufacturing (*t*)	–0.508***	(0.160)	–	
Non-financial KIBS (*t* – 1)	0.005	(0.011)	0.008**	(0.004)
Manufacturing (*t* – 1)	0.239***	(0.073)	0.249***	(0.026)

Note: *10% significance; **5% significance; ***1% significance; bootstrapped standard errors are shown in parentheses.

Table 4. VARLiNGAM estimates of the parameters of the structural autoregression (equation 1) when modelling KIBS growth versus growth in all the other service sectors.

Model 7: All KIBS versus all other (non-KIBS) service sectors				
Dependent variable	**All KIBS (*t*)**		**All other (non-KIBS) service sectors (*t*)**	
All KIBS (*t*)	–		–	
All other (non-KIBS) service sectors (*t*)	0.025	(0.132)	–	
All KIBS (*t* – 1)	0.019	(0.016)	0.035***	(0.009)
All other (non-KIBS) service sectors (*t* – 1)	0.132***	(0.048)	0.222***	(0.027)
Model 8: Financial KIBS versus all other (non-KIBS) service sectors				
Dependent variable	**Financial KIBS (*t*)**		**All other (non-KIBS) service sectors (*t*)**	
Financial KIBS (*t*)	–		–	
All other (non-KIBS) service sectors (*t*)	0.184**	(0.080)	–	
Financial KIBS (*t* – 1)	0.075***	(0.021)	0.046**	(0.019)
All other (non-KIBS) service sectors (*t* – 1)	0.067**	(0.030)	0.212***	(0.029)
Model 9: Non-financial KIBS versus all other (non-KIBS) service sectors				
Dependent variable	**Non-financial KIBS (*t*)**		**All other (non-KIBS) service sectors (*t*)**	
Non-financial KIBS (*t*)	–		–	
All other (non-KIBS) service sectors (*t*)	–0.224	(0.241)	–	
Non-financial KIBS (*t* – 1)	0.006	(0.012)	0.011***	(0.003)
All other (non-KIBS) service sectors (*t* – 1)	0.290***	(0.103)	0.216***	(0.027)

Note: *10% significance; **5% significance; ***1% significance; bootstrapped standard errors are shown in parentheses.

where Ψ are the parameters connecting shocks and variables of interest (cf. equation A1 in the supplemental data online); and where l indicates the number of time units (lags) after the shock impact. The 'accumulated' impulse response function in equation (2) is instrumental to answer the research question because of the complicated time structure of the impact. Indeed, having only one lag in the autoregressive representation means that the level, this

year, of a variable of interest, say of employment growth in KIBS, has an influence on next year's level of the other variable of interest, say of growth in the rest of the economy. But the growth of the rest of the economy next year will influence the growth of KIBS, and of the rest of the economy, the following year (i.e., in two years from now): an exogenous shock applied today to any variable can change the whole evolution of all the variables throughout all the following years. In order to understand the overall effect on the rest of the economy, after five years, of a shock to KIBS that occurred today, it is necessary to sum all the effects that today's shock will have year after year: the accumulated impulse response function of equation (2).

Table 2 shows the estimates of the parameters of the structural autoregression (equation 1) when modelling KIBS growth versus growth in all the other sectors. In particular, the top panel shows the estimates for model 1, when not distinguishing between financial and non-financial KIBS. Because of the imposed 'acyclicality' assumption, the VAR-LiNGAM algorithm has to choose the prevailing causality direction for instantaneous inter-sectoral diffusion. The causality direction goes from the rest of the economy to KIBS. Notably, the parameter estimation is negative (estimation value = –0.258): an increase in employment in the regional economy brings immediately a decrease in the employment in KIBS. This could be due to outsourcing by which the employees from other parts of the economy move to KIBS, so that a decrease in employment in the rest of the economy comes along with an increase in the KIBS employment. This represents a negative relationship between the two kinds of employment as stated in H4 (Labour sharing). Instead, H3 (Local multiplier) on the positive income effect of KIBS workers' high wages on the local economy is not corroborated by the evidence within the first year.

After one year, however, the picture is completely different: the growth in the rest of the economy calls for a higher demand of business services, which in turn translates into KIBS growth (parameter estimate = 0.381). This result is in line with H2 (Demand-pull). Because there is a positive lagged effect of KIBS on the rest of the economy (parameter estimate = 0.024), as expected from H1 (Knowledge diffusion), a positive feedback loop is set into motion.

The left panel of Figure A1(a) in the supplemental data online shows that after one year KIBS are likely to recover from the initial negative impact, and after three years the cumulated effect becomes significantly positive.

The central and lower panels of Table 2 (where, respectively, only financial and only non-financial KIBS have been considered) show that the non-financial KIBS are the only ones experiencing the instantaneous negative repercussion (parameter estimate = –1.133). According to the explanation presented above, this means that labour sharing with the rest of the economy (H4) mainly concerns non-financial service activities. It is also a first element corroborating H5 (Financial versus non-financial KIBS). Indeed, financial KIBS experience a positive effect already during the first year of general growth in the region (parameter estimate = 0.130), although it is not possible to discern whether the negative repercussion does not exist at all, or is simply overcompensated by a very fast increase in demand for financial expertise from the rest of the economy, as expected by H2 (Demand-pull). At this point, the reader is reminded that the relations of the system, as modelled in equation (1), are linear, and thus symmetrical: a positive estimated coefficient indicates a potential source of contagion to other industries of a crisis originated in one sector, i.e., a procyclical behaviour. In this sense, financial KIBS would prosper during the goodtimes of the economy, but suffer already in the immediate aftermath of a bad event affecting the region.

The fact that H4 (Labour sharing) only seems to be validated in the case of non-financial KIBS could be due to the reduced labour sharing opportunities between financial KIBS and the rest of the economy associated with a lower level of transferability of skills. Indeed, Neffke and Henning (2013) have shown that financial services are highly clustered in the periphery of the industry space, meaning they require highly specialized labour for which the skills are difficult to transfer to other sectors. In the case of Germany, Klagge and Martin (2005) qualify these specialized labour markets as 'financial communities'. Instead, business services (and by extension to the typology used here, non-financial KIBS) are positioned in a wide range of locations of the industry space, thus sharing skills with many non-KIBS activities.[7] Basically, H4 predicts that there will be negative, short-run effects in potentially both directions: from KIBS growth to growth in the other parts of the economy and the opposite direction. As argued in section A2 in the supplemental data online, the approach used in this paper is only able to detect short-run effects in one direction. Results only show short-run causal effects from other parts of the economy to KIBS. However, this finding should not be overinterpret, as stated above. H4 predicts a relationship without any direction. The empirical approach imposes a direction. Hence, all that we can be expected according to H4 is finding a significant effect in one direction. This is the case, so that H4 is confirmed as far as it is possible with the chosen approach.

The left panel of Figure A1(c) in the supplemental data online puts in evidence how non-financial KIBS may never fully recover from the negative impact of the rest of the economy, despite a positive feedback effect after a one-year delay, from non-financial KIBS to the rest of the economy (0.009, third column of the bottom panel of Table 2) and from the rest of the economy to non-financial KIBS (0.763, second column of Table 2). Contributing to the 'cycle' of growth connecting financial KIBS to the rest of the economy, there is the high positive estimate (0.027, third column of the central panel of Table 2) of the parameter linking growth in the rest of the economy to the previous year's growth of financial KIBS, as well as from the rest of the economy to financial KIBS (0.181, third column of Table 2). Thus, the development of non-financial and financial KIBS in the following years as a response to an exogenously caused change in the rest of the economy is quite different, providing empirical support to H5.

The rest of the economy profits from growth in non-financial KIBS as well as from financial KIBS. So, in

general, it can be said that a positive exogenous shock on KIBS, although with some lag, creates employment growth in the rest of the economy, as also depicted in the right panels of Figures A1(b) and A1(c) in the supplemental data online. The study continues with the investigation of whether the positive shock of KIBS spills over the whole economy indistinctly, or instead employment is created only in manufacturing or in service sectors.

Table 3 (top panel) shows that the previous findings on the negative contemporaneous impact of the rest of the economy on KIBS is confirmed in the case of the manufacturing sector. It results from the strong negative effect on non-financial KIBS (–0.508, in the bottom panel of Table 3), not compensated by any influence on financial KIBS (–0.086, n.s.). After one year, there is a positive interrelation between manufacturing and non-financial KIBS only, and no relation at all with regard to financial KIBS. This can be explained by the fact that relations between manufacturing sectors and non-financial KIBS have been recently made stronger by a higher intensity of outsourcing of non-financial service activities, such as cleaning and building management but also research, computer-related and marketing activities, by those manufacturing firms (see also Castellacci, 2008).

In Figure A2(b) in the supplemental data online, the separation between the financial KIBS and the manufacturing sector is evident: none of the two variables experiences an appreciable effect of a shock to the other variable. The right panel of Figure A2(c) instead shows that the manufacturing sector employment grows after a positive shock to non-financial KIBS.

Similarly, the rest of the service sector follows, with some lag, the growth in non-financial KIBS (0.011, bottom panel of Table 4), while, contrary to the manufacturing case, labour sharing between service sectors and non-financial KIBS is not observed (–0.224, n.s.). Hence, growth in non-KIBS services can reach higher levels (Figure A3(c), right panel, in the supplemental data online). The interaction between financial KIBS and other service industries is strong, with financial KIBS experiencing an immediate growth spurt following a positive change in other services (Figure A3(b)). The stronger influence of the rest of the economy on financial KIBS with respect to non-financial KIBS, supporting H5, is therefore only due to the impact of other services on the different KIBS groups. Yet, the marked difference between the relations between financial KIBS and manufacturing, on the one hand, and between financial KIBS and services, on the other hand, was not anticipated by H5, and a proper explanation of this would call for a more refined theoretical framework. The stronger effects for services compared with manufacturing may be due to the stronger embeddedness of services in the local economy as compared with manufacturing. Finally, by comparing results across models, the mechanisms anticipated by H3 can be detected after the first year: the positive impact of KIBS on services (models 7–9) is stronger than its impact on manufacturing (models 4–6).

Table 5 summarizes the hypotheses and findings. It shows that H3 and H4 lead partly to contradicting predictions. Results suggest that the mechanisms behind both hypotheses can, however, be found in different configurations. Indeed, if H3 never dominate within the first year, it explains the lagged impact of KIBS on services. In turn, H4 explains the contemporaneous negative relation between non-financial KIBS and manufacturing. Table 5 also shows that knowledge diffusion and demand-pull effects (H1 and H2) are found true in similar cases.

Before concluding this paper, a structural VAR (SVAR), which is estimated via ordinary least squares for all nine models, is implemented as a robustness test. For the SVAR to be estimated, it is only necessary to impose that structural innovations are orthogonal, but normally

Table 5. Summary of hypotheses and findings.

			Hypotheses				
Model	**KIBS**	**Rest of the economy**	**H1 Knowledge diffusion**	**H2 Demand-pull**	**H3 Local multiplier**	**H4 Labour sharing**	**H5 Financial versus non-financial**
			+ → (long-run)	**+ ← (long-run)**	**+ → (short-run)**	**− ↔ (short-run)**	**Financial ++ ← rest (with respect to non-financial)**
			Findings				
1	All KIBS	All rest	Yes	Yes	–	Yes*	–
2	Financial		Yes	Yes	–	No	Yes
3	Non-financial		Yes	Yes	–	Yes*	
4	All KIBS	Manufacturing	No	No	–	Yes*	–
5	Financial		No	No	–	No	No
6	Non-financial		Yes	Yes	–	Yes*	–
7	All KIBS	Services	Yes	Yes	Yes**	No	–
8	Financial		Yes	Yes	Yes**	No	Yes
9	Non-financial		Yes	Yes	Yes**	No	–

Notes: 'Yes' = hypothesis confirmed; 'No' = hypothesis not confirmed; '–' = no hypothesis.
*Only (– ←), see the methodological issue described in the supplemental data online; **after one year.

distributed. The short-run restriction is that the KIBS sector has no contemporaneous impact on the rest of the economy (the contemporaneous causal ordering is fixed *ex-ante* instead of being data driven). This exercise is intended to confirm that imposing the causal ordering but weakening the assumption on the structure of shocks does not alter the findings. The results show that the signs and magnitudes of the coefficients are very similar to the initial results under this alternative methodology, giving breadth to the findings of this paper.

CONCLUSIONS

Using a new statistical technique, this study analyses the causal relations between regional employment growth in KIBS and overall regional employment growth in Germany for 1999–2012. The findings can be summarized in three main messages, one general and two more specific.

First, there are clear connections between KIBS and the rest of the regional economy in terms of employment growth. Growth in other industries can influence the expansion of KIBS and leads the feedback to the regional economy in the long run. It follows that regions might experience a positive feedback loop for some years if either KIBS activities or activities in the rest of the economy are triggered by exogenous events, such as policy measures. Hence, these results support the earlier arguments that KIBS should be made part of regional policy (Den Hertog, 2000; Muller & Zenker, 2001).

Second, further investigation of the feedbacks showed that the manufacturing sector benefits from growth in non-financial KIBS in the long run, but not from growth in financial KIBS. Insofar as the objective of regional policy is to enhance the manufacturing sector, and KIBS is supportive of these sectors, such policies should focus on non-financial KIBS rather than financial KIBS. It would be interesting to study exactly which kind of non-financial KIBS activities are most supportive for the local economy, as well as exploring the importance of regional characteristics. However, to analyse this in detail goes beyond this paper and has to be tackled in a future study.

Third, the effects of growth in the rest of the economy, especially the other service industries, on financial KIBS seem to be strongest. In general, financial KIBS seem to have connections only with service industries, and their interactions with the overall regional growth seem to occur uniquely through their effect on, and influences from, the growth in other services. That is, financial KIBS do not suffer from short-term negative interactions with the rest of the economy, and seem instead to feed back on the rest of the economy in both the short- and long-terms, and at higher magnitude levels than the other KIBS. In bad times, such procyclical behaviour could backfire: in case of a negative shock to the economy, no matter whether the original shock hits financial KIBS or some other industries, the crisis can enter a vicious depressing circle. Thus, financial KIBS can be seen as accelerators in the regional economy as well in positive developments as in negative developments. In line with recent evidence (Borio, Furfine, & Lowe, 2001; Pike & Pollard, 2010), financial services tend to have destabilizing effects on a sustained growth path of regions.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

SUPPLEMENTAL DATA

Supplemental data for this article can be accessed at https://doi.org/10.1080/00343404.2016.1265104

NOTES

1. Klagge and Martin (2005) have confirmed the local bias in the case of venture capital firms in Germany.
2. Acyclicality imposes that positive shocks on one variable immediately affect the other variable, but not the other way around.
3. For details about the methodology and its limitations, see Appendix A sections A1 and A2 in the supplemental data online.
4. The KIBS sector could be further partitioned to study the effects in more detail. However, the above theoretical discussion does not provide more detailed predictions that would make such a partitioning necessary. In turn, the number of models would further increase, so that this option is left for further studies.
5. The rationale behind the NACE code list used here is the following. The Organisation for Economic Co-operation and Development (OECD) (see http://stats.oecd.org/glossary/detail.asp?ID=2435) does not consider construction, or energy or public administration sectors as part of the service sector. Castaldi (2009) also excludes, from an analysis of intersectoral linkages, education, health and social work 'because, by responding only partially to market forces, they follow different patterns of competition and growth' (p. 714). For similar reasons, the sectors related to water supply, sewage and waste management are also excluded from the services NACE list.
6. The figures are available from the authors upon request.
7. Such variety across KIBS sectors' occupational structures and skill requirements is in accordance with other contributions from the literature (Consoli & Elche-Hortelano, 2010).

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