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Spatial Distribution of Knowledge-Intensive Business Services in a Small Post-Communist Economy

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Abstract The authors examine the patterns and determinants of spatial distribution of selected knowledge-intensive business services in Czechia, a small post-communist country whose capital city holds a strong position and where a significant share of manufacturing and business R&D employment is located in non-metropolitan regions. The central research question asks to what extent the localization of knowledge-intensive business services can be explained by the position of cities in urban hierarchy. Correspondingly, the authors analyse the role of local factors such as regional economic specialization, regional firm size distribution or concentration of (high-tech) manufacturing or business R&D centres. The authors specifically concentrate on the role of large industrial centres in non-metropolitan regions and on the hypothesis of a spatial mismatch between knowledge-intensive business services and manufacturing, dispersed and overrepresented in smaller cities. Empirical results clearly confirmed the former hypothesis. Although the evidence on the latter hypothesis is more complex, it does not hold for the most of knowledge-intensive business services in Czechia.

Keywords Knowledge-intensive business services · Urban hierarchy · Non-metropolitan regions · Diversity · Czechia

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Introduction

In this paper, we aim to discuss and empirically document the effects of city size on the spatial distribution of selected knowledge-intensive business services (KIBS) in a small country, namely Czechia. More specifically, we ask if the spatial distribution of KIBS is solely explained by city size or whether other factors, such as collocation with manufacturing, plants and R&D centres or regional economic specialization/diversity, also contribute. Do KIBS serve their customers from central locations in the largest cities, or do they collocate with manufacturing plants in non-metropolitan industrial centres too? And what are the implications for knowledge-based regional policies?

This issue was picked up by Shearmur and Doloreux (2008), who empirically demonstrated the increasingly strong role of city size (urban hierarchy) in the spatial distribution of KIBS in Canada. One of their main conclusions was that KIBS that serve manufacturing firms do not have to leave metropolitan areas in order to locate close to manufacturing firms based in non-metropolitan areas.

In many small countries with developed transport and information and communication technology (ICT) infrastructure, the majority of industrial and commercial centres are located within a 1-h driving perimeter from the largest metropolitan regions. As long as there is a general tendency for KIBS to concentrate in the largest cities (e.g. Aslesen and Isaksen 2007; Shearmur and Doloreux 2008; Gallego and Maroto 2013; Müller and Doloreux 2009; Cuadrado-Roura 2013; Wood 2002), there are two possible scenarios of spatial distribution of KIBS.

The first scenario predicts the emergence of a spatial mismatch between the location of manufacturing firms and KIBS: manufacturing may be relatively dispersed and significantly represented in small- and medium-sized cities (Henderson 2003), while KIBS should be heavily concentrated in the largest cities. The second scenario predicts centrifugal forces to be prevalent, pushing KIBS firms to locate outside metropolitan areas, either to reduce costs or to capitalize on the proximity of large manufacturing firms, their principal customers.

Drawing on empirical evidence from Czechia, we aim to contribute to this debate from the perspective of a small post-communist country, capitalizing on its favourable geoeconomic location in Central Europe. In contrast to Canada, Czechia is a small country with rather short distances, good accessibility, extremely strong economic position of the capital city Prague and a significant portion of manufacturing and R&D business employment located in non-metropolitan regions (Ženka et al. 2015). If we detected the collocation of KIBS and manufacturing in non-metropolitan regions despite the fact that metropolitan regions are well accessible, it would be a strong argument supporting the claim that innovation process in manufacturing requires face-to-face contact and thus spatial collocation.

We therefore ask which of the two abovementioned scenarios is more relevant for Czechia.

The remainder of this text is organized as follows. In the next two sections, we discuss arguments for and against the concentration of KIBS in the largest cities—theoretically ('Spatial Distribution of Knowledge-Intensive Services—Theoretical Discussion') and in terms of the specific context of Central Europe and Czechia ('Knowledge-Intensive Services in Czechia: Discussion'). 'Data and Variables' describes data and variables. 'Regional Distribution of Knowledge-Intensive Services in Czechia—

Description of the Patterns' provides a descriptive outline of the spatial distribution of KIBS in Czechia. In 'Regional Distribution of Knowledge-Intensive Services in Czechia—Results of Multivariate Spatial Regression Analysis', we present empirical results on the multivariate statistical analysis of spatial distribution of KIBS and its predictors. 'Conclusion and Policy Implications' provides conclusions and policy implications.

Spatial Distribution of Knowledge-Intensive Services—Theoretical Discussion

There are several reasons why various KIBS should gravitate towards the largest cities (e.g. Coffey and Shearmur 1997). We can distinguish between two broad groups of location factors—those on the demand side and those on the supply side (Aslesen and Isaksen 2007).

The demand side factors shape the location choices of KIBS[1] for the following reasons:

- KIBS require *proximity to their principal customers* (Cuadrado-Roura 2013)—headquarters of large transnational corporations, public institutions and various KIBS firms including ICT, banks and R&D centres, which are disproportionately concentrated in the largest cities (e.g. Senn 1993; Keeble and Nachum 2002; Francois and Woerz 2007; Camacho-Ballesta, Melikhova and Hernández-Peinado 2013; Gallego and Maroto 2013). Their supply chains are often very complex, building on close and continual innovation collaboration with clients (Delgado-Márquez & García-Velasco 2013). Services are increasingly customized, based on tacit knowledge that is not easily transferable outside a particular geographical context (Cuadrado-Roura 2013).
- Larger cities usually perform economically better than smaller cities,[2] exhibiting not only higher per capita GDP but also market dynamism in terms of many business start-ups. This requires entrepreneurial infrastructure, financial and innovation support, which are often facilitated by KIBS (Rubalcaba et al. 2013).
- Large cities concentrate all kinds of services. Although manufacturing is a very important customer for KIBS, the share of the service sector in total KIBS sourcing is significantly higher and services are more intensive users of KIBS than manufacturing (Ciarli et al. 2012; Shearmur and Doloreux, 2014).
- The diversified firm size structure that is typical for large cities may be more conducive to the development of KIBS in comparison to more concentrated firm size structure in terms of the dominance of a single or a few large firms (Chinitz 1961). Large firms are more likely to source service inputs from extra-regional suppliers (Crone and Watts 2003) or to conduct them in-house. On the other hand, a plethora of small- and medium-sized local firms may create significant demand

[1] We are quoting authors that refer to either knowledge-intensive services, or KIBS, or business services, or producer services, or knowledge-intensive industries. However, we selected those statements that are applicable to various groups of knowledge-intensive business services.

[2] David et al. (2013), however, argue that city size per se is not decisive; related structural features and the position of cities in national, European and global networks is what really matters.

for knowledge-intensive services, because small- and medium-sized enterprises (SMEs) are more constrained in their innovation capabilities (Müller and Zenker 2001).

The following arguments support the supply side factors:

- *Urbanization economies* related to urban size and population density allow external scope economies to take effect. Not only do these include public utilities; municipal, business and commercial services and transport and communication infrastructure (Parr 2002) but also employment growth, market and innovation opportunities arising from economic diversity (Glaeser et al. 1992; Duranton and Puga 2000).
- *Factor endowments*—KIBS locate near the pools of skilled and experienced labour force, which is their key input (Coffey and Shearmur 1997; Daniels and Bryson 2002; Merino and Rubalcaba 2013).
- *Proximity of secondary suppliers*—local backward linkages of KIBS are usually stronger than in the case of the industrial sector (Coffey & Shearmur 1997; Müller and Doloreux 2009) and KIBS firms require to locate not only close to their principal customers but also close to their suppliers (Camacho-Ballesta et al. 2013).
- *Accessibility*—KIBS may agglomerate to gain better access to transport and telecommunication hubs located in metropolitan regions (Gallego and Maroto 2013). KIBS firms often do not require local proximity to their customers, but prefer locations in transport hubs that provide good accessibility to a wide range of customers at a regional, national and global level (Shearmur and Doloreux 2008). Developed transport and ICT infrastructure may enable the strategic functions of firms to decouple from their production plants located in non-metropolitan areas and to establish headquarters and service centres in metropolitan regions (Coffey and Shearmur 1997, p. 406).
- *Knowledge spillovers and proximity to sources of information* also favour the concentration of KIBS into large cities (Henderson 2003; Gallego and Maroto 2013), especially when based on tacit knowledge and highly complex collaboration that requires intensive face-to-face contact (Storper and Venables 2004). KIBS firms located in large cities have better access to knowledge transmitted not only through local interaction but also through trans-local knowledge pipelines (Moulaert and Djellal 1995; Keeble and Nachum 2002).
- *Capital cities* offer access to government bodies and related administration agencies; considerable population and economic weight … 'as well as wealth of infrastructures, services, and institutions (from universities to business and professional associations), which are frequently far above the rest of the cities in the country' (Cuadrado-Roura 2013).

There are also some reasons that favour the location of KIBS outside metropolitan regions of the largest cities:

- KIBS may emerge in non-metropolitan areas as spin-offs from manufacturing firms (Keeble and Nachum 2002).

- There is a pervasive tendency for spatial deconcentration of the following three types of knowledge-intensive services: (i) low value-added, routine or generic services and activities whose production can be standardized; (ii) services that do not require frequent contact with their customers (such as back-office services) and (iii) intensive users of ICT services (and Rubalcaba 2013). These activities may be attracted to hinterlands of metropolitan areas in order to benefit from agglomeration economies and to reduce diseconomies of central location at the same time (Coe and Townsend 1998; Jacobs et al. 2014). KIBS may be located even in rural areas at a significant distance from large cities (Wernerheim and Sharpe 2003), attracted by environmental and residential quality, lower labour costs, space for expansion, labour availability and stability or closeness to entrepreneurs (Keeble and Nachum 2002).
- Establishment of a stand-alone headquarter located in a large city—away from own production plants located in non-metropolitan areas—can be very costly for manufacturing firms due to increased communication and coordination costs (Henderson and Ono 2008).

Correspondingly, there is empirical evidence from the EU NUTS2 level that intermediate demand from manufacturing industries is a major factor of regional specialization in business services and that the location of business services depends on the former sectoral specialization of EU regions (Meliciani and Savona 2014). This holds especially for firms in knowledge-intensive/high-tech manufacturing industries, which are intensive users of KIBS (Guerrieri and Meliciani 2005). More importantly, the position of plants in global production networks, their strategic role and local presence of headquarters, R&D centres and other strategic functions significantly affect location patterns of KIBS and vice versa (Jacobs et al. 2014).

Knowledge-Intensive Services in Czechia: Discussion

In this section, we continue our discussion of factors that support the concentration and dispersion of KIBS in the specific context of Czechia and Central Europe. We start with a few arguments explaining the importance of city size for the spatial distribution of KIBS in Czechia.

Firstly, in all Central European countries, there is a sharp polarity in economic performance between the metropolitan regions of capital cities and all other regions (Petrakos 2001; David et al. 2013). The gap between the capital city of Prague and the rest of Czechia has significantly increased since 1989 (Hampl 2007; Dostál 2008; Czech Statistical Office 2014). In the period 1995–2012, Prague experienced the most rapid economic growth among the Czech NUTS3 regions. Its share in national GDP increased from 19.7 to 24.7 %; its GDP per capita increased from 168 to 208 % of the national average (Czech Statistical Office 2014). Between 1992 and 2006, only Prague and Středočeský region (surrounding the capital city) improved their economic performance compared to the EU27 average; all other Czech NUTS2 regions either stagnated or lagged behind (Novotný 2010). Therefore, Prague, followed by the second and the third largest cities in Czechia (Brno and Ostrava), provide by far the largest markets for the localization of KIBS.

Secondly, in small unitary states such as Czechia, capital cities may concentrate a disproportionately higher share of KIBS employment compared to their share in the total population or GDP (Kanó and Vas 2013). The superdominant position of capital cities and their attractiveness for the localization of KIBS result from the combination of a gateway function for foreign capital and investment (Drbohlav and Sýkora 1997), concentration of state administration bodies, corporate headquarters, transactional activities such as finance and insurance and also of a highly skilled labour force (Dostál 2008; Hardy et al. 2011, Sass and Fifeková 2011). Considering the relatively small size of the Czech economy, the strong position of manufacturing industries and the lower share of KIBS in total employment (Eurostat 2014), we argue that probably only the largest cities provide the critical mass necessary for successful development of KIBS.

Thirdly, the image and reputation of capitals and the largest cities has an important effect. In the 1990s, the majority of foreign direct investment (FDI) into KIBS was mostly market-seeking and concentrated primarily in Prague (Capik and Drahokoupil 2011) and to a lesser extent also in Brno and Ostrava (Blažek 2002). Since 2000, there has been a shift towards cost-seeking KIBS investment as a result of rapid expansion of service offshoring (Stare and Rubalcaba 2009; Hardy et al. 2011). Gateway capital cities including Prague have maintained their attractiveness because of their reputation based on many large successful investment projects in the 1990s (Sass and Fifeková 2011). Although the offshore cost-oriented routine services are expected to be rather spatially dispersed, Czech metropolitan cities still offer significantly lower labour costs compared to Western Europe (Stare and Rubalcaba 2009). The combination of lower costs, a highly skilled labour force and accessibility has been the key location factor for FDI into KIBS (Sass and Fifeková 2011).

Fourthly, innovative firms in Czech non-metropolitan regions cooperate and source knowledge mostly at the national and international level (Žížalová 2010). There are two main reasons for this. (i) Czech-based firms or subsidiaries are often unable to find innovation partners in their host regions, considering the limited innovation potential of regional midrange universities (Gál and Ptáček 2011) and the often weak knowledge base of local firms. (ii) Czech-based firms in technology-intensive manufacturing and knowledge-intensive services are usually tightly integrated into transnational production networks, positioned mostly as lower tiered suppliers of transnational corporations (TNCs) (Pavlínek and Ženka 2011; Blažek et al. 2011; Blažek 2012; Ženka and Pavlínek 2013). Innovation performance is thus to a large extent FDI-driven, led by foreign-owned TNC subsidiaries and their major suppliers mostly in medium-tech manufacturing industries (Radosevic 2011). Although there are a few large business R&D centres outside metropolitan areas, the majority of Czech-based non-metropolitan industrial concentrations are represented by weakly interconnected and locally disembedded low-end satellite platforms (Ženka et al. 2014)—so-called hollow clusters (Bathelt 2009).

Finally, Czechia is a small[3] country with relatively good transport accessibility. In 2000, almost 60 % of the total area was accessible within 2-h drive of Prague (Hudeček et al. 2011. In 2008, 83.8 % of population lived in municipalities accessible within a

[3] Drejer and Vinding (2005) documented distance decay effects on manufacturing innovation even in the context of Denmark. However, this does not mean that KIBS in Czechia will locate in proximity of manufacturing in non-metropolitan areas.

1-h drive of regional capitals (Czech Statistical Office 2008). Kraft et al. (2014) documented that metropolitan regions integrated by daily commuting transport flows concentrated 61.5 % of the total Czech population in 2010. Therefore, it is questionable how necessary it is for KIBS to locate outside the largest cities in proximity of manufacturing firms when it is relatively easy to commute from almost any municipality in Czechia to the regional capital and also to Prague, Brno or Ostrava. Moreover, the geographical proximity of metropolitan regions in neighbouring countries (Vienna, Berlin, Munich, Dresden, Bratislava, Katowice) may further undermine the locational attractiveness of small- and medium-sized Czech cities, regional capitals and even of Prague itself (Musil 1993).

There are, on the other hand, also some relevant arguments against the excessive concentration of KIBS in the largest cities. Firstly, more than half of Czech manufacturing production and business R&D is located outside metropolitan regions in small- or medium-sized, traditionally heavily industrialized cities (Ženka et al. 2015). KIBS in small- and medium-sized cities may emerge as spin-offs of these manufacturing firms (Keeble and Nachum 2002) or through FDI-driven development of technological or strategic service centres (Pavlínek 2012).

Secondly, compared to Western Europe, the knowledge intensity and innovation performance of the Czech-based knowledge-intensive services are significantly lower (Capik and Drahokoupil 2011). Since 2000, Central Europe has become an attractive locality for service offshoring and many foreign-owned routine service centres (often back-office) were established (Sass and Fifeková 2011). The lower the skill intensity and the more lower-order, the stronger the incentive for spatial dispersion in order to reduce costs or to be close to customers in the case of frequently used routine services (Shearmur and Doloreux 2014).

Data and Variables

Data

The main source of data for this study was a unique microregional level data set from the Czech Statistical Office (2009) covering microeconomic firm-level data aggregated into 206 spatial units—so-called municipalities with extended competence. In order to avoid terminological confusion, we call those units ‘cities’, although some of them include also administrative hinterlands (mainly those small- and medium-sized).

The data are available only for 2009 and contain basic employment and financial indicators such as production, value-added and wage figures, disaggregated to industries according to NACE 2-digit classification. The data set covers more than a half of the total national employment. However, the data are not available for several sectors such as mining and quarrying; energy, water distribution, sewerage, and waste management; wholesale and retail trade, repair of motor vehicles and motorcycles, and public services. The incompleteness of the data should be kept in mind when considering the relative shares of particular industries in regional employment figures. Fortunately, with the exception of mining (approximately 1 % of national employment), the industries not covered in our data set are known to reveal quite even spatial distribution.

As for definition of services, we are proceeding from the Eurostat (2011) classification distinguishing knowledge-intensive services based on the following NACE (Rev. 2) sectors: 50–51, 58–66, 69–75, 78 and 80. Table 1 lists all knowledge-intensive services according to the Eurostat definition covered by our data, ordered by employment size. The table reveals the unequal size of individual knowledge-intensive services in Czechia, with only few of the largest industries accounting for a large share of the total employment in knowledge-intensive services.

Other data used in the analysis come from easily accessible public databases (references below) with the exception of travel accessibility figures, which are based on a travel accessibility model (developed during the TRACC ESPON project at the Faculty of Science, Charles University in Prague).

The Construction of Dependent Variables

The first inspection of the data showed a considerable heterogeneity of both the knowledge-intensive services group and its KIBS subgroup (see Table 1) in terms of both their scope and spatial distribution. As such, instead of considering a single

Table 1 All knowledge-intensive services, according to the Eurostat definition, covered by our data

	Employment	Share in total (%)
M71—Architectural and engineering activities; technical testing and analysis	*76,953*	*16.6*
M69—Legal and accounting activities	*61,373*	*13.2*
J62—Computer programming, consultancy and related activities	*52,606*	*11.3*
N80—Security and investigation activities	*45,683*	*9.9*
M74—Other professional, scientific and technical activities	*33,785*	*7.2*
N78—Employment activities	*33,638*	*7.2*
M73—Advertising and market research	*27,642*	*6.0*
M70—Activities of head offices; management consultancy activities	23,542	5.1
J61—Telecommunications	21,728	4.7
K66—Activities auxiliary to financial services and insurance activities	21,647	4.7
J58—Publishing activities	17,997	3.9
J63—Information service activities	*12,011*	*2.6*
K64—Financial service activities, except insurance and pension funding	11,753	2.5
M72—Scientific research and development	7161	1.6
H51—Air transport	5700	1.2
J59—Motion picture, video and television programme production, sound recording and music publishing activities	4540	1.0
M75—Veterinary activities	3017	0.7
J60—Programming and broadcasting activities	*1760*	*0.4*
H50—Water transport	688	0.2
Total	463,224	100.0

Services analysed in our paper are marked italics. Source: Czech Statistical Office (2009)

dependent variable covering all available KIBS, we preferred to construct two spatially relatively homogenous dependent variables based on selected groups of KIBS.

These dependent variables used in our multivariate analysis of the factors underlying the spatial distribution of KIBS ('Regional Distribution of Knowledge-Intensive Services in Czechia—Results of Multivariate Spatial Regression Analysis') were identified as follows. We first examined the spatial relatedness (extent of similarity in spatial distributions) between the individual knowledge-intensive services industries listed in Fig. 1. For these purposes, we used a measure of pairwise spatial relatedness in terms of the adjusted Dice coefficient as applied in Novotný and Cheshire (2012). This measure quantifies the frequency of joint spatial concentrations of a given pair of knowledge-intensive services based on their localization quotients for employment in Czech regions.

After calculating the matrix of the spatial relatedness figures (adjusted Dice coefficients) between all pairs of knowledge-intensive services, we applied hierarchical clustering to identify basic patterns of spatial relationships between individual service industries. The results are visualized by the dendrogram shown in Fig. 1. Here, we were particularly interested in the position of KIBS industries among other knowledge-intensive services. An inspection of the dendrogram suggests a clear cluster of four KIBS activities, positioned in the very bottom of Fig. 1. Importantly, this group includes four populous KIBS (NACE: 69, 71, 74, 80) that together account for nearly 47 % of the total Czech employment in knowledge-intensive services and for 59 % of KIBS employment. The relative share for the aggregate employment of these four services in total employment was considered as the first dependent variable in our analysis, labelled as the variable of larger spatially related KIBS (KIBS_LSR). As the second dependent variable, we considered the cluster of three KIBS consisting of programming and broadcasting (60), computer programming (62) and information services (63) that have also revealed mutually similar spatial patterns by clustering together in Fig. 1 (hereafter we use the abbreviation KIBS_ICP for the latter dependent variable).

Construction of Independent Variables

The selection of independent variables and specification of particular regression models presented in 'Regional Distribution of Knowledge-Intensive Services in Czechia—

Notes: Hierarchical clustering was applied on the matrix of spatial relatedness figures expressed by the adjusted Dice coefficient as in Novotný and Cheshire (2012).
Source: The Authors

Fig. 1 Dendrogram indicating clustering of knowledge-intensive services according to their spatial relatedness. Hierarchical clustering was applied on the matrix of spatial relatedness figures expressed by the adjusted Dice coefficient as in Novotný and Cheshire (2012) Source: the authors

Results of Multivariate Spatial Regression Analysis' was determined based on (and constrained by) the trade-off between (i) the selection of potentially relevant (theoretically justified) variables, (ii) data availability and (iii) the problem of significant collinearity between several potentially relevant independent variables. In accordance with the theoretical discussion in 'Spatial Distribution of Knowledge-Intensive Services—Theoretical Discussion', we expect KIBS to be attracted by the largest cities and their commuting hinterlands, in proximity of local demand from (high-tech) manufacturing industries, skilled labour, strategic functions and innovation capabilities of local-based firms as well as diversified industrial and firm size structure.

When measuring the city size as an attractor for KIBS, it is necessary to consider not only the economic (in our case employment) base of the city itself but also employment potential of surrounding regions, which can be served from that particular city. In addition, the employment attractiveness is obviously not only a function of the employment size per se. It is also influenced by the number of other (often interrelated) factors such as the level of wages, travel accessibility and geographical position or regional variation in unemployment (and vacancies available). We tried to consider these different aspects of employment attractiveness when constructing the independent variable of *employment potential* of Czech regions (EMPL_POT). We thus firstly considered the pairwise travel accessibility distances d_{ij} between the centres of 206 regions considered in our analysis i and j, measured in time units. To obtain a measure of employment potential, we then used a simple gravity model. We estimated the matrix of 'employment' interactions (g_{ij}) between regions as a function of the travel accessibility d_{ij}, employment size (e), unemployment (u) and wage levels (w) as:

$$g_{ij} = \frac{u_j w_i}{u_i w_j} \sqrt{\frac{e_i e_j}{{d_{ij}}^2}}$$

The measure of employment potential of a city i was subsequently expressed as the sum of employment interactions to other cities:

$$F_i = \sum_j g_{ij}$$

As also mentioned in 'Spatial Distribution of Knowledge-Intensive Services—Theoretical Discussion', the structure of urban economy in terms of the extent of its specialization can be considered as another factor that is potentially relevant for the spatial concentration of KIBS. To account for the *specialization and diversity of local economies*, we applied the common Herfindahl index (HHI), calculated from the relative employment shares of individual industries (59 industries covered by our data). Formally, for a region i, this measure is denoted as follows:

$$HHI_i = \sum_k e_{ik}^2$$

where e_{ik} is the relative share of employment in industry k in total employment of the region i. Apparently, high values of HHI signify specialization and low values indicate regional industrial diversity.

The proxy for the *concentration of business research and development* (BUS_RD), expressed as the number of employees in private R&D per capita, was also included to

test the relationship between localization of KIBS and the local presence of strategic functions and innovation capabilities, indirectly measured by the intensity of business R&D employment.

For similar reasons, we also examined the *concentration of manufacturing* (MAN_D) and the *concentration of high-tech manufacturing* (HT_MAN)[4] as indicators of local demand for KIBS. These variables were expressed as the number of employees in manufacturing industries and high-tech manufacturing industries, respectively, per inhabitant.

Another independent variable taken into account was a measure of the regional *size distribution of firms* (FIRM_DIST), calculated using the Gini coefficient of size distribution of economic entities based on the interval data on size distributions of economic entities in individual regions (Czech Statistical Office 2012). We expect KIBS to be located in cities dominated by SMEs rather than in cities with comparatively more concentrated firm size structure (as justified by the supply factors discussed in 'Spatial Distribution of Knowledge-Intensive Services—Theoretical Discussion').

In addition to the abovementioned independent variables eventually included into the regression models presented in 'Regional Distribution of Knowledge-Intensive Services in Czechia—Results of Multivariate Spatial Regression Analysis', several other potentially relevant independent variables were also examined. However, significant multicollinearity was an issue when we included available proxy variables for regional differences in labour skills (proxied by the stock of university educated in population), firm density (proxy for the availability of customers) and the level of wages. There is a significant collinearity between the above variables and employment potential. Therefore, we decided to exclude these variables from our models.

Regional Distribution of Knowledge-Intensive Services in Czechia—Description of the Patterns

A basic examination of the regional distribution of KIBS selected for this analysis suggests that these activities are heavily concentrated in the largest cities, with the capital city holding a superdominant position (Table 2; Figs. 2 and 3). In 2009, Prague itself concentrated 42.5 % of total employment in the selected KIBS, although its share in the population of Czechia is only 11.9 % (Table 2). As such, Prague accounted for a higher share of KIBS employment than all other metropolitan cities together, and a share more than three times the share of all small- and medium-sized cities combined. By contrast, in 2009, small- and medium-sized cities concentrated 56.3 % of the total population, 45.7 % of total employment, 58.0 % of manufacturing employment and 36.8 % of R&D business employment (data for 2006–2007) in Czechia.

These results suggest the existence of a clear difference between dispersed manufacturing industries, overrepresented in small- and medium-sized cities, and KIBS, heavily concentrated in the largest metropolitan cities—Prague, Brno and Ostrava. The unique position of Prague as the capital and a Gamma world city was

[4] Manufacturing industries include NACE (rev. 2.0) sectors 10–33; high-tech manufacturing industries include manufacturing of pharmaceuticals (21) and manufacturing of computer, electronic and optical products (26); data for the manufacturing of aircrafts were not available.

Table 2 Distribution of KIBS according to city size in Czechia (2009)

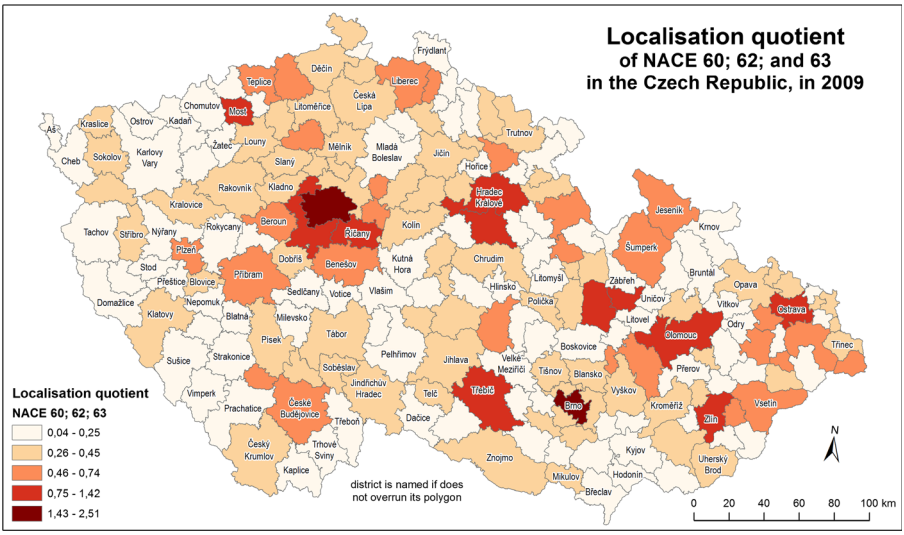
% share	Cities with more than 100,000 inhabitants		Cities with less than 100,000 inhabitants	Total ABS
	Prague	Other core cities		
Built-up land (ha)	3.8	11.8	82.5	131,802
Population	11.9	17.5	70.6	10,506,813
Employment	23.3	20.3	56.4	2,738,478
Employment in manufacturing	10.0	19.1	70.8	1,190,836
Employment in high-tech manufacturing	13.1	26.9	60.0	53,949
Business R&D employment	29.3	26.7	44.0	35,005
Employment 60	78.3	12.7	9.0	1760
Employment 62	50.7	29.1	20.2	52,606
Employment 63	62.1	20.5	17.4	12,011
Employment 69	38.0	23.0	39.0	61,373
Employment 70	49.3	16.8	33.9	23,542
Employment 71	30.6	32.5	36.9	76,953
Employment 73	51.2	23.1	25.6	27,642
Employment 74	32.3	24.8	43.0	33,785
Employment 78	52.3	24.6	23.1	33,638
Employment 80	43.8	25.2	31.1	45,683
Employment KIBS ICP	53.5	27.1	19.4	66,377
Employment KIBS LSR	35.7	27.1	37.2	217,794
Employment KIBS	42.5	25.9	31.6	368,992

Source: Czech Statistical Office (2007); Czech Statistical Office (2009)

discussed in 'Knowledge-Intensive Services in Czechia: Discussion', and so now we will characterize briefly the positions of Brno and Ostrava. The former represents a case of a successful socioeconomic transformation and relatively high economic and innovation performance in Central European conditions. The latter is a typical old industrial city that has maintained a strong industrial base despite an intensive process of deindustrialization.

Both cities are specialized in technical services (NACE 71) and information and communication technology services, as captured by the variable KIBS_ICP introduced above. Considering KIBS_ICP, Brno is the second most specialized city in Czechia and Ostrava is the third (Fig. 2). The specialization in KIBS_ICP follows the city size distribution in Czechia, but Ostrava lags behind Prague and Brno significantly.[5] The reasons for the concentration of technical services and KIBS_ICP in Brno and, to a lesser extent, also in Ostrava, lie in the industrial tradition of both cities. As Simmie and Strambach (2006, p. 36) put it '…regional specialization in knowledge intensive

[5] Location quotients for technical services: Prague 1.31; Brno 2.38; Ostrava 1.29; location quotients for ICT: Praha 2.61; Brno 2.02; Ostrava 1.17 (Figs. 2 and 3).



Source: CSO 2009; The Authors

Fig. 2 Localization quotient of KIBS_ICP in Czechia (2009). Source: Czech Statistical Office 2009; the authors

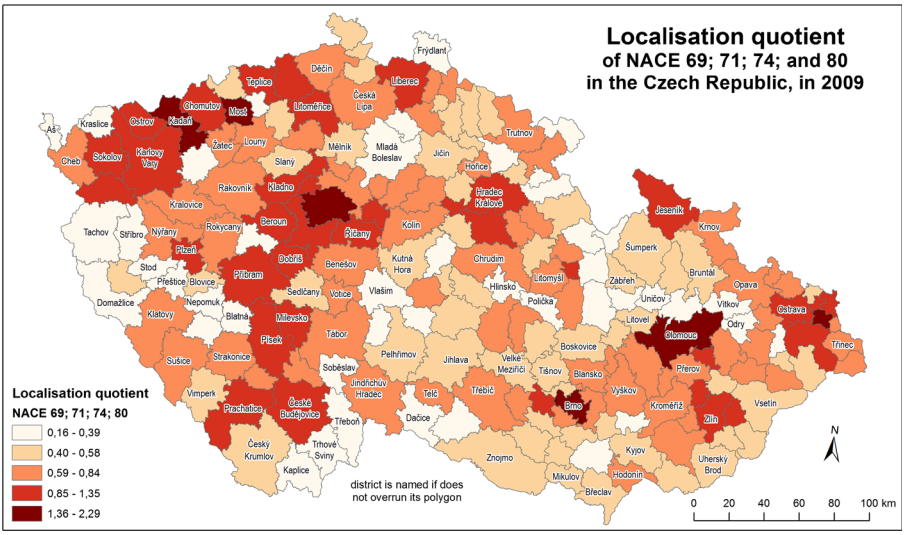
service branches are becoming stronger as a result of cumulative learning processes and knowledge spillovers over time. For this reason it is difficult for cities and regions to position themselves in the fields of knowledge intensive services and technology in which they were not previously established'.

This point is valid for Brno and Ostrava as well. The majority of Central European cities in the period of centrally planned economy were over-industrialized (Tsenkova 2006). Brno was traditionally specialized in machinery and the industrial complex in Ostrava was built on the steel and metal industries and on coal mining.[6] At the beginning of the 2000s, both cities could offer a large pool of technically skilled labour and large technical universities with rapidly developing departments of informatics. In 2000, the KIBS_ICP sectors in Brno and Ostrava were roughly comparable in size (Blažek 2002).

Nevertheless, since 2000, the development trajectories of Brno and Ostrava have started to diverge. Brno has attracted a significantly larger amount of (not only) technical and KIBS_ICP services and has transformed from a manufacturing centre into a service hub. Unlike Ostrava, it could capitalize on its favourable geographical location (proximity to Vienna, Prague and Bratislava) and significantly larger and higher quality pool of technical university graduates (Hardy et al. 2011).

The development of KIBS in Ostrava has been constrained by an excessively narrow specialization in heavy manufacturing industries. On the other hand, both KIBS_ICP

[6] At the end of the 1980s, the machinery industry in Brno accounted for 53,000 employees—57 % share in total manufacturing employment (Tonev and Toušek 2002), while two decades later it was less than 8,500 (Czech Statistical Office 2009). At the end of the 1980s, Ostrava had 57,000 employees in manufacturing of steel and fabricated metal products, which corresponded to 71 % share in total manufacturing employment (Tonev and Toušek 2002) and it also had roughly 20,000 employees in coal mining. By contrast, in 2009, there were 16,000 employees in the manufacturing of steel and fabricated metal products (Czech Statistical Office 2009).



Source: CSO 2009; The Authors

Fig. 3 Localization quotient of KIBS_LSR in Czechia (2009). Source: Czech Statistical Office 2009; the authors

and technical services have emerged on the platform of steel and metal industries that have required increasingly sophisticated technical solutions for their products. Endogenous development of technical and KIBS_ICP services has been, however, significantly weaker than in the case of Brno, where some local KIBS_ICP firms have become global leaders in specialized software development (e.g. firms such as AVG Technologies or Avast, which specialize in PC security software). In 2001, Brno obtained a strong stimulus in the form of a flagship investment by IBM (2300 jobs) and it has implemented a successful innovation strategy leading to the development of its regional innovation system (Blažek et al. 2013).

Apart from the three largest metropolitan cities (Prague, Brno and Ostrava), only six other cities concentrated a significant portion of KIBS_ICP employment; three of them were regional capitals and the remaining three medium-sized cities accounted for less than 1 % of total KIBS_ICP employment in Czechia. Prague itself concentrated 52.8 % of Czech KIBS_ICP employment. Similar patterns were found in the case of all selected KIBS, but the level of geographical concentration was lower.

Moreover, only limited commercial suburbanization effects were found. The share of metropolitan hinterlands in the total KIBS employment of Czechia is 1.7 % in the case of Prague, 0.8 % for Brno and 2.2 % for Ostrava.

Regional Distribution of Knowledge-Intensive Services in Czechia—Results of Multivariate Spatial Regression Analysis

In the regression analysis we began with traditional ordinary least square (OLS) estimates. As we were working with spatial data, we ran appropriate diagnostics to identify possible influences of spatial autocorrelation in the data and, when suggested

by the diagnostics, we applied a maximum likelihood estimation of spatial regressions. Moreover, the employment potential included among the independent variables also captures an important part of the spatial structure of the data due to its calculation from spatial interactions between regional centres.

We had to transform some of the variables including the dependent variables (we used natural logarithmic transformations). We also reanalysed the results when excluding cities with more than 100,000 inhabitants to examine whether the relationships suggested by the results based on the whole data set also hold within a group of solely small- and medium-sized cities.

Table 3 presents basic descriptive statistics for the dependent and independent variables included into the regression models presented in this paper. The final models presented in Table 5 are based on a number of preliminary experiments in which we tested various other model specifications. More specifically, we also examined the effects of other independent variables such as firm density (a proxy for the availability

Table 3 Basic descriptive statistics for the dependent and independent variables ($N = 206$ Czech cities)

Variable	Indicator	Abbreviation	Mean	Std. dev.	Sources of data
Larger spatially related KIBS	Share of NACE 69, 71, 74, 80 in total employment	KIBS_LSR (Ln)	−3.091	0.478	Czech Statistical Office 2009
Information services, computer programming and broadcasting	Share of NACE 60, 62, 63 in total employment	KIBS_ICP (Ln)	−6.655	0.812	Czech Statistical Office 2009
Employment potential	As explained in "Data and Variables"	EMPL_POT (Ln)	5.311	0.759	TRACC ESPON
Economic diversity and specialization	Herfindahl index for employment (see "Data and Variables")	HHI (Ln)	6.637	0.395	Czech Statistical Office 2009
Business R&D intensity	Employment in business R&D per capita	BUS_RD (Ln)	−6.921	1.429	Czech Statistical Office 2007
Manufacturing intensity	Employment in manufacturing per capita	MAN	0.113	0.047	Czech Statistical Office 2009
High-tech manufacturing intensity	Employment in high-tech manufacturing per capita	HT_MAN (Ln)	−7.018	1.758	Czech Statistical Office 2009
Size distribution of firms	Gini coefficient of size distribution of economic entities	FIRM_ DIST	0.244	0.034	Czech Statistical Office 2009

(Ln) indicates that a given variable was transformed by the natural logarithm

of customers for KIBS services), wage level or the availability of skilled labour (proxied by the share of university educated in population). However, with the inclusion of these additional potentially relevant variables, a multicollinearity was a problem, especially (though not exclusively) due to a significant correlation of these variables with the employment potential measure. As the latter provides an aggregate measure of employment attractiveness (see 'Construction of Independent Variables'), we preferred to keep the employment potential variable in the final models and excluded some other variables mentioned above.

Table 5 shows our final estimates for several multivariate regression models examining correlates of the two dependent variables of KIBS (KIBS_LSR and KIBS_ICP). We began with OLS estimates, and in the case of the first dependent variable, we also provided maximum likelihood spatial lag regression estimates because appropriate tests suggested potential problems related to the spatially autocorrelated dependent variable (model 2 in Table 4). We calculated regression estimates for full data sets (models 1, 2 and 4) and for reduced data sets (models 3 and 5). The reduced models 3 and 5 provide results when excluding the 16 largest (most populous) regions with a population above 100,000. This latter exercise was included to confirm the stability of the investigated relationships within the set of small- and medium-sized cities. All of the models incorporate the same set of explanatory variables outlined above.

The inspection of Tables 4 and 5 shows that the results are consistent across models based on the full and reduced data sets and for OLS and spatial lag techniques. The fit of the models in Table 5 is better and the parameters obtained for some of the predictors differ from those in Table 4. This once again confirms the relevance of the separate analysis for the two dependent variables.

For both the dependent variables and all of the examined regression models, employment potential, as a proxy measure of city size, was found as a strong and statistically significant positive correlate of the presence of KIBS in cities. For example,

Table 4 Correlates of KIBS_LSR (Ln)

	(1) OLS full		(2) ML spatial lag full		(3) OLS regions with population below 100,000	
	B	Std. error	*B*	Std. error	*B*	Std. error
EMPL_POT (Ln)	0.241	0.051***	0.239	0.049***	0.201	0.062**
HHI (Ln)	−0.377	0.090***	−0.37	0.085***	−0.376	0.096***
MAN	−4.137	0.888***	−3.9	0.845***	−4.260	0.984***
HT_MAN (Ln)	0.026	0.016	0.024	0.015	0.027	0.017
BUS_RD (Ln)	0.038	0.018**	0.043	0.018	0.039	0.020*
FIRM_DIST	0.574	1.130	0.41	1.074	0.612	1.226
W	–	–	0.279	0.081***	–	–
R^2	0.443		0.482		0.347	
N	206		206		190	

In spatial lag regressions, W refers to spatial lag of dependent variable, which captures spatial autocorrelation of the dependent variable

Significant at ***0.01; **0.05; *0.1

Table 5 Correlates of KIBS_ICP (Ln)

	(4) OLS full		(5) OLS regions with population below 100,000	
	B	Std. error	*B*	Std. error
EMPL_POT (Ln)	0.562	0.080***	0.403	0.096***
HHI (Ln)	−0.7	0.142***	−0.663	0.148***
MAN	3.337	1.404***	5.309	1.518***
HT_MAN (Ln)	−0.007	0.026	−0.011	0.026
BUS_RD (Ln)	0.026	0.029	0.009	0.031
FIRM_DIST	0.422	1.787	−0.673	1.892
R^2	0.518		0.364	
N	206		190	

Significant at ***0.01; **0.05; *0.1

model 4 in Table 5 implies that, holding all other predictors constant, a 10 % change in employment potential is associated with a 5.6 % change in KIBS_ICP. Importantly, our results that were based on the reduced data sets (models 3 in Table 4 and 5 in Table 5) confirmed that this relationship is not only the effect of a few of the biggest cities but that it holds among less populous regions too. The effect of employment potential on KIBS_LSR is somewhat weaker but also positive and statistically significant. These results corroborate the finding that the intensity of KIBS in local employment clearly depends on the city size and employment potential.

The degree of economic specialization (HHI) was identified as a statistically significant predictor for both dependent variables of KIBS, with negative effects that are especially notable for the KIBS_ICP models (Table 5). In other words, the presence of KIBS tends to associate with economic diversity. Again, our estimates based on the reduced data sets confirmed the consistency of this relationship in terms of the similar effects of HHI found for the subsets of less populous regions. Note that the effects of HHI are significant despite us controlling for other independent variables, including employment potential or intensity of manufacturing employment. As such, the results indicate that these effects can neither be attributed solely to the higher intensity of KIBS in large cities (that also tend to have a more diversified economic structure) nor to the possible relationship between economic specialization and the dependence on manufacturing. Economic specialization (and diversity) matters per se; moreover, this was also confirmed by the results obtained for the reduced data sets (models 3 and 5).

Significant but contradictory relationships were identified for the effects of the intensity of manufacturing (MAN) on the two dependent KIBS variables. While in the case of KIBS_LSR (Table 4) the relationship is significant and negative, it is positive and significant for KIBS_ICP. This is surprising, because one would rather expect collocation of manufacturing with technical and professional services than with footloose information services and programming. Nevertheless, Czech cities with more than 80,000 inhabitants and some large non-metropolitan industrial centres not only concentrate KIBS_ICP but also exhibit relatively high specialization in manufacturing (except for Prague). We do not have evidence to support the existence of linkages

between manufacturing and KIBS_ICP (Blažek et al. 2011)—thus, it may be a simple collocation without networking.

On the other hand, no significant relationship was found between KIBS and high-tech manufacturing. This does not come as a surprise as high-tech manufacturing in Czechia is present both in metropolitan regions and in several peripheral and old industrial regions as a result of socialist industrialization, shaped by defence strategy (e.g. optical instruments in Blansko or Přerov). Since the 1990s, this has also been influenced by the FDI-driven establishment of export-oriented assembly plants. In general, however, high-tech Central European industries exhibit significantly lower productivity and innovation performance than their Western European counterparts as they are dominated mostly by foreign-owned export-oriented assembly plants (Srholec 2007).

Also the effects of other variables examined in our analysis (BUS_RD and FIRM_DIST) appeared insignificant. The majority of Czech-based business R&D centres were established, or at least expanded, by large transnational corporations and their subsidiaries. Cities with significant business R&D employment are mostly those with concentrated firm size structure. We did not find any systematic pattern of KIBS concentration in these cities.

Conclusions and Policy Implications

We examined the spatial distribution of KIBS in a small, export-oriented post-communist economy. Drawing on empirical evidence from Czechia, we tried to determine whether, and to what extent, the spatial distribution of selected KIBS is associated with city size. We also attempted to identify the role of local factors related to the dependence on manufacturing, economic diversity/specialization or firm size distribution. We found that KIBS are strongly spatially distributed according to the city size and employment potential. This finding is in line with findings of Slach et al. (2013) that documented the same pattern for the spatial distribution of creative industries in Czechia. Regarding the role of other local factors, we found a strong association between economic diversity and spatial distribution of KIBS. This is also related to the finding of significant negative effects of the dependence on manufacturing on the group of larger spatially related KIBS (KIBS_LSR—legal, technical, professional, employment and security services) that accounts for a major share of KIBS employment. By contrast, and rather surprisingly, we also identified collocation between manufacturing and KIBS_ICP (information services, computer programming and broadcasting). Further empirical research is needed to explain this spatial pattern.

Czechia was chosen as a small country with relatively good accessibility of most regions, dominant position of the capital city of Prague and also sharp polarity in economic performance between Prague and most other cities. As such, Czechia should exhibit a high level of spatial concentration of KIBS in the largest cities, such as countries in southern Europe, especially Greece and Portugal. On the other hand, a significant portion of manufacturing and business R&D employment is located in non-metropolitan small- and medium-sized cities, thus providing potential for spatial dispersion of KIBS, similarly as in northern Europe and Germany (Wood 2006). Similar to conclusions of Ciarli et al. (2012), our results show that Czechia is closer

to the southern European model: KIBS are excessively concentrated in the three largest cities, with the capital city holding an exclusive position.

Nevertheless, in contrast to Spain, Portugal and Greece, Czechia and also other Central European countries (especially Slovakia and Hungary) are characteristic by a higher level of industrialization and significant portion of manufacturing employment located outside metropolitan areas. As such, we can talk about a specific Central European model, characteristic by a spatial mismatch between relatively dispersed manufacturing and heavily concentrated KIBS, overrepresented in the largest cities despite the higher potential demand for KIBS in non-metropolitan industrial centres.

These findings therefore support the arguments of Shearmur and Doloreux (2008, 2014) that innovative manufacturing does not require a local presence of KIBS and vice versa. Considering the relatively short geographical distances in Czechia, KIBS located in the three largest cities may serve manufacturing plants located elsewhere in the country with relative ease. The same holds for high-tech manufacturing, which is in contrast to the situation in Germany and Scandinavia, where intensive local linkages between high-tech manufacturing and KIBS outside the capital cities can be found (Ciarli et al., 2012). The conclusions of Gallego and Maroto (2013) or Delgado-Márquez and García-Velasco (2013) about the collocation of KIBS and high-tech manufacturing at EU27 NUTS3 level are not applicable to a microregional level location analysis of KIBS in Czechia.

Based on the theoretical discussions in 'Knowledge-Intensive Services in Czechia: Discussion' and our empirical results, we propose two main implications for regional policies. First, policies aimed at the attraction or endogenous development of KIBS in core cities apart from Prague should prioritize those KIBS which are related to an existing knowledge base and expertise. Only Prague as a Gamma world city seems to capitalize significantly on its market size and economic diversity, providing favourable conditions for the development of a full range of KIBS. Other Czech metropolitan cities are more likely to develop specialization in selected KIBS only, integrated and related to their respective local production systems. This finding was empirically demonstrated on the case of Brno since 1990s, which has developed a strong base of ICT due to its past specialization in machinery industries and the presence of high-quality technical universities. In contrast, development of ICT sector in Ostrava with past specialization on mining and heavy manufacturing industries has lagged significantly behind.

Our second implication is related to the role of KIBS as integrators of regional innovation systems (Müller and Zenker 2001). Considering the lower quality of regional midrange universities and weak local industrial linkages, we argue that the potential for the formation of networked regional innovation systems outside the three largest cities in Czechia is rather limited (see also Ženka et al. 2014). Therefore, firms in non-metropolitan regions or regional capitals should be encouraged to build external knowledge pipelines rather than relying solely on a limited local knowledge base and localized spillovers. With the exception of information and communication technology services and technical services with some export potential, the prospects for KIBS development in smaller Czech metropolitan cities are constrained by the size of the respective local markets.

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