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The regional significance of university locations in Lower Saxony

Britta Stöver

Abstract

Universities are important economic actors in having a considerable impact on the demand and supply side of their local economy. The aim of this paper is to quantify, compare and classify the different economic demand- and supply-side contributions of the university locations within Lower-Saxony using a combination of multiplier analysis and spatial econometrics on a NUTS-3 level. In comparison to numerous other studies this paper does not focus on the economic impact of single cases or a selected university location but gives a complete picture of the importance and significance of all university locations within Lower-Saxony. The income induced direct and indirect demand effects are estimated with a rich data set from higher education statistics in combination with an income and employment multiplier derived from a regional input-output table while the supply-side effects, i. e. the impact of the education and research outcomes, are calculated by estimating with spatial panel regressions a model derived from human capital theory and knowledge spillover theory. The estimation results give a complete and reproducible impression of the importance and significance of the different university locations offering the opportunity for comparisons and classifications.

JEL-Classification: I23, R11, R12, R15

Keywords: Demand and supply-side effects, multiplier analysis, spatial panel model, university location

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1 Introduction

Universities are important economic actors in affecting the local economy in two ways: on the demand side they consume labour and materials for the provision of education and administrative tasks inducing direct and indirect multiplier effects. On the supply side they generate human capital by educating students. Additionally, many research findings suggest that universities regionally support innovation and development as well as the foundation of new ventures.

The quantification of the significance and the economic value of universities for their respective region is of interest for local politicians as well as the universities themselves: it helps to legitimate public funds and the use of tax money, can be used as image campaign or supports reform or investment programmes. As a consequence, there already exist numerous national and international publications evaluating the economic importance of universities. However, many of the published studies are single case studies focusing on single universities or university locations. With regard to German studies, the findings are often based on different definitions of the spatial dimensions as well as statistical and empirical methods (Blume and Fromm, 1999, p. 418). Thus, a classification, combination and comparison of the different local results is not straightforward. Another drawback is that a lot of the studies focus on the quantification of the demand side neglecting the positive impact on qualification and innovation.

The aim of this study is to quantify, compare and classify the different economic demand and supply side contributions of the university locations within Lower-Saxony using a combination of multiplier analysis, cluster analysis and spatial econometrics on a NUTS-3 level.

The demand-side driven economic impact of the university locations on the local economy and the local labour market is calculated using multiplier analysis. The income induced direct and indirect demand effects are estimated with a rich data set from higher education statistics in combination with an income and employment multiplier derived from a Regional Input-Output table (RIOT). Contrary to the demand side, there exist no monetary values for the supply-side effects, i. e. for the education and research outcomes. While the demand side is hence relative easily quantifiable the economic value for the provision of highly educated manpower and research cannot be measured directly. As a consequence, the supply side effects are calculated by estimating with spatial panel regressions a model derived from human capital theory and knowledge spillover theory.

Based on the consistent data set and the well defined methodology the estimation results give a complete picture and reproducible impression of the importance and significance of the different university locations on a disaggregated spatial level. Comparisons between regions and clusters are possible offering the opportunity for classifications.

The remainder is structured as follows. In section 2 the data set, implemented theories and applied methodologies for the demand side as well as the supply side are described. The results are given in section 3 first presenting the demand-side and then the supply-side effects. In section 4 the paper is summarised and discussed.

2 Methodology

The economic contribution and impact of university locations consists of demand-side as well as supply-side effects. Demand-side effects arise out of the expenses for the provision of education services such as staff expenditure, cost of materials and investment. Supply-

side effects result from the university output, i. e. knowledge transfer in the form of human capital as well as research and innovation. While expenses and their multiplier effects can be measured in monetary values, the supply-side effects can only indirectly be quantified. Before going into methodological detail some background information about data sources, terminologies and the higher education landscape within Lower Saxony is given.

All values used in this analysis are derived from official statistics: University related information is provided by higher education statistics (LSN, 2019); information on GDP and the labour market are derived from the Regional Accounts (VGRdL, 2018); values regarding migration, commuting and population are published by *Regionaldatenbank Deutschland* (StABL, 2017, 2018, 2019); the Household Budget Survey is provided by the Statistical Office in Lower Saxony (*Landesamt für Statistik Niedersachsen*, LSN, 2015) and information on patents is given by the European Patent Office (EPO, 2019).

The term university encompasses all kinds of universities in Lower Saxony listed in the higher education statistics (LSN, 2019).¹ This includes private universities as well as universities of Applied Sciences. Regions are defined by the NUTS-3 administrative borders (*kreisfreie Städte und Kreise*) and university location is hence a region one or more universities are located in.

In 2016, 205 thousand students were enrolled in 30 universities at 24 locations in Lower Saxony.² The majority of regions within Lower Saxony – 24 out of 45 NUTS-3 regions – locate at least one university. The university locations can be found in urban as well as rural areas and vary considerably in size (see Figure 4 in the Appendix). Overall, 51.8 thousand persons are employed in universities with the majority (52.8%) being scientific personnel.

2.1 Measuring the demand side contributions

The quantification of the demand side contribution of each university location is based on multiplier analysis: The universities' expenses for personnel, materials and investment as well as the students' consumption expenditures induce direct and indirect demand for goods and services within the university location that would otherwise not exist and that has hence a positive effect on local production. The increase in local production also positively affects the labour market representing the employment effect.

In the study at hand the multiplier effects are estimated using a rich data set with financial and economic information on NUTS-3-level as well as income and employment multipliers derived from a regional input output table (RIOT). The variables and calculation procedures are as proposed by Caffrey and Isaacs (1971) and Garrido-Yserte and Gallo-Rivera (2010).³

A difference to the general approach is however, that the estimation concentrates on the direct and indirect demand effects originating from the consumption expenditure of the university personnel and the students. This has several reasons: First of all, little is known about the regional share in material expenditure, i. e. the part of materials that is

¹The university in Hermannsburg is excluded as university location because it is a university with a short history being founded in 2012. As it is also a very small university with only 83 enrolled students in 2017 and with a small economic impact it has been abstained to include it in the data set and to shorten the time series of the panel.

²The general information in this paragraph includes the university location Hermannsburg though this location is later excluded in the estimation process.

³There exists many applications of this methodology. See e. g. Bauer (1997), Blume and Fromm (2000) or Glückler and König (2011) for German case studies or Business Research Division (2017), Pellenberg (2007), Umbach (2018) for international ones.

bought from local producers. Samples conducted at a few universities suggest that most of the products for material expenses are imported from other NUTS-3-regions. Secondly, expenses for investment take only place on an irregular basis. Amounts and time varies a lot between the university locations making the selection of a reference year difficult. In order to avoid an overestimation of the regional impact of university locations, the positive demand effects arising out of expenses for materials and investment are not taken into account. This procedure can also be justified by the fact that the staff expenditure holds in average with 59% the biggest share in the total expenses for personnel, materials and investment.⁴ As income for the university personnel it contributes on a regular basis a big part to local consumption. In combination with the consumption expenditures of the students the income effects hence unfolds the highest direct and indirect effects of the demand side contribution. Nevertheless, it should be kept in mind that the results tend to underestimate the local economic contribution of the university locations.

For the calculation of the direct and indirect income effects it is assumed that the disposable income of university personnel and students is not spent completely. Additionally, only parts of the consumption is spent locally due to commuting as well as holiday and business trips of employees and students.

The local consumption of the university personnel is calculated as follows.

$$DINC_{UP} = SEXP_{UP} - PT_{UP} - T\&SSC_{UP} \quad (1)$$

$$C_{UP} = DINC_{UP} * APC_{UP} \quad (2)$$

$$LC_{UP} = C_{UP} * 0.9 * (1 - ICR) + C_{UP} * 0.1 * (ICR) \quad (3)$$

with *DINC* being the disposable income of the university personnel. It is calculated by subtracting from the staff expenditure (*SEXP*) the payroll taxes (*PT*) as well as the taxes and social security contributions (*T&SSC*). The calculation procedure differentiates between different employment relationships⁵ *C_{UP}* represents the total consumption expenditure of the university personnel depending on the average propensity to consume (*APC*).⁶ The average propensity to consume for different household types can be derived from the Household Budget Survey (LSN, 2015). However, the information is only available at NUTS-2-level for Lower Saxony. It is therefore assumed that there exist no spatial differences and that the propensity to consume is equal in all NUTS-3-regions.⁷ *LC_{UP}* is the local consumption expenditure, i. e. the amount of the consumption expenses that is spent within the university location and not elsewhere. It depends on the share in commuters working in the university location. It is assumed that the share of in-commuters in total university personnel is as high as in the total local labour market. The local consumption is then calculated assuming that university personnel living within the university location spent 90 percent of their consumption locally whereas university personnel

⁴Details about the amount and shares of the expenses for personnel, materials and investment for each university location can be found in Table 6 in the Appendix.

⁵The university personnel consists of employees and *Beamte*. The difference between the two types of civil servants expresses (among other things) in the type and amount of social security contributions and hence in the level of disposable income.

⁶Again, it is distinguished between the different consumption behaviour of employees and *Beamte*.

⁷This is a rather strong assumption as the living costs vary between urban and rural areas. Especially rents for dwellings are considerably higher in urban areas. Households living in NUTS-3-regions consisting mainly of metropolitan areas are more likely to spend more of their disposable income for consumption and to have a higher propensity to consume. In default of more detailed information however the assumption of equal consumption rates has to be maintained.

in-commuting from another NUTS-3-region spent only 10 percent of their consumption within the university location.⁸

The amount that is locally consumed by students is estimated by

$$C_S = DINC_S * APC_S, \text{ with } APC_S = 0.9536 \forall S \quad (4)$$

$$LC_S = 0.8 * C_S \quad (5)$$

The disposable income $DINC_S$ and the average propensity to consume APC_S is information derived from the Household Budget Survey (LSN, 2015). Again, the information is only available at NUTS-2-level for Lower Saxony and it is hence assumed that the disposable income and the propensity to consume for each student in every NUTS-3-regions is the same.⁹ As for the local part of the total students' consumption (LC_S) a 80 percent share is used. This assumption was derived from Blume and Fromm (1999, p. 423).

The combination of the local consumption of the university personnel and students yields the total direct demand effects. The total (indirect and direct) effects can be derived by using the income multiplier from the RIOT for Lower Saxony (Stöver, 2018). The income multiplier is estimated by

$$IM = \frac{income.ef}{a_{ml}} \quad (6)$$

$$income.ef = a'_{ml} * (I - A)^{-1} \quad (7)$$

$$a_{ml} = \frac{comp.empl}{production} \quad (8)$$

The income multiplier IM is composed of the total direct and indirect income effect $income.ef$ and the monetary labour input coefficient a_{ml} . The monetary labour input coefficient a_{ml} – also representing the direct income effect – is given by the compensation of employees ($comp.empl$) per production unit.¹⁰ The total (in)direct income effect $income.ef$ is the product of the labour input coefficient vector with the Leontief inverse $(I - A)^{-1}$.

The calculated direct and indirect income induced demand effect leads to a higher local production that would not have occurred if the university location did not exist. For this extra production additional labour is necessary, i. e. the indirect employment effect that adds to the labour demand for university personnel. The total direct and indirect employment effect $Empl.Effect$ then is the sum of the number of university employees $uni.personnel$ and the additional labour demand $indir.empl$ calculated by:

⁸The shares in local consumption are taken from Blume and Fromm (1999, p. 422).

⁹The Household Budget Survey information was preferred to the information provided by HIS (*Sozialerhebung des Deutschen Studentenwerks*) as it offered more precise monetary values on the same spatial level. Additionally, the information from the Household Budget Survey was also used for the construction of the RIOT and the estimation of the consumption expenditure of the university personnel. Thus, the further usage of the Household Budget Survey for the students' consumption allowed for an overall consistent data base.

¹⁰Production is estimated using the definition of the Statistical Office for non-market producers, i. e. producers such as the government, non-profit organisations or public universities whose services are not sold, but mainly provided as public goods. Accordingly, production is the sum of expenditures (e. g. compensation of employees, intermediate input, depreciation etc.).

$$Empl.Effect = uni.personnel + indir.empl \quad (9)$$

$$indir.empl = income.ef * (empl.ef - a_l) \quad (10)$$

$$empl.ef = a_l' * (I - A)^{-1} \quad (11)$$

$$a_l = \frac{uni.personnel}{production} \quad (12)$$

The indirect employment effect *indir.ef* is the difference between the total employment effect *empl.ef* (estimated from the Leontief Inverse) and the physical labour input coefficient a_l .¹¹ The physical labour input coefficient – also representing the direct employment effect – is given by the number of university employees per production unit.

2.2 Measuring the supply side contributions

The model used for estimating the supply side effects of university locations is derived from human capital theory and knowledge spillover theory.¹² More precisely, the impact arising from educating students is explained using human capital theory. The contribution of research and knowledge generation is deducted from the theory of knowledge spillovers.

Human capital theory introduced by Schultz (1963) and Becker (1964) and the theory of investment in human capital proposed by Mincer (1974) constitute the positive relationship between education and economic growth or income respectively. It is the basis for the assumption that a highly educated workforce is more productive. Employees with higher education are assumed to adapt easier to new production facilities or find new and more efficient ways of production (e.g. Bartel and Lichtenberg, 1987). They are more likely to invent new products (e.g. Lucas, 1988, Romer, 1990, Barro and Sala-i-Martin, 2004) or to start a business (e.g. Fritsch, 2011) and their wages and salaries are higher (e.g. Krueger and Lindahl, 1999). Taken together, the positive effects of higher education support economic growth.

There are several critiques stating that education alone is not sufficient for the accumulation of human capital and hence the positive impact on economic growth. Additional factors that also play an important role are the family background and the related appreciation of education (Fuller and Clarke, 1994, Wößmann, 2003, Bourdieu, 1979, Kellaghan et al., 1993) as well as the social conditions such as social capital and values and norms (Coleman, 1988, Putnam, 2000).

Nevertheless, a variety of empirical studies confirm the direct positive relationship between human capital, income and economic growth. A summary provided by Psacharopoulos and Patrinos (2004) gives an overview of the empirically measured returns to education that support the existence of a positive relationship between education and income implying that university graduates can expect a higher level of income. In the “The Well-being of Nations” (OECD, 2001) the results of empirical studies measuring the direct effect of education on economic growth is discussed. The main conclusion (OECD, 2001, p. 31 f.) derived from (Nehru et al., 1995) and Temple (2001) is that human capital does

¹¹The employment multiplier can be derived in a similar fashion as the income effect in Equation 6 by dividing *empl.ef* through a_l .

¹²An overview over the characteristics of the variables used in this model for all NUTS-3 regions in Lower-Saxony is given in the appendix in Table 10. The spatial distribution of GDP per capita and patents per capita are visualised in Figure 5 and Figure 6.

have a substantial and positive impact on growth in GDP or income per capita and that especially more recent research give evidence of the positive effects of education.

For the estimation function it is hence assumed that there exist a positive relationship between the number of graduates as a result of the universities' education process and local GDP.

Technological innovation depends on the combination of relevant regional circumstances and conditions such as the organisational networks of innovators, the regional innovation complexes and the regional knowledge infrastructure (Anselin et al., 1997, p. 423). One main factor in the innovation generation process are universities: university research is seen to be important for the development of new knowledges and technologies as well as for the broadening of the knowledge base and its diffusion. Additionally, the educated university graduates apply their acquired knowledge on the job introducing new ideas, concepts and procedures in the companies. Overall, those positive university driven innovation externalities can be interpreted as knowledge spillovers from universities to the private sector. This line of argumentation was first introduced by Nelson (1959) and Arrow (1962).

Many empirical studies have investigated the innovation spillovers arising from universities confirming a positive relationship between the number of universities or university-company-networks and innovations represented by the number of patents (e.g. Anselin et al., 1997, 2000, Criscuolo et al., 2010, Jaffe, 1989, Mansfield, 1991, Varga, 2006).

The influence of universities on innovation is hence estimated in this paper assuming a positive relationship between the number of patents and university related values on research. Those explanatory variables encompass the number of university personnel, the number of students differentiated by area of study, the number of university graduates and the amount of third party funds. A higher number of universities employees is supposed to have a positive impact on innovation as more resources can be dedicated to research. However, during the estimation process a differentiation between scientific and non-scientific personnel proved to be useful with only the non-scientific personnel showing a significant negative effect. The line of argumentation is that university locations with a high number of administrative employees are less involved in research and should hence exhibit less knowledge externalities. The number of students by area of study represent the relative importance of research intensive areas (such as medicine and engineering) in the university location and the probability for local research clusters with high knowledge spillovers. The number of graduates are supposed to serve as indicator for the spillovers arising through knowledge transfer. Third party funds are assumed to display how much effort is placed in conducting additional research projects.

The impact of university locations on GDP and patents is estimated using the R-package `splm` for Spatial Panels (Millo and Piras, 2012). The estimation equation for GDP is:

$$GDP = \lambda(I_T \otimes W_N)GDP + X\beta + (\iota_T \otimes I_N)\mu + (\iota_T \otimes D_N)\alpha_{cl} + \rho(I_T \otimes W_N)v + \epsilon \quad (13)$$

with I_T and I_N being an identity matrix of dimension $T \times T$ and $N \times N$ respectively and ι_T being a vector of ones with dimension $T \times 1$. W_N is the spatial weights matrix with dimension $N \times N$ and λ the spatial autoregressive parameter (spatial lag). X with dimension $NT \times K$ consists of the K explanatory variables, β are the K related coefficients. μ represents the time-invariant individual specific effects ($N \times 1$) and α the cluster-specific fixed effects of cluster $cl = 1, \dots, 4$. The error term consists of a spatial autoregressive

process with the spatial autoregressive parameter (spatial error) ρ and a well behaved error term ϵ .

Accordingly, for the estimation of the patents the following equation is used:

$$\begin{aligned} Patents = & \lambda(I_T \otimes W_N)Patents + X\beta + (\iota_T \otimes I_N)\mu + (\iota_T \otimes D_N)\alpha_d \\ & + \rho(I_T \otimes W_N)v + \epsilon \end{aligned} \quad (14)$$

The explanatory variables in both estimation equations are complemented by control variables consisting of the migration balance of 25 to 30 year-olds, the labour force, the percentage of (self)employed persons in manufacturing sector as well as the percentage of (self)employed in agricultural sector. The first control variable is an indicator for the mobility of young people and the attractiveness of the respective region for the younger labour force. The second control variable labour force represents the sheer magnitude of the local labour market. The percentage of (self)employed persons in manufacturing sector shows the importance of the high technology sector in the region. The last control variable is a measure for rurality.

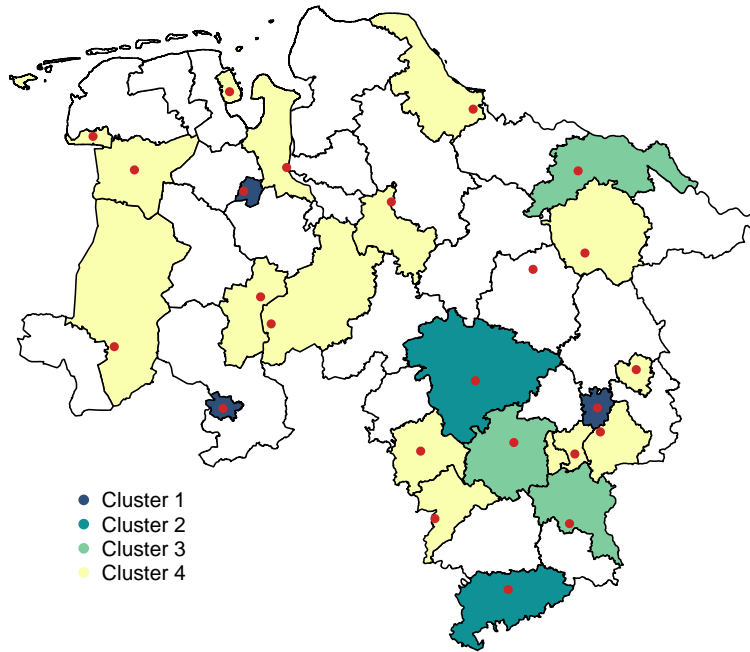
Next to the control variables cluster variables were added as well. They are supposed to show university specific effects that would be normally hidden in the time-invariant individual specific effects.¹³ In order to keep the number of coefficients as low as possible the university locations were grouped to clusters. The clusters are determined using the k-means method. The variables that are relevant for the determination of the clusters are university personnel, university expenditures, university investment, students, university graduates and third party funds.¹⁴

The evaluation values given in Table 10 in the Appendix suggest a differentiation of the university locations in four clusters of the size three, two, three and 15 university locations. An overview over the mean values for each cluster is given in the appendix in Table 11. Figure 1 shows the spatial distribution of the clusters and Table 1 compares Cluster 1, 3 and 4 with Cluster 2. Cluster 2 consists of the two very large university locations Hannover and Göttingen where a lot of traditional and old universities can be found. On average, 15 thousand people are working there for 36 thousand students. 6 thousand students graduate there on average per year. The expenses for personnel and materials add up to 1174 million Euro and investments amount to 71 million Euro. Additionally, those university locations receive third party funds amounting to 174 million Euro. The other clusters can be characterised as follows. Cluster 1 consists of large university locations, that are located in cities (Osnabrück, Oldenburg, Braunschweig). The university locations of Cluster 1 are on average half the size of Cluster 2 university locations with regard to the number of students and fourth the size regarding the university personnel. University locations of Cluster 3 are even smaller reaching only 7% to 25% the size of Cluster 2. These medium-sized locations in Clausthal, Hildesheim and Lüneburg are situated in rather rural areas. Cluster 4 is characterised by very small university locations often cooperating in partnerships to generate economies of scale. They do not even are a tenth the size of Cluster 2 locations.

¹³The time-invariant individual effects drop out when estimating a panel with fixed effects due to the demeaning process.

¹⁴Standardised mean values of the years 2010–2016 were used.

Figure 1: Local distribution of university cluster types



Source: Own calculations. Map: GADM data, Version 2.8.

Table 1: Size of university Clusters 1, 3, and 4 relative to Cluster 2 (in percent)

	Cluster 1	Cluster 3	Cluster 4
University personnel	26.0	10.3	1.8
University expenditures	18.6	6.8	1.1
University investment	37.4	17.1	2.2
Students	50.7	20.5	5.6
University graduates	54.9	24.8	5.6
Third party funds	27.9	11.1	0.6

The spatial weights matrix consists of row-standardised contiguity weights. The definition of neighbours depends on the one hand on the queen method and on the other hand on the existence of a university location. That means, that neighbours are only linked with each other if at least one of the neighbours locate a university. If both neighbouring regions have no university location they are not considered neighbours. The resulting spatial weights matrix consisting of the 46 NUTS-3 regions in Lower Saxony possesses 164 nonzero links implying that 7.75% of the weights are nonzero. The average number of links are 3.57. The regions “Grafschaft Bentheim”, “Stadt Osnabrück”, “Wilhelmshaven” and “Wittmund” are least connected having only one neighbour. The most connected regions are “Hildesheim” and “Region Hannover” being linked with eight other regions.

During the estimation process all variables were excluded that did not show any significance, i. e. that did not add to the explanation of the dependent variable. Spatial Panel estimation was used as the NUTS-3-regions proved to influence each other. The

interrelation could be found in the dependent variable (the spatial lag) as well as in the errors. Thus, for a consistent, unbiased estimation of the parameters and errors the spatial interaction was taken into account. Due to the result of the Spatial Hausman test Fixed Effects were applied.

3 Results

3.1 Results of the demand side contributions

Table 2 shows the direct and indirect demand-side effects for the university locations and Figure 2 visualises their regional distribution.¹⁵ The results for the employment effects are given in Table 3 and Figure 3.

University locations contribute 2275 million Euros to total demand in Lower Saxony or 0.8% to GDP respectively.¹⁶ 1888 million Euros result directly from the local consumption expenditures of the university personnel and the students, 388 million Euros arise indirectly from the income effects. The contribution of each university locations vary a lot ranging from 3 million Euros in Diepholz to 677 million Euros in Hannover. Nevertheless, even locations with comparatively low demand effects can be important for their region if the demand effects make a major contribution to the overall local economic performance. The university location Oldenburg for example lies with a share of 2.14% in local GDP in the top quarter of all university locations. With regard to the absolute value of the total demand effect it only accomplishes a value in the third quarter. The demand-side contribution of the university location is hence more important for its region itself than in comparison to all university contributions. The university locations *Elsfleth (Landkreis Wesermarsch)* and *Holzminden* manage to improve in the quartiles as well when taking the relative value of the contribution and are thus important for their local economy. The spatial distribution in the left map of Figure 2 shows that the university locations in the south-east of Lower-Saxony are more successful in generating large demand effects. On the contrary, the smallest demand effects can be found in the northern part of Lower-Saxony. In relation to the local GDP shown in the right map of Figure 2 the spatial partition seems not to be so clear-cut any more.

The demand-side effects lead to 8270 additional jobs in Lower-Saxony. Adding the university personnel, 60030 employments can be traced back to the existence of university locations. For the employment effects can be found regional disparities as well (see the maps in Figure 3). Large effects can be mainly assigned to the south-east with a maximum of 19900 employments in Hannover. The smallest impacts with less than 200 direct and indirect jobs are generated in the northern parts of Lower-Saxony. Again, even small absolute employment effects can be important for the region when relating the effect to the total local labour market. Osnabrück and Oldenburg e.g. show an already upper-medium size total effect in the third quarter, but with regard to the importance for their local labour market those university locations reach next to Göttingen the highest effects. A high local significance relative to total employment can also be found for Holzminden. On contrary, the locations Hannover and Braunschweig lose in importance when relating

¹⁵More estimation details can be found in Table 7 and Table 8 in the Appendix.

¹⁶The total demand effect is the sum of the local demand contributions of each university location. Due to the underlying assumption regarding the local part of the consumption, consumption expenditures from university personnel or students that were spent in a neighbouring university location are not considered in this summation. Therefore, a contribution calculated on NUTS-2 level might be higher.

the employment effect to total employment as the two regions are prosperous economic areas with huge, well diversified and functioning labour markets.

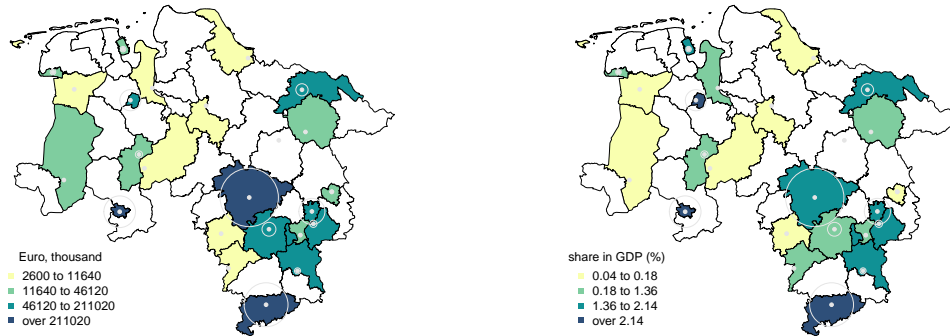
Table 2: Direct and indirect income induced demand effects

	LC.UP	LC.S	LC	IM	TD	S.GDP
Braunschweig	48200	124600	172800	1.20	207500	1.77
Buxtehude	1600	5700	7200	1.16	8400	0.14
Clausthal	18800	30500	49300	1.19	58600	1.52
Diepholz	400	1700	2200	1.17	2600	0.04
Elsfleth	900	3800	4700	1.20	5700	0.18
Emden	5000	26800	31800	1.18	37600	1.06
Göttingen	187100	204900	392000	1.21	473700	4.33
Hameln	1100	3100	4200	1.17	4900	0.10
Hannover	268800	279900	548700	1.23	677100	1.37
Hildesheim	22700	64000	86700	1.18	102000	1.36
Holzminden	1600	7700	9300	1.19	11100	0.51
Leer	700	3100	3700	1.18	4400	0.10
Lingen	4400	14200	18500	1.18	21800	0.17
Lüneburg	19500	57600	77100	1.18	90800	1.88
Oldenburg	33200	97000	130200	1.19	155000	2.14
Osnabrück	32200	147100	179200	1.18	211900	2.66
Ottersberg	500	3100	3500	1.18	4200	0.10
Salzgitter	1800	15600	17400	1.19	20700	0.41
Suderburg	2300	7700	10000	1.19	12000	0.49
Vechta	8800	29200	38000	1.18	44800	0.76
Wilhelmshaven	6400	28400	34800	1.20	41800	1.42
Wolfenbüttel	8200	34900	43100	1.19	51400	2.13
Wolfsburg	1700	21200	22800	1.19	27200	0.12
Lower-Saxony	676000	1211500	1887500	1.21	2275000	0.79

Note: *LC.UP*: Local consumption expenditure spent by university personnel, *LC.S*: Local consumption expenditure spent by students, *LC*: total local consumption expenditure, *IM*: income multiplier, *TD*: total demand induced by direct and indirect income effects, *S.GDP*: share of the total demand effect in GDP. All values are given in thousand Euros rounded to the nearest 100 except for the income multiplier and the percentage share.

Source: LSN (2019), LSN (2015), StABL (2017), VGRdL (2018), own calculations based on a RIOT (Stöver, 2018).

Figure 2: Total demand effect and the share in local GDP (2016)



Source: LSN (2019), own calculations based on a RIOT (Stöver, 2018). Map: GADM data, Version 2.8.

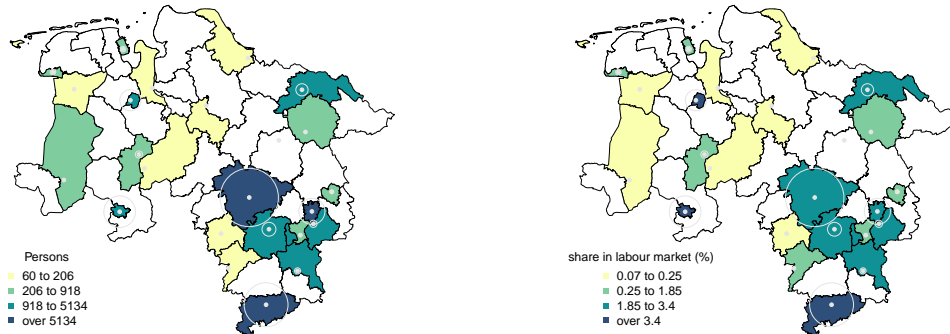
Table 3: Direct and indirect employment effects

	E.UP	E.Ind	TE	EM	S.LM
Braunschweig	4440	750	5190	1.25	3.17
Buxtehude	110	30	140	1.13	0.16
Clausthal	1150	210	1360	1.25	2.21
Diepholz	60	10	60	1.13	0.07
Elsfleth	60	20	80	1.21	0.20
Emden	630	140	770	1.18	1.83
Göttingen	13230	1720	14960	1.26	8.60
Hameln	100	20	120	1.12	0.17
Hannover	17440	2460	19900	1.29	2.96
Hildesheim	2080	370	2450	1.15	1.95
Holz Minden	160	40	200	1.16	0.64
Leer	50	20	70	1.18	0.09
Lingen	380	80	460	1.15	0.25
Lüneburg	1570	330	1900	1.17	2.31
Oldenburg	3400	560	3960	1.18	3.46
Osnabrück	4140	770	4910	1.17	3.88
Ottersberg	100	20	110	1.12	0.18
Salzgitter	200	80	270	1.16	0.47
Suderburg	170	40	210	1.16	0.51
Vechta	740	160	900	1.18	0.97
Wilhelmshaven	520	150	680	1.21	1.51
Wolfenbüttel	800	190	990	1.16	2.65
Wolfsburg	240	100	340	1.16	0.26
Lower-Saxony	51760	8270	60030	1.24	1.44

Note: *E.UP*: university personnel, *E.Ind*: indirect employment induced by income effect, *TE*: total employment induced by direct employment and income effects, *EM*: employment multiplier, *S.LM*: share of the employment effect in the total labour market. All values are given in number of persons rounded to the nearest 10 except for the employment multiplier and the percentage share.

Source: LSN (2019), LSN (2015), VGRdL (2018), own calculations based on a RIOT (Stöver, 2018).

Figure 3: Total employment effect and share in the local labour market (2016)



Source: LSN (2019), own calculations based on a RIOT (Stöver, 2018). Map: GADM data, Version 2.8.

3.2 Results of the supply side contributions

The output of the educational mission of universities is important for the economic development. Educating students has a positive impact on the local GDP: The regression results shown in Table 4 confirm a positive relationship between the number of university graduates and the size of GDP. Under the condition that everything else is unchanged and not considering the second round spillover effects due to the spatial lag GDP per capita will increase by 555018 Euro per capita with a one unit increase in graduates per capita. At first glance this result seems to be very high. However, the mean value of graduates lies at 0.003 persons per capita so that a one unit increase is very unlikely. Converting the values to a more realistic unit an increase in one graduate per 100 inhabitants would result in an increase in GDP of 5550 Euros per capita. There are no significant cluster-specific effects except for Cluster 3, which means that university locations of Cluster 1, 2 or 4 are not different from other regions and cannot notably take advantage from their education output. The significant coefficient of Cluster 3 is even negative meaning that the positive impact of graduates on GDP in those university locations is smaller than in other regions. This implies that the mobility of graduates is very high and that the good job markets do not necessarily coincide with the university location. As Cluster 3 is characterised by rurality job opportunities are likely to be small in this locations. A probably disproportionately high number of graduates hence leave those university locations so that the related regions are not able to internalise the positive educational effects.

Table 4: Regression results for GDP

	Estimate	Std. Error	t-value	Pr(> t)
Lambda (spatial lag)	-0.249	0.063	-3.986	0.000
Rho (spatial error)	0.249	0.086	2.909	0.004
University graduates	555018	208138	2.667	0.008
Net migration (25-30 year-olds)	1197225	466443	2.567	0.010
Share of manufacturing industry in tot. empl.	1367	80	17.135	0.000
Share of agriculture in total employment	-1506	291	-5.175	0.000
University Cluster 1	6049	4766	1.269	0.204
University Cluster 2	4147	3895	1.065	0.287
University Cluster 3	-7236	2842	-2.547	0.011
University Cluster 4	2115	1488	1.422	0.155
R-Squared: 0.69				

For innovation represented by patents a positive relationship with university locations can be detected as well. However, the overall effect and its magnitude depends on the characteristics of the university location and its alignment. The estimation results are given in Table 5. An increase in non-scientific personnel by one person per 100 inhabitants c. p. would reduce the number of patents by 8.8 pieces per 100 inhabitants. This means that a shift in interest away from research has a negative impact on innovation. The offer of scientific subjects and hence the alignment of the university location show opposing effects on the number of patents: While an increase in students in medical sciences lead to a higher number of patents, the relationship between arts and patents is the other way round. Students in medical science are presumably more involved in applied research and hence more likely to cooperate with local companies. The same could be expected from engineering sciences but the regression results do not yield a significant coefficient for this subject group. In contrast, science of arts is not associated with applied research and hence shows a negative relationship. The acquisition of third party funds affects the number of patents positively, albeit at a very low level. One extra Euro per 1000 inhabitant will result in a plus of 0.001 patents per 1000 inhabitants. Additionally, regions with university locations of Cluster 1, 2 or 4 can profit from university research by generating more patents. Here all clusters have a positive influence on patents except of cluster 3 for which no significant positive impact can be detected. Finally, the spatial lag was excluded due to insignificance. The spatial effects did only show in the error term, so that the generation of patents seem to be a more local process.

Table 5: Regression results for patents

	Estimate	Std. Error	t-value	Pr(> t)
Rho (spatial error)	0.1387	0.0672	2.0659	0.0388
Non-scientific personnel	-0.0883	0.0224	-3.9465	0.0001
Students in liberal arts	0.0185	0.0100	1.8603	0.0628
Students in sport science	0.1133	0.0785	1.4440	0.1488
Students in law, econ. and social sc.	-0.0042	0.0033	-1.2643	0.2061
Students in math. and natural sciences	-0.0420	0.0086	-4.9067	0.0000
Students in medical science	0.2286	0.0209	10.9240	0.0000
Students in veterinary science	-0.0549	0.0760	-0.7218	0.4704
Students in agricultural sciences	-0.1015	0.0211	-4.8066	0.0000
Students in engineering sciences	0.0032	0.0040	0.8202	0.4121
Students in arts	-0.0552	0.0194	-2.8451	0.0044
Third party funds	0.0000	0.0000	1.9871	0.0469
Share of manufacturing industry in tot. empl.	0.0000	0.0000	7.6110	0.0000
Share of agriculture in total employment	-0.0000	0.0000	-4.3219	0.0000
University Cluster 1	0.0008	0.0003	2.9071	0.0036
University Cluster 2	0.0008	0.0002	3.2938	0.0010
University Cluster 3	0.0001	0.0001	0.6365	0.5244
University Cluster 4	0.0001	0.0000	2.1785	0.0294

R-Squared: 0.7

4 Conclusion

The estimation results give an impression about the economic importance and the size of the demand- and supply-side effects of university locations in Lower-Saxony: University locations contribute up to 4.3% to their local GDP and represent up to 8.6% of their local labour market. Their existence leads to a total demand of around 2275 million Euros and 60 thousand employments. GDP could increase by 5550 Euros per capita when the university locations succeed in having one graduate per 100 inhabitants more (c. p. and without second round spatial effects). However, the university locations can not internalise this positive effect for their regions, i. e. all regions within Lower Saxony can equally profit from the education supply. An increase in the relative number of students in medical sciences or in the amount of third party funds promote innovation. Additionally, university locations create favourable research conditions for spillovers so that their regions exhibit higher positive innovation effects.

Nevertheless there are some critical remarks to be made. Though the demand-side effects suggests to be exact results, a lot of assumption had to be made during the calculation process, leading to statistical imprecision and uncertainties. Thus, the estimated direct and indirect effects should primarily give an impression about the importance and the contribution of university locations. One critical assumption result from the RIOT based multipliers: Due to data availability it had to be assumed that the input coefficients (of production) for education services are the same for all university locations implying that the indirect employment and income effects are identical for each location. University locations that are more integrated in the economic structure of their region would normally show higher indirect effects. Together with the fact that materials and investment are excluded from the impact assessment the demand-side results can be interpreted as conservative meaning that the positive effects are likely to be even higher.

As with regard to the supply-side effects it has to be noted that social factors such as family and social background are not included in the estimation function. Social factors

are assumed to influence the generation and successful distribution of human capital as well. Lucas (1988, p.19) states that human capital accumulation is a social activity as household members has to pass on their knowledge in order to increase the household's stock of human capital. As a consequence, the positive social effects might be captured by the other regression coefficients so that the impact of the university locations might be overstated.

Taken together the results are important in that they give a complete picture of the importance and significance of the different university locations within Lower-Saxony on a disaggregated spatial level using consistent data sets and methodologies.

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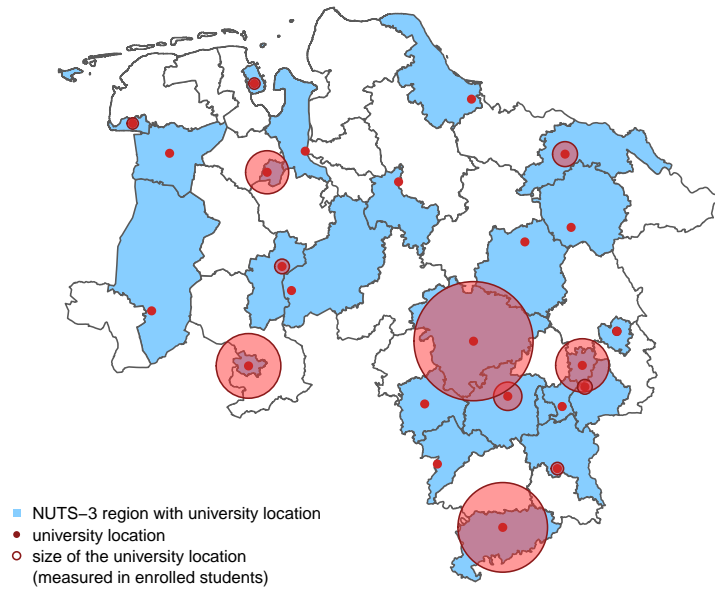
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Appendix

Figure 4: Size and distribution of university locations in Lower Saxony (2016)



Source: LSN (2019), own calculations. Map: GADM data, Version 2.8.

Table 6: University Expenses in personnel, materials and investment (2016) in 1000 Euros or percent

	SEXP	MC	INV	TOT	QSEXP	QMC	QINV
Braunschweig	205400	83700	31600	320700	64.0	26.1	9.9
Buxtehude	4500	900	200	5600	80.2	16.1	3.7
Clausthal	61000	28500	8200	97700	62.4	29.1	8.4
Diepholz	1400	500	100	2100	68.6	24.5	7.0
Elsfleth	2700	1100	100	4000	68.2	28.4	3.4
Emden	24100	10100	3400	37600	64.1	26.8	9.1
Göttingen	660100	375400	43700	1079300	61.2	34.8	4.1
Hamel	3100	700	200	4000	77.4	16.5	6.1
Hannover	881900	646300	86200	1614400	54.6	40.0	5.3
Hildesheim	64300	19600	6300	90200	71.3	21.7	7.0
Holzminde	4900	2000	600	7500	65.2	27.2	7.6
Leer	1900	800	300	2900	64.3	26.6	9.0
Lingen	11600	3700	2000	17300	67.2	21.5	11.3
Lüneburg	57300	16400	23900	97600	58.8	16.8	24.5
Oldenburg	144000	65300	25900	235300	61.2	27.8	11.0
Osnabrück	152100	55100	27900	235200	64.7	23.4	11.9
Ottersberg	1700	500	100	2300	73.4	23.4	3.2
Salzgitter	7300	3300	2100	12800	57.2	26.2	16.7
Suderburg	6300	2900	1900	11100	57.1	26.2	16.7
Vechta	27300	7800	800	35900	76.0	21.8	2.1
Wilhelmshaven	23800	9800	1200	34700	68.4	28.3	3.3
Wolfenbüttel	30100	13700	8800	52600	57.2	26.1	16.7
Wolfsburg	8900	4100	2600	15600	57.1	26.2	16.7

Note: *SEXP*: staff expenditure, *MC*: material costs, *INV*: investment, *TOT*: total expenses in personnel, materials and investment, *QSEXP*: share of staff expenditure in total expenses, *QMC*: share of material costs in total expenses, *QINV*: share of investment in total expenses. Except for the quotas that are given in percent, all values are reported in thousand Euros rounded to the nearest 100.

Source: LSN (2019), own calculations.

Table 7: Local consumption of the university personnel (2016) in 1000 Euros or percent

	SEXP	T&SSC	PT	DINC	APC	C	ICR	LC
Braunschweig	205400	55500	22200	127700	75.4	96300	50.0	48200
Buxtehude	4500	1200	400	2900	75.7	2200	23.4	1600
Clausthal	61000	16700	7200	37200	75.1	27900	28.2	18800
Diepholz	1400	400	100	900	76.0	700	34.5	400
Elsfleth	2700	700	200	1800	76.0	1400	28.4	900
Emden	24100	6200	2100	15800	76.0	12000	60.5	5000
Göttingen	660100	187000	98100	375000	74.4	279000	28.7	187100
Hameln	3100	800	200	2100	76.2	1600	27.6	1100
Hannover	881900	247300	117800	516800	74.5	385200	25.3	268800
Hildesheim	64300	16800	5300	42200	76.2	32200	24.3	22700
Holzminden	4900	1200	200	3400	76.2	2600	33.9	1600
Leer	1900	500	100	1300	75.6	1000	25.1	700
Lingen	11600	2900	600	8100	76.8	6200	25.0	4400
Lüneburg	57300	15100	4500	37700	76.0	28700	27.3	19500
Oldenburg	144000	38700	14900	90500	75.4	68300	51.6	33200
Osnabrück	152100	40200	13700	98200	75.8	74400	58.4	32200
Ottersberg	1700	500	200	1100	75.5	800	41.6	500
Salzgitter	7300	1900	600	4900	75.9	3700	51.9	1800
Suderburg	6300	1600	400	4300	75.6	3200	24.3	2300
Vechta	27300	7200	2400	17800	75.8	13500	30.9	8800
Wilhelmshaven	23800	6300	2300	15200	75.5	11500	42.2	6400
Wolfenbüttel	30100	8000	2700	19400	75.6	14700	42.4	8200
Wolfsburg	8900	2400	900	5700	75.7	4300	64.6	1700

Note: *SEXP*: staff expenditure, *T&SSC*: taxes and social security contributions, *PT*: payroll taxes, *DINC*: disposable income, *APC*: average propensity to consume, *C*: consumption, *ICR*: in-commuting ratio, *LC*: local consumption. All values are given in thousand Euros rounded to the nearest 100 except for the two quotas *ACP* and *ICR* shown in percentage values.

Source: LSN (2019), LSN (2015), StABL (2017), VGRdL (2018), own calculations.

Table 8: Local consumption of the students (2016) in 1000 Euros

	DINC	C	LC
Braunschweig	163300	155700	124600
Buxtehude	7400	7100	5700
Clausthal	40000	38100	30500
Diepholz	2300	2200	1700
Elsfleth	4900	4700	3800
Emden	35200	33500	26800
Göttingen	268600	256100	204900
Hameln	4100	3900	3100
Hannover	366900	349900	279900
Hildesheim	83900	80000	64000
Holzminden	10100	9600	7700
Leer	4000	3800	3100
Lingen	18600	17700	14200
Lüneburg	75500	72000	57600
Oldenburg	127100	121200	97000
Osnabrück	192800	183800	147100
Ottersberg	4000	3800	3100
Salzgitter	20400	19500	15600
Suderburg	10200	9700	7700
Vechta	38300	36500	29200
Wilhelmshaven	37200	35500	28400
Wolfenbüttel	45800	43600	34900
Wolfsburg	27800	26500	21200

Note: *DINC*: disposable income, *C*: consumption, *LC*: local consumption. All values are given in thousand Euros rounded to the nearest 100.

Source: LSN (2019), LSN (2015), VGRdL (2018), own calculations.

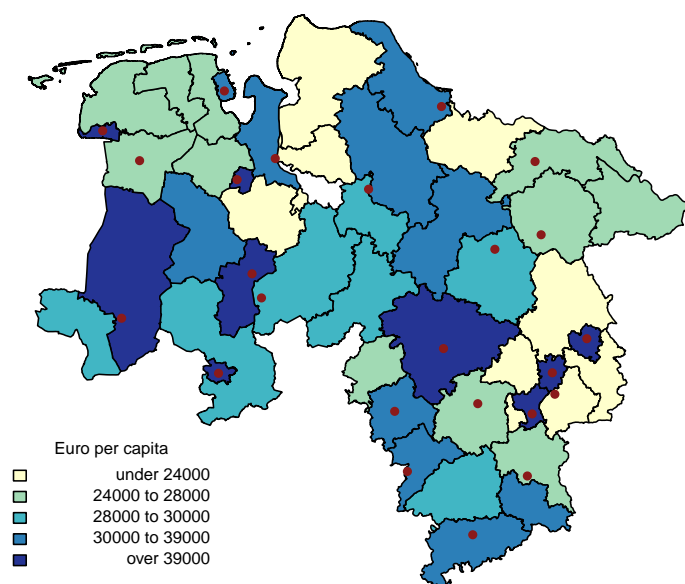
Table 9: Descriptive statistics (2010-2016)

	Mean	SD	Max	Min
GDP (per capita (p.c.))	30881	17653	178706	15760
Patents (p.c.)	0.0002	0.0004	0.0032	0.0000
Students (p.c.)	0.0187	0.0318	0.1553	0.0000
Students in liberal arts (p.c.)	0.0024	0.0059	0.0293	0.0000
Students in sport science (p.c.)	0.0001	0.0004	0.0026	0.0000
Students in law, econ. and social sc. (p.c.)	0.0065	0.0116	0.0597	0.0000
Students in math. and natural sciences (p.c.)	0.0027	0.0058	0.0287	0.0000
Students in medical science (p.c.)	0.0007	0.0022	0.0118	0.0000
Students in veterinary science (p.c.)	0.0000	0.0003	0.0022	0.0000
Students in agricultural sciences (p.c.)	0.0006	0.0027	0.0165	0.0000
Students in engineering sciences (p.c.)	0.0050	0.0092	0.0492	0.0000
Students in arts (p.c.)	0.0006	0.0013	0.0060	0.0000
Students in other fields (p.c.)	0.0000	0.0001	0.0008	0.0000
University personnel (p.c.)	0.0040	0.0081	0.0408	0.0000
University graduates (p.c.)	0.0035	0.0060	0.0293	0.0000
University expenditures (p.c.)	240	527	3184	0
University investment (p.c.)	24	50	279	0
Third party funds (p.c.)	41	95	467	0
Net migration (25-30 year-olds, p.c.)	0.0005	0.0013	0.0052	-0.0040
Workforce (p.c.)	0.6478	0.0164	0.6892	0.6077
Share of manufacturing industry in tot. empl. (%)	16.4457	8.3587	50.9507	4.8927
Share of agriculture in total employment (%)	3.3204	2.3510	9.7019	0.1239

Note: GDP, university expenditures and university investment are given in Euro per capita. All other per capita values are in number of persons or in number of pieces (patents).

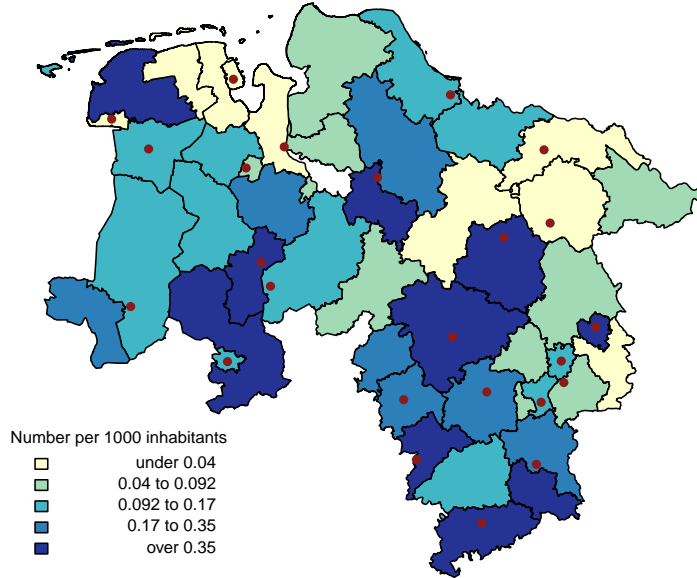
Source: EPO (2019), LSN (2019), StABL (2018), StABL (2019), VGRdL (2018), own calculations.

Figure 5: GDP per capita (2016)



Source: VGRdL (2018), own calculations. Map: GADM data, Version 2.8.

Figure 6: Patents per capita (2016)



Source: EPO (2019), own calculations. Map: GADM data, Version 2.8.

Table 10: Cluster characteristics and evaluation measures

	3 clusters	4 clusters	5 clusters
Within-Cluster Sum of Squares	9.82	6.47	5.71
Between-Cluster Sum of Squares	122.18	125.53	126.29
Total Sum of Squares	132.00	132.00	132.00
RSQ	0.93	0.95	0.96
Dunn index	0.40	0.68	0.49
Average Proportion of Non-overlap	0.01	0.00	0.08
Average distance	0.79	0.52	0.43
Average distance between means	0.24	0.00	0.17
Figure of merit	0.37	0.21	0.19

Table 11: Cluster centers

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
University personnel	3917	15095	1557	268
University expenditures	218646656	1174079247	79754829	12944105
University investment	26628140	71235713	12172160	1541925
Students	18275	36044	7381	2011
University graduates	3470	6324	1568	357
Third party funds	48498069	173894672	19292121	1089410