

Pijnenburg, Katharina

**Working Paper**

## Self-employment and economic performance: A geographically weighted regression approach for European regions

DIW Discussion Papers, No. 1272

**Provided in Cooperation with:**

German Institute for Economic Research (DIW Berlin)

*Suggested Citation:* Pijnenburg, Katharina (2013) : Self-employment and economic performance: A geographically weighted regression approach for European regions, DIW Discussion Papers, No. 1272, Deutsches Institut für Wirtschaftsforschung (DIW), Berlin

This Version is available at:

<https://hdl.handle.net/10419/71120>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

1272

Discussion  
Papers

# Self-Employment and Economic Performance

A Geographically Weighted Regression Approach for  
European Regions

Katharina Pijnenburg

Opinions expressed in this paper are those of the author(s) and do not necessarily reflect views of the institute.

#### IMPRESSUM

© DIW Berlin, 2013

DIW Berlin  
German Institute for Economic Research  
Mohrenstr. 58  
10117 Berlin

Tel. +49 (30) 897 89-0  
Fax +49 (30) 897 89-200  
<http://www.diw.de>

ISSN print edition 1433-0210  
ISSN electronic edition 1619-4535

Papers can be downloaded free of charge from the DIW Berlin website:  
<http://www.diw.de/discussionpapers>

Discussion Papers of DIW Berlin are indexed in RePEc and SSRN:  
<http://ideas.repec.org/s/diw/diwwpp.html>  
<http://www.ssrn.com/link/DIW-Berlin-German-Inst-Econ-Res.html>

# Self-Employment and Economic Performance

## A Geographically Weighted Regression Approach for European Regions

Katharina Pijnenburg\*

February 26, 2013

### Abstract

The self-employment rate includes entrepreneurs out of opportunity and entrepreneurs out of necessity. While the effect of opportunity entrepreneurs on economic development should be positive, there should be no or a negative effect of necessity entrepreneurship. We use a geographically weighted regression (GWR) approach to analyze whether the effect of self-employment on economic development is heterogeneous across European NUTS-2 regions. We find that regions having a significant positive effect of self-employment on economic development in the GWR estimation have, on average, a lower self-employment rate than regions with a significant negative effect. The concept of equilibrium rate of entrepreneurship is applied in an attempt to estimate a level of the self-employment rate from which relatively more entrepreneurs are self-employed out of necessity than out of opportunity. We find that in regions where the self-employment rate is above the equilibrium rate, self-employment has indeed a negative effect, while in regions where it is below the equilibrium rate the effect is positive.

**Keywords:** self-employment, economic performance, geographically weighted regression

**JEL Classification:** C21, L26, R11

---

\*German Institute for Economic Research, Mohrenstraße 58, 10117 Berlin, Germany, Phone: +49 30 89789-589, E-mail: kpijnenburg@diw.de

# 1 Introduction

The literature on entrepreneurship and its effect on economic development is quite scarce for a European regional setting. The main reason is that the only data available at the regional scale is the self-employment rate. Acs and Szerb (2009) argue that the conventional measure of entrepreneurship, i.e. the self-employment rate, is not appropriate. Sanandaji (2010) mentions that self-employment also includes "construction workers, shop owners, taxi and truck drivers, gardeners, plumbers, fast food vendors, hair-dressers" (Sanandaji, 2010, p.1) and so on. Those entrepreneurs are generally not seen as entrepreneurs in the Schumpeterian sense (Schumpeter, 1934), where entrepreneurs are the source of innovative activity. However, the theoretical expected positive effect of entrepreneurship on economic development comes from the innovative nature of entrepreneurship (Audretsch and Keilbach, 2004). Unfortunately, using the self-employment rate means that one is unable to distinguish between necessity and opportunity entrepreneurship. Following Acs and Varga (2005), opportunity entrepreneurs start their own business because they pursue an opportunity, while necessity entrepreneurs start their own business because it is the best, but not the preferred, option available.

In the literature it is argued that the level of the self-employment rate could be used to measure regional entrepreneurship culture (Fritsch and Wyrwich, 2012). Entrepreneurship culture is also known as entrepreneurship capital and was introduced by Audretsch and Keilbach (2004). The authors state that entrepreneurship capital are all factors conducive to the creation of new business. In detail the authors mean by entrepreneurship capital "aspects such as a high endowment with individuals willing to take the risk of starting up a new business. It also implies the existence of a regional milieu that encourages start-up activities such as an innovative milieu, the existence of formal and informal networks, but also the general social acceptance of entrepreneurial activity and the activity of bankers and venture capital agents willing to share risks and benefits involved" (Audretsch and Keilbach, 2004, p. 951). Sorenson and Audia (2000) explain that observing successful entrepreneurs with a similar background may increase an individuals self-confidence and the likelihood to start their own business. Additionally, Fornahl (2003) develops how positive entrepreneurial examples lead to the development of an agent to become an entrepreneur. Thornton et al. (2011) claim that institutional orders may support or discourage entrepreneurial behavior. Moreover, Beugelsdijk (2007) develops that the future entrepreneurs willingness to take risk will result in increased

economic dynamism, innovativeness, and thus economic growth.

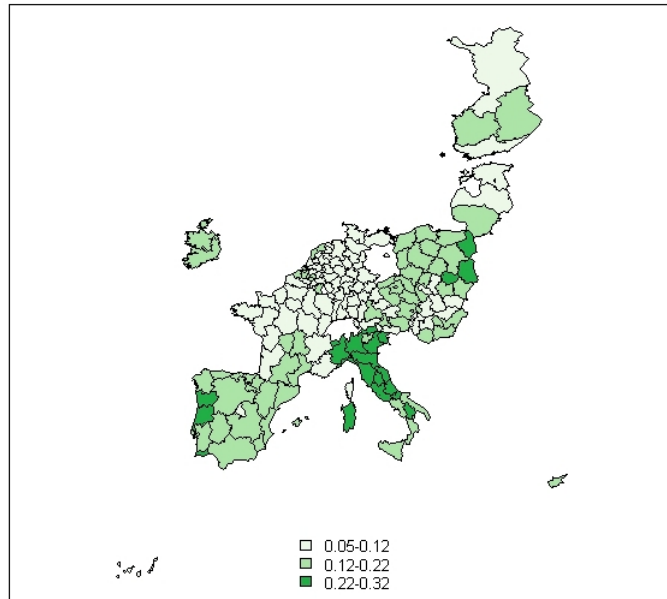
Entrepreneurship culture, defined in this way, should encourage opportunity entrepreneurship and thereby exert a positive effect on economic development. This latent variable should clearly manifest itself in a high self-employment rate.

However, a high self-employment rate could also mirror a lack in wage-employment opportunities (Thurik et al., 2008). This in turn implies that a large part of the self-employed people are necessity entrepreneurs. When there are limited employment possibilities, the opportunity costs of starting a new business decrease. Thurik et al. (2008) state that if opportunity costs decrease, people will start their own business even if they not possess the entrepreneurial talent, the knowledge, and innovative ideas necessary to start and sustain a new firm. Faggio and Silva (2012) find that there is no correlation between self-employment, business creation, and innovation in rural areas of Great Britain, and that this is related to a lack of employment opportunities. These findings suggest that the effect of self-employment on economic development could as well be insignificant. Empirically, even negative effects of self-employment on economic development are found (Blanchflower, 2000; van Stel et al., 2005). van Stel and Storey (2004) argue that a negative effect may appear when subsidized new entrants force established entrepreneurs out of the market and then, after expiration of the subsidization, leave themselves the market because they no longer have a competitive advantage. van Stel et al. (2005) explain that the negative effect may arise from the low human capital of opportunity entrepreneurs, as these entrepreneurs would be more productive as employees in large firms.

In sum, if the self-employment rate mirrors a positive entrepreneurial environment, which attracts innovative opportunity entrepreneurs, the effect on economic development should be positive. If a region is characterized by a lack in wage employment opportunities, the self-employment rate should be dominated by necessity entrepreneurs, and therefore no or a negative effect on economic development should be expected.

In our study we are interested to what extent spatial heterogeneity in the effect of the self-employment rate on economic development is prevalent at the European NUTS-2 (Nomenclature of Territorial Units for Statistics) level. Given the large variation in the self-employment rate across European regions (Figure 1) spatial heterogeneity is likely to occur. If the effect of self-employment on economic output in European NUTS-2 regions depends on the location, the underlying process is called to be spatially non-stationary. To deal with spatial non-stationarity,

Figure 1: Self-employment per working age population, 2004



Note: missing values are blank

Fotheringham et al. (2002) develop the geographically weighted regression (GWR) approach. With this method, a separate regression is estimated for each region. The sample of each regression contains the location of interest and neighboring regions, which are weighted according to their distance from the region of interest (Brunsdon et al., 1996). In this way a separate set of coefficients for each region is obtained and these can be used to visualize the regional varying effect of self-employment on economic development.

In an attempt to find out more about the source of spatial non-stationarity of the effect of self-employment, we subsequently make use of the concept of equilibrium rate of entrepreneurship. In detail, the concept of equilibrium rate of entrepreneurship is applied to estimate a level of the self-employment rate from which point relatively more entrepreneurs are self-employed out of necessity than out of opportunity. Using this concept, we try to find out whether heterogeneity in the effect of self-employment on economic development is indeed due to different relative sizes of necessity and opportunity entrepreneurship in the self-employment rate. The equilibrium rate of entrepreneurship depends on the level of economic development. According to this concept, each level of economic development implies a certain lack of wage employment opportunities that will determine the equilibrium rate of en-

trepreneurship. Thus, if the self-employment rate is above the equilibrium rate there is apparently a bigger lack of wage-employment opportunities than what the level of economic development suggests. This concept of equilibrium rate of entrepreneurship is used, as it is, to our knowledge, the only attempt in the literature to estimate a level of the self-employment rate from which point the rate can be interpreted as being dominated by necessity entrepreneurs. The concept is explained in more detail in section 4. We expect regions having a self-employment rate above the equilibrium rate to exert no or a negative effect on economic development. Furthermore, we expect regions having a self-employment rate below the equilibrium rate to exert a positive effect on economic development, as such a rate should not be dominated by necessity entrepreneurs. Compared to rates above the equilibrium rate, rates below should mirror relatively more entrepreneurial talent and more innovative ideas. For those regions the self-employment rate could be used to measure entrepreneurship culture.

To the best of our knowledge, we are the first applying GWR to visualize the heterogeneous effects of self-employment on economic development on a regional level. Furthermore, this paper is the first one that tries to shed light on the question as to why there is spatial heterogeneity by estimating a level of the self-employment rate from which point the rate can be interpreted as being dominated by necessity entrepreneurship.

Applying GWR, we find a significant positive effect of self-employment on economic development for parts of Austria, Germany, and Italy, as well as for Estonia, Finland, Latvia and the Netherlands. Significant negative effects are found for parts of France, Portugal, and Spain. The GWR results show that in regions where the effect is significantly positive, the self-employment rate is, on average, smaller than in regions where the effect is significant negative.

Using the concept of equilibrium rate of entrepreneurship, we find that in regions where the self-employment rate is below the equilibrium rate it has a positive effect on economic development. In regions where the self-employment rate is above the equilibrium rate, the effect of self-employment on economic development is negative. We see this as evidence, that self-employment rates above the equilibrium rate can indeed be interpreted as being dominated by entrepreneurs out of necessity.

The paper is organized as follows: section two explains in more detail necessity and opportunity entrepreneurship. In section three we describe the model, and the data. Moreover, this section explains the geographically weighted regression theoretically



and provides first empirical results. Section four introduces the concept of equilibrium rate of entrepreneurship and presents the final empirical results. Section five concludes.

## 2 Necessity and Opportunity Entrepreneurship

According to the Eurostat's concept of self-employment, "self-employed persons are defined as persons who are the sole owners, or joint owners, of the unincorporated enterprises in which they work" (European Commission and Eurostat, 1999, p. 38). Thus, the self-employment rate does not allow us to distinguish between necessity and opportunity entrepreneurship. Following the empirical findings by Acs and Varga (2005), necessity entrepreneurship does not result in technological change, while opportunity entrepreneurship does.

Unemployment is often found to result in necessity entrepreneurship. Dejardin and Carree (2011), for example, find that people who decide to start their own business out of unemployment choose industries like shoe stores, flower shops and fast food, which have relatively low entry barriers. Furthermore, Pfeiffer and Reize (2000) find that start-ups out of unemployment have lower survival probability. This is supported by van Stel and Storey (2004), who find that in some areas of Great Britain, which are lacking in enterprises and where policies tried to increase firm formation, the effect on employment is negative. Thus, necessity entrepreneurs cannot be considered as a source of innovative activity.<sup>1</sup>

However, the theoretical expected positive effect of entrepreneurship on economic development comes from the innovative nature of entrepreneurship (Audretsch and Keilbach, 2004): New businesses increase competition and force established firms to be more efficient, innovative and thus more competitive. Moreover, new firms produce variations of existing products and lead thereby to a greater diversity. Product diversity may be stimulating for economic development as it favors follow up innovations. Finally, new firms constitute an important link between knowledge creation and knowledge commercialization. It is not just the creation of knowledge that generates economic output, but rather when knowledge is commercialized. According to the Knowledge Spillover Theory of Entrepreneurship (Acs et al., 2009), a new firm is a vehicle through which knowledge spills over from the source of knowledge production, i.e. an incumbent firm or university, into the economy where it

---

<sup>1</sup>This conclusion is not supported by Caliendo and Kritikos (2010), who find that unemployed persons do not only create their own business out of necessity but because they see an opportunity.

becomes economically relevant knowledge and generates economic output (Braunerhjelms et al., 2010). In a nutshell, Holcombe (2006) states "[Economic] progress occurs because of innovations introduced into the economy, and innovations are the result of entrepreneurship" (Holcombe, 2006, p. 28).

As measures like the self-employment rate cannot make the distinction between necessity and opportunity entrepreneurs, it is not surprising that most studies analyzing the effect of entrepreneurship on economic development find results that are quite heterogeneous across regions. Some studies find a positive relationship between firm birth and local economic performance, like Acs and Armington (2004) for the US, or Fölster (2000) for Swedish counties. Blanchflower (2000) finds a negative effect in OECD countries. Meanwhile, others find a conditional effect: van Stel et al. (2005) detect in their analysis of 36 countries that the effect of entrepreneurial activity on economic growth depends on the level of economic development. The effect is positive in highly developed economies and negative in developing countries. The same is found by Acs et al. (1994). Moreover, Fritsch and Schroeter (2011) find that the effect of new business formation on economic performance in West Germany depends on factors like population density, the amount of innovative activity, or the share of medium-skilled workers. Likewise, Berkowitz and DeJong (2005) find for post-Soviet Russia a positive effect of entrepreneurial activity on economic growth, depending on initial conditions and policy reforms. Finally, Li et al. (2011) find that there are different relationships between business formation and economic development across metropolitan and non-metropolitan counties in the US.

## 3 Geographically Weighted Regression

### 3.1 Description of the model when assuming homogeneous effects across space

We follow Audretsch and Keilbach (2004) and consider a neoclassical production function, which not only includes the standard variables physical capital (K), human capital (H), and labor (L) as explanatory variables but also self-employment (E):

$$Y = F(K, H, E, L). \tag{1}$$

The variables are divided by labor (L) so we work with variables expressed per effective unit of labor and have thereby productivity expressions,  $y$ ,  $k$ ,  $h$ ,  $e$ . We use the Cobb-Douglas specification of the production function for our analysis of the effect of self-employment on economic development:

$$y_{it} = a_i k_{it}^{\alpha_k} h_{it}^{\alpha_h} e_{it}^{\alpha_e}, \quad (2)$$

where  $i = 1, \dots, n$  denotes regions,  $t = 1, \dots, T$  denotes time, and  $a$  represents the state of the technology. Taking logs, the equation we are going to estimate in a first step, without assuming heterogeneous effects across space, is:

$$\ln y_{it} = \ln a_i + \alpha_k \ln k_{it-1} + \alpha_h \ln h_{it-1} + \alpha_e \ln e_{it-1} + \epsilon_i. \quad (3)$$

The dependent variable economic output,  $y$ , is measured by gross value added at basic prices; physical capital,  $k$ , is calculated with the perpetual inventory method using data on gross fixed capital formation.<sup>2</sup> Human capital,  $h$ , is measured by patent applications. Another measure of human capital, namely the share of employees with technical college or university degree, turns out to be insignificant. Self-employment,  $e$ , is included as defined by European Commission and Eurostat (1999). All variables are divided by economically active population. Moreover, population density is included in the estimation of equation 3 as a control variable. All variables are available on a yearly basis. An overview on the variables and sources can be found in Table 2. We estimate an unbalanced panel for 178 regions from 18 European countries for the period 1999-2005. We use the fixed effects estimator to account for region specific effects. Time dummies are included to capture effects that hit all regions at the same time. To account for possible endogeneity problems the explanatory variables are lagged by one period. Given the relative short time span of 7 periods no longer time lags are considered. The regions used in the estimation are plotted in Figure 1.

---

<sup>2</sup>The capital stock  $K_t$  is the sum of gross fixed capital formation in  $t$  and the depreciated capital stock from period  $t - 1$  ( $K_t = I_t + (1 - \delta)K_{t-1}$ ). The initial capital stock for the year 1995 is calculated as:  $K_0 = \frac{1}{T-1} \sum_{t=1}^T \frac{K_t}{Y_t} Y_0$ . We assume a depreciation rate,  $\delta$ , of ten percent.

### 3.2 First empirical results when assuming homogeneous effects

The results of the fixed effects panel estimation can be found in Table 1, column two, '*Baseline*'. Accordingly the self-employment rate has no effect on economic output.<sup>3</sup> Thus, for the European case one could argue that self-employment does not well represent entrepreneurship culture, as the expected positive effect is found to be insignificant. But one should be cautious because it may be the case that this coefficient only represent an average of local coefficients. In the presence of spatial non-stationarity the global coefficient provided by our panel estimation may be misleading locally.

### 3.3 Description of the model when assuming heterogeneous effects across space

To analyze whether our model is spatially non-stationary, geographically weighted regression is applied. Fotheringham et al. (2002) argue that social processes are often non-stationary over space. In this case global values could be misleading locally as they are simply spatial averages. The main reason for spatial non-stationarity mentioned by the authors are intrinsically different relationships across space due to spatial variations in attitudes, preferences, administrative, political, or contextual issues. This holds as well in our application when it comes to economic development (Partridge et al., 2008; Tabellini, 2010). Thus, if the effect of self-employment on economic development varies spatially, assuming a global model will deliver misleading results. GWR is a technique that allows local variations in the coefficients. This means that the estimated coefficients are specific to a region  $i$ . GWR is mainly used for the cross-section. This means that GWR results provide estimates for a specific region at a given moment in time. Geographically weighted panel regressions (GWPR) are in a very early stage of development (Yu, 2011). That is why we have to switch to the cross section to find out more about spatial non-stationarity of the model. In the estimation, we use data for 2005 as it is the largest most recent cross-section available. GWR estimation results for other years than 2005 are similar and will be provided upon request. GWR applied to our model in a cross section takes

---

<sup>3</sup>As all variables are in log form the coefficient of 0.13 for physical capital implies that a ten percent increase in the variable will increase economic output by about one percent.

the following form:

$$y_i = \alpha_{i0} + \alpha_{ik}k_i + \alpha_{ih}h_i + \alpha_{ie}e_i + \epsilon_i, \quad (4)$$

where  $\alpha_{ie}$  is, for example, the coefficient of the self-employment rate in region  $i$ . With these coefficients we can create a map visualizing the locally varying effect of self-employment on economic development.

When using this concept it is assumed that parameters exhibit a certain degree of spatial consistency. That means that the parameter of nearby regions should be similar. This assumption is used in the estimation where different emphases is placed on different observations. In the estimation of the parameters in region  $i$ , only a subset of the full sample, those in regional proximity to region  $i$ , is used. For the next region  $j$ , which is a neighbor to region  $i$ , a similar but not identical subset of the sample is used, and so on. This approach is in contrast to the global model where the estimation is conducted using the full sample.

Two questions arise at this stage of the analysis. First, is it reasonable to assume, for our setting, that parameters of nearby regions should be similar, even across country borders? And second, is the spatial heterogeneity problem solved when accounting for fixed effects in the panel regression? Regarding the first question: The assumption of spatial heterogeneity implies that one intrinsically believes that space and locality matter for the economic development process. Every region has its own cultural history, its own attitudes, or even unique political conditions. This is true within and across borders. Even if every region is unique, there are also commonalities of regions that are physically close to one another. Commonalities are, for example, being member of the same country, speaking the same language, having the same physical locality and the same relevant market. Physical locality means that it makes a difference whether a region is situated in the center of Europe, with well developed infrastructure and low transportation costs, or whether a region is on the periphery (Puga, 2002). It makes a difference whether a region is surrounded by other regions being in the same trade agreement like the European Union, or whether a region is close to the border of the European Union and, thus, partly surrounded by non-member regions. Furthermore, a firm's relevant market with the relevant demand, the relevant labor supply, and relevant knowledge is determined by space in general and not by country or NUTS region. Even if the literature survey by Niebuhr and Stiller (2002) shows that there is a border effect for European countries, which means that firms tend to sell mainly to their local market, this

border effect decreases. The empirical results found by Breinlich (2006) prove that the trade reducing effect of borders and language within European regions decreases with time. Moreover, Puga (2002) finds that the European labor market has a strong geographical component, even after controlling for national and regional characteristics. In addition, Bottazzi and Peri (2003) find knowledge spillovers in Europe even after controlling for country and border effects. Finally, Rodríguez-Pose and Crescenzi (2008) find that knowledge spillovers in European regions are affected by distance decay effects. That implies that regions close to one another may have the same pool of knowledge and, therefore, a similar economic development process. However, as distance increases, the knowledge pool is no longer the same because knowledge spillovers are regionally bounded. As space matters, it is reasonable to assume that regions that are geographically in close distance should have similar coefficients.

Regarding the second question: the reasoning above implies that if we find spatial non-stationarity in the cross-section it should also be present in the panel regression, even if we account for region specific fixed effects. In GWR we assume that the underlying process is, to a large extent, area dependent, where, by area, we mean something larger than a region. And this cannot be captured by the fixed effects. So if we find non-stationarity in the cross-section it should also be present in the panel. In case we find non-stationarity in the cross-section, the results presented in Table 1, column two, '*Baseline*' are misleading. We then try to shed light on the non-stationarity problem using the concept of equilibrium rate of entrepreneurship.

### 3.4 GWR estimation

Two problems arise with GWR. First, if the subset of the full sample is too small, standard errors will be high. Second, if the subsample is too large, coefficients will be biased because they drift across space. This problem is similar to the one we have with the global model. If the process is spatially non-stationary, a regression with a large subsample will result in estimates that are spatial averages. To overcome these problems a weighted calibration is used. Observations in close spatial proximity to region  $i$  have a larger influence in the estimation of the parameters for region  $i$  than those further away. That is why those observations have a larger weight in the sample than observations from regions further away. This weighted calibration will allow a sufficiently large subsample to overcome the problem of large standard errors, and it reduces the drift bias because more influence is attributed to the observations

closer to  $i$ . This implies that the weighting of an observation is not constant but varies with  $i$ . Region  $j$  has a large weight in the estimation of region  $i$  if they are close to each other, and the weight of region  $j$  in the estimation of region  $l$  might be small if the regions are separated by a larger distance. The coefficients for a specific region  $i$  are estimated like this:

$$\hat{\alpha}_i = (X^T W_i X)^{-1} X^T W_i y, \quad (5)$$

where  $W_i$  is the spatial weighting matrix of region  $i = 1, \dots, n$ :

$$W_i = \begin{pmatrix} w_{i1} & 0 & \cdots & 0 \\ 0 & w_{i2} & \cdots & 0 \\ \vdots & \vdots & \cdots & \vdots \\ 0 & 0 & \cdots & w_{in} \end{pmatrix}. \quad (6)$$

The diagonal elements of the individual weight matrix,  $w_{in}$ , determine the strength of the interaction between regions  $i$  and  $n$ .<sup>4</sup> Every single region  $i$  has a different weight matrix. In the next section it is explained how the individual elements of the weight matrix,  $w_{in}$ , are determined.

### 3.4.1 Spatial weighting function

The question at this point is how the observations should be weighted. For this analysis the weighting functions that are most often used in the literature, namely the Gaussian and the bi-square kernel (Shearmur et al., 2007; Breiteneker and Harms, 2010; Müller, 2012) are applied. Using the Gaussian kernel the weighting of data will decrease according to a Gaussian curve as the distance between  $i$  and  $j$ ,  $d_{ij}$ , increases. Up to bandwidth  $b$  the observations have a weight of at least 0.5.

$$w_{ij} = e^{-\frac{1}{2} \left( \frac{d_{ij}}{b} \right)^2} \quad (7)$$

---

<sup>4</sup>GWR is in contrast to simple ordinary least squares,  $\hat{\alpha} = (X^T X)^{-1} X^T y$ , where the diagonal elements of  $W_i$  in equation 5 are equal to one. Furthermore, this is in contrast to weighted least squares,  $\hat{\alpha} = (X^T \Omega^{-1} X)^{-1} X^T \Omega^{-1} y$ , with  $\Omega$  the variance-covariance matrix of the error term:

$$\Omega^{-1} = \begin{pmatrix} \omega_1^{-1} & 0 & \cdots & 0 \\ 0 & \omega_2^{-1} & \cdots & 0 \\ \vdots & \vdots & \cdots & \vdots \\ 0 & 0 & \cdots & \omega_n^{-1} \end{pmatrix}. \quad \text{In weighted least squares the weighting matrix does not}$$

vary with  $i$ . Moreover, the idea behind weighted least squares is to give less weight to observations with a high error variance, and not, as in GWR, to observations which are in larger distance.

The bi-square kernel is a continuous, near-Gaussian weighting function up to bandwidth  $b$ , beyond  $b$  the weights are set to zero.

$$w_{ij} = \left(1 - \left(\frac{d_{ij}^2}{b^2}\right)\right)^2, \text{ if } d_{ij} < b, \text{ else } w_{ij} = 0 \quad (8)$$

Fotheringham (2009) states that the GWR results are relatively insensitive to the choice of the weighting function, but they are not insensitive to the choice of the bandwidth,  $b$ . As the density of regions in our dataset varies we cannot use just one bandwidth. A fixed bandwidth of for example 800 km is too small for the estimation of coefficients in Finland, because there are few regions and, accordingly, few data points in close proximity. The most northern Finish region Manner-Suomi would have only 3 neighbors, and the regions Southern and Eastern Ireland only six. Such a small sample would result in large standard errors. Similarly, this bandwidth is too large for places like Austria, where the density of regions is much higher. The region Tirol would have 129 neighboring regions within a distance of 800 km. Such a large sample could result in serious drift bias. That is why, for our dataset an adaptive kernel is most appropriate. Adaptive kernel means that a fixed proportion of all observation is included in the estimation, for example 20 percent of all regions. Such a kernel is smaller in regions where the density of observations is high (like in Austrian regions) and larger in regions where the density is low (like in Finish regions). While the advantage of an adaptive kernel over a fixed kernel is obvious for regions with a high density of observations, the coefficients of regions with a low density of observations are likely to be drift biased, as they are also influenced by observations of regions which are in large distance.

### 3.4.2 Cross-Validation

The cross-validation (CV) method is used to find the optimal bandwidth. In the adaptive case the optimal bandwidth is not a certain number of kilometers, but a proportion of observations between 0 and 1.<sup>5</sup> CV will allow to create the optimal weighting scheme for our estimation of equation 4:

$$CV = \sum_{i=1}^n [y_i - \hat{y}_{\neq i}(b)]^2, \quad (9)$$

where  $\hat{y}_{\neq i}(b)$  is the fitted value of  $y_i$ , and was estimated without the observation  $i$ . In cross-validation the data is split into two segments. One is used to train the

---

<sup>5</sup>Estimations are conducted in R 2.13.1 with the package spgwr (Bivand and Yu, 2011).



model and the other is used to validate the model. We are interested in the optimal weighting scheme, that means what proportion of the neighboring regions should be used. We start for example with a proportion of 0.3 of the nearest neighbors of region  $i$ . These observations without  $i$  are used to estimate equation 4. The coefficients of the so trained model are validated using observation  $i$ .  $\hat{y}_{\neq i}(b)$  is the result of the validation and is compared to the actual value  $y_i$ . This is done for all regions  $i = 1, \dots, n$ . The sum of the deviations is the CV-score for a bandwidth of 0.3. The procedure is repeated for all bandwidths between 0 and 1. The bandwidth with the lowest CV-score is used in the respective Gauss or bi-square weighting scheme.

For our estimation a proportion of 0.23 should be used with the bi-square kernel weighting function and a proportion of 0.04 should be used with the Gauss weighting function. The large difference can be explained with the construction of the weighting function. The bi-square weighting function only uses the observations up to the proportion of 0.23, observations beyond this bandwidth are set to zero. In the Gauss weighting function all observations are included. The bandwidth of 0.04 defines the observations that have a weight up to 50 percent in the estimation. Observations beyond this point have smaller weights.

### 3.4.3 Tests on spatial heterogeneity

As noted, in the literature it is often found that the effect of entrepreneurial activity on economic performance is heterogeneous across space. In a first step we therefore test whether the parameters in the GWR model vary significantly over space. If that is the case GWR should be preferred over OLS because it is able to explain the underlying relationship significantly better. Leung et al. (2000) propose a test on individual parameter stability over space. Test results for parameter stability of self-employment can be found in Table 3.<sup>6</sup> It appears that in all years the coefficients of self-employment significantly vary over space. The results hold for the Gaussian and the bi-square kernel.<sup>7</sup> As there is significant variation of the parameters across space, GWR can be applied in order to better understand the underlying mechanisms.

---

<sup>6</sup>Details on the test statistic can be found in Leung et al. (2000) on page 22.

<sup>7</sup>Test results for the other explanatory variables reveal that their coefficients also vary across space. However, in this paper we concentrate on solving the spatial non-stationarity problem of the self-employment rate.

#### 3.4.4 Empirical results of the GWR estimation

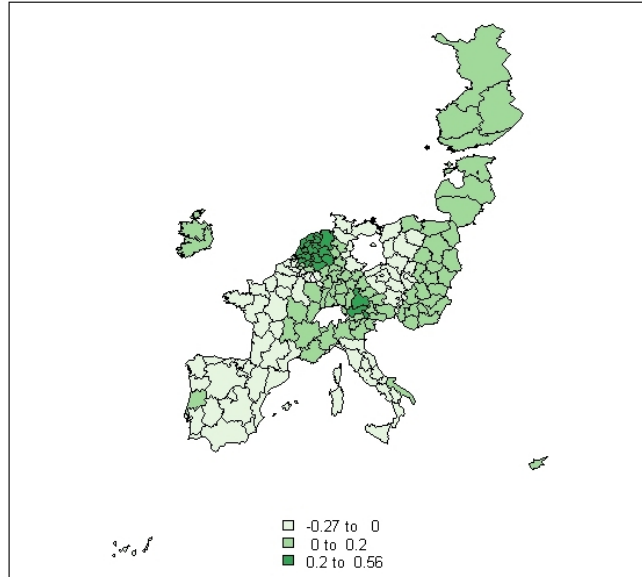
The estimated GWR coefficients of equation 4 for the two different weighting function (Gauss and bi-square) are plotted in Figure 2 and Figure 4, and the corresponding t-values in Figure 3 and Figure 5. Our results confirm Fotheringham (2009), as it appears that the results do not depend much on the choice of the weighting function. The maps show the large spatial heterogeneity of the effect of self-employment on economic performance in European regions. Taking both weighting functions into account, a significant positive effect exists for parts of Austria, Germany, and Italy, as well as for Estonia, Finland, Latvia, and the Netherlands. A significant negative effect is found for parts of France, Portugal, and Spain. In all the other regions there is no significant effect of self-employment on economic development. The GWR results show that the insignificant effect of self-employment on economic output found in the fixed effects estimation may result from the fact that positive and negative effects cancel out.

However, it is not assumed that the underlying process could best be represented using GWR, but GWR is seen as exploratory tool that points to a misspecification of the functional form. If we compare the significant positive and negative GWR coefficients with the self-employment rates, we see that while the average self-employment rate of the full sample is 14 percent, the average self-employment rate of regions having a significant positive GWR coefficient is 12.5 percent, and the average self-employment rate of regions having a significant negative GWR coefficient is 15.9 percent. This gives an initial insight that a comparably high self-employment rate may be dominated by necessity entrepreneurs. In the next step, we try to shed light on the spatial non-stationarity problem of self-employment using this concept of equilibrium rate of entrepreneurship. This concept is applied in an attempt to estimate a level of the self-employment rate from which point relatively more entrepreneurs are self-employed out of necessity than out of opportunity.

## 4 The equilibrium rate of entrepreneurship

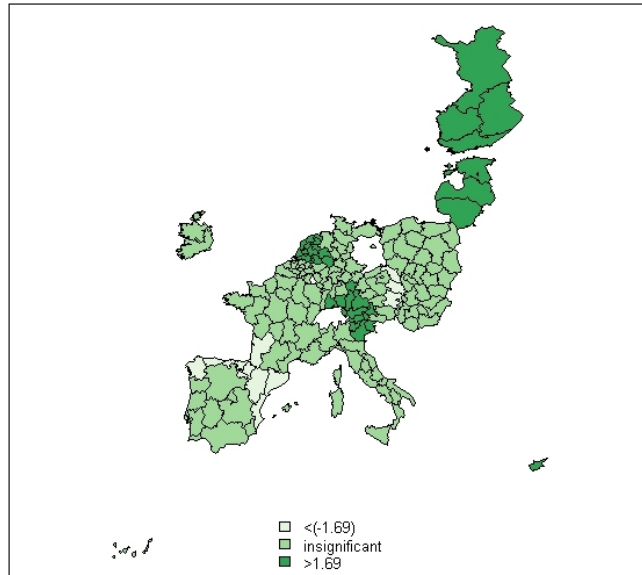
Following Carree et al. (2002), the lack of wage-employment opportunities depends on the stage of economic development, as every stage has different demand conditions. The authors argue that those different demand conditions result in different rates of self-employment. In detail, Carree et al. (2002) and Bosma et al. (2005) distinguish between three stages of economic development. In the first stage per capita income is relatively low and, therefore, demand for goods and services is low as

Figure 2: Plot of GWR parameters of the self-employment rate,  $\alpha_{ie}$ , adaptive Gaussian weighting function



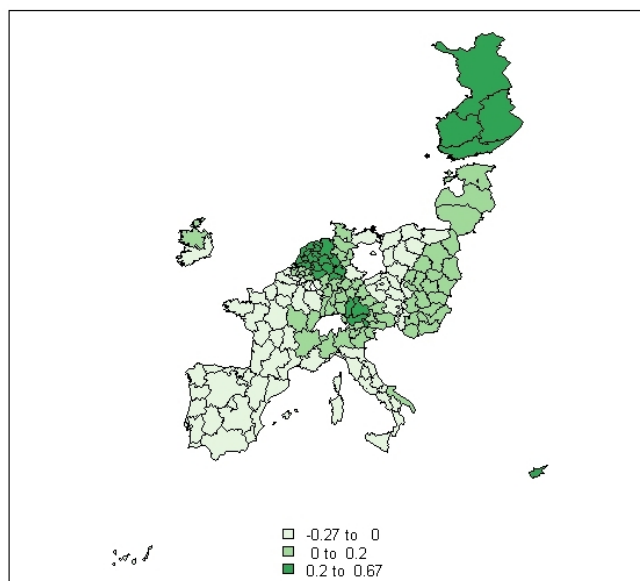
Note: Missing values are blank. Parameters of the self-employment rate vary between -0.27 and 0.56.

Figure 3: Plot of GWR t-values for the parameters of the self-employment rate,  $\alpha_{ie}$ , adaptive Gaussian weighting function



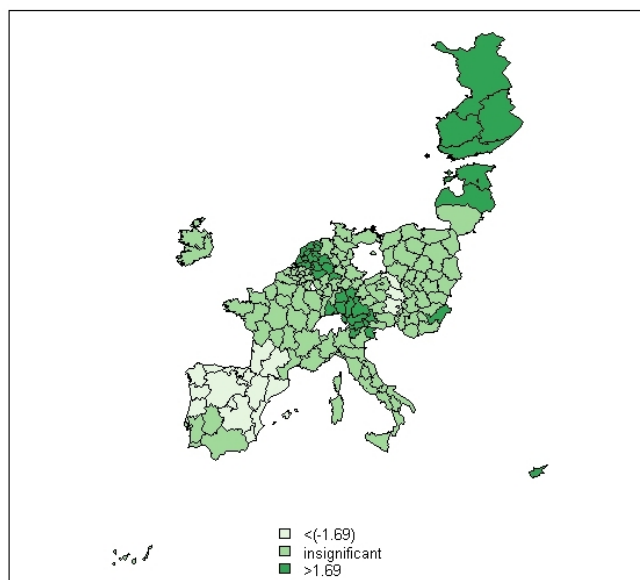
Note: Missing values are blank. The coefficients smaller than zero presented in Figure 2 are significant at a ten percent level in those regions, where the t-statistic is smaller than -1.69. The coefficients larger than zero presented in Figure 2 are significant at a ten percent level in those regions, where the t-statistic is larger than 1.69. The coefficients presented in Figure 2 are insignificant for t-values between -1.69 and +1.69.

Figure 4: Plot of GWR parameters of the self-employment rate,  $\alpha_{ie}$ , adaptive bi-square weighting function



Note: Missing values are blank. Parameters of the self-employment rate vary between -0.27 and 0.67.

Figure 5: Plot of GWR t-values for the parameters of the self-employment rate,  $\alpha_{ie}$ , adaptive bi-square weighting function



Note: Missing values are blank. The coefficients smaller than zero presented in Figure 4 are significant at a ten percent level in those regions, where the t-statistic is smaller than -1.69. The coefficients larger than zero presented in Figure 4 are significant at a ten percent level in those regions, where the t-statistic is larger than 1.69. The coefficients presented in Figure 4 are insignificant for t-values between -1.69 and +1.69.

well. As a consequence large firms do not exist because they could not benefit from economies of scale and scope. A high percentage of the population in economies at this stage of development are self-employed, because many alternatives do not exist. At this stage entrepreneurial activity is negatively related to economic development (Acs et al., 2008). In the second stage per capita income is higher. This allows firms to benefit from economies of scale and scope because now there is increased demand. At this stage there are more opportunities to become an employee. Furthermore, as employees earnings increase Lucas Jr. (1978) states that this "raises the opportunity cost of managing relative to the return" (Lucas Jr., 1978, p. 518). This is why at this stage of economic development there are fewer self-employed individuals. Following Bosma et al. (2005), at a third stage incomes are higher and allow for a realization of individual preferences. That means that there is higher demand for variety and, therefore, more space for entrepreneurial ideas (Verheul et al., 2002). At this stage the rate of self-employment rises and, thus, entrepreneurial activity is again positively related to economic development. These three stages suggest a U-shaped equilibrium rate of entrepreneurship. However, Carree et al. (2007) empirically find for 23 OECD countries that not only is a U-shape consistent with the data but also an L-shape. An L-shape would imply that there is no upswing but a stabilization of the equilibrium rate as the economy develops (Wennekers et al., 2010). Moreover, Wennekers et al. (2010) state that the upswing in the U-shaped relationship is due to an increased number of opportunity entrepreneurs, because of a growing need for independence at higher levels of economic development.

This theory implies that if the self-employment rate is above the equilibrium rate there is apparently a stronger lack of wage-employment opportunities than what the level of economic development suggests. Due to lower opportunity costs more people decide to start their own business even if they do not have the qualifications and capabilities necessary to be a successful entrepreneur. We expect the effect of self-employment on economic development to be insignificant or negative in regions having a self-employment rate above the equilibrium level. The way we estimate the different equilibrium rates is in line with Carree et al. (2002).

## 4.1 The Model

Carree et al. (2002) suggest four different specifications of the equilibrium rate of entrepreneurship,  $E^*$ , two U-shaped and two L-shaped versions:

The quadratic U-shape:

$$E_{i,t}^* = \alpha + \beta YCAP_{it} + \gamma YCAP_{it}^2, \quad (10)$$

the log quadratic U-shape:

$$E_{i,t}^* = \alpha + \beta \ln(YCAP_{it} + 1) + \gamma (\ln(YCAP_{it} + 1))^2, \quad (11)$$

the inverse L-shape:

$$E_{i,t}^* = \alpha - \beta \frac{YCAP_{it}}{YCAP_{it} + 1}, \quad (12)$$

and the log inverse L-shape:

$$E_{i,t}^* = \alpha - \beta \frac{\ln(YCAP_{it} + 1)}{\ln(YCAP_{it} + 1) + 1}. \quad (13)$$

Following the theoretical reasoning mentioned above, in every specification the equilibrium rate of entrepreneurship is a function of per capita income,  $YCAP$ . The two U-shaped functional forms capture the above explained drop and subsequent rise in entrepreneurship as per capita income increases. The two L-shaped functional forms capture the stabilization of the equilibrium rate of entrepreneurship as per capita income increases. To estimate the equilibrium rate of entrepreneurship, the authors use the following equation, which explains changes in entrepreneurship in the following way:<sup>8</sup>

$$\Delta_2 E_{it} = b_1 (E_{i,t-2}^* - E_{i,t-2}) + b_2 (U_{i,t-2} - \bar{U}) + b_3 (LIQ_{i,t-2} - \bar{LIQ}) + \epsilon_{it}. \quad (14)$$

As this concept is applied in an attempt to shed light on the spatial non-stationarity problem of self-employment, the coefficients are estimated in a panel regression and do not vary with  $i$ . Changes in entrepreneurship are explained by deviations of entrepreneurship,  $E$ , from the equilibrium rate,  $E^*$ . If entrepreneurship lies below the equilibrium rate the rate of business ownership is expected to rise. Moreover, if the unemployment rate,  $U$ , is above the average unemployment rate over  $i$  and  $t$ ,  $\bar{U}$ ,

---

<sup>8</sup>Carree et al. (2002) use a different lag specification than we do. In detail they use  $E_{i,t-4}^*$ ,  $E_{i,t-4}$ ,  $U_{i,t-6}$ , and  $LIQ_{i,t-6}$ . They explain that mental preparation for starting a new business needs up to six years. As our time series are not long enough, we cannot use the same lag structure. Moreover, we are not fully convinced, that mental preparation for starting a new business needs that much time.

the rate of business ownership is expected to rise.<sup>9</sup> Finally, the deviation of the labor income share,  $LIQ$ , to the average labor income share of the sample,  $L\bar{I}Q$ , is used as explanatory variable. Labor income share is defined as the share of labor income in national income and tries to capture the earnings differentials between expected profits of entrepreneurs and employees. If this share is relatively high, i.e. labor income is a large part of national income, expected capital and entrepreneurship income are low. In this case it is less likely that a person starts their own business. An overview of the variables and sources can be found in Table 2.

If one of the equations 10 to 13 is substituted in equation 14 we get the following equations:

For the quadratic U-shape:

$$\begin{aligned} \Delta_2 E_{it} = & a_0 - b_1 E_{i,t-2} + b_2 U_{i,t-2} + b_3 LIQ_{i,t-2} + a_4 YCAP_{it-2} \\ & + a_5 (YCAP_{it-2})^2 + \epsilon_{it}, \end{aligned} \quad (15)$$

for the log quadratic U-shape:

$$\begin{aligned} \Delta_2 E_{it} = & a_0 - b_1 E_{i,t-2} + b_2 U_{i,t-2} + b_3 LIQ_{i,t-2} + a_4 \ln(YCAP_{it-2} + 1) \\ & + a_5 (\ln(YCAP_{it-2} + 1))^2 + \epsilon_{it}, \end{aligned} \quad (16)$$

for the inverse L-shape:

$$\Delta_2 E_{it} = a_0 - b_1 E_{i,t-2} + b_2 U_{i,t-2} + b_3 LIQ_{i,t-2} + a_4 \frac{YCAP_{it-2}}{YCAP_{it-2} + 1} + \epsilon_{it}, \quad (17)$$

and for the log inverse L-shape:

$$\begin{aligned} \Delta_2 E_{it} = & a_0 - b_1 E_{i,t-2} + b_2 U_{i,t-2} + b_3 LIQ_{i,t-2} \\ & + a_4 \frac{\ln(YCAP_{it-2} + 1)}{\ln(YCAP_{it-2} + 1) + 1} + \epsilon_{it}. \end{aligned} \quad (18)$$

---

<sup>9</sup>However, the OECD (2000) finds that "only a very small proportion of unemployed people find employment through self-employment" (OECD, 2000, p. 157).

We can use the estimated coefficients,  $a_0, b_1, b_2, b_3$ , and  $a_4$ , to calculate  $\alpha, \beta$  and,  $\gamma$  from equations 10, 11, 12, and 13:

$$\hat{\alpha} = \frac{a_0 + b_2\bar{U} + b_3L\bar{I}Q}{b_1}, \quad \hat{\beta} = \frac{a_4}{b_1}, \quad \text{and} \quad \hat{\gamma} = \frac{a_5}{b_1}.$$

These coefficients are then used to calculate the equilibrium rate of entrepreneurship according to equations 10, 11, 12, and 13.

## 4.2 The estimated equilibrium rates of entrepreneurship

The estimated equilibrium rates of entrepreneurship are plotted in Figure 7. In the same figure the actual self-employment rate in the year 2004 is plotted. It can be seen that there are regions that are quite close to the different equilibrium rates and other regions that are apart. Furthermore, it appears that the four rates are not very different from one another. Our estimated equilibrium rates are similar to the equilibrium rate estimated by Carree et al. (2002). In the estimation we want to work with percentage deviations from those equilibrium rates, as Carree et al. (2007) do. The correlation coefficients between the deviations from the equilibrium rates are close to one. Apparently we are not in the presence of a model selection problem, the percentage deviations of the different equilibrium rates are basically the same. Between a per capita income of 10,000 and 30,000, the four lines are almost the same and the overall average equilibrium self-employment rate is 12.1 percent. When calculating the percentage deviation from this constant rate and comparing it to the percentage deviations from the different equilibrium rates, we, again, get a correlation coefficient that is close to one. Apparently, when working with European regions it is not necessary to estimate a U- or L-shaped equilibrium rate. A constant rate of about 12 percent will provide the same results. For most levels of per capita income the estimated equilibrium rate by Carree et al. (2002) is also 12 percent.

There are two possible explanations for this result. First, one could argue that the present data only mirrors the second stage of economic development, namely the stage where economic development is that high that demand for goods and services allows big enterprises to exist because they can profit from economies of scale and scope. However, in our example gross value added per capita varies between 1,260



and 54,680 Euro. This window is larger than that used in the estimation of the first application of the equilibrium rate of entrepreneurship by Carree et al. (2002) and should therefore capture the downswing of the U- or L-shaped equilibrium rate.

Thus, it may be the case that the theory of a U-, or L-shaped equilibrium rate of entrepreneurship is not appropriate for a regional setting.

When we look at the regional level it is not the case that demand of one region is necessarily met by supply of this same region. That means that demand is met by supply that has its origin in different regions from the same or other countries.<sup>10</sup>

The concept of equilibrium rate of entrepreneurship states that a low level of economic development implies low demand for goods and services and therefore no opportunities for firms to profit from economies of scale and scope. Accordingly self-employment should be high for low levels of economic development. But if a firm decides to locate where wages are comparably low, i.e. in regions with a low per capita income, and serve markets in other regions where demand and per capita income is high, the theory would no longer hold. Self-employment would be low in these regions because there are more opportunities to be wage employed. This should especially be true within a country but also between countries in the European Union. This may be the reason why the U-, or L-shaped equilibrium rate is neither appropriate for our setting nor, possibly, for other regional settings. However, it may still work for countries where most demand is met nationally.

This reasoning may also explain a constant equilibrium rate of entrepreneurship. If demand can be met by supply from different regions, there is no longer an adaption of the regional self-employment rate to changing regional demand.

### 4.3 Results using the equilibrium rate of entrepreneurship

As explained, the U-, or L-shaped equilibrium rates of entrepreneurship are not appropriate for our dataset. That is why we replace the spatial non-stationary self-employment rate with the percentage deviations of self-employment from the constant equilibrium rate. Following Carree et al. (2007) we include positive and negative percentage deviations in absolute terms separately in the fixed effects panel estimation of equation 2. Results can be found in Table 1 in the third column, '*Deviations from equilibrium rate*'. Both positive and negative deviations from the equilibrium rate have a negative sign, which is not significant. That implies that a region having a self-employment rate much above the equilibrium rate does not perform significantly worse than a region having a self-employment rate only a little

---

<sup>10</sup>As mentioned above, there is a positive but decreasing border effect for European regions.

Table 1: Panel estimation

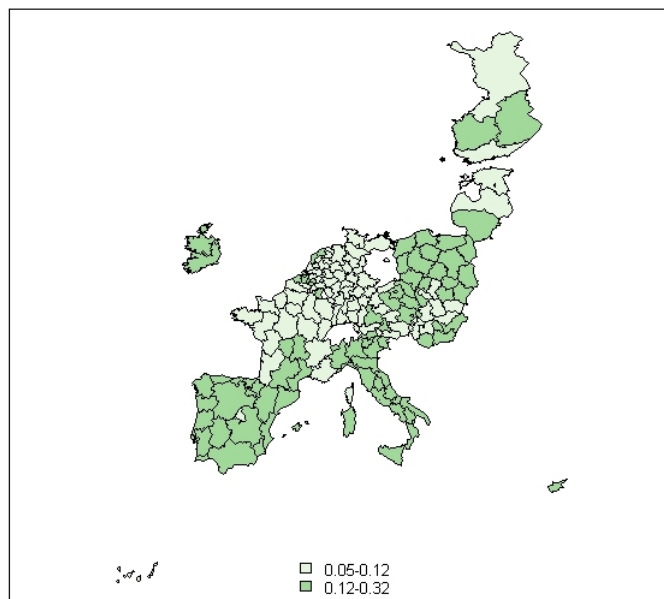
Dependent variable: economic output, $y$				
Variable	'Baseline'	'Deviations from equilibrium rate'	'Sample if rate >12%'	'Sample if rate <12%'
Physical capital $_{t-1}$	0.13*** (0.02)	0.13*** (0.02)	0.25*** (0.05)	0.08*** (0.03)
Human capital $_{t-1}$	0.01** (0.006)	0.01** (0.006)	0.00 (0.005)	0.07*** (0.02)
Self-employment $_{t-1}$	0.04 (0.03)		-0.07** (0.04)	0.08* (0.05)
Positive percentage deviation from equilibrium rate $_{t-1}$		-0.01 (0.03)		
Negative percentage deviation from equilibrium rate $_{t-1}$		-0.05 (0.06)		
Density	-1.10*** (0.18)	-1.11*** (0.18)	-1.16*** (0.18)	-0.67** (0.31)
$R^2$	0.53	0.53	0.71	0.41
Observations	967	967	521	446
Number of groups	178	178	109	103

Notes: Fixed effects estimation of an unbalanced panel with time dummies; annual data for the period 1999-2005; \*\*\*, \*\*, \* statistically significant at one, five, and ten percent, respectively; standard errors in parentheses. Density is included in the estimation of equation 3 as a control variable. To account for possible endogeneity problems the explanatory variables are lagged by one period.

above the equilibrium rate. The same is true for negative deviations. Apparently the gap between actual and equilibrium rate of self-employment is not decisive. The insignificant effect of positive percentage deviations from the equilibrium rate is also found by Carree et al. (2007). However, in their analysis of OECD-countries negative percentage deviations from the equilibrium rate have a significant negative effect.

As we interpret the constant equilibrium rate as the level of the self-employment rate from which point relatively more entrepreneurs are self-employed out of necessity than out of opportunity, in a next step we split the sample into regions having a self-employment rate above the equilibrium rate and into regions having a rate below the equilibrium rate (Table 1, column four, '*Sample if rate >12%*', and five, '*Sample if rate <12%*'). In Figure 6 it is plotted which regions have a self-employment rate below or above the constant equilibrium rate in 2004. In the sample where the self-

Figure 6: Self-employment rates above and below the constant equilibrium rate of 12 percent in 2004



Note: missing values are blank

employment rate is below the equilibrium rate, an increase in the self-employment rate has a significant positive effect on economic output. In the sample, where the self-employment rate is above the equilibrium rate, the self-employment rate has a significant negative effect on economic output. This confirms our initial guess, namely that the insignificant coefficient of 0.04 of self-employment in the baseline

estimation (Table 1, column two, '*Baseline*') is just a global average. Furthermore, we see these results as evidence, that self-employment rates above the equilibrium rate can indeed be interpreted as being dominated by entrepreneurs out of necessity. In regions where the self-employment rate is just high because opportunity cost of starting a new business are low, the so created entrepreneurs are apparently not the ones that, according to Beugelsdijk (2007), increase economic dynamism, innovativeness and, ultimately, economic output.

To find out, whether this approach really solves the spatial non-stationarity problem of self-employment, we should perform the individual parameter stationarity test for the two subsamples. However, given that the number of regions in the two subsamples is comparably small for GWR, and given that the regions in the subsamples are no longer continuous in space, reasonable results of such a test cannot be expected. Thus, we cannot directly answer the question, whether the application of the concept of equilibrium rate of entrepreneurship solves the spatial non-stationarity problem of the self-employment rate. Moreover, we mentioned that the individual parameter stability test for the other explanatory variables pointed as well to a spatial non-stationarity problem. The estimation results for the two subsamples confirm the test result. The parameters of human capital (0.00 and 0.07) and physical capital (0.25 and 0.08) in the two subsamples are quite different from the coefficients estimated with the entire sample (0.01 for human capital, and 0.13 for physical capital). Thus, the results presented in Table 1, column four, and five, are likely to still suffer from misspecification.

However, the GWR results, together with the results of the two subsamples, shed further light on the debate as to why heterogeneous effects of self-employment on economic development are observed. Heterogeneous effects of self-employment on economic development are due to the fact that the self-employment rate does not make the distinction between opportunity and necessity entrepreneurs. The concept of equilibrium rate of entrepreneurship appears to be a suitable tool to estimate a level of the self-employment rate from which point the rate is dominated by necessity entrepreneurs.

## 5 Conclusion

The only available and comparable data on entrepreneurship at the European NUTS-2 level is the self-employment rate. However, the self-employment rate includes entrepreneurs out of opportunity and entrepreneurs out of necessity. While the effect of opportunity entrepreneurs on economic development should be positive, there should be no or a negative effect of necessity entrepreneurship. As the self-employment rate cannot distinguish between necessity and opportunity entrepreneurs it is not surprising that most studies analyzing the effect of entrepreneurship on economic development find results that are quite heterogeneous across regions.

We use a geographically weighted regression approach to find out whether the effect of self-employment on economic development is heterogeneous across European regions. We find a significant positive effect of self-employment on economic development for parts of Austria, Germany, and Italy, as well as for Finland, Estonia, Latvia, and the Netherlands. Significant negative effects are found for parts of France, Portugal, and Spain. The GWR results show that in regions where the effect is significant positive the self-employment rate is on average smaller than in regions where the effect is significant negative.

The concept of equilibrium rate of entrepreneurship is applied in an attempt to estimate a level of the self-employment rate from which point relatively more entrepreneurs are self-employed out of necessity than out of opportunity. Necessity entrepreneurs are considered not having the qualifications and capabilities necessary to be a successful and innovative entrepreneur and, thus, are not expected to exert a positive effect on economic development.

We find that in regions where the self-employment rate is below the equilibrium rate, self-employment has a positive effect on economic development. In those regions the self-employment rate can be used to measure entrepreneurship culture. In regions where the self-employment rate is above the equilibrium rate the effect on economic development is negative. We see this as evidence, that self-employment rates above the equilibrium rate can indeed be interpreted as being dominated by entrepreneurs out of necessity.

Even if we cannot say, whether the application of the concept of equilibrium rate of entrepreneurship solves the spatial non-stationarity problem, as we cannot test for it, our results shed further light to the question as to why we observe spatial heterogeneity.

The results imply that entrepreneurial research at the European regional level requires a cautious approach when using the self-employment rate. At this level the

effect of the self-employment rate on economic development is insignificant, but only because positive and negative effects cancel out.

## Appendix

Figure 7: Plot of the estimated equilibrium rates of entrepreneurship and the actual rate of self-employment for the year 2004

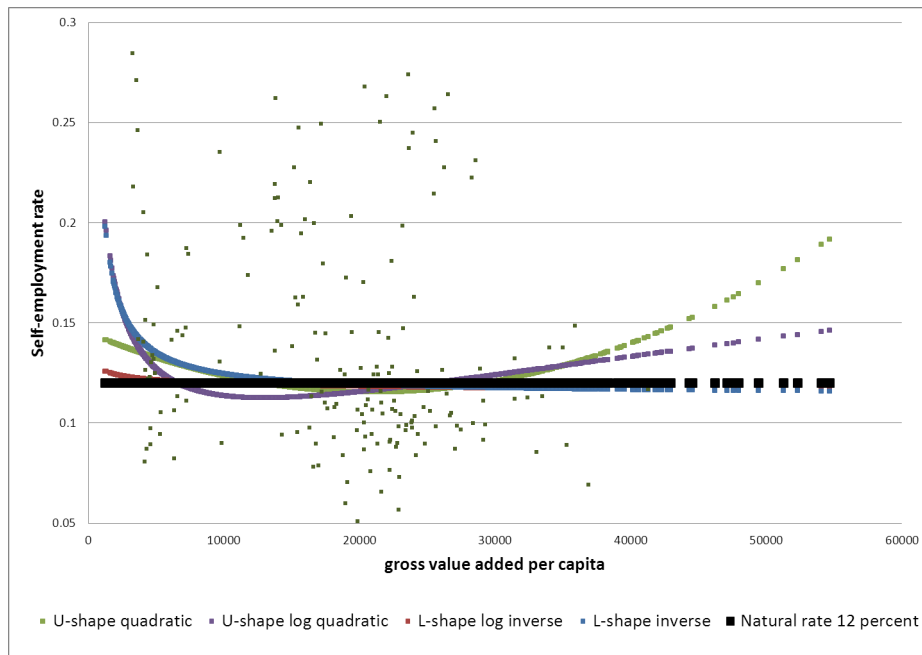


Table 2: Data description

Variable	Description	Year	Source
Baseline Model			
Output	Gross value added at basic prices	1999-2005	Eurostat
Physical capital	Gross fixed capital formation, Perpetual inventory method, $\delta = 10\%$	1995-2005	Eurostat
Human capital	Patent applications at EPO	1999-2005	Eurostat
Self-employment	Self-employment rate	1999-2005	Eurostat
Equilibrium Analysis			
Per capita income	Gross value added at basic prices per capita; due to data availability issues we do not follow Carree et al. (2002) who use gross domestic product per capita. This guarantees a larger dimension in time and space.	1995-2008	Eurostat
Entrepreneurship	Self-employment rate	1999-2010	Eurostat
Unemployment	Unemployment rate	1999-2010	Eurostat
Labor income share	Calculated using total compensation of employees, total employment, number of employees and gross domestic product per capita	1999-2008, for some regions shorter time period	Eurostat

Table 3: Individual Parameter Stationarity Test for self-employment

Year	GAUSS				BI-SQUARE			
	F-stat	df1	df2	p-value	F-stat	df1	df2	p-value
2005	1.98	37.26	139.21	0.00***	3.13	57.30	133.74	0.00***
2004	2.00	43.05	125.68	0.00***	6.02	56.11	142.21	0.00***
2003	1.88	51.37	119.67	0.00***	3.94	66.05	117.86	0.00***
2002	6.02	37.93	134.88	0.00***	7.16	51.87	114.27	0.00***
2001	1.59	17.97	109.51	0.00***	4.69	56.85	114.41	0.00***
2000	7.66	43.28	136.24	0.00***	6.49	52.49	126.91	0.00***

Note: \*\*\* statistically significant at one percent. F-stat is always statistically significant, in all years individual parameters of self-employment are spatially non-stationary.

## References

- Acs, Z., Armington, C., 2004. Employment Growth and Entrepreneurial Activity in Cities. *Regional Studies* 38 (8), 911–927.
- Acs, Z., Audretsch, D., Evans, D., 1994. Why Does the Self-Employment Rate Vary Across Countries and Over Time? CEPR Discussion Paper 871, Centre for Economic Policy Research.
- Acs, Z., Braunerhjelm, P., Audretsch, D., Carlsson, B., 2009. The Knowledge Spillover Theory of Entrepreneurship. *Small Business Economics* 32 (1), 15–30.
- Acs, Z., Desai, S., Hessels, J., 2008. Entrepreneurship, economic development and institutions. *Small Business Economics* 31 (3), 219–234.
- Acs, Z., Szerb, L., 2009. The Global Entrepreneurship Index (GEINDEX). *Foundations and Trends in Entrepreneurship* 5 (5), 341–435.
- Acs, Z., Varga, A., 2005. Entrepreneurship, Agglomeration and Technological Change. *Small Business Economics* 24 (3), pp. 323–334.
- Audretsch, D., Keilbach, M., 2004. Entrepreneurship Capital and Economic Performance. *Regional Studies* 38 (8), 949–959.
- Berkowitz, D., DeJong, D. N., 2005. Entrepreneurship and Post-socialist Growth. *Oxford Bulletin of Economics and Statistics* 67 (1), 25–46.
- Beugelsdijk, S., 2007. Entrepreneurial culture, regional innovativeness and economic growth. *Journal of Evolutionary Economics* 17 (2), 187–210.
- Bivand, R., Yu, D., 2011. Package 'spgwr' Geographically weighted regression (Version 0.6-13).
- Blanchflower, D. G., 2000. Self-employment in OECD countries. *Labour Economics* 7 (5), 471 – 505.
- Bosma, N., Wit, G., Carree, M., 2005. Modelling Entrepreneurship: Unifying The Equilibrium and Entry/Exit Approach. *Small Business Economics* 25 (1), 35–48.
- Bottazzi, L., Peri, G., 2003. Innovation and spillovers in regions: Evidence from European patent data. *European Economic Review* 47 (4), 687 – 710.



- Braunerhjelm, P., Acs, Z., Audretsch, D., Carlsson, B., 2010. The missing link: knowledge diffusion and entrepreneurship in endogenous growth. *Small Business Economics* 34 (2), 105–125.
- Breinlich, H., 2006. The spatial income structure in the European Union - what role for Economic Geography? *Journal of Economic Geography* 6 (5), 593–617.
- Breitenecker, R. J., Harms, R., 2010. Dealing With Spatial Heterogeneity in Entrepreneurship Research. *Organizational Research Methods* 13 (1), 176–191.
- Brunsdon, C., Fotheringham, A. S., Charlton, M. E., 1996. Geographically Weighted Regression: A Method for Exploring Spatial Nonstationarity. *Geographical Analysis* 28 (4), 281–298.
- Caliendo, M., Kritikos, A. S., 2010. Start-ups by the unemployed: characteristics, survival and direct employment effects. *Small Business Economics* 35 (1), 71–92.
- Carree, M., van Stel, A., Thurik, R., Wennekers, S., 2002. Economic Development and Business Ownership: An Analysis Using Data of 23 OECD Countries in the Period 1976-1996. *Small Business Economics* 19 (2), 271–290.
- Carree, M., van Stel, A., Thurik, R., Wennekers, S., 2007. The relationship between economic development and business ownership revisited. *Entrepreneurship & Regional Development: An International Journal* 19 (3), 281–291.
- Dejardin, M., Carree, M., 2011. Firm Entry and Exit in Local Markets: Market Pull and Unemployment Push. Working Papers 1114, University of Namur, Department of Economics.
- European Commission and Eurostat, 1999. Handbook on quarterly national accounts, Theme 2, Economy and finance; Methods and nomenclatures. Luxembourg : Office for Official Publications of the European Communities.
- Faggio, G., Silva, O., 2012. Does Self-Employment Measure Entrepreneurship? Evidence from Great Britain. SERC Discussion Papers 0109, Spatial Economics Research Centre, LSE.
- Fölster, S., 2000. Do Entrepreneurs Create Jobs? *Small Business Economics* 14 (2), 137–148.
- Fornahl, D., 2003. Entrepreneurial Activities in a Regional Context. In: Fornahl, D., Brenner, T. (Eds.), *Cooperation, Networks, and Institutions in Regional Innovations Systems*. Edward Elgar, Cheltenham, pp. 38–57.

- Fotheringham, A. S., 2009. Geographically Weighted Regression. In: Fotheringham, A. S., Rogerson, P. (Eds.), *The Sage Handbook of Spatial Analysis*. SAGE Publications Ltd.
- Fotheringham, A. S., Brunson, C., Charlton, M. E., 2002. *Geographically weighted regression: the analysis of spatially varying relationships*. Wiley.
- Fritsch, M., Schroeter, A., 2011. Why does the effect of new business formation differ across regions? *Small Business Economics* 36 (4), 383–400.
- Fritsch, M., Wyrwich, M., 2012. The Long Persistence of Regional Entrepreneurship Culture - Germany 1925-2005. DIW Discussion Papers 1224, DIW Berlin.
- Holcombe, R., 2006. *Entrepreneurship And Economic Progress. Foundations of the Market Economy Series*. Routledge.
- Leung, Y., Mei, C.-L., Zhang, W.-X., 2000. Statistical tests for spatial nonstationarity based on the geographically weighted regression model. *Environment and Planning A* 32 (1), 9–32.
- Li, H., Cheng, S., Haynes, K. E., 2011. The Employment Effects of New Business Formation: A Regional Perspective. *Economic Development Quarterly* 25 (3), 282–292.
- Lucas Jr., R. E., 1978. On the Size Distribution of Business Firms. *The Bell Journal of Economics* 9 (2), 508–523.
- Müller, S., 2012. Identifying spatial nonstationarity in German regional firm start-up data. *Jahrbuch für Regionalwissenschaft* 32 (2), 113–132.
- Niebuhr, A., Stiller, S., 2002. *Integration Effects in Border Regions - A Survey of Economic Theory and Empirical Studies*. HWWA Discussion Paper 179, Hamburg Institute of International Economics.
- OECD, 2000. The Partial Renaissance of the Self-Employed. In: *OECD Employment Outlook*. OECD, Paris, Ch. 5, pp. 155–199.
- Partridge, M. D., Rickman, D. S., Ali, K., Olfert, M. R., 2008. The Geographic Diversity of U.S. Nonmetropolitan Growth Dynamics: A Geographically Weighted Regression Approach. *Land Economics* 84 (2), 241–266.
- Pfeiffer, F., Reize, F., 2000. Business start-ups by the unemployed - an econometric analysis based on firm data. *Labour Economics* 7 (5), 629 – 663.

- Puga, D., 2002. European regional policies in light of recent location theories. *Journal of Economic Geography* 2 (4), 373–406.
- Rodríguez-Pose, A., Crescenzi, R., 2008. Research and Development, Spillovers, Innovation Systems, and the Genesis of Regional Growth in Europe. *Regional Studies* 42 (1), 51–67.
- Sanandaji, T., 2010. Self-Employment Does Not Measure Entrepreneurship, job market paper, University of Chicago, The Institute For Industrial Economics.
- Schumpeter, J. A., 1934. *The Theory of Economic Development: An Inquiry Into Profits, Capital, Credit, Interest, and the Business Cycle*. Transaction Publishers, New Brunswick, London.
- Shearmur, R., Apparicio, P., Lizion, P., Polèse, M., 2007. Space, Time, and Local Employment Growth: An Application of Spatial Regression Analysis. *Growth and Change* 38 (4), 696–722.
- Sorenson, O., Audia, P. G., 2000. The Social Structure of Entrepreneurial Activity: Geographic Concentration of Footwear Production in the United States, 1940–1989. *American Journal of Sociology* 106 (2), 424–462.
- Tabellini, G., 2010. Culture and Institutions: Economic Development in the Regions of Europe. *Journal of the European Economic Association* 8 (4), 677–716.
- Thornton, P. H., Ribeiro-Soriano, D., Urbano, D., 2011. Socio-cultural factors and entrepreneurial activity. *International Small Business Journal* 29 (2), 105–118.
- Thurik, R., Carree, M., van Stel, A., Audretsch, D., 2008. Does self-employment reduce unemployment? *Journal of Business Venturing* 23 (6), 673 – 686.
- van Stel, A., Carree, M., Thurik, R., 2005. The Effect of Entrepreneurial Activity on National Economic Growth. *Small Business Economics* 24 (3), 311–321.
- van Stel, A., Storey, D., 2004. The Link between Firm Births and Job Creation: Is there a Upas Tree Effect? *Regional Studies* 38 (8), 893–909.
- Verheul, I., Wennekers, S., Audretsch, D., Thurik, R., 2002. An Eclectic Theory of Entrepreneurship: Policies, Institutions and Culture. In: Audretsch, D., Thurik, R., Verheul, I., Wennekers, S., Antonelli, C., Carlsson, B. (Eds.), *Entrepreneurship: Determinants and Policy in a European-US Comparison*. Vol. 27 of *Economics of Science, Technology and Innovation*. Springer US, pp. 11–81.

- Wennekers, S., van Stel, A., Carree, M., Thurik, R., 2010. The relationship between entrepreneurship and economic development: is it U-shaped? *Foundations and Trends in Entrepreneurship* 6 (3), 167–237.
- Yu, D., 2011. Exploring Spatiotemporally Varying Regressed Relationships: The Geographically Weighted Panel Regression Analysis. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* 38, 134–139.