Spatial divergence in living standards during an economic growth phase in the periphery: A case study of North Karelia

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The advisability of an urban-centred growth strategy in sparsely populated parts of Europe has not been much analysed at micro-levels such as that of the post-code area. This paper investigates how regional disparities in living standards continued to increase during the technology-driven growth phase of 1993–2003, as exemplified by the case of North Karelia in Finland. Urban sprawl conveyed the spread effects of the rise in incomes, and the upsurge of living standards was concentrated in the neighbourhood of the provincial centre, Joensuu. Living standards faced a process of double divergence: between the central district of Joensuu and its commuter belt, and between the provincial core area and its hinterland, the latter consisting of rural areas and small towns dependent largely on natural resources. The spatial outcome of this socio-economic reorganization is a three-zone core-periphery pattern. As the economy grew, geographical shifts in wealth were consequences of the growth and mobility of certain social groups and strata. A wave of high living standards towards the outskirts of the provincial centre was generated by an expansion in commuting. The relative decline in living standards in the periphery was due to long-term rural decline and involved spatial restructuring.

Keywords: living standards, spread effects, core-periphery

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Introduction

Economic development tends to constitute a series of cumulative, spatially centripetal processes generated by economies of scale and changes in transportation costs, which result in chains of path-dependent development. These reconstitutions take place through changes in place-bound initial advantages, such as natural resources, hub location and knowledge (Krugman 1991, 1993, 1998; Fujita & Krugman 2004: 145, 147). According to Krugman (1993), there is a strong accidental component in the upsurge of development. Some of the initial advantages, such as the concentration of human capital, are increasingly accentuated by policy measures and named as constructed advantages (Cooke & Leydesdorff 2006). The impact of distance is implicit in spatial development, since spatially uneven industrial growth would not persist if distance had no impact. The impact of distance has traditionally been explained in geographical models by an inverse relationship between spatial interaction and distance: the greater the absolute or relative distance between two areas is, the smaller will be the movement of people, goods or ideas (Bell et al. 2002; Martinez-Zarzoso 2003; Partridge et al. 2007; Coccia 2008; Partridge & Rickman 2008). The pecuniary variant of this principle has been adopted to explain the spatial concentration of economic activities. To put it simply, the farther away an enterprise is located, the higher are the interaction costs (Westin 1999), and hence the lower are the compensations for capital, land and labour, an effect that will finally pull down living standards. The spatial pattern of socio-economics is not easy to anticipate, however, as

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local and regional economies are very open. Many enterprises are now located in global production chains and networks, and hence location and the resulting costs must be interpreted relative to such networks (Garretsen & Martin 2010). Moreover, growth in advanced economies takes place outside the traditional primary manufacturing sectors and an increasing proportion of the value added is generated by the service sector and the production of information. In many regions the economy is evolving in spatially uneven ways, which points to changing revenues and cost structures in local industries, with eventual impacts on local living conditions.

Although much has been written about regional disparities, restructuring and growth, less attention has been paid to the impact of an economic growth phase on the geography of living standards in peripheries at a micro-level. The purpose of this paper is to show how the spatial development in living standards took place in 1993–2003, a time when rapid economic growth prevailed in Finland (Rouvinen & Ylä-Anttila 2003). We discuss changes in living standards in a remote uni-nodal peripheral region, North Karelia, as an example of a sparsely-populated Nordic pattern of development (Gløersen et al. 2005). Finland's GDP increased every year during the period concerned, but North Karelia lagged behind both in absolute terms and per capita (Statistics Finland 2010a). North Karelia is located 400 km northeast of Helsinki and is one of the most problematic regions in Finland, as it has been plagued by low incomes, out-migration, decades of high unemployment and an ageing population. It is a sparsely-populated, largely forested NUTS 3 region with a provincial centre, Joensuu, that had 73,000 inhabitants in 2011.

Growth processes in a geographical space

Knowledge is the key production factor in a technology-driven economy, in that it can improve labour productivity and leads to the invention of new products, thus improving the standard of living. This innovation-oriented paradigm of regional policy has predominated in Finland since the early 1990s (Vartiainen & Viiri 2002; Arbo & Eskelinen 2003), and was considered a central paradigm for survival in the depression of 1990–1993. The main focus was on national and regional innovation systems (NIS and RIS), which offered financial inputs and guidance on how to increase regional competitiveness and foster innovations. Such a policy presupposes that strong growth centres will spread their success to their surrounding areas.

In order to achieve this success, the policy aims at creating a positive relationship between the quality of human capital and local economic growth, as has been observed empirically in many studies. Raspe and Van Oort (2006), for instance, observed that growth in both employment and productivity in municipalities is dependent on the intensity of the knowledge work environment and the emergence of innovations. Consequently, individual city size growth rates run parallel with individual local human capital growth rates as measured by educational attainment (Black & Henderson 1999: 269–271). Glaeser (2000) and Lever (2001) provide empirical evidence of a positive correlation between human capital and regional economic growth. Innovations could provide new production possibilities for keeping people in rural areas, but human capital has not developed much there. So far, the results of growth policy have been meagre in the Nordic peripheries (Gløersen et al. 2005; Suorsa 2007). Growth concentrated in a city usually diffuses into new suburbs and exurbs only in the surroundings of that city (Berube et al. 2006).

Another important factor causing the increased spatial concentration of production is agglomeration economies, originating from the fact that larger centres provide a greater range of traded and untraded interdependences and often at lower prices than the periphery. Together with the increasing importance of knowledge, these agglomerative factors lead to the reallocation of living standards at the regional level. Research findings support this, as Van Oort et al. (2009) found that the density of knowledge workers and innovativeness has a significant positive impact on employment growth, and that this impact is the stronger the larger an urban agglomeration is. One reason for this is that larger agglomerated areas offer more specialized services and a thicker, more specialized labour market. Other sources of agglomeration economies can occur through knowledge spillovers between firms, research institutions, universities and actors in the labour market. One spatial aspect of spillovers is that the size of the centre correlates with the intensity of the spread effects diffused to nearby rural areas (Schmitt & Henry 2000). In vast, sparsely populated areas there are few cities and their sizes are small, which

means that there are intermediary areas which do not reap the benefits of urban-driven growth. Similarly, smaller centres may not be able to create any effects on peripheries (Tervo 2009). Thus, agglomeration-driven growth does not generate much economic growth in sparsely populated peripheries.

The geographical reach of scale economies and the other spread effects mentioned above have occasionally been demonstrated empirically. Rosenthal and Strange (2001) showed that knowledge externalities may attenuate quickly because of their reliance on personal interactions, but the benefits of labour market pooling and shared inputs may extend over wider areas, such as whole states in the US. Partridge et al. (2007: 147) found that agglomeration spillovers and labour market spread effects (through commuting) were more limited, as they extended about 175 km out from the urban centres with a core of at least 10,000 inhabitants in Canada (2007: 134). Similarly, Polèse and Shearmur (2004) reported that distance and city size remain good predictors of location patterns for most industrial classes in Canada, and concluded that the one-hour threshold (100 to 150 km from a major metropolis) has remained a robust predictor of the borders of the spatial concentration of manufacturing activity. In Finland, Tervo (2009) observed both spread and backwash effects from provincial centres, as measured by population changes in the Finnish regions over the period 1970–2004, and North Karelia was the region where spread effects dominated, due to a relatively weak pull effect of its smallish provincial centre.

Answering research questions concerning spatial divergence

The hypothesis, explorative setting and analytical methods

Tervo (2009) found more evidence for backwash effects than for spread effects in the regions of Finland. In particular, if a provincial centre had grown rapidly or if it was a large centre, it generally had negative effects on its hinterland. The time interval 1970–2004 which he examined nevertheless consisted of the industrialization period in the peripheral areas in the 1970s and deindustrialization in the 1980s, and thus it may not effectively reveal the impacts of technology-driven growth in the recent past on living standards. Our focus is on the robust post-1993 economic growth phase, and we shall attempt to unravel the spatio-economic processes at the micro-level using postcode areas as areal units (Fig. 1). The study of Karvonen and Rintala (2005) provides evidence that technology-driven growth favoured urban-adjacent areas and spatial shifts were seen in high living standards along with urban sprawl, even though the central districts were still superior in 2000.

Taking into account the findings of the above-mentioned studies, we hypothesized that a tendency for spatial divergence in living standards would be seen to have taken place in the North Karelian economy during the post-1993 growth phase, largely because the initial advantage for generating growth was highly concentrated in the largest population centre. The initial advantage was actually created by new industrial and regional policies that were based on boosting innovations and expertise (Vartiainen 1998; Vartiainen & Viiri 2002). The idea was that metropolises and provincial centres had better conditions for growth than other areas, as they had a higher intensity of knowledge supported by NIS and RIS and better agglomeration economies. We assume that divergence in living standards happens because the aforementioned factors are tied to the geographical reach, which reflects spatially unequal conditions for growth. This divergence ought to be driven by structural shifts in the economy and agglomeration economies, as argued in theory (Krugman 1991). We assume that a divergence in living standards has taken place between the core and periphery on a regional scale. If so, diverging development has probably created new spatial patterns of living standards, the geographical reach of which we will attempt to unveil.

We set out to examine this hypothesis by means of non-parametric regression analysis, where the standardized, weighted composite variable representing the variables mirroring living standards is explained by the distance by road from Joensuu market square. Such a method is suitable for analysing the impact of urban distance on living standards (Partridge et al. 2007). The changes between 1993 and 2003 were assessed by means of empirical models constructed using the same Kernel function and bandwidth for the two years. The postcode areas were weighted by population in order to capture changes in living standards, in the sense that each inhabitant has the same weight in the model. The trend in living standards on the core-periphery dimension was investigated using

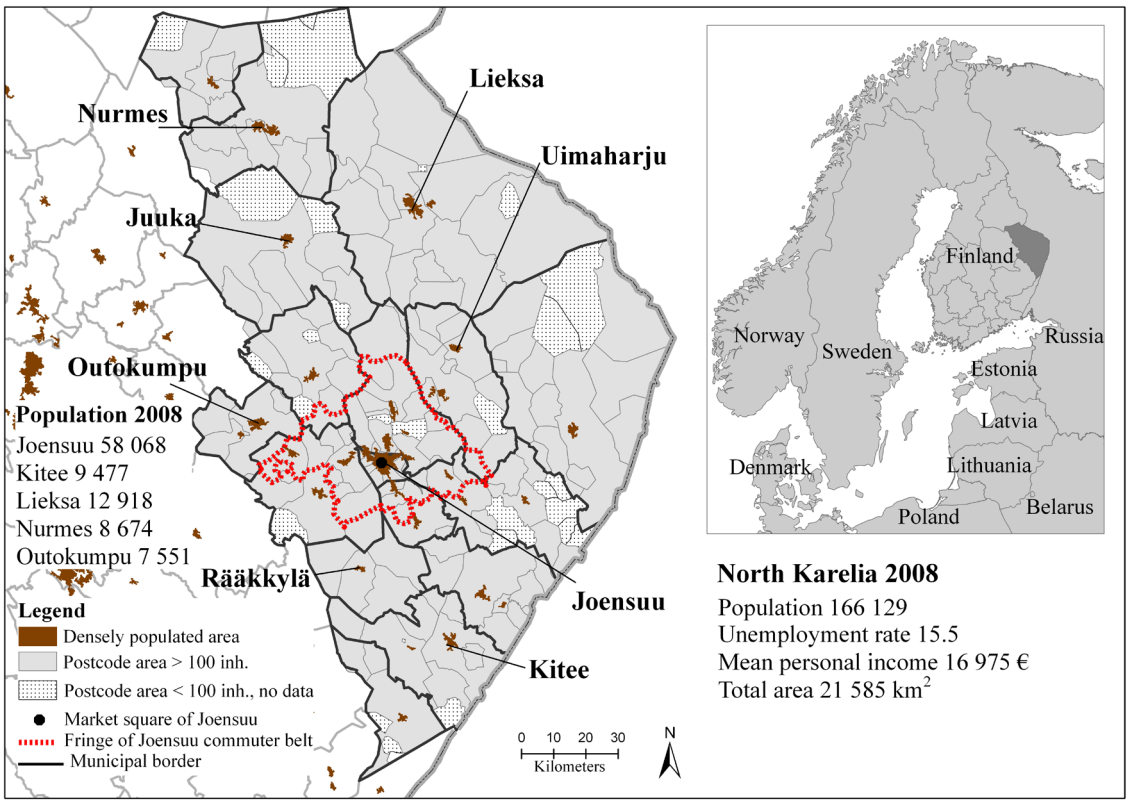

Fig. 1. The 161 postcode areas of North Karelia in 2008. The arrows point to the centres of municipalities.

the Nadaraya-Watson estimator, which is defined as (Faraway 2006):

$$f_\lambda(x) = \frac{\sum_{j=1}^{n} w_j Y_j}{\sum_{j=1}^{n} w_j} \quad (1),$$

$$\text{where } w_j = K\left(\frac{x - x_j}{\lambda}\right)/\lambda. \quad (2).$$

K is a kernel where $\int K = 1$. Kernel functions may be of various shapes: parabolic, uniform, normal etc., but we use a normal kernel in our analysis. λ is the bandwidth which controls the smoothness of the fitted curve and therefore determines how far away observations are allowed to be from the postcode area and still contribute to the estimated living standard ($\hat{f}_\lambda(x)$) The Nadaraya-Watson estimator simply modifies the moving average estimator so that it is a true weighted average where the weights for each y will sum to one (Faraway 2006). This estimation method was selected because of the sparseness of the data.

The spatial changes in living standards are generated with a simple permutation-based simulation model in which the simulated change in living standards is related to the distance by road from the provincial centre. The aim of the simulation was to imitate three theoretical development processes: random, centrifugal and centripetal development. By comparing the theoretical outcomes with the observed development, we were able to test the tendency for spatial divergence in living standard and assess its nature. The random development process is based on random simulation of the differences in PCA scores without replacement

with equal probabilities for all postcode areas, while the latter two simulations are based on probability sampling without replacement. The probabilities for sampling are $P_i = r_i/134$, where r_i is the rank of the postcode area i dependent on its location in relation to Joensuu market square. In the centrifugal simulation the ranks were highest in the distant areas and descended towards the core, while in the centripetal simulation the ranking was reversed. Probabilities are used in the simulations to sample the group of sorted values for the estimated change in living standards $\{\hat{y}_1^{(1)}, \hat{y}_2^{(2)},..., \hat{y}_n^{(m)}\}$, where the index n denotes the number of the postcode areas and m the rank in terms of living standards. The permuted sampling was repeated 1000 times and after each permutation a non-parametric regression model was constructed with the same bandwidth (equation 2). After the simulations the average and standard error of the estimates were calculated as $\bar{y}_i = \frac{1}{1000}\sum_{i=1}^{k}\hat{y}_k$ and $\overline{se}(\bar{y}_i) = s_i/\sqrt{n}$, where s_i is the standard deviation of the individual observations in postcode area i. The confidence intervals for the simulations were calculated as $[\bar{y}_i - z^{(1-\alpha)}\overline{se}(\bar{y}_i),\ \bar{y}_i + z^{(1-\alpha)}\overline{se}(\bar{y}_i)]$, where $z^{(1-\alpha)}$ is the standard normal percentile and $z^{(1-0.025)} = 1.96$.

In order to understand the results of our test of the hypothesis on the divergence of living standards more thoroughly, we posed four questions regarding the impacts of commuting and the properties of residential areas on changes in living standards and analysed what factors explain these changes in living standards and how they are located relative to the regional core. We used the following as independent variables in our explorative setting: the importance of the commuting distance, changes in the commuting distance, the population change 1993–2003 and the construction of housing after 1991, in order to assess living standards in the different locations. Our analysis will reveal how these variables generated changes in living standards at different distances, and since there is no reasonable a priori expectation and thus no reasonable hypothesis regarding the nature of such relations, we approached the issue exploratively.

To test these questions related to our hypothesis, we used the Nadaraya-Watson estimator for multivariate predictors to identify the dependence of living standards on these attributes of a postcode area combined with the distance from Joensuu by road. The multivariate model can be written as (Faraway 2006):

$$f_\lambda(\bar{x}) = \frac{\sum_{j=1}^{n} K(\bar{x} - \bar{x}_j/\lambda)Y_j}{\sum_{j=1}^{n} K(\bar{x} - \bar{x}_j/\lambda)}. \quad (3).$$

The quality of a kernel estimate depends less on the shape of K than on the value of its bandwidth λ. As λ increases, the variance of an estimate decreases because a large number of points are used in the estimation of density, but large values of λ can lead to an over-smoothed surface with increased bias. Since the smoothing is mostly based on the values of the bandwidth, we used the cross-validation (CV) method to select the smoothing parameter λ. The guiding principle was to choose λ such that the integrated mean square error of the estimated density was minimized (Bowman & Azzalini 1997):

$$CV(\lambda) = \frac{1}{n}\sum_{j=1}^{n}(y_j - \hat{f}_{\lambda(j)}(x_j))^2, \quad (4),$$

where the estimate $\hat{f}_{\lambda(j)}(x_j)(j)$ is calculated from the data with the point j left out and the main idea is to predict the dependent variable y_j with the remaining data. The non-parametric regression models were created with the R software and its sm library, as described in more detail by Bowman and Azzalini (1997). The distance was measured as the mean distance of people's homes from the market square of the provincial centre by road, and was calculated using the Network Analyst tool in ArcMap.

Building the living standards variable by PCA

Our chain of reasoning was that spatially unequal economic growth has an impact on income formation, migration and material well-being in a geographical space. Personal incomes are a central constituent of living standards, but we added others that were related to the social environment and human capital and have been used as components of living standards in studies of well-being in Finland (Siirilä et al. 1990; Vaattovaara 1998; Kainulainen et al. 2001; Karvonen & Rintala 2007). A

composite variable for measuring living standards by postcode areas was created for this purpose by principal components analysis (PCA), which converts the properties of the original variables into a very few components according to the best possible fit. The main advantage of this method over those based on income and consumer expenditure is that it captures a broader dimension of well-being than one variable (Kainulainen et al. 2001; Vyas & Kumaranayke 2006). The debate over the use of PCA reflects the fact that principal components are artificially constructed indices and difficult to interpret. PCA falls into the category of factorial ecology within geography (Pacione 2005).

Our analysis consists of 7 variables that measure standards of education and material well-being by postcode area: the median income of individuals (€), the proportion of persons in the lowest income bracket (%), the proportion of high-income households (%), mean household net assets (1000 €), the proportion of indebted households (%), unemployment rate (%) and the proportion of persons with a university degree (%) (for exact definitions of the variables, see Statistics Finland 1996, 2006). The selection of these variables was limited by the availability of data, but they are similar to those used in many previous analyses of well-being in Finland. We use postcode areas because each municipality is rather heterogeneous in terms of socio-economic attributes. Thus, we use a smaller, internally more homogeneous areal unit in order to observe spatial patterns within a municipality and their underlying processes.

Close correlations exist between all of the variables except for household net assets, and the loadings in the years 1993 and 2003 are almost identical. Only the loading on unemployment rate (%) for 1993 is notably lower than the respective figure for 2003 (Table 1). The obvious reason for this was the severe economic recession in the early 1990s, when layoffs caused unemployment even in the wealthier areas. The variance explained by the first component increased up to the end of the period, indicating greater homogeneity amongst the distributions of the variables in this component in 2003.

The sum variable for measuring living standards was created from the first principal component (PC1) using the loadings on the selected variables as weights. Two criteria were adopted. First, a variable was chosen if its loading on PC1 was higher than the traditional threshold value of 0.30 (Dillon & Goldstein 1984). Second, a reliability analysis was conducted with Cronbach's alpha, which gave acceptable values of 0.879 in 2003 and 0.829 in 1993 with the five variables highlighted in Table 1. The higher the median income, the higher were the proportions of persons with a university degree and of high-income households (Table 1), while the unemployment rate and persons in the lowest income bracket were variables that had the reverse characteristics. The principal component analysis was performed with R software and its stats library.

The North Karelia region

North Karelia, an area equivalent in size to 7/10 of Belgium, was earlier highly dependent economically on agriculture, the forest sector and mining

Table 1. Factor loadings on the two principal components for 1993 and 2003. The loadings of the variables which are included in the sum variable appear in bold.

Variable	2003		1993	
	PC1	PC2	PC1	PC2
Median income of individuals (€)	**0.96**	–0.12	**0.96**	–0.01
Unemployment rate (%)	**–0.58**	–0.58	**–0.30**	–0.76
Mean household net assets (1000 €) *	–0.16	0.91	–0.19	–0.83
Persons with a university degree (%)	**0.79**	–0.02	**0.79**	0.09
Persons in the lowest income bracket 8 107 € (%) *	**–0.86**	0.25	**–0.89**	0.17
High-income households, 47 000 € p.a. (%) *	**0.84**	0.30	**0.78**	0.10
Indebted households (%) *	0.69	0.30	0.56	0.31
Total variance explained (%)	55.2	19.9	48.6	19.8

*) Variable from 2004. Source: Statistics Finland (1996, 2006).

(Tykkyläinen 1988). It is an example of a natural resource-based NUTS 3 region the development of which is now being boosted by state-led innovation policy and various regional policy projects. Although this analysis is an empirical case study, its results reflect general problems and processes which many areas face as the rationalization of production reduces their labour force and leads to a vicious circle of depopulation (OECD 2006: 32). We concentrate here on North Karelia for practical reasons, but similar processes are in evidence in natural resource-based northern hinterlands in Europe and America in general (Partridge et al. 2007; Partridge et al. 2008; Gløersen 2009).

Economic growth and development is increasingly becoming concentrated in the provincial centre of Joensuu and its commuter belt. Suburbanization has continued since it emerged with economic boom and industrialization in the mid-1970s (Paasi & Vartiainen 1981). While the population of the city region has grown, the distant industrial communities and scattered settlements have lagged behind, and other municipal centres that previously had expanding populations have begun to decline. Consequently new workplaces in the service sector have tended to be located in the provincial centre and its growing neighbourhoods, indicating the geographical concentration of economic activity on a regional scale. The rural restructuring that occurred after Finland joined the EU in 1995 is still going on, as shown by declining employment in the primary industries and a worsening age structure followed by depopulation.

The growth of the regional core area is bound up with its success in generating and attracting enterprises, the success of education and research and development (R&D) and globalization impulses felt in its industries. The rapid growth of the ICT industries in the late 1990s created many new jobs in the manufacturing of plastics and metal products, but the largest local factories in this field have recently been closed down. Many people continue to be employed in the manufacturing of forest machinery by John Deere, which, like the ICT branch, was boosted by regional policy and since 1998 by the North Karelia centre of expertise programme. The university and polytechnics have expanded, and a science park and related industrial activities have played a part in nurturing new businesses in the core area, which thus has the best regional assets and competitiveness in the regional economy (Vartiainen & Viiri 2002; Arbo & Eskelinen 2003).

The allocation of R&D investment and the distribution of employed persons in North Karelia are concentrated in a uni-nodal manner. On an average 82.7% of the R&D investments at the NUTS 4 level, now termed the LAU 1 level, in the period 1995–1999 were allocated to the Joensuu sub-region, and the average since 2000 has been 85.0% (Statistics Finland 2010b). These figures reveal that access to the possibilities offered by a technology-driven economy is poor everywhere other than in the vicinity of Joensuu. This gives us reason to assume that economic growth, although not directly R&D-driven in all cases, has become spatially concentrated, leading to similar uneven impacts on living standards within the region.

A zonal pattern in the spatial divergence of living standards

Living standards and the formation of zones

Supporting our hypothesis, but in a complicated way, the changes in living standards over the period 1993–2003 manifested themselves in three zones (Fig. 2, bottom right). Surprisingly, the most intensive relative reduction took place in the inner zone constituting the city centre of Joensuu, although a relative decline prevailed everywhere in the outermost zone, i.e. beyond a ½-hour commuting road journey from the centre. Living standards declined markedly in relative terms in the rural areas and in local centres such as Outokumpu, Rääkkylä and Uimaharju, at distances of 40–60 km by road, Kitee, Juuka, Lieksa and Pankakoski at distances of 70–105 km and Nurmes at a distance of 125 km, as anticipated in our hypothesis. The downward transitions in these local centres indicate unfavourable industrial structures and a decline in competitiveness compared with the Joensuu commuter belt (Fig. 2, bottom right). The North Karelian results are congruent with the findings of spatially narrow diffusion effects of economic growth in Nordic sparsely-populated areas (Gløersen 2009: 41–43).

The inner zone

The population of the inner zone increased by 3,576 in 1993–2003 (Table 2), whereas that of the outermost zone decreased, providing evidence of a backwash effect in that some of the migrants coming to the regional core originated from the

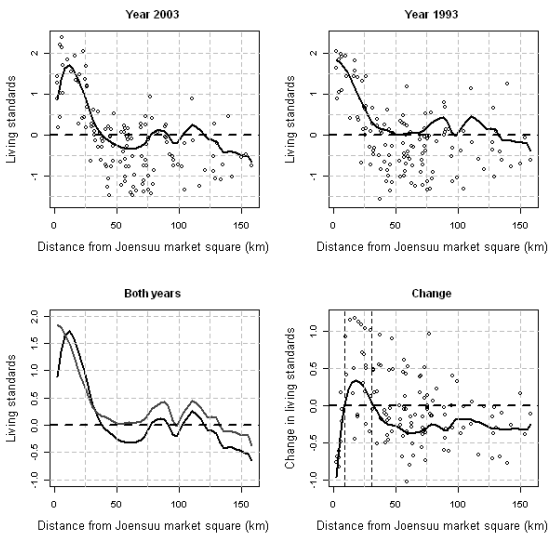

Fig. 2. Non-parametric Kernel fits for the regression of the change in living standards on road distance from Joensuu market square in 1993 and 2003. Bandwidth λ=6 km. Living standards are measured in terms of PCA scores. The division into three zones is marked by vertical broken lines.

depopulating outermost zone. The numbers of pensioners and students increased in the inner zone and the foreign-speaking population grew substantially. This population growth of 6.4% correlates closely with the increase of 8.5% in the number of jobs in the inner zone, which in turn suggests that the business environment is most appealing there (Table 2). The results are consistent with the findings of Raspe and Van Oort (2006), who show that growth in employment is dependent on the knowledge work environment. So far, the inner zone has had the highest index of persons with a university degree. Regardless of the presence of thriving businesses, as revealed by an increasing number of jobs, these do not always lead to an increase in living standards in the same area, as demonstrated by the trend in living standards in the inner zone.

The relative decline in living standards in the inner zone is a result of the increase in certain individual groups, the largest of which are resident students and pensioners (Table 2). The estimates for living standards in the centre have probably been slightly downgraded by an Act of Parliament

Table 2. Indices of spatial divergence in three distance zones. The spatial indices are calculated by weighting them by the population figures of the postcode areas. Regional average = 100. The largest changes appear in bold. Numbers of inhabitants, pensioners, students and jobs are indicated at the bottom.

Spatial indices and variables	Inner zone, 0 km – 9 km by road (n=13)			Intermediate zone, 9.1 km –33 km by road (n=25)			Outermost zone, 33.1 km and over by road (n=98)		
	1993	2003	Δ %	1993	2003	Δ %	1993	2003	Δ %
Median income (€)	118.1	113.1	–4.2	101.6	110.6	**8.9**	89.2	84.5	–5.3
Unemployment rate (%)	93.5	86.7	–7.3	87.7	80.1	**–8.7**	106.5	114.7	7.7
Persons with a university degree (%)	176.8	159.8	–9.6	84.5	100.6	**19.1**	59.3	57.7	–2.7
Persons in the lowest income bracket 8 107 € (%) *	82.2	91.7	**11.6**	102.3	92.1	–10.0	109.7	108.0	–1.5
High income households > 47 000 € p.a., (%) *	129.1	110.8	14.2	102.5	130.1	**26.9**	82.7	84.2	1.8
Population **	55 648	59 224	6.4	21 601	22 624	4.7	96 645	84 013	**–13.1**
Pensioners	10 252	11 435	**10.3**	4 750	5 055	6.0	26 177	26 018	–0.6
Students ***	6 118	6 990	12.5	2 034	1 770	–14.9	7 269	6 225	**–16.8**
Jobs	22 100	23 980	**8.5**	6 159	6 381	3.5	26 676	25 525	–4.5
	Core	km²	%	km²		%	*Periphery*	km²	%
Total area km²		257	1.2	3175		14.7		18153	84.1

*) Variable from 2004.
**) Variables from 1995 and 2005. Source: Statistics Finland (1996, 2006).
***) When the Municipality of Residence Act came into force in1994 the number of students in resident in cities somewhat increased. For comparison, the number of the students at the University of Joensuu increased by 29.3% from 1993 to 2003 and the number of degrees awarded by 23.1%. Source: KOTA Online (2010).

that allowed students to register more freely as residents of the locality where they are studying as from 1994 (see Table 2 and notes). The inner zone lost much of its competitiveness in terms of attracting high-income households and persons with a university degree, as the spatial indices for these deteriorated most here. The well-educated, better-off income earners migrated to the suburbs and exurbs, and it was the poorer people who came to the city. In spite of these regressive changes over time, however, the spatial indices for incomes and persons with a university degree were still higher than in the other two zones in 2003, 113.1 and 159.8 points respectively. High incomes and viable human capital are still conspicuously present as factors for economic growth in the central district of the city.

The intermediate zone

The commuter belt was better off in relative terms in 2003 than it had been a decade earlier, but the best-off locations had shifted about 15 km outwards from the core of the city in the course of 10 years, as the highest living standards were recorded in the city centre in 1993 and in the 15-km ring in 2003 (Fig. 2). The intermediate zone attracted 1,023 new inhabitants during the period, giving a 4.7% rise in population relative to 1993 and indicating spread effects from the inner zone and an expansion of urban sprawl. Once again the growth in population correlates with an increase in the number of jobs. As the total population of North Karelia was distributed among the zones in the ratio 36:14:51 in an outward direction in 2003, the improved living standards in the intermediate zone may be said to have influenced a relative minor segment of the total population of the region.

The post-1993 spatial restructuring created vital but not very populous settlements in the surroundings of the provincial centre, which attracted population in general and especially high-income households from the city. Unemployment decreased most in the intermediate zone, even falling below the regional average, to 80.1 points on the spatial index (Table 2), while the proportion of high-income households increased substantially, raising the spatial index from 102.5 to 130.1 points, and at the same time median incomes rose from 101.6 to 110.6 points, reflecting a gain in personal incomes and even better success in attracting high income households (Table 2). The importance of city income growth for suburban wealth was shown by Voith (1998), but our small-city case shows more clearly the shift of wealth from the inner zone to suburbs and exurbs and the growth of jobs in the inner zone.

The outermost zone

In the outermost zone, located beyond 33 km from the centre of Joensuu, the postcode areas with the lowest living standards were to be found at the distances of 50–70 km and over 130 km by road from the centre of Joensuu (Fig. 2). The steep decrease in living standards from a standardized score of about 1.5 to near 0 between 15 and 40 km indicates that the diffusion effects generated by the boom in Joensuu weakened strongly and came to a halt at the edge of the ½ hour commuting zone.

The spatial indices for the original variables in the outermost zone, except for the proportion of persons in the lowest income bracket and the proportion of high-income households, indicate a relative socio-economic decline (Table 2). The diverging indices reflect significant rural socioeconomic restructuring, as the outermost zone lost 4.5% of its total number of jobs and 13.1% of its total population within 10 years (Table 2). The population loss reduced the potential for reproduction of labour, as the younger population declined and the proportion of pensioners grew from 27.1% to 31.0% of the total. Ageing and the population decline reduce the potential labour force available to industries in the future. In addition to losses in quantity, a brain drain occurred, as revealed by the spatial index of the proportion of graduates, which declined from 59.3 to 57.7 points in 1993–2003. As stated earlier, such empirical results predict low growth or decline (Glaeser 2000; Lever 2001; Raspe & Van Oort 2006), as a scarcity of suitable labour and a lack of people with a higher education makes future development more dependent on external impulses and weakens the potential for creating favourable conditions for economic growth in the outermost zone.

The outermost zone constitutes 84% of the total area of North Karelia. The peripheral municipal centres with industrial estates and separate industrial communities, of which many arose initially because of their advantageous locational factors related to natural resources and were then boosted by regional subsidies and later by economies of scale, especially in the forest industries, are not attractive environments for growing industries in a

knowledge economy. The lack of any relative improvement in living standards in the scattered settlements and local centres had been expected, but not, perhaps, in such a uniform manner. The decline observable in the outermost zone gives a signal that beyond their core areas, regions of the type and size of North Karelia are too extensive and uncompetitive to benefit widely from the impacts of regional development measures based on a single node. Nevertheless, the growth of Joensuu has strengthened its potential for providing services in the outermost zone, and the centre has been the area to which students and persons looking for services and jobs have migrated. North Karelia would certainly have been worse off developmentally without the growth of its provincial core region.

Towards a uni-nodal spatial structure: evidence from simulations

A strong tendency towards socio-spatial segregation prevailed in the region. Living standards improved in relative terms only in the intermediate zone located 9.1–33 km from Joensuu market square, but this does not negate the fact that the regional structure of North Karelia became more markedly uni-nodal as the other towns and municipal centres lost part of their population and some of their relative status as measured by living standards. This became evident from the simulation results, that represented a tendency towards uni-nodalization in the form of a simple model. As described earlier, simulations are based on the sorting of values for estimated changes in living standards, as measured by PCA score differences, in three alternative ways. To begin with, we performed a simulation where changes in living standards varied randomly and independently of distance (Fig. 3, top left). As expected, the spatially even results showed that the inner and outermost zones performed worse in the real world than they would do by chance, while the areas in the intermediate zone succeeded better than with a random pattern of development, and confidence levels remained narrow (Fig. 3, top left). Hence, distance matters significantly as a proxy for centripetal and centrifugal forces.

In addition to the random simulation of distance, two other simulations were performed assuming that changes in living standards prevailed over the period 1993–2003 but in either a descending or ascending order as a function of distance. An "emphasis on nearby areas" simulation was constructed assuming that the highest observed improvement of living standards would be located at Joensuu market square, with a decline towards the periphery (Fig. 3, top right). The highest increase in living standards was then shown to have happened in the city centre, with the other changes leading to progressively poorer conditions with increasing distance. By contrast, the "emphasis on distant areas" simulation assumed that living standards would develop in the reverse manner, so that the highest living standards occurred in the periphery, with a decline towards the centre, according to a centrifugal pattern (Fig. 3, bottom left).

The "emphasis on nearby areas" simulation revealed that in this situation the areas in the inner zone and at distances of 28–90 km from Joensuu market square fared worse than they should have done according to the centripetal simulation results. This experiment demonstrates the relative

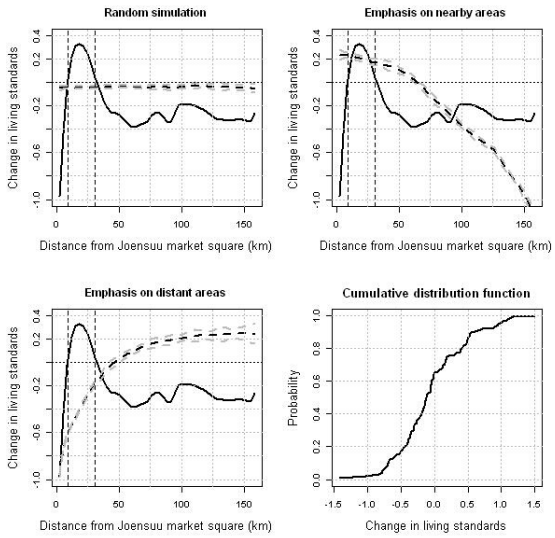

Fig. 3. Estimated relative changes in living standards (solid line) and simulated changes (broken line) as a function of road distance (with 95 percent confidence intervals) in three theoretical simulations, and the cumulative distribution function (CDF) of change. Bandwidth λ=6 km. The changes in living standards from 1993 to 2003 are represented by differences in PCA scores. The division into three zones is marked by vertical broken lines.

social decline that occurred in the central district, but also shows that the real decrease of living standards did not accelerate towards the periphery as it would have done in a purely centripetal system. In practice, the decline in living standards in the inner zone was partly due to a shortage of superior housing and a demand for building sites that channelled development to the intermediate zone, and partly due to low-income groups moving into the inner zone. The diffusion of the rise ends at the point in the intermediate zone where commuting ceases. In straightforward terms, the spatial manifestation of development was directed by the supply of urban housing.

The results of our centrifugal simulation, where the highest living standards were assumed to be found in the periphery, with a decline towards the centre, reveal the scale and force of the agglomeration tendencies and urban sprawl in the real world (Fig. 3, bottom left). Theoretically, a relative rise in wealth above the average could have emerged all over the outermost zone if demand and competitiveness had decreased step by step inwards from the periphery. In practise, a relative decline in living standards is now taking place in the small industrial towns and rural areas. Earlier, and especially in the 1970s, the countryside supplied labour for manufacturing industries in Lieksa, Nurmes, Outokumpu and Kitee in addition to Joensuu, reflecting competitive local economies, whereas the current development is heading towards a situation in which these former manufacturing towns are becoming suppliers of labour to the provincial core area and a few large, growing agglomerations in the south of Finland. This has happened due to the relative poor competitiveness of these areas for emerging new forms of production, which is characterized by R&D environments, service-orientation and global outsourcing rather than being in the nature of traditional branch-plant manufacturing. In the converse experiment, the centripetal simulation assumed that the worst effects were felt farthest away. In such a case, a relative decline in living standards could have engulfed large peripheral areas more than 100 km from the core, reducing their actual development (Fig. 3, top right). The counterfactual simulations show that a different pattern of spatial reorganization of wealth creation could have had substantial impacts on living standards.

Impacts of commuting and the properties of residential areas on changes in living standards

Commuting distance and their changes

To understand the impact of the changes in commuting patterns associated with our hypothesis, we analysed the importance of commuting distance for living standards in the postcode areas, in order to demonstrate the dynamics and pattern of observed commuting and the consequent change in living standards. Based on the same data for 1993–2003, the 10-year change in living standards shows that the localities with long distances to workplaces have benefited most from the improvement in living standards (Fig. 4, top left). A few places have such strong impacts that the highest increase is noted within a distance of 18–32 km by road from the population's workplaces. Due to the limited supply of appealing building sites, commuting has expanded to new areas in the intermediate zone and towards the periphery, although the increase in living standards drops rapidly beyond the outer fringe of the commuter belt. The commuting distances do not have much explanatory power in the inner zone, where they are in any case mostly short.

In the outermost zone, the effects of growth are to be observed in the fringe area proximal to the core, combined with commuting distances of more than 20 km, while the negative contours farther away denote that living standards in the subregional centres and distant rural areas (>70 km) combined with journeys to work of 10–20 km declined most in relative terms. In general, living standards grew in relative terms in a few areas in the intermediate zone and beyond when combined with long distances to work and in some places in the intermediate and outermost zones which had very local labour markets, as in farming areas.

The impacts of the changes in commuting distance were bifurcated, in that both an increase and a decrease in commuting distance increased living standards in relative terms (Fig. 4, top right). The influx of new commuters disappeared beyond the intermediate zone, and hence the relative increase in living standards dropped rapidly and became negative beyond the outer fringe of the commuter belt. Likewise, living standards declined in areas where the change in commuting distance was negligible, wherever these were located. In the inner

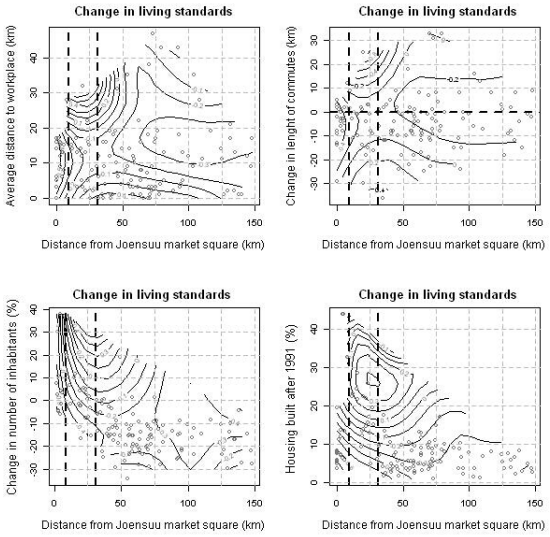

Fig. 4. Non-parametric regression for changes in living standards by postcode area, 1993–2003. Standardized PCA scores for change are simultaneously explained by road distance from Joensuu market place and distance from one's workplace, changes in commuting distance from 1993 to 2003, changes in the numbers of inhabitants from 1993 to 2003 and proportions of housing built after 1991. λ=15 km.

zone the commuting distance actually decreased in many postcode areas, indicating a social change, while in the outermost zone the spread effects of growth were to be observed in the fringe area proximal to the core and up to 50 km, combined with an increase in commuting distance. The decline in commuting distance in a minority of small areas in the intermediate and outermost zones correlates with an increase in living standards. There may be several explanations for this, such as reductions in the number of longer commuting distances for reasons of demography and migration.

Population change and new residential building

To understand the socio-spatial processes associated with the hypothesis further, we analysed the importance of population growth and housing construction for the changes in living standards in the postcode areas, in order to demonstrate the role of newcomers in diverging living standards. The impacts of the 10-year change in population on the 10-year differences in living standards reveal that living standards improved in relative terms in the areas where the population grew, namely in the intermediate zone, and declined most in the central district (Fig. 4, bottom left). The most severe estimated downward impact, a standardized score of –0.6, was recorded in the postcode areas of the city, where zero population growth prevailed, while growth impacts peaked in the areas located in the intermediate zone proximal to the outer zone, where the population increased by 30%, having the highest impact on the relative improvement in living standards. More affluent migrants from the city raised standards in the suburbs and exurbs, while out-migration created a backwash effect in the inner zone. Affluence was clearly diffusing outwards across the border of the outermost zone, where the population grew most. The relative increase in living standards was solely contingent upon in-migration.

Distance penalties pushed living standards down in relative terms in all the areas beyond 55 km from the centre of Joensuu regardless of their population change, but a similar decline in living standards was also noted in the central district (Fig. 4, bottom left). The relative decline in living standards combined with depopulation in the more remote areas levels off in the places where depopulation is worst (Fig. 4, bottom left). These most marginalized areas were not especially viable at the beginning of the period and had already reached a low ebb at which incomes were dominated by low wages and salaries, pensions and welfare payments.

In a core-periphery setting, as studied here, a decline of population proves to be a sign of relative deterioration in living standards everywhere, while population growth in suburbs and exurbs usually means a rise in wealth due to an influx of better-off migrants. In this case, however, the central district lost its relative living standard independently of population growth. The main analysis of population change is indicative of the importance of the underlying mechanisms related to migration, with residential preferences and demography acting as stimuli for changes in living standards. All these factors are sensitive to distance.

The newest residential areas are located in the intermediate zone, and growing living standards are focused on those neighbourhoods where more than 15% of the housing had been constructed af-

ter 1991 (Fig. 4, bottom right). These relatively new areas contained mostly families of wage and salary earners with high enough incomes to buy or build a detached house in a suburban and exurban environment and commute to work. In general, the newer the houses are the better the standards of living. An exception to this was provided by one of the newest areas located in the central district, which had no such experience of growth, pointing to a more equalizing form of town planning in this case. As the proportion of houses built after 1991 in the outermost zone varied from a few to as many as 10% or more, some replacement and rebuilding had evidently taken place there. As expected, new houses are a relatively good indicator of changing living standards, in this case depicting urban sprawl and the restructuring of rural settlements.

Conclusions from the analyses

Our hypothesis stated that a divergence in living standard happens because new, mostly technology-driven, constructed advantages are tied to geographical proximity. This statement did not prove to be literally true when we compared changes in living standards between the central district and the extreme peripheries, however. These two area classes have converged, but the comparison of development between the commuter belt and the hinterland is in accordance with our hypothesis. Hence, urban sprawl had to be taken into account if one is attempting to interpret diverging living standards in the context of Krugmanian economics. The hinterland of North Karelia was inferior to the provincial core region in terms of most development indices. On a sub-regional scale, the strongest divergence has taken place between the central district and the commuter belt, as a result of short-distance migration. As predicted by our hypothesis, the remote industrial towns and municipal centres lost ground relative to the suburbs and exurbs of the provincial centre and its commuter belt.

In order to consider the results more profoundly we analysed changes in the living standards in terms of four variables. To begin with, we raised the question of the importance of commuting and its development for living standards in different locations. Commuters were better-off than the people working locally, and the effect was most pronounced in the commuter belt as commuting expanded to new areas in the intermediate zone, and it was here that the spatial pattern of living standards changed radically. Outside the Joensuu commuter belt there was a decline in standards of living among people who had a middle-range commuting distance. The change in commuting distance was bifurcated, however, as both an increase and a decrease increased to a rise in living standards. Such developments must have an impact on the settlement pattern in the long run, as they mean that middle-range commuters decline in numbers.

We next addressed the question of the importance of newcomers for living standards in various locations. The most severe estimated downward trend was recorded in the central district, where zero population growth prevailed, while growth impacts peaked in the parts of the intermediate zone proximal to the outer zone, where the population increased by 30%, having the highest impact on the relative improvement in living standards. The more affluent migrants from the city raised standards of living in the suburbs and exurbs, while out-migration created a backwash effect in the central district. The growth and mobility of certain social groups and strata proved to be important for the geographical shifts in wealth that stimulated the changes in living standards. Affluence was diffusing outwards with newcomers, passing across the border of the outermost zone, which was where the population grew most. As expected, the newer the houses were, the better the standards of living developed to a certain extent. An exception arose, however, since some of the newest housing areas had a mixed population structure, including social housing, and the increase remained small. To sum up, commuting and housing decisions were of greatest importance in the commuter belt around the provincial centre, where they had a decisive impact on the spatial manifestation of changes of living standards, whereas in the periphery such changes were more closely linked to long-term rural decline.

Discussion of the results, theory and potential implications

The robust post-1993 economic growth in the region studied here brought about three clearly discernible and well differentiated zones, implying a tendency towards a wider, segregated provincial centre as an outcome of the transformation. This is

not a new phenomenon, as this urban sprawl is a continuation of the development which started when Joensuu began to grow in response to industrialization and regional development policy measures. Rural decline has been a part of this regional restructuring since the late 1960s. On the other hand, the plunge in living standards in the central district, in so far as it really happened, was contrary to what might have been expected and what the city council was striving at.

The findings with regard to the post-1993 regional divergence of wealth are clearly a result of the uni-nodal pattern which seems to be typical of the stage of technology-driven growth in a region such as North Karelia. This is in contrast to the more spatially even, multi-nodal industrialization which took place in the 1970s. Consequently, our findings support the results of Partridge et al. (2008), who argue that recent technological advances make access to agglomeration economies even more important than in earlier periods of regional development. The relative decline in living standards in hinterlands indicates that remote local economies are searching for a socioeconomic balance. This relative decline may not necessarily be a persistent tendency within regional development in our current peripheries, however, as Krugman's approach envisages (Krugman 1993; Combes et al. 2008: 130–152). Any parameter can change in the course of time, leading to new tipping points and radical developments.

A spatially limited urban sprawl and rural decline indicate that, in an environment such as North Karelia, affluence created in a smallish provincial centre will spread efficiently only to neighbourhoods located at relatively short distances from the central district. Improvements in living standards will be closely related to commuting to the central and industrial districts of the provincial centre. Small centres combined with a low regional population density bring about a very fragmented settlement structure where diffusion remains sporadic and geographically lacking in coverage (Gløersen et al. 2005: 35). Hence, such characteristics in a remote region inevitably create a regional structure where agglomeration spillovers are limited, contrary to the structure of a densely populated environment. In addition to this, the peripheral areas with their scattered settlements and small towns have remained at a standstill, as demand has been low in the traditional economic sectors. Spatial diffusion as measured by living standards was actually less marked than could have been expected in light of the results from Canada (Partridge at al. 2007).

Since Joensuu is a small provincial centre, it remains to be seen whether such a node in the national innovation system can construct an initial advantage for itself that will lead to path-dependent growth, and if so, for what period. Results do provide evidence, however, that the geographically limited regional policy was one factor that occasioned spatially selective growth in living standards within the region, even though it led to net benefits in terms of welfare in the region as a whole.

As the spatial indices revealed, the economic development that took place in 1993–2003 generated higher incomes and net migration and enforced spatially divergent socioeconomics which manifested themselves as differences in living standards between the central districts and the commuter belt and in a vicious circle of decline in the more remote areas due to population loss and disintegration of the economic structure. This detracted from the regional competitiveness of the remote areas and limited their potential for absorbing growth impulses. The non-working population of these areas grew in relative terms and required support in the form of welfare payments. Such backing makes migration less appealing (Lundholm 2007), but it doesn't generate new jobs or improve skills. We have not yet observed any signs of a reversal of these centripetal tendencies on a regional scale. As an urban-rural development, the migration of wealthier people to the commuter belt was the result of seeking a better residential environment for established households of persons employed by the industries of the core area. This may be regarded as a manifestation of the pulse of urban sprawl and expansion of housing to vacant suburban and urban-adjacent rural environments typical of a phase of economic growth that has been observed nationwide (Lehtonen & Tykkyläinen 2009).

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