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Does Agglomeration Explain Regional Income Inequalities?

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Does agglomeration explain regional income inequalities?

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Abstract

This paper seeks to explain regional income inequalities in Norway. Similar to the EU countries, Norway is characterized by substantial income disparities. I use sub-regional NUTS 4 data for the Norwegian manufacturing sector to analyze to what extent agglomeration effects and skills can explain regional variation in productivity and income. Both intra-sectoral and inter-sectoral agglomeration effects are analyzed. The reported estimates suggest the presence of both types, and that the latter are slightly stronger than the former. Contrary to popular views, I moreover find that location and agglomeration effects have become more, not less, important. In contrast to empirical evidence on sources of regional inequalities in other European countries skill composition as a determinant of regional income variations appears to have declined in importance over time. Hence, high income appears to be an outcome of high activity density – agglomeration – rather than being due to differences in education and skills.

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1 Introduction

Economic integration has led to convergence in income across Europe, but at the same time regional disparities are large and persistent, and represent a source of significant policy concern. As a consequence, regional issues are receiving increasing attention from policy makers and researchers. From an empirical point of view, the crucial question is: what are the sources of regional inequalities? It goes without saying that knowledge of what these sources are, is a prerequisite to any policy that aims at eliminating or reducing inequalities effectively.

This paper seeks to explain regional income inequalities in Norway. Similar to the EU countries, Norway is characterized by substantial income disparities: GDP per capita in the poorest regions of Norway is around 70 percent of that of the richest regions.[1] However, once one focuses on one single sector, namely manufacturing, the spatial differences in income appear to be even more pronounced: GDP per hour in the regions with lowest income is merely 30 percent of GDP per hour in the regions with highest income. Earnings per hour in the poorest regions are around 60 percent of the earnings in the richest regions.[2]

A set of recent empirical studies (see Ciccone, 2002; Rice and Venables, 2004; and Combes et al, 2004) have investigated the sources of income inequalities across national sub-regions in Europe and the US. Their point of departure is that spatial differences in income can be ascribed to productivity differences. Higher (lower) productivity is in turn assumed to be reflected in value added per unit of labor, or in earnings.[3] In their analyses they have in particular focused on three main explanations for spatial disparities in productivity and income: exogenous regional characteristics, skill composition of the workforce, and agglomeration economies (external economies of scale). Agglomeration economies arise because of market or non-market interactions (spatial externalities), and imply that proximity to larger markets – areas with higher density of activity – leads to productivity gains.

Ciccone (2002) uses regional data for the EU to estimate agglomeration effects for France, Germany, Italy, Spain and the UK, by analyzing the role played by employment density for spatial differences in income measured by value added per worker. He finds that employment density as a measure of agglomeration, together with education controls and regional dummies, explains 62 percent of the variation in value added per worker across European regions. He concludes that agglomeration effects do not vary significantly across countries, nor do they differ substantially from those found in the US (see Ciccone and Hall, 1996).

Rice and Venables (2004) adopt the empirical model of Ciccone, and analyze spatial income differences for the UK for the late 1990s. They introduce a slightly different measure of spatial mass exploiting more of the geographical

[1] Calculations based on data for 2000 from Statistics Norway.

[2] Calculations are based on the Manufacturing timeseries database of Statistics Norway for the year 1999.

[3] As pointed out by e.g. Rosenthal and Strange (2004) enhanced agglomeration economies may manifest themselves in higher productivity, increased factor employment, and increased factor prices. What factors are affected, and whether in terms of employment, and/or prices, depends i.a. on market structures.

information attached to sub-national areas, namely travel distance between regions, and use two different measures of income, value added per hour worked and earnings. Their results are consistent with the findings of Ciccone for earlier periods, as they find a significant positive relationship between population density and income measured by earnings, but not between population density and value added per hour worked.[4]

Combes et al (2004) investigate the determinants of spatial wage disparities in France using a large panel for French workers. Their estimated elasticity of earnings with respect to employment density is around 2 percent, and considerably lower than what has been found by others. According to their analysis, high local wages are primarily the outcome of high-skilled workers gathering in dense local labor markets.

I adopt the specification developed by Hall and Ciccone (1996) and Ciccone (2002), and examine the role played by agglomeration effects (measured by employment density) and skill composition of the labor force in explaining spatial differences in income in Norway. In doing so I apply data for the subregional NUTS 4 spatial units of Norway, and focus on income disparities within the manufacturing sector. Unlike earlier studies we analyze both intra-sectoral and inter-sectoral agglomeration effects. My estimates suggest the presence of both types, and that the latter are slightly stronger than the former.

Rapid technological progress has influenced the way firms and workers interact, and I also aim at assessing if, and how, this has affected the relative importance of agglomeration effects. Contrary to popular views, it is found that, if anything, location (agglomeration effects) has become more, not less, important.

In contrast to findings for other European countries, skill composition as a determinant of regional income variations is found to have declined in importance over time. Hence, high income appears to be an outcome of high activity density – agglomeration – rather than being due to differences in education and skills.

The paper is organized as follows. In section 2 I describe the nature of spatial income variations across Norwegian subregions and provide summary statistics for measures of regional employment density and education levels across regions. Section 3 presents the empirical model, and describes the data. The results are summarized in section 4, where I also consider the major problem related to analyses of productivity and agglomeration, the endogeneity problem, and eventually discuss and compare my estimates with those in earlier studies. Section 5 concludes.

[4] Rice and Venables note that one reason for this may be the fact that regional GDP is sensitive to the spatial allocation of profits and other non-wage income across the units of a multiplant firm.

2 Income, agglomeration and education: a regional perspective

Point of departure is the hypothesis that regional income disparities can be ascribed to regional productivity differences, which in turn are due to exogenous regional characteristics, skill composition of the workforce, and spatial externalities or agglomeration effects.

I start with a descriptive review of the data underlying the empirical analysis. The data are regionally distributed manufacturing data from Statistics Norway and the data set consists of 90 NUTS 4 subregional units, so called *economic regions*. Previous studies of regional income disparities in Europe have based their analyses on NUTS 3, see e.g. Ciccone (2002) and Rice and Venables (2004). However, I want to be able to compare my results to those achieved for other European countries, and this requires a data set of subregional units that is comparable to that used in earlier analyses. Working on the NUTS 4 level in Norway gives me a data set which is similar to NUTS 3 regions in larger EU countries in terms of (i) number of subregional units, and (ii) area of the subregional unit in square kilometers. As a consequence, the average population of each unit is but smaller than that of a NUTS 3 unit in a large EU country. This reflects the fact that Norway only has a population of 4-5 million.

Two different measures of income are considered: GDP per hour worked by employees and average hourly earnings. The latter measure has the advantage that it is not sensitive to the spatial allocation of profits and other non-wage income across the units of a multiplant firm.[5] Nor is it affected by differences in factor intensities such as capital intensity and land use. Data for two time periods,1989 and 1999, are employed. This allows us to assess whether the role played by agglomeration effects and education in determining spatial income differences has changed over time. There are at least two reasons to expect a change in the relative importance of these variables: First, rapid technological change and internationalization have affected ways of communication, interaction and transport, and thus the role played by location for productivity and income. Second, over the last decades there have been massive investments in education in Norway, leaving the country with one of the most educated populations in the OECD.

Tables 1a and 1b report values for the two income measures for 1989 and 1999. We see that the regional disparities are significant, and much more distinct if we focus on GDP per hour, rather than if we consider earnings per hour. In line with what has been observed in the EU (see e.g. Puga, 2002, and Rice and Venables, 2004), there are also signs of widening disparities if we look at GDP per hour. However, measured in terms of earnings, there has actually been a slight reduction in regional inequalities over the same period.

[5] This point is also made by Rice and Venables (2004).

Table 1a: Summary statistics for NUTS 4 regions: GDP per hour and Average hourly earnings, 1989

	GDP per hour worked	Average hourly earnings
Mean	0.181	0.120
Std. Deviation	0.065	0.016
Minimum	0.079	0.078
Maximum	0.422	0.160
Max/Min	5.3	2.1

Note: All value terms are in 1000 NOK.

Table 1b: Summary statistics for NUTS 4 regions: GDP per hour and Average hourly earnings, 1999

	GDP per hour worked	Average hourly earnings
Mean	0.273	0.185
Std. Deviation	0.081	0.023
Minimum	0.094	0.146
Maximum	0.707	0.249
Max/Min	7.5	1.7

Note: All value terms are in 1000 NOK.

Agglomeration economies may be generated by within- or between-sectors interactions (externalities). Depending on the source of the agglomeration economies, agglomeration effects may be measured by manufacturing employment density (intra-sectoral agglomeration effects), or overall employment density including all sectors in the economy (inter-sectoral agglomeration effects). Tables 2a and 2b report measures for both densities for 1989 and 1999. Not surprisingly, one can see that the ratio between the most densely and the least densely populated area is higher when focusing on the manufacturing sector only, than when taking all economic activity into account. But one can also observe that while regional disparities in manufacturing employment density have been slightly reduced, disparities in overall employment density have *grown* slightly (cf. the coefficient of variation reported in Tables 2a and 2b).

Table 2a: Summary statistics for NUTS 4 regions: Manufacturing density and Employment density, 1989

	Regional Manufacturing Density	Regional Employment Density
Mean	3989.0	17.07
Std. Deviation	13102.5	73.00
Minimum	22.3	0.273
Maximum	120064.5	665.54
Coefficient of variation	3.28	4.28

Table 2b: Summary statistics for NUTS 4 regions: Manufacturing density and Employment density, 1999

	Regional Manufacturing Density	Regional Employment Density
Mean	3762.3	20.14
Std. Deviation	10498.7	89.23
Minimum	17.2	0.276
Maximum	94087.5	817.72
Coefficient of variation	2.79	4.43

Note: Manufacturing density is measured as the ratio between manufacturing employment (in terms of man-hours) in a region and total land area of the region (in square kilometers). Employment density is the ratio between total employment (in terms of employees) in a region and the total land area of the region.

Expected to be an important determinant of productivity and income disparities is also the skill composition of the workforce. The educational data allow me to split regional populations into four groups according to their highest level of education:

(i) low skilled labor (with primary school only)
(ii) lower medium skilled labor (with secondary education)
(iii) higher medium skilled labor (with college or a lower university degree)
(iv) high skilled labor (with a higher university degree).

Comparison of the summary statistics in Tables 3a and 3b illustrates how massive investments in education have affected the skill composition of the Norwegian labor stock over the decade 1989-99. As a result the average regional share of the population with low skills only has fallen, while all other skill groups have increased their respective share. At the same time one observes that regional disparities in skill composition, measured e.g. by the coefficient of variation or by the ratio Maximum/Minimum for each of the skill groups, have fallen over the years 1989-99.

Table 3a: Summary statistics for NUTS 4 regions: Skill composition of the regional population, 1989

	Share of low skilled	Share of low med. skilled	Share of higher med. skilled	Share of high skilled
Mean	0.38	0.49	0.09	0.02
Std. Dev.	0.11	0.13	0.04	0.01
Minimum	0.06	0.04	0	0
Maximum	0.84	0.86	0.23	0.10

Table 3b: Summary statistics for NUTS 4 regions: Skill composition of the regional population, 1999

	Share of low skilled	Share of low med. skilled	Share of higher med. skilled	Share of high skilled
Mean	0.25	0.57	0.14	0.03
Std. Dev.	0.04	0.03	0.03	0.02
Minimum	0.11	0.47	0.08	0.01
Maximum	0.38	0.62	0.28	0.13

3 Explaining regional disparities

3.1 The empirical model

Next, let us turn to the empirical analysis of regional productivity and income disparities. The empirical model is based on Ciccone (2002), who lets the production function on an acre of land in region s contained in the larger region c be defined by

$$q = \Omega_{sc} f\left(nH, k; Q_{sc}, A_{sc}\right) \tag{1}$$

with q denoting output produced, or income earned, on the acre of land, n the number of workers employed on the acre, H the average level of human capital of workers employed on the acre, and k the amount of physical capital used on the acre, Ω_{sc} denotes an index of total factor productivity in the region, Q_{sc} total production and A_{sc} total acreage in the region. Spatial externalities are assumed to be driven by the density of production in the region, Q_{sc}/A_{sc}. Hence, spatial externalities generate agglomeration of activity, and enhance productivity. Letting N_{sc} depict employment in the region, from the general equation (1), the estimating equation

$$\begin{aligned} \log Q_{sc} - \log N_{sc} \quad = \quad & \text{Larger Region dummies} + \theta\left(\log N_{sc} - \log A_{sc}\right) \\ & + \sum_{e=1}^{E} \delta_e F_{esc} + u_{sc} \end{aligned} \tag{2}$$

can be derived.[6] The left-hand side variable denotes output or income per unit labor. u_{sc} captures differences between exogenous total factor productivity in region sc and the larger region that contains region sc. F_{esc} denotes the fraction of workers with education level e in region s contained in the larger region c, E gives the number of education levels, and δ_e the effect of education e on output or income per unit labor. The regional dummies are included to control for exogenous, region specific differences in total factor productivity and rental prices of capital across regions.

The model may then be further extended to allow for spatial externalities not only within regions, but also between regions. Allowing for spatial externalities from neighboring regions is done by assuming that total factor productivity in a region sc depends on the density of manufacturing production in neighboring regions:

$$\Omega_{sc} = \Phi_{sc} \left(\frac{Q_{scn}}{A_{scn}} \right)^{\mu} \tag{3}$$

Φ_{sc} denotes exogenous total factor productivity in region sc, and Q_{scn} and A_{scn} denote total production and total acreage in neighboring regions. Combining (2) and (3) gives

$$\begin{aligned} \log Q_{sc} - \log N_{sc} \quad = \quad & \text{Larger Region dummies} + \omega\mu \left(\log Q_{scn} - \log A_{scn} \right) \\ & + \theta \left(\log N_{sc} - \log A_{sc} \right) + \sum_{e=1}^{E} \delta_e F_{esc} + u_{sc}. \end{aligned} \tag{4}$$

Analogue to Rice and Venables (2004), I estimate (2) and (4) using the two alternative measures of income per worker presented in the previous section as left-hand-side variables: GDP per hour worked and average hourly earnings. I include regional dummies for NUTS 3 regions (of which NUTS 4 regions represent sub-regional units), and education controls with local labor stock split into the four educational groups defined in section 2. Intra-regional agglomeration effects are measured as man-hours in manufacturing divided by size of the area in square kilometers. Inter-regional agglomeration effects are measured using data for neighboring regions' value added and size of area in square kilometers.

Compared to earlier studies I extend the analysis to include two types of intra-regional agglomeration effects: intra-sectoral and inter-sectoral effects.[7] I let the former be measured by manufacturing employment density, and the latter by overall employment density including all sectors in the economy.

3.2 Data

All data are from Statistics Norway. Data on value added, labor compensation, number of hours worked, and employment are from the Manufacturing Time-

[6] See Ciccone (2002) and Hall and Ciccone (1996) for the detailed derivation of this relationship.

[7] In the literature on spatial externalities, intra-sectoral agglomeration economies are typically also referred to as localisation economies; while inter-sectoral agglomeration economies are referrred to as urbanisation economies.

series database. The database consists of plant level data for all Norwegian manufacturing firms, and these are aggregated up for each NUTS 4 region. Total employment, population and educational data are from the Regional Statistics database, and so are data on the size of subregional units in square kilometers. The analysis is based on two different points in time, the year 1989 and the year 1999. All data are accordingly assembled for these two years.

4 Results

4.1 Intra-sectoral agglomeration effects

Table 4a reports the OLS estimates for intra-sectoral agglomeration effects for 1989 taking as dependent variable the log of each of the two income measures; GDP per hour worked and average hourly earnings. Columns 2 and 4 report the estimates for equation (2), i.e. for the model without inter-regional externalities, while columns 3 and 5 report the estimates for equation (4), where also inter-regional externalities are taken into account. Table 4b reports the analogue evidence for the year 1999.

Let us start by considering the results for the model without inter-regional externalities. It appears that the specification using average hourly earnings as the dependent variable is better determined than the one using GDP per hour worked. In 1989 there is a significant positive relationship between manufacturing employment density and income, regardless of income measure. But in 1999, there is only a significant positive relationship between earnings and manufacturing employment density. Moreover, with GDP per hour as dependent variable the estimated model is able to explain 47 percent (1989) and 38 percent (1999) of the variation in income across regions. With earnings as dependent variable the estimated model explains more than 70 percent of the variation in regional income. The elasticity of earnings with respect to manufacturing employment density is 3.6 percent in 1989 as well as in 1999.

Regarding the education controls, these only have a significant impact on earnings, and not on GDP per hour. And even the relationship between earnings and education is only significant in 1989, while it appears to have vanished in 1999. The estimates indicate that in 1989 there is a positive relationship between earnings and the fraction of the population with qualifications above primary school (low skills)

Considering the model with inter-regional agglomeration effects, it appears that regardless of choice of dependent variable and year, there is no evidence of inter-regional effects.[8] Intra-regional agglomeration effects remain unaffected by the inclusion of inter-regional effects, and nor is the percentage of variation in income explained by the model altered by the inclusion of inter-regional effects.

[8] One exception being the model with GDP per hour worked as dependent variable for the year 1999. In this case there is no evidence of intra-regional agglomeration, while manufacturing production density in neighbouring regions appears to have a negative significant effect on income. But this effect is only significant at the 10 percent level.

Table 4a: Intra-sectoral agglomeration effects, NUTS-4 regions, 1989, OLS

Dependent variable	Ln(GDP per hour worked)		Ln(Average hourly earnings)	
Ln (Manufacturing density)	0.068	0.068	0.036	0.036
	(2.20)	(2.17)	(4.68)	(4.62)
Ln (% of population with	0.092	0.092	0.095	0.095
higher medium level of education)	(1.12)	(1.11)	(3.30)	(3.28)
Ln (% of population with	0.049	0.048	0.038	0.039
lower medium level of education)	(1.03)	(1.03)	(2.73)	(2.75)
Ln (% of population with	0.057	0.057	-0.076	-0.076
low level of education)	(0.57)	(0.57)	(-2.24)	(-2.22)
Ln (Neighboring regions		-0.002		0.004
manufacturing density)		(-0.06)		(0.34)
Regional dummies	Yes	Yes	Yes	Yes
R-squared	0.47	0.47	0.73	0.73
Number of observations	87	87	87	87

Note: Figures in parentheses are t-ratios based on White robust standard errors.

Table 4b: Intra-sectoral agglomeration effects, NUTS-4 regions, 1999, OLS

Dependent variable	Ln(GDP per hour worked)		Ln(Average hourly earnings)	
Ln (Manufacturing density)	0.042	0.045	0.036	0.036
	(1.35)	(1.46)	(4.72)	(4.85)
Ln (% of population with	-0.073	-0.171	0.049	0.036
higher medium level of education)	(-0.24)	(-0.53)	(0.50)	(0.33)
Ln (% of population with	0.121	0.053	0.077	0.068
lower medium level of education)	(0.17)	(0.07)	(0.34)	(0.29)
Ln (% of population with	-0.376	-0.477	-0.174	-0.187
low level of education)	(-1.10)	(-1.33)	(-1.66)	(-1.64)
Ln (Neighboring regions		-0.068		-0.009
manufacturing density)		(-1.75)		(-0.75)
Regional dummies	Yes	Yes	Yes	Yes
R-squared	0.38	0.41	0.71	0.71
Number of observations	90	90	90	90

Note: Figures in parentheses are t-ratios based on White robust standard error.

4.2 Inter-sectoral agglomeration effects

Spatial externalities or agglomeration effects may arise from activity within the same sector or from other sectors. In order to address the latter, I analyze the

role played by the overall employment density in a region rather than just the density of manufacturing activity.

Estimation results for the two alternative income measures are reported in Tables 5a and 5b for 1989 and 1999 respectively. The findings on inter-sectoral agglomeration economies are very similar to those on intra-sectoral agglomeration economies presented above: I find a positive significant relationship between overall employment density and earnings in both 1989 and 1999, while no significant relationship appears to exist between employment density and GDP per hour. The elasticity of earnings with respect to overall employment density rises from 2.9 percent in 1989 to 3.3 percent in 1999 – indicating that inter-sectoral agglomeration effects have become more important over the decade.

Comparing the evidence for intra- and inter-sectoral agglomeration effects, the former type of agglomeration effects appears somehow stronger than the latter. The elasticity of earnings with respect to manufacturing employment density is higher and more significant than the elasticity of earnings with respect to overall employment density. The model with manufacturing employment density, NUTS 3 dummies, and educational controls also explains a slightly greater share of the variation in earnings than the model with overall employment density, NUTS 3 dummies, and education controls.

Table 5a: Inter-sectoral agglomeration effects, Nuts-4 regions, 1989, OLS

Dependent variable	Ln(GDP per hour worked)		Ln(Average hourly earnings)	
Ln (Employment density)	0.052	0.052	0.029	0.029
	(1.22)	(1.21)	(2.21)	(2.18)
Ln (% of population with higher medium level of education)	0.101	0.101	0.097	0.097
	(1.12)	(1.11)	(2.94)	(2.91)
Ln (% of population with lower medium level of education)	0.053	0.053	0.040	0.041
	(1.16)	(1.17)	(2.89)	(2.93)
Ln (% of population with low level of education)	0.041	0.052	-0.076	-0.076
	(0.47)	(0.46)	(-1.87)	(-1.84)
Ln (Neighboring regions manufacturing density)		0.001		0.005
		(0.05)		(0.49)
Regional dummies	Yes	Yes	Yes	Yes
R-squared	0.44	0.44	0.68	0.68
Number of observations	87	87	87	87

Note: Figures in parentheses are t-ratios based on White robust standard errors.

Table 5b: Inter-sectoral agglomeration effects, Nuts-4 regions, 1999, OLS

Dependent variable	Ln(GDP per hour worked)		Ln(Average hourly earnings)	
Ln (Employment density)	0.025	0.027	0.033	0.033
	(0.61)	(0.67)	(2.91)	(2.95)
Ln (% of population with	-0.015	-0.103	0.046	0.037
higher medium level of education)	(-0.05)	(-0.30)	(0.43)	(0.32)
Ln (% of population with	0.058	-0.011	0.077	0.070
lower medium level of education)	(0.08)	(-0.01)	(0.32)	(0.28)
Ln (% of population with	-0.333	-0.425	-0.161	-0.171
low level of education)	(-0.97)	(-1.16)	(-1.48)	(-1.43)
Ln (Neighboring regions		-0.064		-0.006
manufacturing density)		(-1.62)		(-0.49)
Regional dummies	Yes	Yes	Yes	Yes
R-squared	0.37	0.39	0.67	0.68
Number of observations	90	90	90	90

Note: Figures in parentheses are t-ratios based on White robust standard errors.

4.3 Endogeneity

The major problem attached to any analysis of the role played by agglomeration for productivity and income, relates to the fact that it is very hard to distinguish between two possible explanations for a positive relationship between productivity and agglomeration. Productivity and income may be high because of agglomeration effects – which is the underlying assumption of the present analysis. But, agglomeration may (in turn) be a consequence of high productivity and income due to e.g. positive regional specific shocks that attract firms and workers to an area. This potential reverse-causality may bias the estimate of agglomeration effects upward, and represents a potentially serious concern for the estimation.

My approach to this problem is to include regional fixed effects, and instrument for the regional density variables using population density of the respective regions for 1951. In line with the estimation equations (2) and (4) regional fixed effects are already included in the OLS estimation through dummies for NUTS3 regions. Choice of instrument relies on the assumption that the instrumental variable represents an exogenous regional characteristic that has lasting influence only on localization decisions (and thus on agglomeration), but not on today's productivity and income. Spatially lagged population density fulfils this requirement, and has also been used by Ciccone and Hall (1996) and Combes et al (2004) in their regional income analyses. Ideally, one could argue that an even longer spatial lag would have been preferable, but no data were available for any period earlier than 1951.

To get a sense of the quality of 1951 population density as an instrument one can regress the regional density measures (manufacturing density and overall

employment density) for 1989 and 1999 on the 1951 population density while controlling for larger region fixed effects (i.e. by including the NUTS 3 regional dummies). The coefficient on 1951 population density is significant at the 1 percent level in all cases. R-square of the regressions is between 92 and 96 percent. Dropping 1951 population density from the regressions reduces the R-squares to 59 for both years and density measures.

Carrying out the same test for neighboring regions' manufacturing density with an analogue instrument variable based on neighboring regions' population density in 1951, a positive significant relationship is also found. R-square of these regressions is 92 percent for 1989 and 94 percent for 1999, and drops to 76 percent for both years once neighboring regions' population density in 1951 is dropped.

Tables 6a and 6b report two-stage-least squares (2SLS) estimates of equation (4) for intra-sectoral and inter-sectoral agglomeration effects respectively. The 2SLS estimates of intra-regional and inter-regional agglomeration effects are lower than the OLS estimates. This indicates the presence of an endogeneity problem when estimating the relationship using OLS. However, the positive significant relationships found to exist between earnings and intra- as well as inter-agglomeration effects remain when using instruments.

Employing 2SLS to deal with the endogeneity problem, we observe that the magnitude of the intra-sectoral agglomeration effects are reduced from 3.6 percent to 2.0 percent in 1989, and from 3.6 percent to 2.5 percent in 1999. As for inter-sectoral agglomeration effects, these decline from 2.9 percent to 2.4 percent in 1989, and from 3.3 percent to 2.8 percent in 1999. This suggests that the endogeneity problem is more present in the analysis of intra-sectoral agglomeration effects, than in the analysis of inter-sectoral agglomeration effects.

Comparing the results for the two types of agglomeration effects also makes clear that not accounting for endogeneity may lead to incorrect conclusions regarding their relative magnitude. While the OLS estimates suggested that intra-sectoral agglomeration effects were stronger than inter-sectoral agglomeration effects, the 2SLS estimates lead to the reversal of this conclusion.

Table 6a: Intra-sectoral agglomeration effects, Nuts-4 regions, 2SLS

Dependent variable	Ln(GDP per hour worked)		Ln(Average hourly earnings)	
Year	1989	1999	1989	1999
Ln (Manufacturing density)	0.035	0.014	0.020	0.025
	(0.92)	(0.42)	(1.75)	(2.37)
Ln (% of population with	0.135	-0.058	0.115	0.086
higher medium level of education)	(1.57)	(-0.17)	(3.84)	(0.77)
Ln (% of population with	0.056	-0.088	0.042	0.025
lower medium level of education)	(1.15)	(-0.11)	(2.85)	(0.11)
Ln (% of population with	0.014	-0.417	-0.096	-0.155
low level of education)	(0.13)	(-1.13)	(-2.70)	(-1.36)
Ln (Neighboring regions	0.039	-0.075	0.020	-0.004
manufacturing density)	(0.86)	(-1.41)	(1.21)	(-0.31)
Regional dummies	Yes	Yes	Yes	Yes
R-squared	0.44	0.36	0.69	0.68
Number of observations	86	89	86	89

Note: Figures in parentheses are t-ratios based on White robust standard errors.

Table 6b: Inter-sectoral agglomeration effects, NUTS-4 regions, 2SLS

Dependent variable	Ln(GDP per hour worked)		Ln(Average hourly earnings)	
Year	1989	1999	1989	1999
Ln (Employment density)	0.045	0.016	0.024	0.028
	(0.90)	(0.41)	(1.64)	(2.25)
Ln (% of population with	0.120	-0.070	0.105	0.065
higher medium level of education)	(1.23)	(-0.20)	(3.03)	(0.54)
Ln (% of population with	0.058	-0.073	0.043	0.053
lower medium level of education)	(1.20)	(-0.09)	(2.96)	(0.21)
Ln (% of population with	0.036	-0.417	-0.084	-0.154
low level of education)	(0.31)	(-1.12)	(-1.99)	(-1.31)
Ln (Neighboring regions	0.044	-0.074	0.022	-0.002
manufacturing density)	(0.95)	(-1.40)	(1.30)	(-0.15)
Regional dummies	Yes	Yes	Yes	Yes
R-squared	0.42	0.35	0.66	0.65
Number of observations	86	89	86	89

Note: Figures in parentheses are t-ratios based on White robust standard errors.

4.4 Discussion of results

The results on agglomeration economies as source of regional income disparities in the Norwegian manufacturing sector are in line with those of recent analyses

of regional inequalities in the EU and US. Hence, agglomeration of economic activity appears to be an important determinant of regional variation in productivity and income in Norway. Similarly to Rice and Venables (2004) and Combes et al (2004) I find a positive significant relationship between earnings and employment density – both when focusing on density of activity within the manufacturing sector as well as when considering overall employment density including all economic sectors. Ciccone (2002) and Hall and Ciccone (1996) find a positive significant relationship between value added per worker and employment density, while my data do not confirm such a relationship.

Why are the findings on agglomeration effects sensitive to what income measure that is used as dependent variable? One rather likely reason for this, is that earnings provide a more accurate measure of labor productivity than does GDP per hour worked. Unlike the latter, a measure based on earnings is not affected by differences in capital intensity and land use, nor by spatial allocation of non-wage income across plants.

As for the magnitude of agglomeration effects, the estimates here are somehow lower than those found in most of the previous literature. Accounting for endogeneity our coefficients on employment density lie in the range between 2.0 and 2.8 percent, depending on year and type of employment density (manufacturing versus overall). This is in line with the findings of Combes et al (2004) and Rice and Venables (2004), but below the estimates of Ciccone and Hall (1996), Ciccone (2002) and Rosenthal and Strange (2004).[9]

Unlike most other recent studies of spatial income disparities and agglomeration, I have aimed at shedding some light on the role played by two different types of agglomeration effects. The first are intra-sectoral agglomeration effects (localization economies), and the second are inter-sectoral agglomeration effects (urbanization economies). As income data are for the manufacturing sector, I let the former effects be measured by density of manufacturing employment, and the latter by density of overall employment including all sectors. Accounting for endogeneity problems, the findings suggest that the magnitude of the two types of agglomeration effects is very alike. If anything, inter-sectoral agglomeration effects appear to be more important than intra-sectoral effects. This is contrary to the findings of Combes et al (2004) who also address the issue of localization versus urbanization economies. They find that both are important, but that only the latter matter quantitatively. There are a set of possible reasons for the discrepancy in results. First, Combes et al's approach to the measurement of localization economies is significantly different from mine. Second, the French industrial structure is rather different from the Norwegian industrial structure, and types of local interactions may thus vary accordingly.

The analysis of inter-sectoral agglomeration economies is less vulnerable to the kind of criticism that analyses of intra-sectoral agglomeration economies easily face. One may argue that when employment density is used as a measure

[9] Ciccone (2002) reports an elasticity with respect to employment density equal to 4.4, Rice and Venables (2004) report an elasticity of 2.8 percent; Rosenthal and Strange (2004) indicate a range of 3 to 8 percent; and Combes et al (2004) find an elasticity of just below 2 percent when they analyse individual data instead of aggregated data (as is done in the other studies).

of agglomeration economies, one cannot really distinguish between internal and external economies of scale. Hence, evidence on agglomeration economies only allows us to conclude on the presence of economies of scale, and not on the presence of externalities. This problem is clearly less severe when inter-sectoral and inter-regional agglomeration effects are analyzed.

Due to the rapid technological change witnessed over the last decades, one may expect the interactions among firms and workers that give rise to spatial externalities and agglomeration effects to have changed in nature and magnitude. In order to address this issue, I have examined agglomeration effects at two points in time; 1989 and 1999.[10] The analysis suggests that both intra-sectoral and inter-sectoral agglomeration effects have grown more important over time. Contrary to the popular view that technological development has made location irrelevant, my results indicate that location may actually matter more than ever.

But while intra-regional agglomeration effects appear to have become more important as a determinant of income over time, the opposite applies to the skill composition of the workforce. Rather surprisingly, when compared to previous studies in the area, it is found that the skill composition becomes less important over time. In 1989 skill composition of the local labor stock has a significant impact on earnings. This is no longer so in 1999. Hence, unlike for instance in France, where a larger share of the spatial variations in earnings can be ascribed to skills than to agglomeration economies (see Combes et al, 2004), in Norway "place of location" and agglomeration effects turn out to matter more for earnings than does education. One source of this discrepancy between the results for Norway relative to other European countries may be that the analysis for Norway focuses on earnings in the manufacturing sector only, while other studies consider earnings in the business sector. However, another explanation – supported by international studies of skill premia – relates to international differences in returns to education: Harmon et al's (2003) calculations of returns to education, show that the skill premium in Norway is merely half of that paid in other European countries such as France and the UK – a fact that in turn may be explained by the massive investment in education over the last decades, as well as the emphasis on horizontal equality that characterizes the Norwegian society.

Earlier studies have also examined the role played by inter-regional spatial externalities (agglomeration effects). Ciccone (2002) finds significant positive inter-regional effects among NUTS 3 regions. Rice and Venables (2004) report that neighboring NUTS 3 regions within 60 minutes' travel time of an area, have a positive and significant impact on regional income. In contrast, the estimates reported here do not suggest that inter-regional effects play any role in explaining regional income variations in Norway. However, the above analyses are based on EU (or UK) NUTS 3 regions with boundaries determined by administrative rather than economic considerations, while the present study is based

[10] The choice of 1999 is due to the fact that this is the last year for which the required data are available.

on data for NUTS 4 regions that are not constructed on an administrative basis alone. When defining the NUTS 4 regions Statistics Norway exploits economic information on trade, product and labor markets. In particular information provided by commuting tables is being used. This implies that also a priori, there would be less reason to expect activity density in neighboring regions to have an impact within the framework of a Norwegian regional analysis.

5 Concluding Remarks

In this paper I have sought to shed some light on the source of regional income inequalities in Norway. In particular I have wanted to focus on the role played by the agglomeration of economic activity for regional disparities in productivity and income. It is found that agglomeration economies are important determinants of regional variations in income. The empirical evidence for Norway moreover indicates that agglomeration effects are relatively more important for earnings than is education. This stands in sharp contrast to empirical evidence for other European countries, e.g. France, where skills appear to be significantly more important than agglomeration effects.

The relative importance of the determinants of regional disparities appears to have changed over the last years. As a consequence, location and agglomeration economies appear to have become more important for earnings, while education has become less so.

The reported results have important implications for regional policy. It means that impeding the agglomeration of activity in order to encourage dispersion and equality, hurts productivity. Moreover, the damage caused by such policy initiatives may actually be worse today than a decade or two ago. In order to reduce regional income inequalities concentrating on the development of regional agglomerations of activity instead of spreading resources out to each and every subregion appears to be the right way to proceed.

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