Variety, Employment and Regional Development in the Netherlands

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Abstract

We explain employment growth in 40 Dutch regions for the period 1996-2002. Our main interest is to test the effect of sectoral variety using data on five-digit sector employment, while controlling for traditional variables. Our measure of variety is entropy, as this measure allows for decomposition of variety into related and unrelated variety. We distinguish between related and unrelated variety effects. Related variety is associated with Jacobs externalities (spillovers), while unrelated variety tests portfolio advantages. We also take into account the effect of specialisation on employment growth. The results suggest that only related variety significantly contributes to employment growth. The popular dichotomy between variety and specialisation may thus be misleading. Our study underlines the more recent concept of "diversified specialisations" as central driver of growth.

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1. Introduction

The relationship between variety[1] and economic development has been a neglected research area in economics. For long, economic theory has been focused on explaining economic growth by a combination of growth in inputs and efficiency improvements. The underlying qualitative nature of economic development, for example, in terms of the variety of sectors or the variety of technologies, has been addressed only rarely.

One can distinguish between at least two types of relationships between variety and economic development, one based on the spillover concept and one based on the portfolio concept.[2] The first approach centres on variety, spillovers and growth, which has become a central theme in what is called new growth theory. It has been argued that, apart from spillovers occurring between firms within a sector, spillovers also occur between sectors. Following this argument, the present variety in an economy can be an additional *source* of economic growth (Jacobs 1961; Van Oort 2004). This means that not only the stock of inputs affects growth, but the precise composition in qualitative sense as well. Only some technologies or sectors are complementary in that their joint presence within an economy causes additional growth. And, since spillovers are geographically bounded, differences in regional growth should be related to qualitative differences in an economy's composition at the regional level. A region specialising in a particular composition of complementary sectors will experience higher growth rates than a region specialising in sectors that do not complement each other.

A second way to relate variety to regional economic development, and more specifically, to unemployment, is to view variety as a portfolio strategy to protect a region from external shocks in demand (Attaran 1985). In this context, one also speaks of regional diversification analogous to corporate diversification as a risk spreading strategy. A high sector variety of a regional economy implies that a negative shock in demand for any of these sectors will have only mild negative effect on growth and employment. By contrast, a region specialising in one sector, or a group of sectors with correlated demand, runs the risk of serious slowdown in growth and high rates of unemployment as a result of a demand shock.

The two approaches are not mutually exclusive, and can thus be considered complementary. The different views relate variety either to the economy's supply-side, or demand-side. The spillover approach argues that variety can be an additional *supply* source of economic growth, while the portfolio approach views variety as a buffer from external shocks in sectoral *demand*. Another issue, closely related yet analytically distinct from the issue of variety and regional growth, is the relationship between variety and urbanisation. There is a wide agreement that variety is positively related to the degree of urbanisation, the reason being that a variety of products and sectors can only be sustained with sufficient local demand, both for intermediate inputs and final products. Urbanisation being positively related to variety, and variety being positively related to economic growth, urbanisation will generally have a positive impact on economic growth. However, it is important to distinguish, both theoretically and empirically, between urbanisation as a source of economic growth and variety *per se* as a source of economic growth (that is, when controlling for urbanisation).

Below, we first discuss the spillover theories (*section 2*) and portfolio theory (*section 3*).[3] The entropy measure, which we use to indicate variety at different levels of sector

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[1] We prefer to use the term variety rather than diversity, as diversity is closely linked to biology, while variety is the common term in economics. By variety we mean sector variety, unless stated otherwise.

[2] Frenken et al. (2004) also mention a third, evolutionary approach, which argues that an increase in variety is a prerequisite for long term growth and full employment. This approach is not taken into consideration here.

[3] A survey of previous empirical research on variety and regional development is given by Frenken et al. (2004). Other reviews are available from Feser (2002), Parr (2002), Dissart (2003), Fingleton (2003) and Van Oort (2004).

aggregation, is discussed next (*section* 4). Then, we present our research design (*section 5*) and discuss the outcomes (*section 6*). At last we end with conclusions (*section 7*).

2. The economics of agglomeration

2.1 New growth theory

The important role of spillovers in explaining economic growth is central to a family of economics models headed under the label of new growth theory. The 'new' is to be understood with reference to the standard growth model developed by Solow (1957) and others. In this older view, the economy is represented by a production function transforming inputs into outputs. The growth of an economy can then be related to a combination of (i) the growth of inputs such as capital, labour and land which lead to a growth in output, and (ii) technological change that increases the efficiency with which inputs are transformed into outputs. Technological change is treated as being dependent solely on time. The rate or nature of technological change underlying the process of economic growth is not addressed in these models.

During the late eighties, it was acknowledged that the Solow-type of growth accounting lacks a theory of innovation (Romer 1986, 1990; Lucas 1988). The determinants of technological change became subject of further theorising, which led to the advent of new growth models. These models include education, Research and Development or learning-by-doing as additional inputs affecting growth. Knowledge has come to be regarded as a core input in economic growth, and, economies have come to be considered as 'knowledge economies'. Importantly, the market structure is assumed to affect growth as well, because monopolistic firms facing less competition will invest more in R&D as they are better able to appropriate the rents of R&D.

Since, debates in economic growth theory have shifted from material to immaterial inputs, and, in particular, to the positive externalities arising from knowledge spillovers (Jaffe 1986; Griliches 1992). And, as spillovers imply the possibility of under-investment in knowledge (as firms recognise the danger of knowledge leaking towards competitors), government policy increasingly focused on providing subsidies for R&D. Related to this, recent policy discourse centres on potential spillovers between public research institutions and the business sector, both in Europe and in the United States.

2.2 Agglomeration economies

A research area that is related to the new growth theory, though it is only partially overlapping, concerns the economics of agglomeration. In its crudest form, this field of research aims to explain the spatial distribution of economic activity, and changes herein over time. The core idea underlying the economics of agglomeration holds that clustering of economic activity occurs because firms experience some form of benefit from locating near one another. One of the reasons for firms to cluster, is the existence of positive spillovers between firms that are located nearby. There is evidence that knowledge spillovers are indeed geographically localised at a regional level (Jaffe 1989; Jaffe et al. 1993; Audretsch and Feldman 1996). This means that firms profit most from spillovers if they are located near to the other firms or public research institutions producing the knowledge.

Before going into the debate about the causes of spillovers, it is useful to give a broader definition of agglomeration economies, and to distinguish between different types of agglomeration economies. A broad definition of *agglomeration economies* is that it concerns those external economies from which a firm can benefit by being located at the same place as one or more other firms. Many standard textbooks on economic geography and urban economics have incorporated the distinction between localisation and urbanisation economies. Localisation economies differ from urbanisation economies in that localisation economies are associated with benefits for firms that arise when locating near to other firms in the same industry, while urbanisation economies are associated with benefits for firms that arise when locating near to firms irrespective of their activity. Urbanisation economies are, therefore, also viewed as being a function of the population density in general, hence the term urbanisation. The distinction between localisation and urbanisation economies links to a threefold classification, which goes back to Hoover (1948) and Isard (1956), in which the sources of agglomeration advantages are grouped together as:

(1) *Internal increasing returns to scale*. These may occur to a single firm due to production cost efficiencies realised by serving large markets. There is nothing inherently spatial in this concept other than that the existence of a single large firm in space implies a large local concentration of factor employment,

(2) External economies available to all local firms within the same sector: *localisation economies*,

(3a) External economies available to all local firms irrespective of sector: *urbanisation economies.*

(3b) External economies available to all local firms stemming from variety of sectors: *Jacobs externalities.*

Localisation economies usually take the form of what are called Marshallian (technical) externalities whereby the productivity of labour in a given sector in a given city is assumed to increase with total employment in that sector. Marshallian externalities arise from three sources: labour market pooling, creation of specialised suppliers, and the emergence of technological knowledge spillovers (Henderson 2003; Feser 2002). The above classification of the sectoral range of economies cuts across Marshall's functional typology, with each of his potential sources of externalities potentially obtaining within one or more groups of sectors (Gordon and McCann 2000; Duranton and Puga 2000). The strength of local externalities is thus assumed to vary, so that these are stronger in some sectors and weaker in others. Localisation economies apply when the industry to which the firm belongs (rather than the firm itself) is large. Under further assumptions on crowding (congestion costs that increase with population triggers dispersion), perfect product and labour mobility within and between locations and the influence of large agents, the urban system is composed of (fully) specialised cities, provided that the initial number of cities is large enough (Henderson 1974; Richardson 1973).

Urbanisation economies reflect external economies passed to enterprises as a result of savings from the large-scale operation of the agglomeration or city as a whole, independent from industry structure (3a). Relatively more populous localities, or places more easily accessible to metropolitan areas, are also more likely to house universities, industry research laboratories, trade associations and other knowledge generating organisations. It is the dense presence of these organisations (not solely economic in character, but also social, political and cultural) that support the production and absorption of know-how, stimulating innovative behaviour, and contributes to differential rates of interregional growth (Harrison *et al.* 1997).

The diverse industry mix in an urbanised locality also improves the opportunities to interact, copy, modify and recombine ideas, practices and technologies in the related or unrelated industries (3b). The functional specialisation of firms in heterogeneous industries in close proximity of each other is supposed to generate spatial interdependencies and generates benefits (and costs such as congestion) for everyone in that specific location (Quigly 1998). Thus, variety in itself may be an extra source of knowledge spillovers and innovation. As this was first suggested by Jacobs (1961), this type of agglomeration economies is often referred to as Jacobs externalities.

2.3 Variety, economies of scale, and division-of-labour

To disentangle the different sources of agglomeration economies analytically, it is useful to go into the relationship between variety and economies of scale more deeply. Traditionally, variety in the economics literature has been referred to as the number of variants within a specific *product group*. The debate in this area addressed the relationship between product differentiation, market structure, economies of scale and consumer welfare within a neoclassical framework of complete information and equilibrium analysis.[4]

Two traditions of thought, going back to Chamberlin (1933) and to Hotelling (1929), have given rise to this literature. Chamberlin stressed differentiation and limited substitutability of products within an industry/product group, and the effects it would have on competition, by giving each firm a degree of monopoly (called monopolistic competition). Hotelling examined product differentiation from a strategic perspective, now better known as game theory, addressing the problem of where different sellers of a given commodity would locate in a one-dimensional space (e.g. a street or a product characteristic). In this case the growing dispersion of sellers would imply a greater product differentiation or variety. Interestingly, the two core models on product variety reach different conclusions. From a welfare perspective, Chamberlin's model of monopolistic competition would lead to an excessive variety, each firm monopolising a different niche, while according to Hotelling's model, too little differentiation would take place as each firm 'moves to the middle'. Though outcomes of equilibrium models on product variety may sometimes be sensible to the specific assumptions made, for example, regarding the market structure,[5] a number of conclusions seem quite robust. In particular, product variety in equilibrium will be greater (Saviotti 1996, pp. 100-101):

1. the smaller the economies of scale;
2. the lower the substitutability of goods within the group and with outside goods;
3. the width of the market (the degree of dispersion of preferences)
4. the depth of the market (density of consumer purchasing power for each variant)

The inverse relationship between variety and scale economies is also underlying the idea of agglomeration economies stemming from regional specialisation, though the relationship here is a more subtle one. As for a single firm specialising on the production of one product variant allowing for a greater division of labour *within the firm*, agglomeration economies stem from a region specialising on one sector allowing for a greater extent of division-of-labour *among firms*. The finer degree of specialisation among firms corresponds to the two classical Marshallian sources of agglomeration, that of specialised suppliers and specialised labour. In both cases, the benefits from clustering stem from a greater division-of-labour (among suppliers and among labour) such that inputs are more efficiently transformed into outputs. Note that in the hypothetical absence of transport costs, such benefits fade away as specialised suppliers and specialised labour would then be available for all regions.

2.4 New economic geography

When we introduce the distinction between urban and rural areas, one can understand that urban regions harbouring wider and deeper markets, as defined above, also allow for a greater variety of goods being produced. As long as transport costs are important, one expect a

[4] Some of this equilibrium-based economic literature recently introduces geographical space in its analytical framework (e.g., Murata 2003).

[5] Several neo-Chamberlin (Dixit and Stiglitz 1977) and neo-Hotelling (Eaton and Lipsey 1975; Lancaster 1979) models arrive at different results using different assumptions.

greater variety of products to be produced in the vicinity of wider and deeper markets. Thus, one can expect a greater variety of goods to be produced in urban regions compared to rural areas.

Using a neo-Chamberlin set-up, product variety in cities is also underlying the 'new economic geography' models, pioneered by Krugman (1991) and elaborated by, among others, Brakman et al. (2001) and Fujita and Thisse (2002). In these models, consumers are willing to accept higher cost-of-living in cities in order to be close to a large variety of goods as the presence of variety increases the chances of preferences being met more accurately (called the *love-of-variety effect*). At the same time, it pays for firms to locate near consumers as to minimise transport costs to final markets. Automatically, this also implies that firms optimise internal economies of scale, as they produce on one location only. In this way, a typical equilibrium is characterised by complete clustering of all firms and consumers in one city (the core) with only sectors using immobile inputs, such as agriculture and tourism, being located outside the agglomeration (the periphery).

2.5 Spillovers

From the previous discussion, we understand that variety is typically greater in urban areas than rural areas. The presence of wider and deeper markets, as well as the opportunities for internal economies of scale, explains that firms and consumers prefer locating in one central city leaving the hinterland for agriculture and tourism. Following the reasoning of the new economic geography, variety is solely an *outcome* of the decisions of economic agents to cluster, and is not regarded as a source of economic growth. More specifically, the new economic geography models do not take into account geographically localised spillovers (or, non-pecuniary externalities in general), which would account as an additional, or even alternative explanation for urbanisation to occur. An important reason for firms to cluster, is the existence of positive spillovers between firms (and research institutions) that are located nearby. Evidence has been accumulating that suggests that knowledge spillovers are indeed geographically localised at a regional level (Jaffe 1989; Jaffe et al. 1993; Audretsch and Feldman 1996). This means that firms profit most from spillovers if they are located near the actor from which the knowledge originates.

If one accepts, following the new growth theory, that spillovers are an important source of urban and regional economic growth, an important empirical question holds whether these spillovers occur primarily when a region is specialised in few sectors (localisation economies), or diversified into a large variety of sectors (Jacobs externalities), or whether it is primarily related to city size as such (urbanisation economies). In principle, all three types of agglomeration economies can occur as a result of spillovers, as a firm can learn from firms in the same industry (localisation economies), from firms in other industries (urbanisation economies), or from a concentration of actors other than firms, including consumers, universities, and governments[6] (urbanisation economies).

Focusing on the question whether regional growth benefits most from localisation economies or Jacobs externalities, the issue at hand is one of composition. As the amount of spillovers differs, both within each sector, and between each pair of sectors, the question is which precise composition of sectors in a regional economy creates most spillovers. Ideally, a regional economy is specialised in a limited number of sectors (as to profit from localisation economies), while the sectors in question are 'related' in that R&D investment in one sector spills over to other sectors.

The distinction between the different sources of spillovers bears important implications on theorising, because different types of spillovers are expected to lead to qualitatively different types of benefits. Localisation economies are expected to spur incremental innovation and process innovation, as the knowledge that spills over originates from similar firms producing similar products. The impact of localisation economies is thus expected to lie primarily in

[6] The importance for firms to interact with actors other than firms to innovate successfully underlies the concept of (regional) innovation system (Freeman, 1987; Braczyk et al. 1998).

productivity increases. By contrast, Jacobs externalities are expected to facilitate more radical innovation and product innovation as knowledge and technologies from different sectors are recombined leading to complete new products or technologies (compare Schumpeter's concept of 'Neue Kombinationen'). And, since radical innovations and product innovation lead to the creation of new markets and employment, rather than productivity increases, their impact may be very different from the incremental and process innovations caused by localisation economies (see more on this, Frenken et al. 2004). In the context of our empirical research question dealing with the determinants of employment growth, we expect variety to contribute positively to employment growth.

3. Portfolio theory

3.1 Corporate diversification

As outlined in the introductory chapter, a second theory relating variety to economic growth concerns portfolio theory. The concept of portfolio stems from the business economics. It is usually applied to the valuation of a collection of assets, or to the impact of product diversification on corporate profitability and growth. Whatever the context of application, the concept of portfolio amounts to saying that variety reduces risk. Placing bets on more than one horse reduces the risk of high losses (although it also reduces the probability of high profits).

The extent to which a portfolio reduces risk is dependent upon the correlation between economic outcomes associated with each of the elements within a portfolio. For example, a firm that diversifies its sales into twenty different products with correlated demand (say, twenty different holiday destinations in Greece) will not substantially reduce the risk of going bankrupt, as a sudden fall in demand will hit all twenty products. By contrast, a firm that diversifies into only ten different products with uncorrelated demand, will be more effective in reducing risk, as a fall in demand in one product is most likely to be compensated by a rise in demand for another product.

Though diversifying into products with uncorrelated demand is preferable as a risk reducing strategy, the economies of scope[7] will generally, though not necessarily, be lower in a portfolio with uncorrelated demand compared to economies of scope in a portfolio with correlated demand. Thus, diversification into related products is often more rewarding for firms as a firm's core competencies can be better exploited. This hypothesis is in accordance to the resource-based and evolutionary theory of the firm that both explain growth through diversification as being motivated by utilising excess capacity of resources, including knowledge specific to the firm, and by exploiting economies of scope (Montgomery 1994). Ideally, a firm diversifies into products that are related (to exploit economies of scope), while uncorrelated, or negatively correlated, in terms of demand.

3.2 Regional diversification

The sector composition of a regional economy can be approached in a way analogous to corporate diversification in product portfolio's. Regional variety can be considered as a portfolio strategy to protect regional income from sudden sector-specific shocks in demand (also called asymmetric shocks that hit only one or few sectors, such as oil price shocks, a trade war, a radical innovation). This will especially protect labour markets, and thus prevent sticky unemployment to occur. Even if inter-regional labour mobility is high preventing

[7] Economies of scope arise when the joint production of multiple products by one firm is cheaper than the production of products by different firms, due to the reuse or better use of inputs (such as knowledge or machinery).

unemployment to occur, asymmetric shocks reduce economic growth as agglomeration economies and the tax base deteriorate (Krugman 1993). Following this reasoning, variety at the regional level would be enhancing employment growth as it prevents labour to migrate when asymmetric shocks occur.

As for firms, a central question is whether related or unrelated diversification is most rewarding for stability and growth. One can expect that related industries more often (though, again, not as a rule) have correlated demand shocks. Therefore, spreading risk over unrelated sectors is to be preferred from the viewpoint of a portfolio strategy. However, one should take into account the possible benefits from related diversification as well. Analogous to economies of scope at the firm level, one expects external economies within the region to occur primarily among related sectors, and only to a limited extent among unrelated sectors. In terms of agglomeration theory, Jacobs externalities are expected to be higher in regions with a related variety of sectors compared to unrelated variety of sectors, because knowledge spills primarily between firms that use similar technologies and knowledge. The effects of related and unrelated sector variety, therefore, are expected to differ. Unrelated variety protects a region best against external asymmetric shocks in demand. By contrast, related variety in a sector is expected to be beneficial for knowledge spillovers. To test both theories, we will use two variety indictors below, one for related and one for unrelated variety.

4. Measurement of variety

The entropy measure provides one with a straightforward indicator of variety. As set out earlier by Theil (1972), Jacquemin and Berry (1979), and Attaran (1985), the main reason for using entropy is its decomposable nature. In the context of measuring regional variety to analyse the effects on growth, decomposition is informative as one expected (lack of) variety at a high level of sector aggregation to have different effects on the regional economy than (lack of) variety at a low level of sector aggregation (Frenken 2004).

4.1 The entropy measure

The origin of the entropy concept goes back to Ludwig Boltzmann in 1877 and has been given a probabilistic interpretation in information theory by Shannon (1948) and Theil (1967, 1972). The entropy formula expresses the expected information content or uncertainty of a probability distribution. Let E_i stand for an event (e.g., one technology adoption of technology i) and p_i for the probability of event E_i to occur. Let there be n events E_1, …, E_n with probabilities p_1,…, p_n adding up to 1. Since the occurrence of events with smaller probability yields more information (since these are least expected), a measure of information h should be a decreasing function of p_i. Shannon (1948) proposed a logarithmic function to express information $h(p_i)$:

$$h\,(p_i) = \log_2\left(\frac{1}{p_i}\right) \qquad (4.1)$$

which decreases from infinity to 0 for p_i ranging from 0 to 1. The function reflects the idea that the lower the probability of an event to occur, the higher the amount of information of a message stating that the event occurred. Information is here expressed in bits using 2 as a base of the logarithm, while others express information in ‘nits’ using the natural logarithm.

From the n number of information values $h\,(p_i)$, the expected information content of a probability distribution, called entropy, is derived by weighing the information values $h\,(p_i)$ by their respective probabilities:

$$H = \sum_{i=1}^{n} p_i \log_2\left(\frac{1}{p_i}\right) \qquad (4.2)$$

where H stands for entropy in bits.
It is customary to define (Theil 1972: 5):

$$p_i \log_2\left(\frac{1}{p_i}\right) = 0 \quad \text{if } p_i = 0 \qquad (4.3)$$

which is in accordance to the limit value of the left-hand term for p_i approaching zero (Theil 1972: 5).

The entropy value H is non-negative. The minimum possible entropy value is zero corresponding to the case in which one event has unit probability:

$$H_{\min} = 1 \cdot \log_2\left(\frac{1}{1}\right) = 0 \qquad (4.4)$$

When all states are equally probable ($p_i = \frac{1}{n}$), the entropy value is maximum:

$$H_{\max} = \sum_{i=1}^{n} \frac{1}{n} \log_2(n) = n\frac{1}{n} \log_2(n) = \log_2(n) \qquad (4.5)$$

(proof is given by Theil 1972: 8-10). Maximum entropy thus increases with n, but decreasingly so. This property reflects the idea that each new variety contributes positively to the total variety in a system, yet this contribution is marginally decreasing with each additional variety added.

4.2 Related and unrelated diversification

An important measurement issue is how to distinguish between related and unrelated diversification. As explained above, the concept of related variety holds that some sectors are more related than other, in terms of inputs they use, and, as a result, will profit from the same infrastructure (urbanisation economies) and will generate relatively more inter-industry knowledge spillovers. To examine empirically the effect of related or unrelated diversification is not a trivial matter, as sophisticated methodologies to measure inter-sectoral spillovers are scarce.

The entropy measure can be used to deal with related and unrelated diversification, both at the firm level (Jaquemin and Berry 1979) and the regional level (Attaran 1985). The main advantage of the entropy measure, and the reason for its use in the context of diversification, is that entropy can be decomposed at each sectoral digit level (see the decomposition theorem in the appendix). This allows one to measure the effect of variety at different levels of aggregation. The decomposable nature of entropy implies that variety at several digit levels can enter a regression analysis without necessarily causing collinearity (Jacquemin en Berry 1979; Attaran 1985). In this way, one can interpret entropy at high levels of sector aggregation to reflect the portfolio nature of variety, and entropy at low levels of sector aggregation as indicating Jacobs externalities.[8]

[8] A more recent methodology is developed by Los (2000), and aims to capture inter-sectoral spillovers by measuring the degree of similarity between two sectors' input mix from input output tables. As input mixes reflect production technologies, a high similarity in input mixes of two sectors implies a

5. Research design

The dependent variable in our study is employment growth at the regional level (NUTS3). Figure 1 shows the percentage employment growth for 1996. Note that in the following we will show results for the logarithm of percentage employment growth.

5.1 Conceptual framework for agglomeration hypotheses

In the empirical part of this paper we will test for the role of variety as an indicator of agglomeration economies that are related to intra-sectoral spillovers, leading to employment growth. Two important papers that empirically test these hypotheses, and on which our analysis builds further, are by Glaeser *et al.* (1992) and Henderson *et al.* (1995). Following these approaches, we will not only include variety as an explanatory variable, but also indicators of specialisation and competition. Specialisation accounts for specific localisation economies within a sector as in new growth theory. Competition accounts for the alleged advantage of larger firms to appropriate returns to R&D, as stressed by new growth theory models, thus predicting a negative sign.

The two papers both use employment data to measure growth, but reach different conclusions, particularly regarding effects of regional industrial concentration versus regional industrial diversity. The former study finds evidence supporting the Jacobs hypothesis, whereas the latter finds evidence consistent with both the new growth theory and Jacobs' view, depending on whether mature capital goods or high-tech industries are considered. Recent evidence for France and the Netherlands shows that indeed the composition of the dataset may at least partially explain the difference in findings. Combes (2000) and Van Oort (2004) find that diversity tends to enhance employment growth in services whereas it tends to retard growth in manufacturing industries, but specialisation does not seem to foster growth in either type of activity.

Finally, in addition to variables measuring agglomeration economies, Glaeser *et al.* (1992) included control variables in their regressions measuring employment growth rates outside the region. This variable was included to account for national demand shifts, to capture general (industry-wide) technological progress and to correct for spatial dependence in the subject researched (see Blanchard and Katz 1992). These elements will not be included in our analyses, yet constitute a natural extension in future research.

5.2 Regional variety in The Netherlands

In our econometrical models, the main focus will be on the role of regionalised, industrial variety in relation to employment growth. To distinguish between the effects of unrelated and related regional diversification on regional growth, or, differently stated, between degrees of relatedness in diversification, we concluded in the previous section that one should use information on all levels of sector aggregation. In this context, the use of entropy is advocated because it can be decomposed in marginal entropy values at multiple levels of sector aggregation.

An additional reason to rely on sector data at multiple digit levels, rather than solely on one level (as has been done in most empirical studies so far), holds that the levels of variety turn out to be very different at different levels of sector aggregation. Thus, outcomes of empirical tests may well be sensitive to the (otherwise arbitrarily) chosen level of sector aggregation. To illustrate this point, we show in figure 2 and 3 the entropy levels at the two-digit level and the marginal two-to-five-digit entropy, for the year 1996. Recall that the

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small 'technological distance' between two sectors, and a high amount of spillovers. Conversely, two industries with very different input mixes are technologically distant, and, consequently, will hardly mutually benefit from spillovers.

marginal entropy is the increase in entropy when one moves from a particular digit level to the next digit level (see appendix). As it is clear from the maps, variety at high levels of aggregation shows little correlation with variety at low levels (*-0.040, sig. 0.805*), which strongly suggests that the choice of sector aggregation is not at all trivial. The maps also suggest that unrelated variety is higher in rural areas, while related variety is higher in urban areas (the Randstad area in the West). Indeed, unrelated variety correlates negatively with population density *(-0.482, sig. 0.002*), while related variety correlates positively with population density although not significant (*0.246, sig. 0.125*). These results suggest that the relationship between urbanisation and variety, as discussed above in the context of theories of agglomeration, is strong only in terms of very related variety, i.e. when one moves from four digit to the five digit level of the sector classification.

5.3 Other variables

Specialisation of an industry in a corop region (NUTS3) is measured using the location quotient shown in equation (5.2). The location quotient is the percentage of a region's employment in an industry in 1996 divided by the corresponding Dutch percentage in 1996.

$$Specialisation = \frac{employment\ in\ industry\ k\ in\ region\ j/total\ employment\ in\ region\ j}{employment\ in\ industry\ k\ in\ the\ country/total\ employment\ in\ the\ country}. \quad (5.2)$$

We computed specialisation for four main ‘industries’, being manufacturing, distribution, producer services, and consumer services.

Regional competition is measured by the 1996 ratio of establishments per worker in a region to establishments per worker in the Netherlands as a whole.

$$Competition = \frac{firms\ in\ in\ region\ j\ j/employees\ in\ region\ j}{firms\ in\ the\ \text{country}/employees\ in\ the\ country}. \quad (5.3)$$

5.4 Heterogeneity

Heterogeneity among regions and possible endogeneity of explanatory variables must be considered. Regarding heterogeneity, the relative small size of The Netherlands provides a natural institutional control for some, but not all, important region-specific factors that affect the growth or attraction of economic activity. For example, wage rates within a sector will be uniform. Additionally, differences between locations in energy prices, taxes, environmental amenities (such as climate), environmental regulations, and cultural aspects are quite small. However, unmeasured land use patterns, zoning regulations, access to raw materials, and prior input choices of existing establishments do vary between regions and will bias the resulting estimates if they remain uncontrolled. Regarding this endogeneity, an unobserved characteristic of a region may affect the future pattern of economic activity, which feeds back through establishment behaviour to affect the level of agglomeration. This problem is troublesome when employment growth is to be explained. One option for dealing with endogeneity in this situation is to instrument for the agglomeration variables. This approach was not pursued because it is unclear how these instruments are appropriately constructed and alternative methods of constructing instruments may result in widely differing estimates. In the employment growth analysis, another approach to deal with the unmeasured heterogeneity problem is study long-term growth as to minimise the importance of location-specific factors and so that all establishments are effectively new. However, this approach taken in the Glaeser *et al.* (1992) study is not available here because data comparable to those used here did not exist prior to 1996. A third alternative, and much simpler approach rests on assuming that regional fixed effects capture unmeasured characteristics of a region that might make it a more or less productive place to do business, thus driving the correlation between the covariates and the error term to zero. From earlier research (Van Oort 2004) we know that this heterogeneity appears on the level of clusters of regions in the Netherlands, namely whether a region is located in the Randstad (economic core region of the Netherlands), in the so-called Intermediate Zone (the regions adjacent to the Randstad region) or in the Periphery (see figure 4). Dummy variables (fixed effects) are therefore included for each of the three zones.

Apart from the variables indicating variety, specialisation, competition and the three zones, we use control variables wage, investment, R&D, and supply of business sites. The variables that in principle are entered in the analyses thus are[9]:

Dependent variable:

1 Employment growth (1996-2002, log (t_1/t_0))

Independent variables:

2 Unrelated variety (1996, two-digit entropy)
3 Related variety (1996, marginal two-to-five-digit entropy)
4 Population density (1996, residents per square kilometre)
5 Specialisation (1996, classification into four industries: manufacturing, distribution, producer services and consumer services)
6 Competition (1996, number of firms per employee)
7 Dummy-variables for regions in (1) Randstad, (2) Intermediate zone, (3) Periphery
8 Wage (1996, index, total wage paid in corop region divided total fte, NL=100)
9 Regional investments (1996, index, total regional investments divided by total fte, NL=100)
10 R&D level (1999, R&D expenditures divided by total fte)[10]
11 Total supply of business sites (1996-2002, index, NL=100)

6. Empirical findings: testing the regional variety-as-externality hypothesis

To test for potential multicollinearity, all explaining variables were tested on correlation. From this, it was concluded that the following pairs of variables are not entered into the model together:

- The dummy variable of Randstad with the variable of population density. Both variables have to a large extent the same spatial layout in the Netherlands. Because we want to control for potential endogeneity on the level of the division Randstad-Intermediate Zone-National periphery, we include the dummy variables and leave out the population density indicator in the estimated models.

- Industrial specialisation with related variety. Because the performance of the variety indicators is our main focus, the industrial specialisation variable has been dropped. Note that we still use the specialisation indicators for producer services, consumer services and distribution activities.

[9] Our dataset was constructed from the LISA-database (1996-2002). The dataset contains information on employment for five different digit levels for the 40 Dutch so-called corop (NUTS3) regions. Other variables, for example wages, regional investments, population density are obtained from the Dutch Central Bureau of Statistics (CBS) and the Netherlands Institute for Spatial Research (RPB).

[10] R&D data for 1996 were not available.

Table 1 Determinants of employment growth per corop (NUTS3) region (t-values are presented in parenthesis):

	EMPLOYMENT GROWTH (All variables)	EMPLOYMENT GROWTH (Parsimonious specification)
CONSTANT	-0.118 (-0.377)	0.232 (2.083)
SPECIALISATION PRODUCER SERVICES	0.022 (0.712)	-
SPECIALISATION CONSUMER SERVICES	0.048 (0.646)	-
SPECIALISATION DISTRIBUTION	0.003 (0.055)	-
UNRELATED VARIETY	0.242 (1.290)	-
RELATED VARIETY	0.107 (1.318)	0.140 (2.806)
REGIONAL COMPETITION	-0.066 (-3.722)	-0.068 (-4.321)
WAGE LEVEL	-0.003 (-2.646)	-0.003 (-2.896)
INVESTMENT LEVEL	0.001 (3.226)	0.001 (3.335)
R&D EXPENDITURES	0.0019 (0.689)	-
SUPPLY BUSINESS SITES	0.0039 (0.142)	-
RANDSTAD	0.032 (2.182)	0.023 (2.007)
PERIPHERY	0.008 (0.558)	-
N	40	40
Adjusted R^2	0.389	0.426

In table 1 the results of the OLS-regression analyses are presented. In the first column, the specification with all variables is presented; in the second column only the most parsimonious specification is presented. Some important control variables turn out to be highly significant with the expected sign: the Randstad dummy (positive), the average regional investment level (positive) and the wage level (negative). Apart from these significant controls, some interesting results come to the fore regarding the agglomeration indicators. Regional specialisation patterns in producer services, consumer services and distribution activities turn out to be not significantly related to employment growth in the multiple regression analysis. Also, competition as measured by relative firm size, is negatively related with employment growth. Regions characterised by relative larger firms have higher growth performances than regions characterised by relative small, competitive firms. This leads us to conclude that there is little to no evidence that the specialisation and competition hypotheses. Regarding variety, we put forward two hypotheses: unrelated variety is attached to the portfolio hypothesis, related variety to the spillover hypothesis. From table 1 it is clear that our analysis, corrected for spatial heterogeneity by the other variables, rejects only the portfolio hypothesis, while the spillover hypothesis can not be rejected. This suggests that regions with a high degree of related variety have experienced higher rates of employment growth.

7. Conclusion

We distinguished between two types of effects of variety on employment growth. The first approach centres on variety, spillovers and growth, and sees variety as a source of agglomeration economies stimulating growth. A second way to relate variety to regional economic development, is to view variety as a portfolio strategy to protect a region from external shocks in demand. Though empirical studies have been numerous over the past decades, the literature has failed to provide unambiguous answers. The lack of consistency in empirical outcomes may be related, to a large extent, to differences in research designs. For this reason, we carefully constructed an empirical research design, which includes entropy measures on multiple digit levels as to distinguish between related and unrelated variety, specialisation and competition measures, and controls for investment, wage, population density, spatial zones, supply of business sites, and R&D.

The distinction between related and unrelated variety proved informative. The results show that only related variety is positively related to regional employment growth, while no evidence has been found to support the portfolio thesis. Moreover, specialisation indicators were also found to be insignificant. Taken together, one could argue that the popular dichotomy between variety and specialisation, both theoretically and in policy discourse, is potentially misleading. Neither one affects employment growth, whereas related variety does. Our study underlines the more recent concept of “diversified specialisations” (Dissart 2003) as central driver of growth, and, as such, a new policy fundament.

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Appendix: The entropy decomposition theorem

One of the most powerful and attractive properties of entropy statistics is the way in which problems of aggregation and disaggregation are handled (Theil 1972: 20-22). This is due to the property of additivity of the entropy formula.

Let E_i stand again for an event, and let there be n events $E_1, \dots, E_n$ with probabilities $p_1, \dots, p_n$. Assume that all events can be aggregated into a smaller number of sets of events $S_1, \dots, S_G$ in such a way that each event exclusively falls under one set S_g, where $g=1,\dots,G$. The probability that event falling under S_g occurs is obtained by summation:

$$P_g = \sum_{i \in S_g} p_i \qquad (7)$$

The entropy at the level of sets of events is:

$$H_0 = \sum_{g=1}^{G} P_g \log_2 \left(\frac{1}{P_g} \right) \qquad (8)$$

H_0 is called the between-group entropy. The entropy decomposition theorem specifies the relationship between the between-group entropy H_0 at the level of sets and the entropy H at the level of events as defined in (2). Write entropy H as:

$$H = \sum_{i=1}^{n} p_i \log_2 \left(\frac{1}{p_i} \right) = \sum_{g=1}^{G} \sum_{i \in S_g} p_i \log_2 \left(\frac{1}{p_i} \right)$$

$$= \sum_{g=1}^{G} P_g \sum_{i \in S_g} \frac{p_i}{P_g} \left(\log_2 \left(\frac{1}{P_g} \right) + \log_2 \left(\frac{P_g}{p_i} \right) \right)$$

$$= \sum_{g=1}^{G} P_g \left(\sum_{i \in S_g} \frac{p_i}{P_g} \right) \log_2 \left(\frac{1}{P_g} \right) + \sum_{g=1}^{G} P_g \left(\sum_{i \in S_g} \frac{p_i}{P_g} \log_2 \left(\frac{P_g}{p_i} \right) \right)$$

$$= \sum_{g=1}^{G} P_g \log_2 \left(\frac{1}{P_g} \right) + \sum_{g=1}^{G} P_g \left(\sum_{i \in S_g} \frac{p_i}{P_g} \log_2 \left(\frac{1}{p_i / P_g} \right) \right)$$

The first right-hand term in the last line is H_0. Hence:

$$H = H_0 + \sum_{g=1}^{G} P_g H_g \qquad (9)$$

where:

$$H_g = \sum_{i \in S_g} \frac{p_i}{P_g} \log_2 \left(\frac{1}{p_i / P_g} \right) \quad g = 1,\dots,G \qquad (10)$$

The probability p_i / P_g, $i \in S_g$ is the conditional probability of E_i given knowledge that one of the events falling under S_g is bound to occur. H_g thus stands for the entropy within the set S_g and the term $\sum P_g H_g$ in (9) is the *average within-group entropy*. Entropy thus equals the between-group entropy plus the average within-group entropy. Two properties of this relationship follow (Theil 1972: 22):

(i) $H \geq H_0$ because both P_g and H_g are nonnegative. It means that after grouping there cannot be more entropy (uncertainty) than there was before grouping.

(ii) $H = H_0$ if and only if the term $\sum P_g H_g = 0$ and $\sum P_g H_g = 0$ if and only if $H_g = 0$ for each set S_g. It means that entropy equals between-group entropy if and only if the grouping is such that there is at most one event with nonzero probability.

In informational terms, the decomposition theorem has the following interpretation. Consider the first message that one of the sets of events occurred. Its expected information content is H_0. Consider the subsequent message that one of the events falling under this set occurred. Its expected information content is H_g. The total information content becomes $H_0 + \sum P_g H_g$. Applications of the decomposition theorem will be discussed in the third and fourth section.

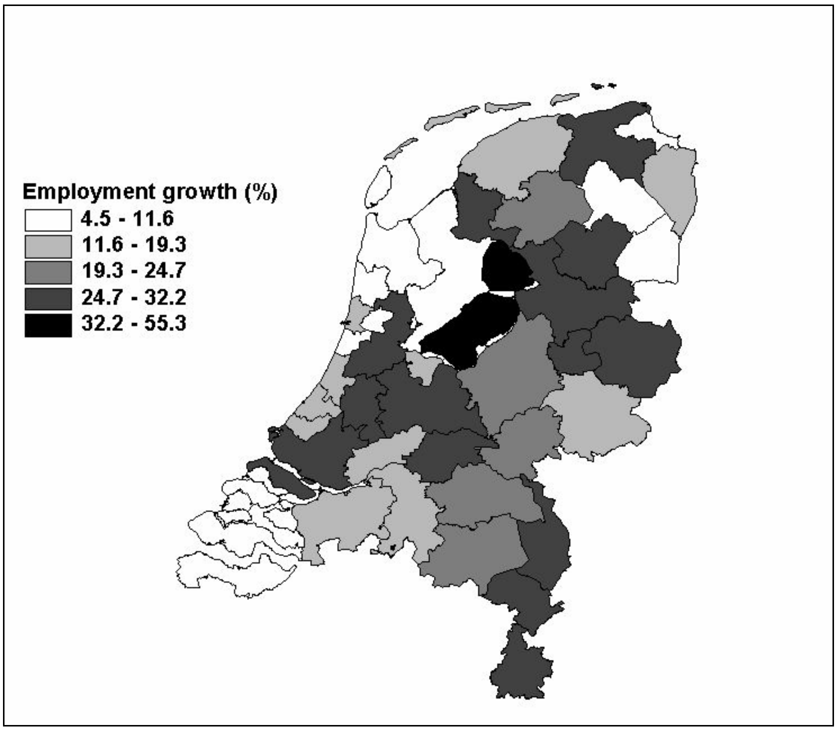

Figure 1: Percentage employment growth, 1996-2002

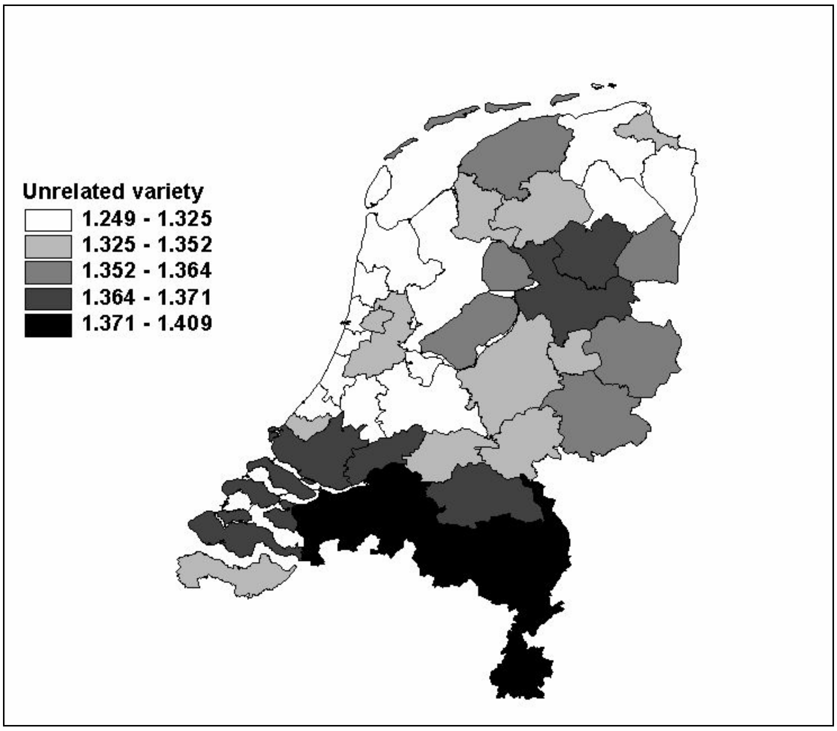

Figure 2: unrelated variety measured by the two-digit entropy, 1996

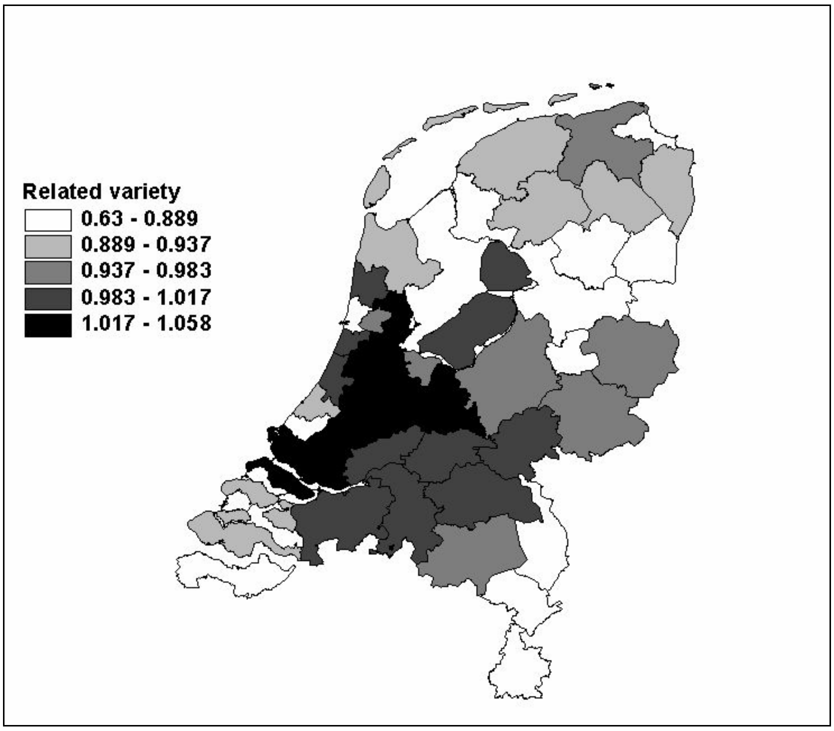

Figure 3: related variety measured by the marginal two-to-five entropy, 1996

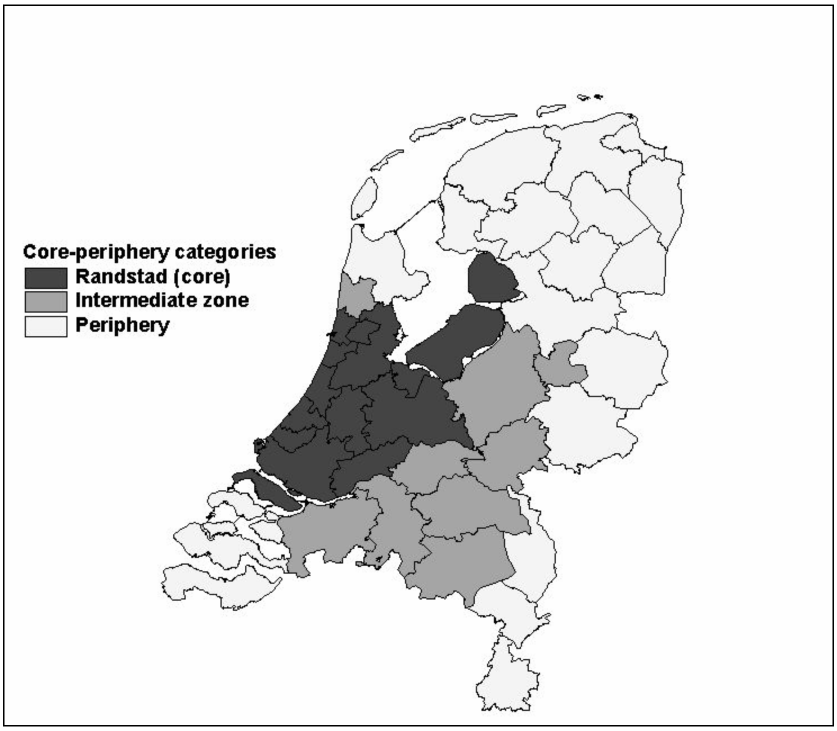

Figure 4: spatial zones in The Netherlands