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SPATIAL DIFFERENTIATION IN INDUSTRIAL DYNAMICS

A CORE-PERIPHERY ANALYSIS BASED ON THE PAVITT-MIOZZO-SOETE TAXONOMY

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Abstract: We compare the industrial dynamics in the core, semi-periphery and periphery in The Netherlands in terms of firm entry-exit, size, growth and sectoral location patterns. The contribution of our work is to provide the first comprehensive study on spatial differentiation in industrial dynamics for all firm sizes and all sectors, including services. We find that at the aggregate level the spatial pattern of industrial dynamics is consistent with the spatial product lifecycle thesis: entry and exit rates are highest in the core and lowest in the periphery, while the share of persistently growing firms is higher in the periphery than in the core. Disaggregating the analysis to the sectoral level following the Pavitt-Miozzo-Soete taxonomy, findings are less robust. Finally, sectoral location patterns are largely consistent with the spatial product lifecycle model: Fordist sectors are over-represented in the periphery, while sectors associated with the ICT paradigm are over-represented in the core, with the notable exception of science-based manufacturing.

Keywords: Entry, exit, spatial product lifecycle, Fordist paradigm, ICT paradigm

JEL-codes: L25 – L26 – L60 – L80 – O18 – O33 – R10

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Section 1. Introduction

It is well known that industrial dynamics are sector-specific (Gort and Klepper 1982, Malerba and Orsenigo 1996; Marsili, 2001; Bottazzi et al., 2007), but rather less is known about their spatial differentiation. Industrial dynamics patterns may differ across regions, at both the aggregate and sectoral levels. An understanding of the spatial differentiation of industrial dynamics is important to understand the different paths of development across regions and, possibly, to design specific urban and regional policies to influence these paths.

The aim of the current study is to analyse the dynamics of different manufacturing and service sectors in a spatial perspective, comparing the core and periphery zones, and the intermediate zone or the semi-periphery. This focus is motivated by product lifecycle (PLC) approaches in the geography literature, which hypothesise that industries in the early stages of their lifecycles are overrepresented in the core area while those industries in the later stages of their lifecycles are overrepresented in the periphery (Thompson 1968; Duranton and Puga 2001).

We test this basic thesis in a cross-sectional research design, analysing the entry, exit, size and growth patterns in the core, semi-periphery and periphery, at the aggregate and the sectoral levels, using the extended Pavitt-Miozzo-Soete taxonomy of manufacturing and service sectors. The sectoral analysis allows us to compare the location patterns of information and communication technology (ICT)-based sectors with many early lifecycle products (which we expect to be overrepresented in the core), with Fordist-based sectors with fewer early lifecycle products (expected to be overrepresented in the periphery). We conduct our analysis using data on Dutch firms of all sizes, from all sectors, during the period 1994-2005.

The contribution of our study is to provide the first comprehensive study on the spatial differentiation in industrial dynamics for firms in all sectors and all size classes. There are two main findings. First, with the exception of the science-based industries, the spatial product lifecycle (PLC) well explains the differences in industrial dynamics across the metropolitan core area, the semi-periphery and the periphery. Second, the observed differences between core, semi-periphery and periphery, although systematic, are rather small.

The paper is organised as follows. Section 2 provides a review of studies of the spatial PLC. Section 3 introduces the approached adopted in this paper, and Section 4 discusses the data. Section 5 presents the results and Section 6 concludes.

Section 2. The Literature

2.1 Product life cycle

The product lifecycle (PLC) is a very well established concept in industrial dynamics, dating back to the seminal work by Levitt (1965) in management, Vernon (1966) in international trade and Utterback and Abernathy (1975) in industrial organisation. The notion of a lifecycle suggests that industries typically evolve in particular stages. In the explorative stage of an industry, entrepreneurs pursue commercial opportunities based on new products resulting from product innovation. At this stage, the technological possibilities and preferences of consumers are poorly understood by the firm. Progressive standardisation of product designs triggers process innovation and this marks the transition from the explorative stage to the mature stage in the product lifecycle. The mature stage is exhausted when technological and market opportunities become depleted and decreasing returns to R&D set in.

The patterns of innovative activity in the PLC have important consequences for industrial dynamics. Initially, many firms enter in the attempt to exploit the opportunities provided by a new product. Over the product life cycle, increasing economies of scale combined with learning economies in R&D, lead to a rapid rise in the minimum efficient scale. The resulting higher entry barriers limit new entry, and price competition forces the less efficient firms to exit. This “shake-out” phenomenon leads to a rapid fall in the number of participating firms, and the industry becomes highly concentrated (Klepper 1996; Klepper and Simons 1997).

Various attempts have been made to systematically test the product lifecycle model based on analysis of the data on innovation and industrial dynamics. Abernathy and Utterback (1978) introduced the concept of a dominant design in their analysis of the automobile industry. A dominant design marks the standardisation of a product and the transition from the explorative to the mass production stage in the product lifecycle. Once a dominant design emerges, innovation becomes more incremental in nature, and the number of firms decreases as the efficient scale of production increases. Utterback and Suarez (1993), in a follow-up study, looked at the histories of eight technologies and found that dominant designs emerged in six industries. In all six cases, a rapid rise in the number of firms was observed before standardisation, and a sudden fall was observed after this point. In the case of the two technologies where no standardisation was observed, the number of firms did not fall rapidly. These findings support the hypothesis that dominant designs lead to an industry “shake-out”.

An extensive study by Gort and Klepper (1982) investigated the product lifecycle dynamics for 42 products. They collected numerous statistics for each product, which allowed systematic testing of the predictions of the PLC model. One of the findings from this study is that net entry tends to rise in the early history of a product life cycle and tends to fall, thereafter. Another findings holds that net entry is positively correlated with the rate of innovation, which is in line with the PLC model. In terms of the dynamics in the rate of different types of innovation over time, distinguishing between major and minor innovation, they find that, on average, major innovation rates peaked earlier than minor innovation rates. In a subsequent study, Klepper and Simons (1997) report similar findings for three out of four industries investigated.

Malerba and Orsenigo (1996) study the relationship between innovation and industrial dynamics. They categorise 49 technology classes into two groups: a group containing industries with small-sized firms, high entry, low concentration, and low stability, in ranking of innovators, and a group containing industries with large-sized firms, low entry, high concentration, and high stability in ranking of innovators. These cross-sectional findings are in agreement with the PLC thesis: the first group of industries is characteristic of the explorative stage of the PLC and the second group is typical of the mature stage of the PLC.

2.2 Spatial product lifecycle

PLC theory has important spatial ramifications, which have been discussed by economic geographers (Thomson 1968; Rees 1979; Markusen 1985; Davelaar 1991; Duranton and Puga 2001). The main hypothesis in a spatial context is that industries at an early stage in their lifecycles will be overrepresented in the metropolitan core areas, while mature industries are expected to be overrepresented in peripheral areas. Metropolitan areas where venture capital, talent, early users and supporting institutions are more abundant are more likely to host (usually) small firms, in emerging industries, which exploit these attributes for their product innovation activities. Larger firms in mature industries are more likely to be located in peripheral areas in order to benefit from low wages, lower land prices and less stringent environmental regulations. As an industry moves from the explorative to the mature lifecycle stage, its dominant location can be expected to migrate from the core to the periphery (with the reverse occurring in the case of a de-maturing industry). The shift from exploration to standardisation is accompanied with a shift from product to process innovation. This changes the nature of the competition from predominantly product competition to mostly cost competition, which favours firms in low-cost locations. PLC theory predicts that the pattern of relocation will be mainly from the core to the periphery (Duranton and Puga 2001).[1]

Another explanation for the expected spatial lifecycle pattern is that the metropolitan core area is attractive to small innovative firms in their explorative stage, since a high density of innovative firms generates tacit knowledge spillovers, specialised support services and opportunities for collaboration (Audretsch and Feldman 1996). When products are still being developed, inter-industry spillovers (or Jacob's externalities) are relatively important, and are provided by the diversified nature of the core area in an economy (Henderson et al. 1995).

[1] International trade theory is based on similar reasoning in that in the course of the product lifecycle, the industry will change its location from a high-income economy to a low-income economy (Vernon 1966).

Thus, the many small firms active in the early stage of a PLC profit from the agglomeration economies generated in the core. Larger firms in mature industries rely more on in-house R&D aimed at process innovation and, therefore, would benefit less from location in a core metropolitan area. As products become standardised and stable value chains are created, intra-industry spillovers (or Marshall-Arrow-Romer (MAR) externalities) become more important, and are most likely to occur within specialised clusters outside the core (Henderson et al. 1995).

Though spatial PLC theory was developed as a model to explain the location patterns of manufacturing industries, the same reasoning can be applied to the service industries. Core areas are equally well suited to generating new services. Once a service has become standardised and is being mass-produced, the routinised operations can be located in peripheral areas with lower factor prices. However, the pattern may be less pronounced in services than in manufacturing, since many routinised services continue to depend for their provision on close physical proximity to users. That is, front office operations are generally located close to dense markets and, hence, are more often in core than in peripheral areas. One can thus expect that mostly the routinised back office operations are located in peripheral areas with lower factor prices. Advances in ICT since the early 1990s have further facilitated this physical separation pattern between front and back office operations.

2.3 Empirical studies

Empirical studies addressing the spatial PLC thesis are based on longitudinal data used to investigate whether the location of industries shifts from core to periphery over time. Both the study by Markusen (1985) and a follow-up study by Sorenson (1997) examine the dispersion patterns for a small number of US manufacturing industries in 1954-1977 and 1954-1987 respectively. Both studies show that the pattern of increasing spatial dispersion predicted by PLC theory is confirmed only for a small number of industries. In a more recent study on France, Pumain et al. (2006) find that in the period 1960-2000 the electronics, chemicals, textiles, metal products, machinery and equipment, and wood, pulp & paper industries progressively relocated from metropolitan to smaller cities. At the same time, in the period considered, the metropolitan cities became increasingly specialised in R&D. Contrary to the aforementioned U.S. studies, the French evidence regarding the location pattern of industries over the product lifecycle is more robust.

Spatial PLC theory predicts that the dominant migration flow involves innovative firms relocating from a diversified core to a specialist location in the periphery after achieving mass-production of a standardized product. Duranton and Puga (2001) find that most relocating French firms move from areas with above median diversity (typically the large metropolitan areas) to areas with below median specialisation in the corresponding sector (typically the smaller cities). They find also that high-tech industries account for a much higher share of relocations than mature sectors (which are already overrepresented in the periphery). In a study of Portuguese firms, Holl (2004) finds that start-ups are attracted by large diversified cities while relocating firms are attracted to locations with a specialized industrial base and good road infrastructure. In a study of relocating firms in The Netherlands, Pellenbarg and Van Steen (2003) find that most inter-regional relocations in The Netherlands involve firms leaving the metropolitan core. In all these studies, the relocation patterns observed are consistent with spatial PLC theory.

A related strand of empirical research looks at the role of agglomeration economies in new versus mature industries, based on the reasoning that new industries benefit most from inter-industry spillovers and therefore locate in core metropolitan areas with a variety of industries (Jacobs externalities), while mature industries based on standardised products profit more from intra-industry spillovers in smaller, specialised areas (MAR externalities). Henderson et al. (1995) find such patterns in a study analysing the growth of eight manufacturing industries in US cities. They find that new industries prosper in large diversified metropolitan areas while mature industries profit from location in specialised cities. Similarly, Neffke et al. (2010) in a study of Swedish plants find that inter-industry spillovers become less important as an industry matures, and intra-industry spillovers become more important over time.

Finally, several empirical studies examine the spatial differentiation of innovation patterns. Here, the prediction of the PLC thesis is that core areas are more innovative than peripheral areas, and that product innovation is overrepresented in the core, while process innovation is expected to be relatively dominant in the periphery. Using survey data, Oakey et al. (1980) find that both large and small establishments in the UK's core area (the South-East Region) are indeed more innovative than firms located in other regions. They attribute these differences primarily to the levels of non-production employment in each region rather than to plant size structure or regional industrial structure. In contrast, studies by Davelaar and Nijkamp (1989) and Kleinknecht and Poot (1992) do not find the Netherlands's core to be more innovative than its periphery. However, and in line with PLC theory, they find that the periphery has relatively higher shares of process innovation than the core area. This finding is confirmed in a follow-up study of Dutch firms by Brouwer et al. (1999).

Finally, we should comment on the possibility of the economic core shifting over time. The urban lifecycle thesis predicts that the urban core, once formed, can continue to renew itself based on the advantages created for product innovation and new industry formation. However, historically, there are examples of cores shifting, famously, in the United States from the 'Manufacturing Belt' to the 'Sunbelt' (Rees 1979) and in Belgium from the Walloon area to Flanders (Boschma 1997). In both these cases, the locus of product innovation and new industry formation shifted from one region to another, shifting what was regarded as the country's economic core. Some associate these fundamental shifts with Kondratieff waves leading to new techno-economic paradigms (Freeman and Perez 1988). Given that our study is of industrial dynamics occurring in the space of a decade, these long-term trends are of no particular concern.

Section 3. Methodology

The approach in this paper is to analyse sectors in a cross-sectional manner by pooling observations from several years and comparing industrial dynamics across the core, semi-periphery and periphery. This allows us to use data on entry, exit, size, growth and location of *all* Dutch firms, thereby including all firm sizes and all sectors, including the service sectors.

To compare the location patterns of sectors in the context of PLC theory, we need to classify sectors into PLC stages. In the absence of comprehensive innovation data for all sectors (let alone firms), we use Pavitt's (1984) taxonomy. Based on a detailed analysis of about 2,000 UK inventions and respective firms in 1945 to 1979, Pavitt (1984) proposed a four sector taxonomy based on size, innovation patterns and sources of innovation: scale-intensive, supplier-dominated, science-based and specialised supplier.

Miozzo and Soete (2001) proposed the exclusion of services from the supplier-dominated industries in Pavitt's original classification, and suggested distinguishing instead among four different service sectors: supplier-dominated services, physical network services, information network services and knowledge-intensive business services. Castellacci (2008) points out that this distinction among different kinds of service sectors follows Pavitt in focusing on differences in size, innovation patterns and sources of innovation, with special attention to the role of ICT.

The Pavitt-Miozzo-Soete taxonomy can be summarised as follows (Castellacci 2008; Castaldi 2009):

Manufacturing

- **Scale-intensive (SI):** includes both complex and consumer durables (food, chemicals, motor vehicles), and processed raw materials (e.g. metal manufacturing, glass and cement). Firms tend to be large and to rely mainly on internal resources for their innovations. Carrier industries in the Fordist paradigm.
- **Supplier-Dominated (SD):** includes industries where firms mostly produce technologically simple goods (e.g. textiles, leather goods, pulp and paper), where the capital and intermediate components suppliers are the main sources of innovation.
- **Science-Based (SB):** includes industries where innovation is linked directly to advances in academic research (e.g., pharma, electronics, scientific instruments). Innovation rates are particularly high. Carrier industries in the ICT paradigm.

- **Specialized Supplier (SS):** includes equipment building, design and mechanical engineering, where innovation typically emerges from informal activities. Firms in this group tend to be small, and innovation rates particularly high. Supportive of the Fordist paradigm.

Services

- **Supplier Dominated Services (SDS):** rely on the purchase of capital goods for their innovation. They are mostly small companies providing services directly to customers (e.g., hotels, restaurants, rental services and personal services). Innovation rates are particularly low.
- **Physical Network Services (PNS):** include all transport, retail and wholesale trade related services. Supportive of the Fordist paradigm.
- **Information Network services (INS):** include all information-intensive activities (communication, financial intermediation, insurance, real estate). Firms tend to be large and to innovate in interaction with suppliers and users. Supportive of the ICT paradigm.
- **Knowledge Intensive Business Services (KIBS):** include R&D services, consultancy and computer-related activities. Firms tend to be small and medium firms that produce their own innovation. Innovation rates are particularly high. Supportive of the ICT paradigm.

Our study compares the industrial dynamics in the core, semi-periphery and periphery for the economy as a whole, and for each Pavitt-Miozzo-Soete sector separately. This will show whether the generic economy-wide patterns are reproduced in each of the eight sectors or whether there are sectoral specificities that we can relate to the sectoral characteristics on which the Pavitt-Miozzo-Soete taxonomy is based. We also analyse the location patterns of different sectors in relation to spatial PLC theory.

We look first at spatial differentiation in entry, exit, turbulence (sum of entry and exit) and size. Following spatial PLC theory, we expect the core to show the highest entry and exit rates and the highest share of what we call 'micro-firms', defined as firms with less than four employees. These numbers should decrease when moving from the core to the semi-periphery and then to the periphery. For each geographical area *g* and each sector *i*, we compute a weighted average of the yearly entry rates between 1995 and 2005, where the weights correspond to the yearly total number of existing firms (*total*) in each year *t* between 1995 and 2005, as in the following:

$$entry\_rate_{gi} = \frac{\sum_{t=1995}^{2005} entries_{git}}{\sum_{t=1995}^{2005} total_{git}} = \frac{\sum_{t=1995}^{2005} \left(\frac{entries_{git}}{total_{git}} \times total_{git} \right)}{\sum_{t=1995}^{2005} total_{git}} = \frac{\sum_{t=1995}^{2005} \left(entry\_rate_{git} \times total_{git} \right)}{\sum_{t=1995}^{2005} total_{git}} \quad (1)$$

where: *g*= *core, semi-periphery, periphery*; and *i = 1, ..., j,...8* represents the four manufacturing sectors and the four service sectors respectively according to the Pavitt-Miozzo-Soete taxonomy. From hereon, we consider this weighted average whenever we refer to the entry rate of a given area without specifying a particular year.

We use an analogous method to build a weighted average of the exit rates:

$$exit\_rate_{gi} = \frac{\sum_{t=1995}^{2005} exits_{git}}{\sum_{t=1995}^{2005} total_{git-1}} = \frac{\sum_{t=1995}^{2005} \left(\frac{exits_{git}}{total_{git-1}} \times total_{git-1} \right)}{\sum_{t=1995}^{2005} total_{git-1}} = \frac{\sum_{t=1995}^{2005} \left(exit\_rate_{git} \times total_{git-1} \right)}{\sum_{t=1995}^{2005} total_{git-1}} \quad (2)$$

We look at firm growth patterns (in terms of numbers of employees). Here, spatial PLC teaches us that, given the high wages and high land prices in the core compared to the periphery, we should expect to find fewer growing firms in the core than in the periphery. This pattern is expected to hold especially for the mature Fordist sectors where competition is based mainly on cost efficiency. We look at persistently growing firms, that is, firms that experience positive growth in two consecutive years (cf. Capasso et al. 2009). We compare the share of persistently growing firms between spatial areas and between sectors using only size-conditioned data. We chose this procedure because the share of persistently growing firms increases with firm size, since it is 'easier' for a large firm to 'grow' (i.e. increase its number of employees) in two consecutive years than for a small firm to do so.[2] Since two successive growth events can be observed only over a time span of at least three years, our analysis of firm growth patterns is performed over a semi-balanced version of our database, including only firms that were in operation for at least three consecutive years. The ten cross-sectional waves (each referring to a three-year span and balanced over the same span) obtained for the period 1994-2005 were then pooled; thus, the results refer to the pooled cross-section.

[2] This phenomenon can be due to discreteness in the employment variable. Imagine two firms, one with 2 employees and one with 20 employees, both with an expected growth rate of 10 per cent (and the same variance). The firm with 2 employees will most likely stay at the size of 2 employees in the next year, while the firm with 20 employees will most probably grow. However, Coad (2007) shows empirically that smaller firms not only show less persistent growth, but often display negative growth autocorrelation, suggesting that the observed effect of firm size on growth persistence has economic roots, and is not simply the consequence of a technical artifact.

Finally, we look at the location patterns for each Pavitt-Miozzo-Soete sector. Here, we exploit Castellacci's (2008) distinctions between sectors that belong to the mature Fordist paradigm and sectors that belong to the emerging ICT paradigm. We expect the carrier and supporting sectors in the ICT paradigm (SB, INS, KIBS) – with many products and services at an early stage of their lifecycle – to be overrepresented in the core, and the carrier and supporting sectors in the Fordist paradigm (SI, SS, PNS) – with many product and services at a mature stage of their lifecycle – to be overrepresented in the periphery.

In order to analyse location patterns we calculate the natural logarithm of the ratio of the area's sectoral level employment shares and the area's total employment share:

$$loc_g = ln\left(\frac{Empl_{gi} / \sum_a Empl_{ai}}{\sum_j Empl_{gj} / \sum_a \sum_j Empl_{aj}}\right) \qquad (3)$$

where *g,a= core, semi-periphery, periphery* (*a* being a generic geographical area and *g* the geographical area under study) and $i, j = 1, ..., 8$ represent Pavitt's four manufacturing sectors and Miozzo/Soete's four service sectors (*j* being a generic sector and *i* the sector under study). Negative values denote under-representation in a particular area, and positive values denote over-representation in a particular area.

Section 4. The Data

Our data are provided by Statistics Netherlands (CBS) from the Business Register (BR) of enterprises. The BR database includes the entire population of firms registered for fiscal purposes in the Netherlands, in the year considered. The database contains detailed information on sector at the 5-digit SBI (the Dutch standard industry classification) level, number of employees and dates of market entry and exit. Relocating firms are treated as new entries if their move is combined with a large increase/decrease in employment. Given that precise identification of relocating firms is not possible, our analysis considers only firms that survived and remained in the same area (core, semi-periphery or periphery) for the whole of the time span considered (2 years or 3 years, depending on the statistics computed). For firms with multiple sites, total employment is based on the location acting as the firm's address for fiscal purposes. Our observation period covers the years 1994 to 2005. The population includes self-employment (firms with zero employees), which we refer to as size one firms.

The Pavitt-Miozzo-Soete taxonomy used for this study corresponds to the classification in Castaldi (2009) with the exception of SIC classes 334 and 335 (optical and other instruments), which we reclassified as SS (see e.g. Bürger and Cantner 2010). The list of SIC sectors and the corresponding Pavitt-Miozzo-Soete sector is provided in the *Appendix*.

The definition of core, semi-periphery and periphery in The Netherlands is taken from Van Oort (2004). This is a standard classification of Dutch labour market regions (NUTS3) as core, semi-periphery or periphery (see *Figure 1*):

Figure 1 around here

- the densely populated **core** metropolitan area in the western part of The Netherlands (also known as the Randstad area) which includes the four largest cities of Amsterdam, Rotterdam, The Hague and Utrecht, and the Port of Rotterdam and Amsterdam's Schiphol Airport, accounting for 48 per cent of employment in the eight sectors
- the less densely populated **semi-periphery** covering the regions adjacent to the core area (with Eindhoven, Tilburg and Nijmegen as the main cities), providing 29 per cent of employment in the eight sectors
- the least populated **periphery** at the Northern, Eastern and Southern borders (with Groningen in the north, Enschede in the east, and Maastricht in the south as the main cities) providing 23 per cent of employment in the eight sectors

Section 5. Results

5.1 Economy-wide patterns

Table 1 provides the results for entry, exit, turbulence (sum of entry and exit) and size for firms in all eight sectors for the country as a whole, and for the core, semi-peripheral and peripheral areas. These results are based on pooling all observations in the period 1994-2005 (i.e. using an unbalanced panel).

Table 1 around here

The first result holds, that entry and exit rates are indeed highest in the core and lowest in the periphery, with the semi-periphery taking intermediate values. Hence, the basic prediction of the spatial PLC holds – that PLCs tend to start in the core leading to higher entry and exit rates in the core compared to the periphery.

In terms of size differences, we observe that – unexpectedly – firms in the core are on average larger than firms in the periphery, with the semi-periphery again taking an intermediate value. Based on spatial PLC theory, we expected that firms in the core would be of smaller average size than those in the periphery. However, this finding should be interpreted with caution since the underlying firm size distributions are extremely skewed. To gate a better sense of the spatial size differentiation, it is helpful to look at the share of firms with at most 1, at most 2 and at most 3 employees. These indicators are more revealing since these are the most frequent firm size classes. These indicators show the expected patterns with the core having the largest share of these micro-firms, followed by the semi-periphery and the periphery. Thus, although average size is larger in the core than the periphery and semi-periphery, the core also hosts the largest share of micro-firms, indicating that the variance of the log size distribution is likely to be higher in the core area.

Figure 2 depicts the share of persistently growing firms in the core, semi-periphery and the periphery. We compute the share of persistently growing firms for each size class, for the reasons set out above. We observe that the core – as expected – has the lowest share of persistently growing firms, while there are no clear differences between the semi-periphery and the periphery.[3] It is interesting that the spatial differentiation in growth dynamics is observable only for firms exceeding a certain size (about 10 employees). That is, only for

[3] We obtain the same result if we redefine persistent growth as a sequence of 3 rather than 2 consecutive growth events.

relatively large firms the core seems to be the least favourable environment for expansion. This is in line with spatial PLC theory: the core – although being a favourable environment for small firms – is not the ideal environment for up scaling operations, due to the high prices of land and labour, to the greater congestion and stricter environmental regulations.

Figure 2 around here

To summarise, all the patterns predicted by the spatial lifecycle are confirmed by our analysis. The most pronounced one is related to differences in entry and exit: entry rates are 16 per cent higher in the core than in the periphery, while exit rates are 19 per cent higher in the core than in the periphery. In relation to micro-firms with less than four employees, the core hosts only 3.3 per cent more of such firms than the periphery. The share of persistently growing firms is at most 1 per cent higher in the periphery than in the core, for all size classes. Thus, we can conclude also that the observed differences between core, semi-periphery and periphery, although systematic, are rather small.

5.2 Sector specificities

Table 2 presents the same results as *Table 1*, but for the eight Pavitt-Miozzo-Soete sectors separately. Entry and exit rates are highest in the core and lowest in the periphery for all sectors, with the exception of SB, where the highest entry and exit rates are observed in the semi-periphery. Looking at the share of firms with at most 1, at most 2 and at most 3 employees, we see that, with the exception of SDS and KIBS, all sectors follow the predicted core-periphery pattern.

Table 2 around here

In terms of growth patterns, *Figures 3a* to *3h* plot the share of persistently growing firms for each firm size class, for each sector separately. The core-periphery pattern observable at the economy-wide level – with the share of persistently growing firms lower in the core than elsewhere – is clearly visible only for SI and PNS. These are considered Fordist sectors, where cost competition dominates and, hence, growth is most easily realised outside the core area. The other sectors do not seem to follow any clear pattern. That is, the pattern observed at the economy-wide level is not robust when disaggregated to the sectoral level.

Figures 3a to 3h around here

Finally, we analyse the location pattern of different sectors using equation (3), dividing the employment share of an area in a sector by the employment share of the area in all sectors. Note that the log-transformation of this ratio renders the values are symmetric around zero. Negative values indicate under-representation in a particular area and positive values indicate over-representation in a particular area. The hypothesis holds that the carrier and supporting sectors in the ICT paradigm (SB, INS, KIBS) are over-represented in the core, and the carrier and supporting sectors in the Fordist paradigm (SI, SS, PNS) are over-represented in the periphery.

Results are given in *Table 3*. If we turn to the ICT-paradigm-sectors, we observe that INS and KIBS follow the predicted pattern of over-representation in the core, while SB is over-represented in the semi-periphery. The highest rates of entry and exit for SB are also in the semi-periphery. Thus, while SB does not exactly follow the predictions within the ICT paradigm, the two supporting sectors in this paradigm are highly over-represented in the core. Turning to the Fordist-paradigm sectors, we observe the predicted pattern for SI and SD of over-representation in the periphery, while the values for PNS are very close to zero (indicating that this sector follows the economy-wide location patterns). Thus, consistent with spatial PLC theory, the location patterns of the sectors operating primarily in the Fordist paradigm are almost the reverse of the location patterns for the sectors in the ICT paradigm.

Table 3 around here

Section 6. Conclusions

We can draw three main conclusions from our analysis of spatial differentiation in industrial dynamics in The Netherlands.

First, at the level of the whole economy, there is a spatial pattern of industrial dynamics that is consistent with spatial PLC thesis: entry and exit rates are highest in the core and lowest in the periphery, while the share of persistently growing firms is higher in the periphery than in the core.

Second, disaggregating the analysis from the economy-wide level, to the sectoral level, following the Pavitt-Miozzo-Soete taxonomy, the spatial PLC patterns are not systematically reproduced. In fact, only one out of the eight sectors – scale-intensive manufacturing – follows *all* the predicted patterns of industrial dynamics for entry-exit, turbulence, size, and persistent growth. Not coincidentally, this sector hosts what Castellacci

(2008) calls the carrier industries of the Fordist paradigm, on which (spatial) PLC theory was originally based. The remaining sectors do not follow all the patterns predicted by the spatial PLC, although for each sector most of the patterns were consistent with the spatial PLC model.

Third, we analysed location patterns by distinguishing between carrier and supporting sectors in the ICT paradigm with many products and services at an early stage in their lifecycle, and carrier and supporting sectors in the Fordist paradigm (SI, SS, PNS) with many products and services at a mature stage in their lifecycle. Sectors operating primarily in the Fordist paradigm were found to be over-represented in the periphery, while the opposite location pattern holds for sectors in the ICT paradigm, which are over-represented in the core. Thus, the location patterns of sectors are in line with the spatial PLC.

Overall, spatial PLC theory explains the spatial differentiation in industrial dynamics fairly well, for both manufacturing and services. However, we found a strong presence of science-based manufacturing in the semi-periphery rather than in the core. The semi-periphery is also the most dynamic area in terms of entry and exit in the science-based industries. Thus, it seems that – at least in the Dutch case – the core does not provide the ideal context for high-tech dynamism. Rather, since the core is dominated by the service sectors, innovative manufacturing is crowded out to the surrounding semi-periphery. This may well indicate that science-based firms can profit from the services provided by the nearby core without having to bear the diseconomies associated with agglomeration. This pattern may apply also to other countries where large metropolises have become functionally specialised in ICT-based business services possibly generating negative externalities for innovative manufacturing, with the latter pushed to the surrounding areas (Duranton and Puga 2005).

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Table 1. Descriptive Statistics (all sectors)

All sectors	core	semi-periphery	periphery	whole country
entry rate	0.126	0.117	0.109	0.119
exit rate	0.109	0.096	0.091	0.100
turbulence	0.236	0.213	0.201	0.219
average size	7.839	6.487	5.949	6.914
size=1	0.214	0.189	0.188	0.199
size=1,2	0.622	0.583	0.565	0.594
size=1,2,3	0.770	0.749	0.737	0.755
total number of firms	3,973,525	2,879,578	2,537,431	9,390,534

Table 2. Descriptive Statistics per sector

Scale-Intensive (SI)	core	semi-periphery	periphery	whole country
entry rate	0.086	0.082	0.076	0.081
exit rate	0.085	0.073	0.071	0.076
turbulence	0.171	0.155	0.147	0.157
average size	20.174	21.762	20.414	20.831
size=1	0.101	0.093	0.096	0.097
size=1,2	0.400	0.360	0.357	0.371
size=1,2,3	0.516	0.477	0.475	0.488
total number of firms	85,332	105,311	100,467	291,110

Supplier-dominated (SD)	core	semi-periphery	periphery	whole country
entry rate	0.100	0.088	0.087	0.092
exit rate	0.091	0.080	0.075	0.083
turbulence	0.192	0.168	0.162	0.175
average size	10.360	12.298	15.826	12.595
size=1	0.145	0.115	0.129	0.130
size=1,2	0.581	0.515	0.516	0.540
size=1,2,3	0.714	0.665	0.663	0.682
total number of firms	124,976	114,606	96,973	336,555

Science-based (SB)	core	semi-periphery	periphery	whole country
entry rate	0.089	0.102	0.093	0.095
exit rate	0.071	0.073	0.065	0.070
turbulence	0.160	0.175	0.159	0.165
average size	13.530	41.682	20.226	24.949
size=1	0.147	0.141	0.141	0.143
size=1,2	0.510	0.469	0.459	0.482
size=1,2,3	0.670	0.621	0.609	0.637
total number of firms	16,527	14,716	12,181	43,424

Specialised supplier (SS)	core	semi-periphery	periphery	whole country
entry rate	0.088	0.094	0.086	0.090
exit rate	0.075	0.068	0.066	0.070
turbulence	0.164	0.162	0.152	0.159
average size	17.151	18.524	18.359	18.069
size=1	0.120	0.103	0.099	0.107
size=1,2	0.419	0.389	0.357	0.387
size=1,2,3	0.528	0.512	0.473	0.504
total number of firms	23,090	29,908	26,308	79,306

Supplier-Dominated Services (SDS)	core	semi-periphery	periphery	whole country
entry rate	0.112	0.107	0.102	0.107
exit rate	0.082	0.075	0.076	0.078
turbulence	0.194	0.183	0.178	0.186
average size	5.503	4.369	3.945	4.678
size=1	0.179	0.179	0.185	0.181
size=1,2	0.580	0.573	0.556	0.570
size=1,2,3	0.748	0.752	0.749	0.749
total number of firms	729,633	542,541	591,618	1,863,792

Physical Network Services (PNS)	core	semi-periphery	periphery	whole country
entry rate	0.111	0.101	0.096	0.103
exit rate	0.103	0.087	0.083	0.092
turbulence	0.214	0.188	0.179	0.196
average size	7.737	6.320	5.441	6.630
size=1	0.143	0.133	0.131	0.136
size=1,2	0.531	0.500	0.485	0.508
size=1,2,3	0.713	0.693	0.687	0.699
total number of firms	1,311,496	1,040,821	94,897	3,300,814

Information Network Services (INS)	core	semi-periphery	periphery	whole country
entry rate	0.149	0.144	0.136	0.144
exit rate	0.184	0.172	0.160	0.175
turbulence	0.333	0.316	0.295	0.320
average size	8.755	3.441	3.423	6.025
size=1	0.492	0.433	0.432	0.462
size=1,2	0.765	0.727	0.720	0.744
size=1,2,3	0.872	0.865	0.856	0.867
total number of firms	546,431	323,652	251,924	1,122,007

KIBS	core	semi-periphery	periphery	whole country
entry rate	0.150	0.146	0.143	0.147
exit rate	0.103	0.099	0.099	0.101
turbulence	0.253	0.244	0.242	0.248
average size	7.542	5.296	4.755	6.263
size=1	0.203	0.197	0.213	0.203
size=1,2	0.710	0.703	0.710	0.708
size=1,2,3	0.834	0.840	0.842	0.837
total number of firms	1,136,040	708,023	509,463	2,353,526

Table 3. Sectoral location patterns

	core	semi-periphery	periphery
Scale-Intensive (SI)	-0.525	0.273	0.375
Supplier-Dominated (SD)	-0.452	0.145	0.443
Science-Based (SB)	-0.844	0.677	-0.022
Specialised Supplier (SS)	-0.552	0.295	0.371
Supplier-Dominated Services (SDS)	-0.041	-0.057	0.141
Physical Network Services (PNS)	-0.034	0.044	0.014
Information Network Services (INS)	0.389	-0.558	-0.600
KIBS	0.192	-0.123	-0.347

Natural logarithm of the ratio of area's employment shares at sectoral level and area's total employment share. Negative values indicate under-representation in a particular area and positive values over-representation in a particular area

Figure 1. Map of The Netherlands

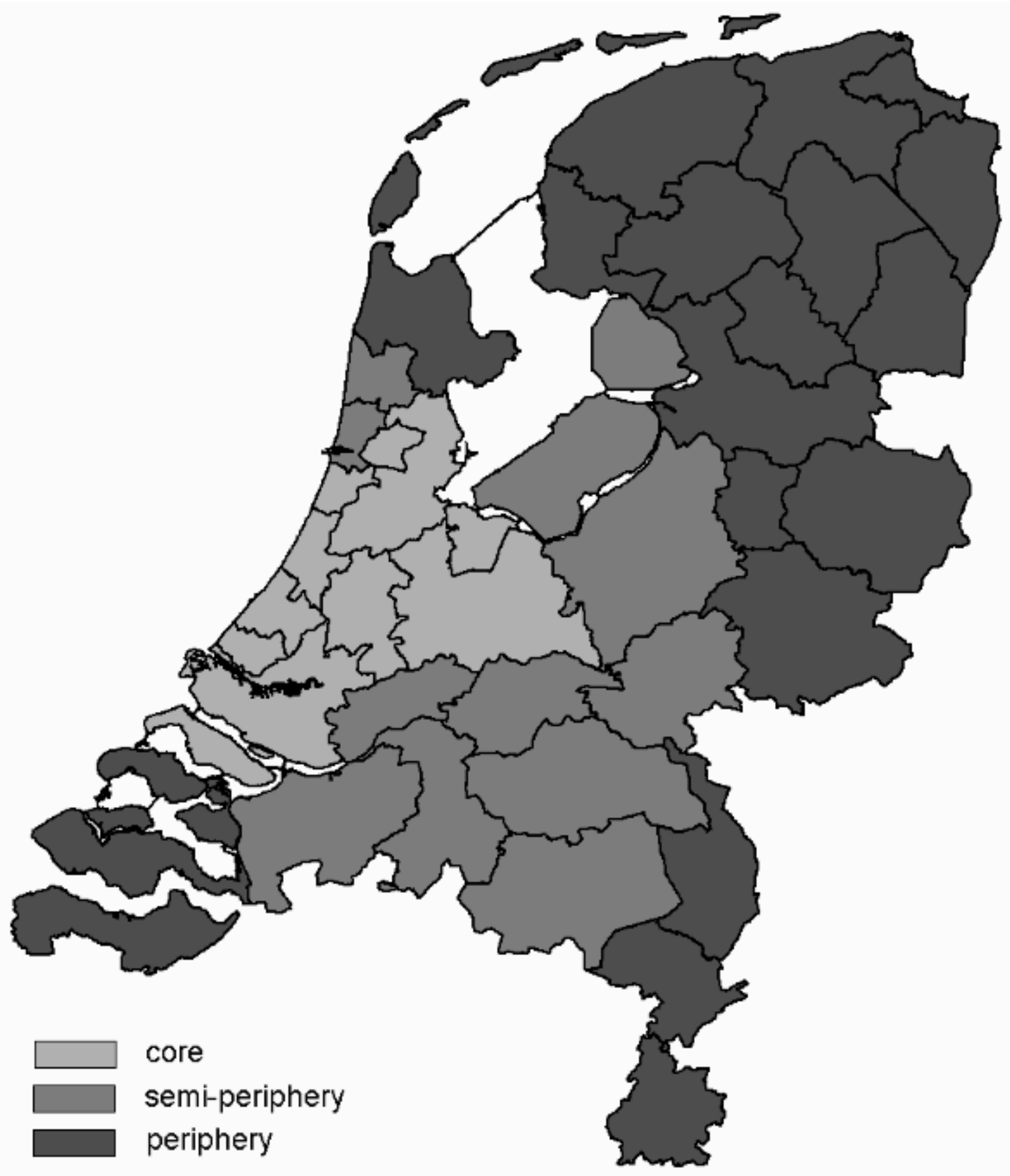


Figure 2. Share of persistently growing firms for different size classes. Some numbers stands for intervals (e.g., 12 stands for 11-13 employees, 15 for 14-16 employees, etc.)

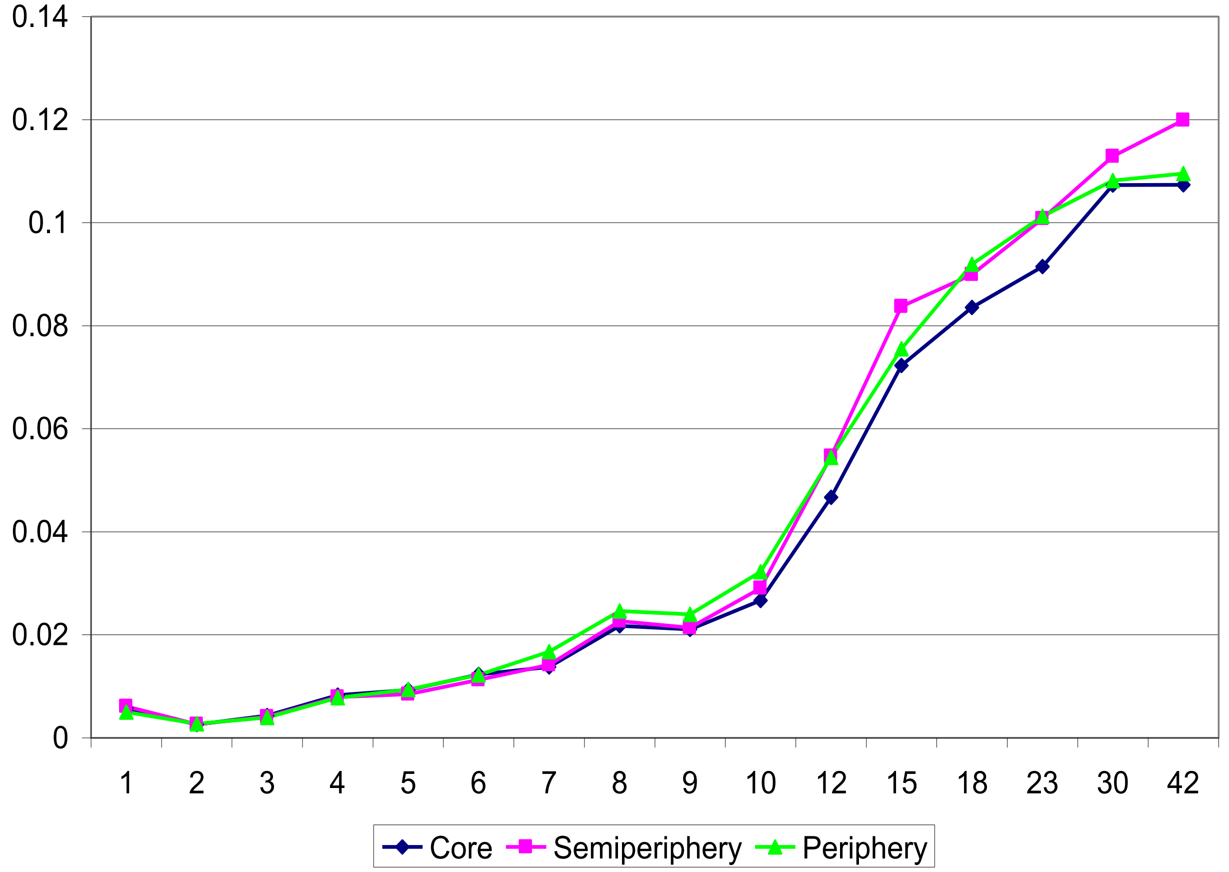


Figure 3a. Share of persistently growing firms for different size classes
Scale-intensive (SI)

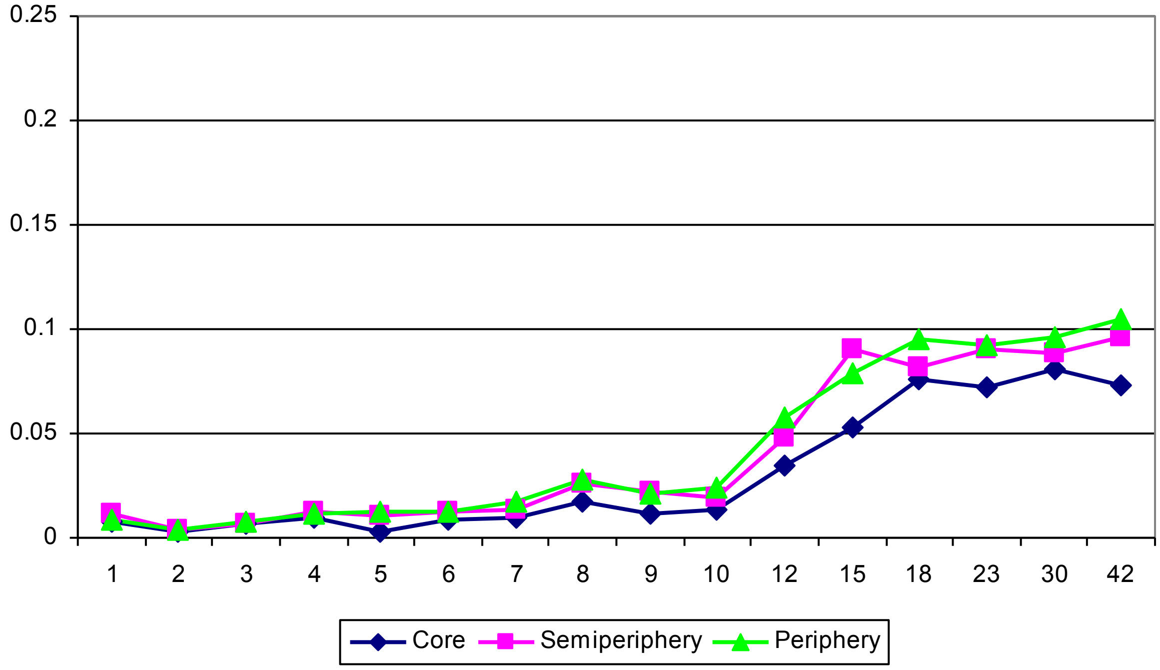


Figure 3b. Share of persistently growing firms for different size classes
Supplier dominated (SD)

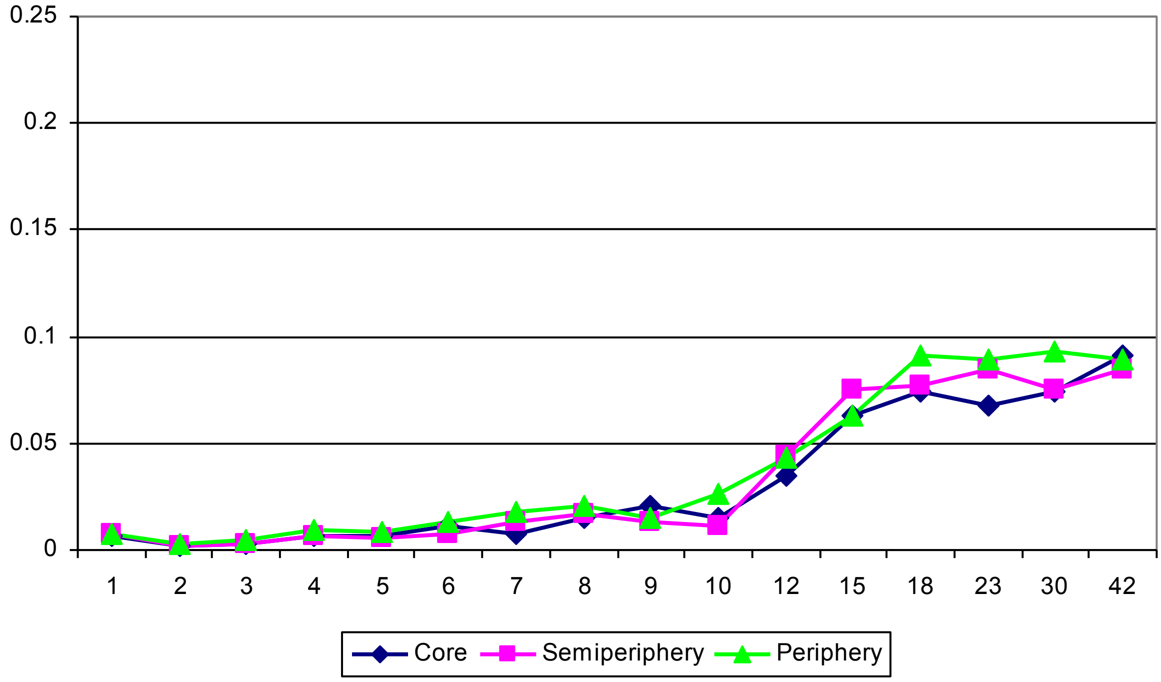


Figure 3c. Share of persistently growing firms for different size classes
Science-based (SB)

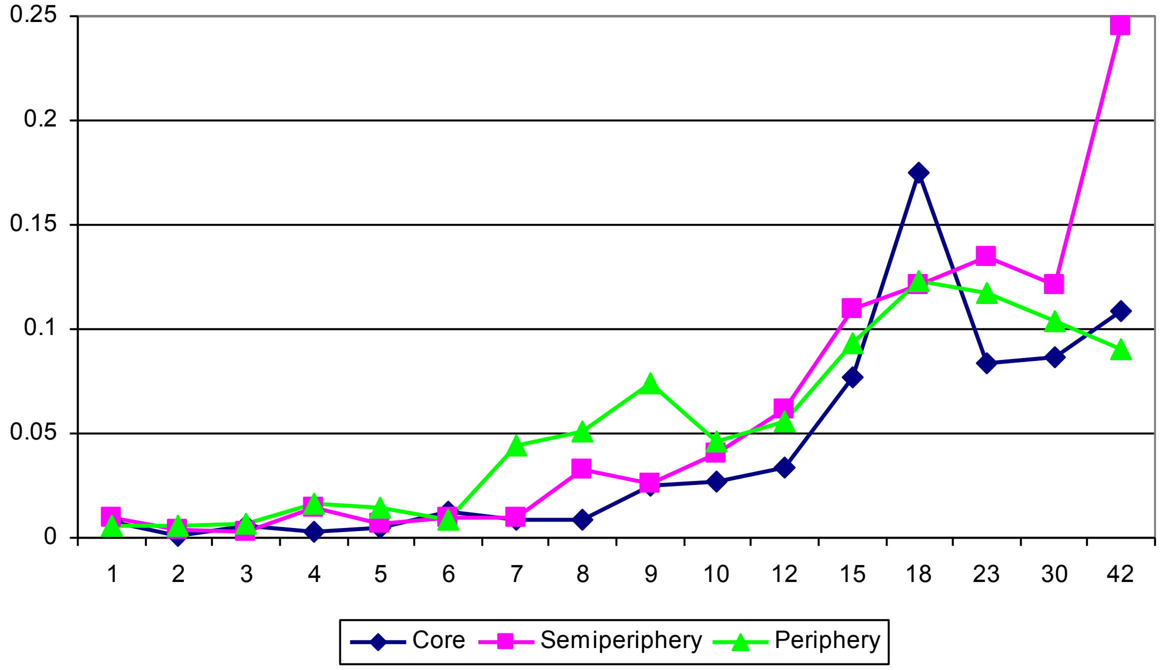


Figure 3d. Share of persistently growing firms for different size classes
Specialised supplier (SS)

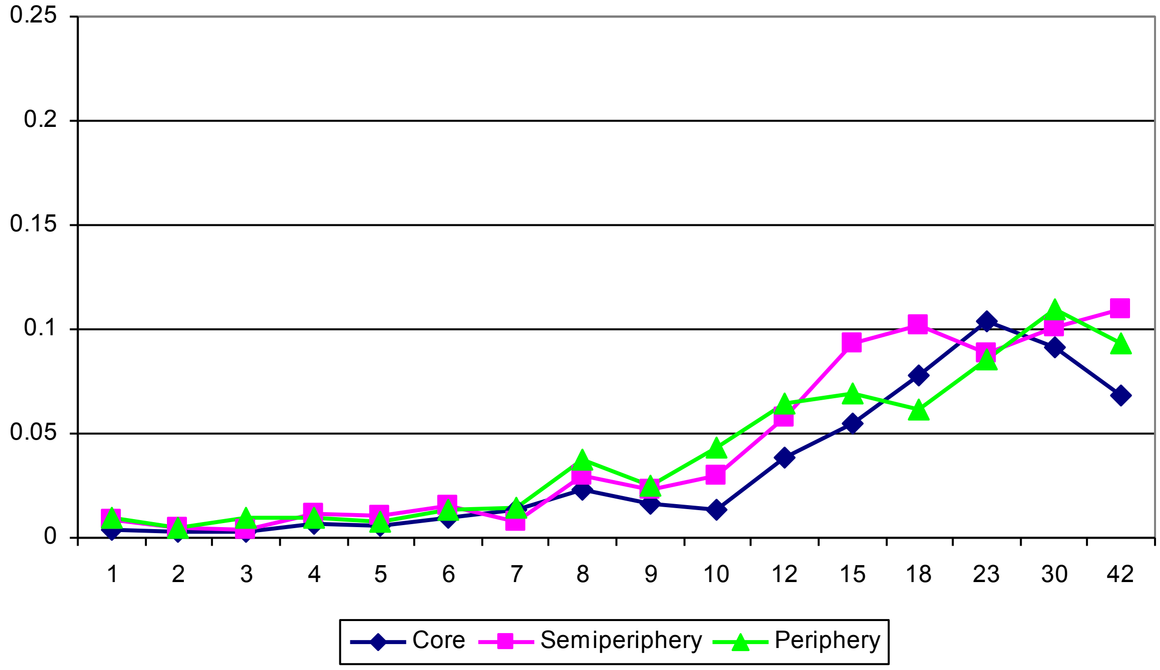


Figure 3e. Share of persistently growing firms for different size classes
Supplier-dominated services (SDS)

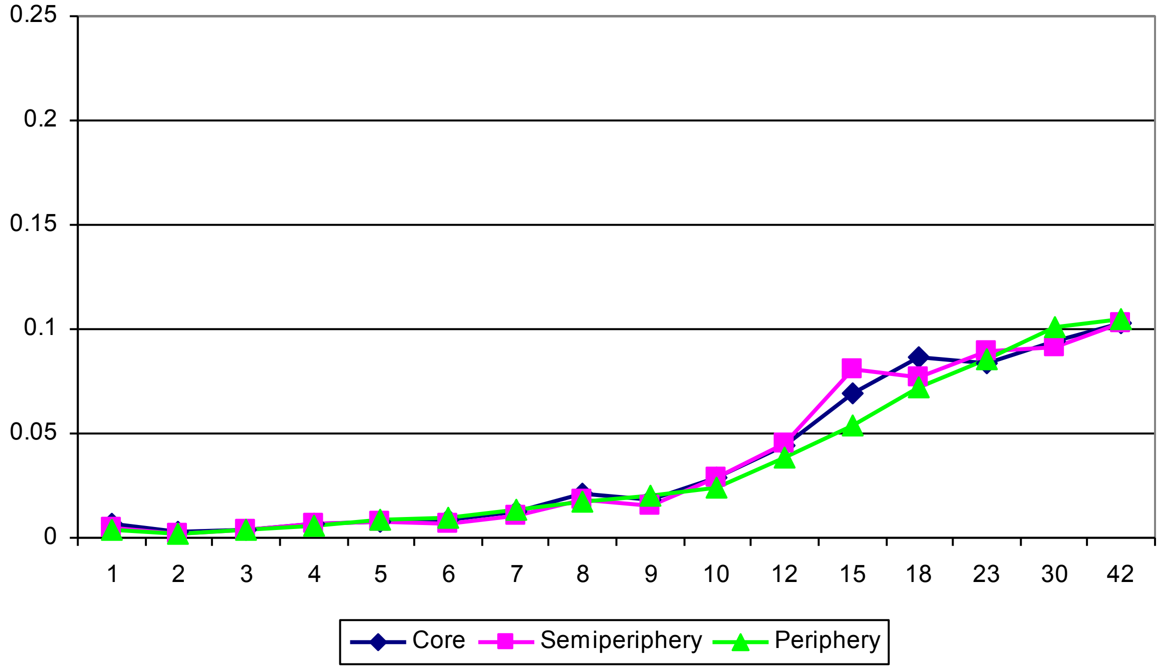


Figure 3f. Share of persistently growing firms for different size classes
Physical network services (PNS)

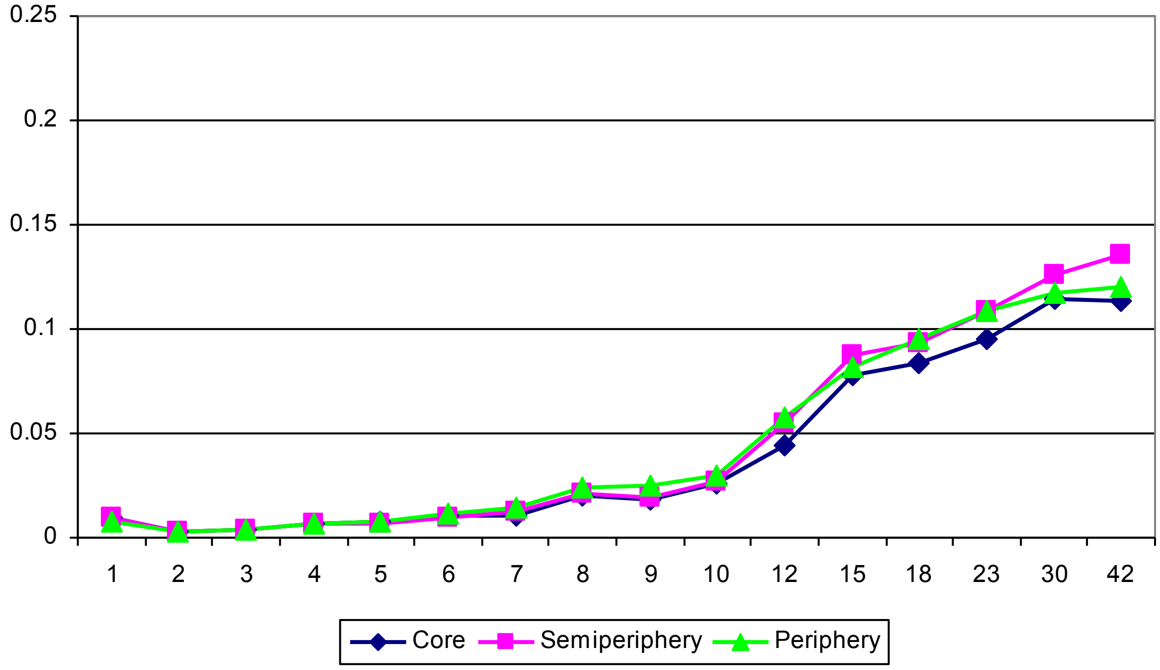


Figure 3g. Share of persistently growing firms for different size classes
Information network services (INS)

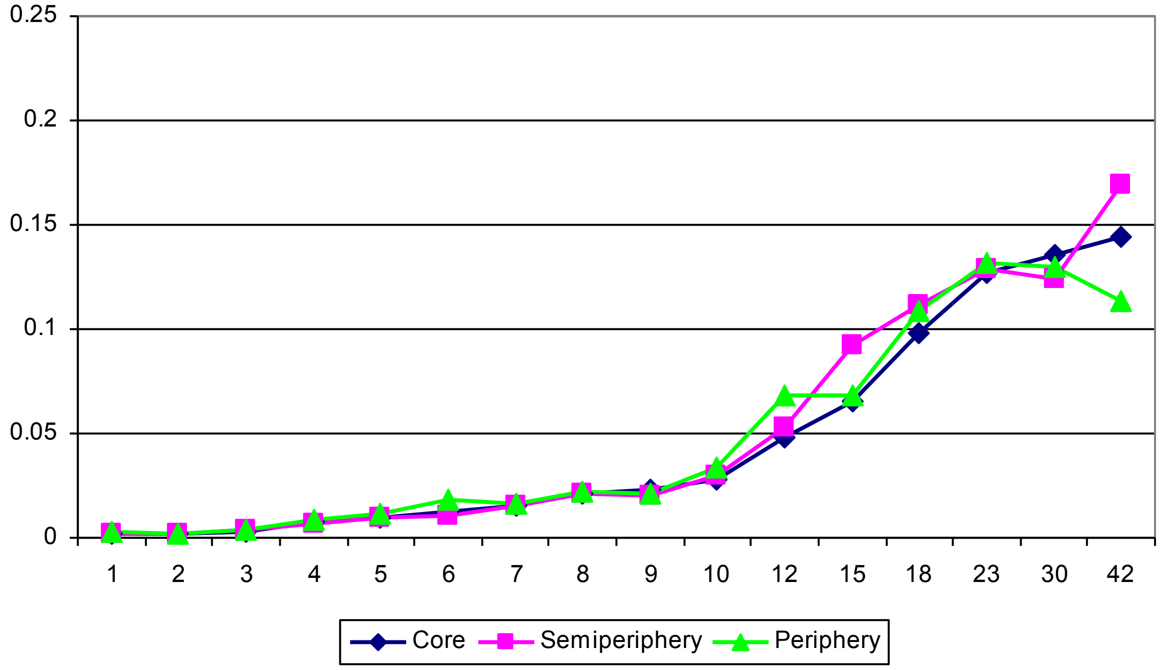
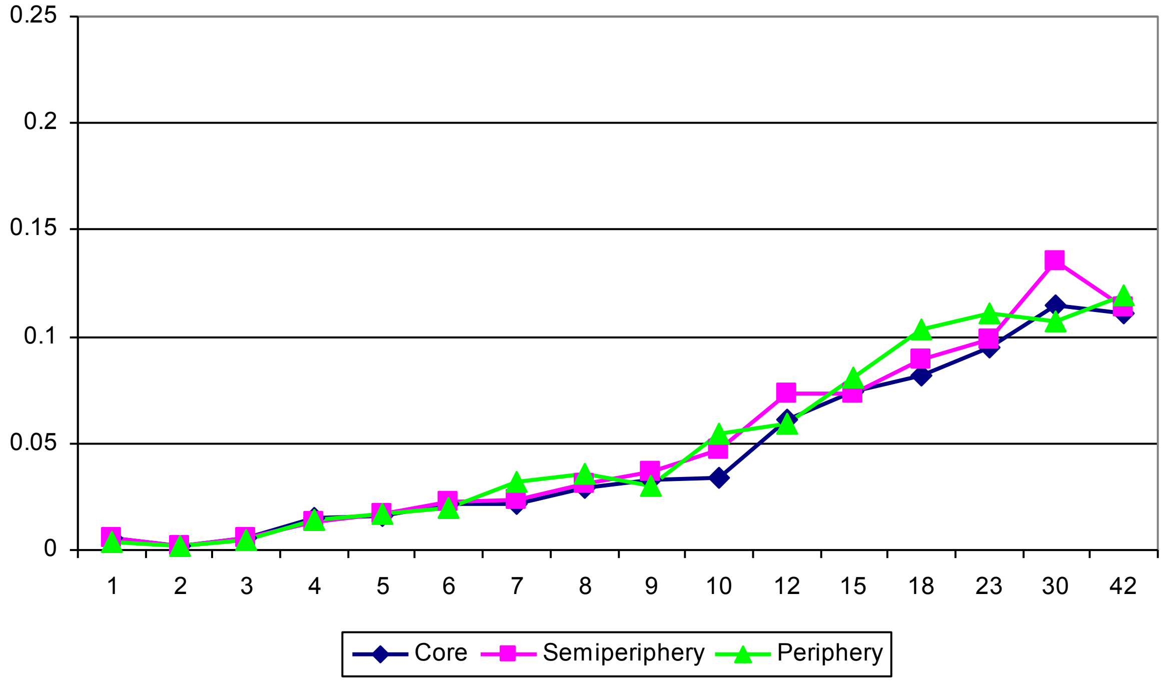


Figure 3h. Share of persistently growing firms for different size classes
Knowledge-intensive business services (KIBS)



Appendix

SIC codes and corresponding Pavitt-Miozzo-Soete (PMS) sectors

Industries	SIC	PMS
Food, drink and tobacco	15-16	SI
Textiles and clothing	17-18	SD
Leather and footwear	19	SD
Wood and products of wood and cork	20	SD
Pulp, paper and paper products	21	SD
Printing and publishing	22	SD
Mineral oil refining, coke and nuclear fuel	23	SI
Pharmaceuticals	244	SB
Chemicals excl. Pharmaceuticals	24×	SI
Rubber and plastics	25	SI
Non-metallic mineral products	26	SI
Basic metals	27	SI
Fabricated metal products	28	SI
Mechanical engineering	29	SS
Office machinery	30	SB
Insulated wire	313	SD
Other electrical machinery and apparatus	31x	SS
Radio, TV and comm. Equipment	32	SB
Scientific instruments	331-3	SB
Optical and other instruments	334-5	SS
Motor vehicles	34	SI
Other transport equipment	35	SI
Furniture, miscellaneous manufacturing; recycling	36-37	SD
Sale, maintenance and repair of motor vehicles; retail sale of automotive fuel	50	PNS
Wholesale trade and commission trade, exc. motor vehicles	51	PNS
Retail trade, exc. motor vehicles; repair of personal and household goods	52	PNS
Hotels and restaurants	55	SDS
Inland transport	60	PNS
Water transport	61	PNS
Air transport	62	PNS
Supporting and aux. transport activities; activities of travel agencies	63	PNS
Communications	64	INS
Financial intermediation	65-67	INS
Real estate activities	70	INS
Renting of machinery and equipment	71	SDS
Computer and related activities	72	KIBS
Research and development	73	KIBS
Other business activities	74	KIBS
Other community, social and personal services	90-93	SDS