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Core periphery analysis of the European Union: a location quotient approach

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Abstract. Given recent changes in the methods of collecting international trade data and long-standing doubts about the validity of these data—but particularly with respect to services—this paper develops and applies a location quotient-based methodology for analyzing core-periphery dualism. This method obviates the need to use trade data in this type of analysis. Application to the European Union shows agglomeration in core areas of high technology, large scale manufacturing, and producer services. Peripheral countries and subnational regions are shown to specialize in agriculture, extractives, low technology manufacturing, and standardized production.

1. Introduction

Over the last two decades a considerable literature has developed that analyzes the existence and implications of a core-periphery dualism among the nations of the European Union. This dualism associates economic and developmental superiority with the core nations, those that are geographically central to market centers. The superiority is evident in a greater concentration of high technology industries, producer services, job creation potential, and overall development potential (Keeble *et al.* 1988; Cuddy and Keane 1990). The resulting disadvantages of the peripheral nations stem from their locations and their sizes as to transportation costs, industrial agglomeration, and scale economies. Analysis of economic relationships between cores and peripheries has relied primarily on international trade data. The accuracy of these data has been questioned in the past (Feketekuty 1988; Molle 1990), primarily because of the invisibility of services. With the elimination of customs postings under the single European market, trade data now are based on surveys of business firms; this method exacerbates previous inaccuracies (Baker 1994.)

This paper develops and applies a location quotient-based methodology for analyzing core-periphery dualism that obviates the use of traditional sources of trade flow data. The paper describes the shortcomings of existing international trade data, explains the use of the location quotient methodology in international analysis, applies the methodology to the trade flows of the European Union, and examines the

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nature of trade flows between core and periphery nations, as well as between objective one regions (those lagging subnational areas eligible for EU structural development assistance because their GDP per capita is at least 25 percent below the EU mean) and the rest of the EU. Then we compare on a sector by sector basis core-periphery trade patterns calculated with the location quotient method with those developed from past trade data.

Our findings confirm the core-periphery relationships found by traditional techniques: agglomeration in core areas of high technology, large scale manufacturing, and producer services; specialization by peripheral places in agriculture, extractives, low technology manufacturing, and standardized production; importation of producer services by the periphery; and provision of consumer and government services on a residentiary basis in both the periphery and the core. Similar findings are obtained in a comparison of objective one regions to core regions. Trade flow data obtained by customs postings are remarkably similar to those proxied by location quotients. Therefore, as trade flow estimates obtained by the location quotient methodology are as reliable as the old customs postings-based trade data and the new survey-based trade data are less reliable than the old customs postings-based trade data, the location quotient method is an improvement over the new trade data.

2. The problems of data deficiency

In this section we review the developments in the identification and estimation of data inaccuracies and omissions for trade in services and goods. With increasing integration, existing problems with trade data accuracy likely will be exacerbated. Furthermore, EU 1992 liberalization is expected to increase trade in service activities markedly. Given the panoply of difficulties in tracking service trade, these increases in activities also will increase the absolute and relative amount of service trade not accounted for in the statistics.

One of three key aspects of the completion of the single European market in 1992 was the elimination of internal customs barriers. (The other two were the removal of fiscal barriers and the harmonization of technical standards.) A consequence of eliminating customs barriers was that customs forms no longer had to be presented, in relation to intra-EU trade. These forms were the basis for international trade data in member countries until the end of 1992. Since 1993 survey methods have had to be adopted. What this means is that all large firms—i.e., all significant contributors to the flows of goods and services between member countries—are sent an international trade survey form by member governments. Only a sample of the smaller participants are surveyed. While it may take time for the difference in accuracy between the old system based on customs forms and the new system based on surveys to become clear, what is already clear is that there is a degree of discontinuity in the data. The more disaggregated the data, the greater is the possibility of discontinuity.

Services account for about 20 percent of world trade (Riddle 1986). Yet national trade balances include extractive and manufacturing activities, but no services. The data on services suffer from too much aggregation relative to the fine disaggregation

of manufacturing. They also are expressed as net exports; that is, they do not differentiate a nation's imports and exports. The measurement of international trade in services is plagued with a number of other problems, each contributing to inaccuracy in the different accounts.

The first problem is definitional—which activities should be considered as services? Although numerous attempts have been made to define services by intangibility, perishability, and simultaneity of production and consumption, services frequently are defined negatively as those sectors that are not agriculture, manufacturing, or mining (Riddle 1986). The classification problems that affect manufacturing categorization are multiplied for services; consider the difficulties associated with the treatment of goods that have mixed service and manufacturing characteristics. Feketekuty (1988) notes the differing definitions of services used by policy makers, businesspersons, and statisticians and comments on the resultant differences in measurement. This causes problems over time, as growth is exaggerated by splintering in some measures of services. For example, certain functions (e.g., cleaning, designing) that had been performed by manufacturing firms have become independent and, as a result appear as services (Molle, p. 321).

A second set of service data problems originates in delivery mechanisms; they are the direct cause of many service activities slipping through the net of statistical measures. Services are delivered in a number of ways that defy the traditional measures of border crossings: they are delivered in person or via mail, e-mail, telephone, or fax. In face-to-face deliveries either the provider or the consumer may travel. Like manufacturing, service trade can be defined either on the basis of location or of ownership. In-house services provided by divisions of multinational corporations (MNCs) located in different countries often escape enumeration in international trade statistics. Even arms-length trade in services is more difficult to detect than that in goods.

Given the complexities of these problems, there are no firm measures of bias in existing measures of international trade in services. Riddle (1986) compares total worldwide exports and imports of services for 1983 and notes that exports in services were underreported by at least $100 billion. That is, $100 billion more imports than exports were reported, a difference of 30 percent of world service trade (Riddle 1986, p. 112). There is also a possibility of a simultaneous underreporting of imports.

3. Methodology

Estimating international trade flows shares many common problems with identifying basic or export sectors among the industrial sectors of core and peripheral regions within a nation. In the intranational case there are no records of trade flows, and all estimates of basic activities or exports from a given city to other areas within the nation or region must be proxied. In the international case, data on trade flows are both incomplete and inaccurate. Data detailing subnational flows within the EU are nonexistent. In this article proxying international and subnational flows is based upon a location-quotient technique common to regional economics. It is modified to incorporate elements specific to an international application.

Table 1. Notation

Employment in industry i	Total employment
e_{ir} = A peripheral place	e_{or} = A peripheral place
E_{io} = Employment in core + periphery	E_{oo} = Total employment, core, + periphery

In regional economics base studies divide economic activities into basic activities that produce goods and services for export outside the place of study and nonbasic (or residentiary) activities that are produced for local consumption. The basic sector's importance stems from its provision of a means of payment for imports and nonbasic production. The concept in regional economics of basic activities and the concept in international trade of exports are functionally close, albeit not absolutely parallel. Both areas use the concept of net exports in a parallel manner. We will use the terms *locality, place,* or *region* interchangeably to denote the geographic location of focus. The term *European Union* (EU) will refer to the aggregation of 12 countries: Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom.

The tool most often employed to identify and separate basic and nonbasic production is the location quotient (LQ). A location quotient is a simple measure of spatial concentration based upon either employment or income; it is a ratio of a local industry's share of total local income or employment to this same share in a larger place. Using the notation of Table 1, the LQ of an industry, i, in a peripheral place, r, is:

$$LQ_{ir} = \frac{e_{ir}/e_{or}}{E_{io}/E_{oo}}.$$

The rationale underlying the location quotient as a means of separating basic and nonbasic production is based on two measures: variance and magnitude. The variance of location quotients for basic production will be large—measured across a number of places—indicating specialization at some places; on the other hand, location quotients for nonbasic production will have small variances, indicating a common level of activity in that industry. Thus, variance reflects the degree of dedication of employment or income to a specific industry across a number of places and accordingly implies degrees of specialization, exportation, and importation. The second measure, magnitude of the LQ for a specific industry and place, can be interpreted to indicate that the activity is residentiary, exported, or imported, depending upon whether the LQ is greater than, less than, or equal to 1.0.[1]

[1] The central value of 1.0 is important to both this discussion and to the forthcoming discussion of agglomeration and, accordingly, merits further consideration. As an example, assume basic employment in place j (b_j) varies widely from place to place and that nonbasic employment in industry i (n_{ij}) is proportional to the economic base:

$$b_j$$

As in intranational regional analysis, basic and nonbasic industries also can be identified in an international context by considering the mean and standard deviation of the location quotient for an industry, measured across a large number of places. Nonbasic (or residentiary) industries are those with average LQs near 1.0 and with small standard deviations; LQs for basic industries have a much larger standard deviation, as the pattern of exports and imports imparts a range of values respectively above and below 1.0. Granted, one can envision a situation of intraindustry trade with equal dedication of labor to a specific industry and with resultant LQs of 1.0 and a low variance across places; this would be interpreted as residentiary activity by the above rules. As the ultimate goal of the proxy process is to indicate net exports, however, such a situation would be interpreted correctly as residentiary.

The problems associated with this method have been discussed in the literature for decades. Norcliffe (1982) develops an excellent synopsis of both theoretical considerations and empirical evaluations. He finds the theoretical basis to be sound and explains that the differences in empirical evaluations between the LQ methodology and other methods stem from problems in the LQ methodologies used. Empirical evaluations of accuracy by Tiebout (1962), Greytak (1969), Leigh (1970), Gibson and Worden (1981), and Mathur and Rosen (1974) indicate varying degrees of underestimation of economic base with a resultant overestimation of multipliers. Techniques to correct the sources of this underestimation of export base are developed by Isserman (1977a and 1977b) who demonstrates that disaggregation of industries to the

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The location quotient is always 1.0 in all nonbasic industries and in all places. Similarly, if:

e_{oj} = Total employment, basic and nonbasic, in place j

$$= b_j \left(1 + \sum_{i=1}^{n} a_i\right)$$

n_{io} = Total nonbasic employment, region-wide in industry i

$$= a_i \cdot \sum_{j=1}^{m} b_j$$

E_{oo} = Region-wide employment, basic and nonbasic

$$= \left(1 + \sum_{i=1}^{n} a_i\right) \sum_{j=1}^{m} b_j .$$

Some algebraic manipulation quickly shows that:

$$LQ_{ij} = \frac{n_{ij}/e_{oj}}{n_{io}/E_{oo}} = 1.0.$$

Thus, the dividing line between basic and nonbasic industries is made on the value of the location quotient measured across a number of places. A large variance indicates basic activity; a small variance and a location quotient with a value typically close to one indicate nonbasic activity.

three and four digit SIC level and inclusion of service and government exports will lessen these biases. He also recommends a bracketing approach, using both LQ and econometric techniques. Difficulties associated with the assumption of a closed national economy are approached by Norcliffe (1982) who incorporates national consumption data to correct the tendency of the LQ technique to underestimate the level of basicness of those regional industries in which the nation is an exporter.

The traditional assumptions for location quotient analysis of product homogeneity, consistency of production functions, and identical consumer preferences across places are admittedly even more difficult to justify in a multinational context than in the context of interregional differences within a country. Similarly, the assumption of a closed system, where the base represents the universe of places, also becomes more problematic as one moves to the international arena. Although one can turn a blind eye to some of these problems in light of the estimated 30 percent shortfall (Riddle 1986) in coverage of international trade in services, these questions evoke the need for empirical examination of the accuracy of the LQ method in an international setting. Later we compare the results of our LQ-derived measures to actual trade data. The close proxying of actual trade flows by this LQ method implies that the LQ method is a good proxy of real flows despite the less than perfect adherence to the assumptions. Further comparisons of the accuracy of LQ-derived estimates to measures based other methodologies in the international arena are necessary; comparisons of international LQ use that parallel the analyses of Tiebout (1962), Greytak (1969), Leigh (1970), Gibson and Worden (1981), or Mathur and Rosen (1974) would be an appropriate starting point.

3.1 Agglomeration and the location quotient

Up to this point we have assumed that the location of a specific industry in a core or a peripheral place is a function of comparative advantage in the traditional sense; we have not assumed that size of place is a factor in the location decision. Positing a hierarchical relationship between core and peripheral places for some industries would mean that the location of these activities is not a decision made independently of the nature of the place. In particular, core areas may offer some industries external economies through the concentration of larger numbers of other related industries in the area; financial and advanced business services are examples of industries that are concentrated in core areas. The resulting economies of agglomeration are manifested through the concentration of many forms of business in core places and in the sales of these products by industries in core places to peripheral areas. Because of these agglomerative economies, core places would exhibit location quotients larger than 1.0 in these lines of business; peripheral places would have smaller LQs. One therefore would expect an agglomeration of financial and advanced business services in core countries, with peripheral nations importing those services; core nations would exhibit higher-than-unity LQs in financial and advanced business services, and peripheral nations would have less-than-unity LQs. A measure of LQs for an agglomerative industry across all nations likely would show a high variance in LQs. But when is this variation in LQs the result of agglomeration, and when is it due to

exports and imports that arise from some comparative advantage derived from factors other than being in a core place? An answer to this question is developed below in the form of a correction for economies of agglomeration.

We now move beyond the traditional location quotient method of export identification toward correcting for agglomeration by first observing the effects of changing the denominator or base of the location quotient. Such changes in the denominator are made because the traditional calculation of location quotients on an all inclusive denominator (such as a group of nations) obscures the nature of export trade in peripheral places. The changes in location quotients that result from changing the denominator can reveal these obscured trading patterns.

Consider a large multinational economy comprising a number of nations that vary in population size and that are classified as either core or peripheral. If we pare the core areas from the denominator and recalculate the location quotients for the industries in peripheral places, we obtain location quotients whose size and standard deviations indicate trading patterns more fully. Furthermore, the changes in the location quotients of the peripheral places are systematically related to the aggregated or average location quotients of the eliminated core places in a way that can reveal additional information about the nature of the trading pattern. Again using the notation of Table 1, it can be shown that shifting from a total denominator to a peripheral denominator changes the location quotient for a peripherally located industry as follows:

$$LQ'_{ir} = LQ_{ir} - \Delta LQ_{ir} \tag{1}$$

where:

LQ'_{ir} = The adjusted location quotient;
e_{iu} = Employment in industry i in all core places; and
e_{ou} = Total employment in all core places.

$$\Delta LQ_{ir} = \frac{e_{ir}/e_{or}}{E_{io}/E_{oo}} - \frac{e_{ir}/e_{or}}{(E_{io} - e_{iu})/(E_{oo} - e_{ou})} \tag{2}$$

and after some algebraic manipulation:

$$\Delta LQ_{ir} = \frac{LQ_{ir}[(E_{io}e_{ou} - E_{oo}e_{iu})/E_{oo}]}{E_{io} - e_{iu}} \tag{3}$$

Because $e_{iu} < E_{io}$, the denominator of this term must be non-negative and would rarely be 0.0. By multiplying the numerator and denominator of equation (3) by $E_{oo}/(E_{io}e_{or})$ the equation can be reduced to the more elegant:

$$\Delta LQ_{ir} = \frac{LQ_{ir}(1 - LQ_{iu})}{(E_{oo}/e_{ou}) - LQ_{iu}}$$

The sign of ΔLQ_{ir} will depend only on LQ_{iu}—whether it is greater than, less than, or equal to 1.0. (LQ_{iu} is the location quotient of industry i in the core.) For example, if there is core agglomeration ($LQ_{iu} > 1.0$), shedding the core from the denominator will increase the peripheral location quotients; if basic activity flows from the peripheral to the core areas ($LQ_{iu} < 1.0$), shedding the core from the denominator will decrease the peripheral location quotients. There will be no change in the location quotients of purely residentiary activity ($LQ_{iu} = 1.0$) when the core is shed from the denominator.

Because we work at a level of disaggregation below the national level in our application, it is necessary to define those lesser places and to incorporate them into the analysis. Accordingly, we will use the term *hinterlands* to designate those subnational or lower order places; hinterland size will vary by industry.

We ideally would like to distinguish products that originate in higher order places in a nation and are exported only to lower order places and those exports that cross national boundaries and go to like-sized and higher order places. The first of these are *agglomerative exports*. The second, exports that flow to like-sized places and larger places, are *basic exports*. As a practical matter we assume that extensive trade with other places of similar or smaller size that are nested in other hierarchies is unlikely to occur—unless it is accompanied by extensive trade with higher order places. This higher order trade seems likely to dominate, so we will refer to *basic* flows as moving upward through the hierarchy, and *agglomerative* flows as moving downward.

We also need to define basic and agglomerative imports. Their relationship to the export definition is parallel. Imports that originate solely in a higher order place are *agglomerative imports*. Imports that cross the boundaries to higher order places are *basic imports*. Thus agglomerative imports flow down the hierarchy, and basic imports flow upward.

Table 2 summarizes a set of rules to determine direction of flow of economic activity through a hierarchy, as well as the economic rationale for the flow's existence. The rules are based on:

- The direction of the change in the value of a location quotient when its denominator is shifted; and
- The value of the location quotient after the shift is made.

For example, suppose that an industry for a peripheral country has a location quotient of 0.79 on the total denominator and a location quotient of 1.08 on the adjusted denominator. As ΔLQ is negative, the industry is agglomerative in nature; because $LQ' > 1.0$, this place is an agglomerative exporter of the good. Flows may extend upward or downward between periphery and core.

To summarize the rules and definitions, a basic flow moves upward for peripheral countries and is indicated by a positive sign for ΔLQ when LQ is recalculated with all higher strata eliminated from the denominator. A basic good or service can be exported or imported. A basic export is the sale by a particular level of place to higher levels of the hierarchy, and it is indicated by $LQ' > 1.0$. Similarly, a basic import is indicated by a positive ΔLQ and $LQ' < 1.0$. On the other hand, a downward flow of trade occurs due to agglomeration at higher levels of the hierarchy and is indicated by a negative change in the location quotient. For a particular size of place,

Table 2. Summary of classification rules

ΔLQ	LQ'	Direction and type of trading activity
Basic (upward flow of trade)		
> 0.0	> 1.0	Exporter: Contributes to flow to higher levels
> 0.0	< 1.0	Import receptor: Absorbs the upward flow
Agglomerative (downward flow of trade)		
< 0.0	> 1.0	Hinterland service: Serves own hinterland
< 0.0	< 1.0	Importer from higher levels: Own hinterland is partially served by higher order places
Residentiary (self-sufficient)		
= 0.0	= 1.0	

agglomerative exports (LQ' > 1.0) are simply sales to its hinterland. The opposite case, agglomerative imports (LQ' < 1.0), arises when agglomerative economies occur at higher levels of the hierarchy than the place considered. Then the place considered and its hinterland will be served at least partly by the higher order place. Self-sufficiency—the residentiary case—is noted in the table. There is no change in the value of the LQ when the denominator shifts and LQ' remains near 1.0.

There are overlapping measures that indicate the extent of trade activities after the shift in denominator: residential activity is indicated by relatively low standard deviations for an industry across all places, whereas exports and imports are indicated by large standard deviations for the industry across places. Finally, the degree of agglomeration in core places is indicated by the magnitude of the negative change in LQs when the denominator is shifted.

3.2 Differences between LQ-determined specializations and trade flows

Using the LQ method described above we can delineate categories of imports and exports that are grounded upon our earlier definitions of basic and nonbasic activities. These differ from imports and exports delineated in trade data by the inclusion of service industries. As long as employment is dedicated to these industries, the degree of exportation, importation, and core agglomeration is indicated when the method is applied. The method of delivery is not of consequence, nor is the use of services as inputs into the production of goods and services that are exported. Thus, an LQ greater than unity after the core is shed from the denominator indicates a basic activity, production of which ultimately brings funds into the place and contributes to economic growth.

4. Application of the method

This location quotient methodology is used in an analysis of industry exports for two aggregations of European regions. The first aggregation compares trade patterns of

the European peripheral nations to core nations. The peripheral category comprises Greece, Ireland, Portugal, and Spain; the core category includes the remaining EU nations, with the exception of Italy for which adequately disaggregated regional data are not available. The second study analyzes the trade patterns of the EU regions identified as *objective one*, those lagging subnational areas eligible for structural development assistance because their GDP per capita is at least 25 percent below the EU mean (Commission of the European Community 1991).

The database used is the Eurostat regional employment set at the two digit NACE classification for the 66 regions of the NUTS 1 level of geographic disaggregation, 1989. In the data set Denmark and Ireland each are treated as a single region; this presents no problems, given the homogeneity of income levels within each of the countries. As there is no regional breakdown available for Italy, the country is excluded from the analysis, in both its potential roles as an EU nation in the denominator and as a nation with objective one regions. (Excluding Italy leaves 54 regions in the data set.)

The first step in the core-periphery analysis is the calculation of location quotients for each two digit NACE industry in each of the 54 regions. LQs are calculated for each industry of each region across the total EU and across the peripheral nations. Then means and standard deviations of two aggregations of LQs are calculated: those for the aggregation of the 16 regions on the denominator of 54 regions (these 16 are all the regions of the peripheral countries) and those for all nations on the denominator of 54 regions.

Table 3 summarizes the results of those calculations. It is evident from the LQs of the aggregated peripheral nations on the total EU denominator (column 1) that relative to the core nations, the peripherals export agricultural and primary extractive materials. Among manufactured goods, LQs are greater than 1.0 for those manufactured goods that generally are of low technology and standardized production: food, drink, and tobacco; textiles, footwear, and clothing; and timber and wooden furniture. High technology and large scale manufactures are imported from the core nations, as evidenced by LQs less than 1.0. A similar dualism prevails among the services: in the peripheral nations wholesale distribution, retail distribution, communication, and educational services are residentiary (as indicated by close-to-unity LQs), whereas all categories of producer and business services show importation from the core. The only services in which LQs for the peripherals exceed the mean are the four categories of transportation services: land, sea, air, and transportation support, as well as the hotels and tourism support services. All of these conform to the traditional roles of peripheral nations vis-á-vis the core; furthermore, the magnitude of the transportation specialization LQs in the periphery underscores the costs of physical peripherality.

After the denominator shift is made to adjust for the agglomeration of some industries to core places, what profile of the peripheral nation remains? A glance down the mean LQs on the revised denominator (column 2) shows significant changes in the first three industries, the extractive sectors. Although agriculture clearly remains as an export, the LQs for both fishing and forestry drop to import levels when the core nations are stripped from the denominator, implying that the peripherals do not specialize in forestry and fishing. There is little change in the

Table 3. Mean LQs, change in LQs, standard seviations of LQs by industry

NACE categories	(1) Mean LQs 16/54	(2) Mean LQs 16/16	(3) CHLQ column 1 minus column 2	(4) Standard deviation 54/54	(5) Mean LQs OB1/54	(6) Mean LQs OB1/OB1	(7) CHLQ column 5 minus column 6
01 Agriculture	3.01	1.29	1.72	1.69	3.52	1.11	2.41
02 Forestry	1.73	0.64	1.08	1.74	1.90	0.52	1.38
03 Fishing	3.25	0.82	2.43	3.53	3.32	0.67	2.65
11 Solid fuels	0.44	0.96	-0.53	2.54	0.48	0.74	-0.26
12 Coke ovens	0.00	0.00	0.00	4.99	0.00	0.00	0.00
13 Petroleum & natural gas	0.00	0.00	0.00	3.19	0.00	0.00	0.00
14 Oil refining	0.89	0.84	0.04	2.48	0.55	0.91	-0.36
15 Nuclear fuels	0.00	0.00	0.00	3.30	0.00	0.00	0.00
16 Electricity, gas, steam	0.55	0.72	-0.17	0.57	0.55	0.73	-0.18
17 Water supply	0.57	0.79	-0.21	1.32	0.43	0.71	-0.29
21 Extrusion of metal ores	1.75	1.02	0.72	3.95	2.15	0.81	1.35
22 Production of metals	0.46	0.92	-0.46	1.62	0.37	0.73	-0.36
23 Other minerals, peat wxtraction	1.47	0.81	0.66	1.70	1.66	0.71	0.95
24 Manufacturing nonmetal mineral products	0.86	0.71	0.16	0.60	0.76	0.67	0.09
25 Chemicals	0.45	0.67	-0.22	0.69	0.25	0.59	-0.34
26 Man-made fibers	0.00	0.00	0.00	5.32	0.00	0.00	0.00
31 Metal articles	0.70	0.75	-0.06	0.63	0.41	0.63	-0.22
32 Mechanical engineering	0.32	0.71	-0.39	0.59	0.15	0.69	-0.54
33 Manufacturing office & data processing machinery	0.25	1.00	-0.75	0.97	0.18	1.06	-0.88
34 Electrical engineering	0.34	0.75	-0.41	0.56	0.19	0.71	-0.52

Table 3 (cont.). Mean LQs, change in LQs, standard seviations of LQs by industry

NACE categories	(1) Mean LQs 16/54	(2) Mean LQs 16/16	(3) CHLQ column 1 minus column 2	(4) Standard deviation 54/54	(5) Mean LQs OB1/54	(6) Mean LQs OB1/OB1	(7) CHLQ column 5 minus column 6
35 Motor vehicles, parts, accessories	0.36	0.79	-0.44	0.78	0.18	0.85	-0.68
36 Other transportation manufacturing	0.76	0.80	-0.05	1.22	0.84	0.79	0.04
37 Instrument engineering	0.23	0.83	-0.60	0.96	0.13	1.06	-0.93
41 Food, drink, tobacco	1.21	0.98	0.23	0.50	1.17	1.01	0.16
43 Textile	2.17	1.22	0.95	2.78	2.48	1.27	1.21
44 Leather, leather goods	1.16	0.52	0.64	1.46	0.61	0.46	0.15
45 Footwear, clothing	1.33	0.72	0.61	0.88	1.40	0.67	0.73
46 Timber, wood furniture	1.17	0.92	0.24	0.50	1.13	0.90	0.23
47 Paper/paper products/printing/publishing	0.49	0.72	-0.23	0.44	0.35	0.74	-0.39
48 Rubber, plastics	0.51	0.75	-0.24	0.74	0.36	0.72	-0.36
49 Other manufacturing	0.76	0.59	0.18	1.22	0.52	0.51	0.01
50 Building, civil engineering	1.21	1.09	0.11	0.23	1.27	1.09	0.17
61 Wholesale distribution	0.91	1.02	-0.10	0.35	0.90	1.11	-0.21
62 Scrap, waste materials	0.65	0.41	0.24	2.00	0.00	0.00	0.00
63 Agents	0.90	1.03	-0.13	1.63	0.88	1.04	-0.16
64 Retail distribution	0.93	1.04	-0.11	0.17	0.99	1.01	-0.02
66 Hotels, catering	1.73	1.10	0.63	0.62	1.69	1.13	0.55
67 Repair/goods & vehicles	1.21	0.82	0.39	0.44	1.19	0.78	0.41
71 Railways	0.49	0.76	-0.28	0.80	0.27	0.62	-0.34
72 Other land transport	1.30	0.94	0.35	0.43	1.18	0.96	0.22

Table 3 (cont.). Mean LQs, change in LQs, standard seviations of LQs by industry

NACE categories	(1) Mean LQs 16/54	(2) Mean LQs 16/16	(3) CHLQ column 1 minus column 2	(4) Standard deviation 54/54	(5) Mean LQs OB1/54	(6) Mean LQs OB1/OB1	(7) CHLQ column 5 minus column 6
73 Inland water	0.00	0.00	0.00	4.52	0.00	0.00	0.00
74 Sea transport	1.66	0.80	0.86	1.91	1.50	0.70	0.80
75 Air transport	1.09	0.90	0.19	1.49	0.73	0.87	-0.14
76 Transportation support services	1.33	0.91	0.42	1.45	1.18	0.89	0.29
77 Travel agents/freight. broks.	0.37	0.96	-0.60	1.15	0.28	1.11	-0.84
79 Communication	0.52	0.80	-0.28	0.40	0.44	0.82	-0.37
81 Banking, finance	0.75	0.91	-0.15	0.51	0.63	0.96	-0.33
82 insurance	0.38	0.75	-0.37	0.70	0.33	0.84	-0.51
83 Finance auxiliary/real estate/business services	0.49	0.84	-0.35	0.47	0.38	0.94	-0.56
84 Renting of Movables	0.06	0.56	-0.50	1.20	0.00	0.00	0.00
85 Owner let real estate	0.15	0.56	-0.40	1.28	0.27	2.02	-1.75
91 Public administration, defense	0.89	1.12	-0.23	0.37	0.95	1.13	-0.18
92 Sanitary services	0.73	0.88	-0.15	0.71	0.51	0.86	-0.36
93 Education	0.90	0.99	-0.09	0.28	0.92	1.05	-0.13
94 Research & development	0.30	0.92	-0.62	0.95	0.13	0.98	-0.85
95 Medical services	0.67	0.98	-0.31	0.30	0.68	1.06	-0.38
96 Other services	0.35	0.68	-0.33	0.58	0.29	0.89	-0.59
97 Recreation/cultural services	0.70	0.86	-0.16	0.56	0.59	0.90	-0.31
98 Personal services	1.41	0.92	0.48	0.49	1.28	0.87	0.41
99 Other	0.28	0.62	-0.34	1.75	0.88	1.38	-0.51

manufacturing sectors: several of the low tech industries drop below the absolute margin of exportation, and most of the services categorized as exports relative to the core drop toward the residentiary classification. This implies that after the adjustment for agglomeration is made and the comparison is based upon the activities of peripheral nations, these nations manifest expected levels of transportation services, that is, expected by the standards of peripheral places. Producer and business services are still being imported. Column 3 presents the change in LQs attributable to the change in denominator; it is the difference between columns 1 and 2. Most of the services have substantively negative changes in LQs associated with the shift of denominator. This implies that there is a great deal of agglomeration of these sectors in core places. The shift of denominator has removed the agglomeration and adjusted the LQs upwards so that most of these services approach residentiary status.

The implications of the sign of the change in LQ when the denominator is shifted (presented in column 3) are also consistent with the designation of exports and imports. That is, exports from the peripheral nations are associated with a positive change in LQs, indicating an upward flow of trade. Conversely, those industries designated as having products that are imported into peripheral nations have negative changes in LQs, indicating the downward flow of trade associated with agglomeration. The only exceptions are NACE categories 24, 49, and 62, where smaller-than-unity LQs combine with positive changes in LQs to indicate that those industries in peripheral countries are importing from their hinterlands or from the hinterlands of equal size or smaller places.

Standard deviations of LQs across all 54 regions provide an overlap measure, the magnitude of which indicates the degree to which the products of a given industry are traded around the EU. The location quotients for all 54 regions in aggregation are not shown in Table 3; as only the standard deviations of these calculations are germane, only these are shown in column 4 of the table. Based on our previous work (Gilmer, Keil, and Mack 1989), we use 0.40 as a more or less arbitrary cut-off point to delineate the traded from the nontraded industries. Accordingly, the output of most of the industries is traded. Those that are deemed residentiary by a standard deviation of less than 0.40 are mechanical engineering, building and civil engineering, wholesale trade, retail trade, communications, real estate, public administration, education, and medical services. Extremely high standard deviations, such as those for textiles, ore, and peat moss extraction imply not only trade across places, but imply the likelihood that only one or two countries are exporters of the commodities.

A second set of measures is developed for the objective one regions; these comprised all so designated regions, except all those in Italy, for which data are not available. Given that objective one regions are defined in terms of NUTS 2 and our data set provides only employment by NUTS 1 regions, a small amount of inclusion of non-objective one and exclusion of objective one employment is necessary. Thus, for example in the case of Spain, all of Noroeste (Galicia, Asturias, and Cantabria) is included as objective one even though only Galicia and Asturias are objective one regions. In the case of France, its objective one region, Corsica, is excluded because it would be a small part of the NUTS 1 region, Mediterranée. The main differences between the peripheral 16 regions and the 13 regions defined as objective one are the

exclusion of Denmark and three of the seven Spanish regions in the latter, as well as the inclusion of Northern Ireland from the U.K.

LQs first are calculated on a total EU denominator, and then the denominator is shifted to the peripheral regions in order to adjust for agglomeration. Column 5 of Table 3 shows the mean LQs for objective one regions calculated on the total EU denominator. Despite the fact that total employment in objective one regions is equivalent to only 65 per cent of that in peripheral nations, their trade relationships to the core closely parallel those for the peripheral nations. This is as expected and is shown in the comparison of the respective LQs in columns 1 and 4. A closer examination of these columns indicates several interesting trade patterns. First, those industries that are residentiary in the peripheral aggregation are still residentiary in the objective one aggregation. Surprisingly, almost every industry that is classified as an export in the peripheral aggregation remains so for the objective one aggregation. The exceptions are leather and leather goods and air transport which are classified as exports for the peripheral aggregation but not for the objective one aggregation. When manufactured imports are examined for the two aggregations, all those industries designated as imported into the peripheral aggregations are carried as imports for the objective one places. Furthermore, with the exception of only one industry (other transport manufacturing) all manufacturing imports for the objective one places have smaller LQs than those for the peripheral classification. The smaller magnitude of those LQs that are less than unity indicates that the objective one places are importing even more from core places than are the peripherals. Finally, as in the peripheral aggregation, the change in sign of the LQs (presented in column 7) is consistent with the import/export designation by means of the magnitude of LQ. With the exception of NACE sectors 24, 36, 44, and 49, all exports from objective one industries are associated with downward trade flows justified by agglomeration. In those four cases the magnitude of the changes is close to 0.0.

For the service industries similarly consistent patterns emerge. The LQs for service industries are consistently smaller for objective one places than for the peripheral aggregation, indicating that the former import even more producer, business, and financial services than do the latter. For those few services that are designated as exports for the peripheral aggregation, LQs are smaller in the objective one places, indicating a lesser tendency toward exportation. This runs counter to the greater exportation for the objective one places in the extractive and manufacturing industries.

How can these consistent patterns be interpreted? Evidently objective one places have the same relationship to the core as the peripherals do. They are even more peripheral in that they export extractives and low technology manufactures to an greater extent than do the peripheral classification. Similarly, they have more of a tendency to import high tech manufactures and business services. Finally, those few services that exist in higher proportion in the periphery than in the core (transportation and hotel services) are less evident in the objective one places.

Table 4. Rank ordering of mean LQs and (X - M) data

NACE categories	(1) LQs in rank order	(2) X - M in rank order	(3) Columns (1) - (2)
Fishing products	1	18	-17
Agriculture	2	6	-4
Textile	3	2	1
Extraction of metal ores	4	9	-5
Hunting/forestry	5	11	-6
Other minerals, peat extraction	6	10	-4
Footwear/clothing	7	5	2
Food/drink/tobacco	8	1	7
Timber/wood/furniture	9	4	5
Leather/leather goods	10	13	-3
Oil refining	11	8	3
Manufacturing nonmetal mineral production	12	3	9
Other manufacturing	13	16	-3
Metal articles	14	12	2
Water supply	15	7	8
Electricity/gas steam	16	14	2
Rubber/plastics	17	15	2
Paper/paper products/publications	18	21	-3
Production of metals	19	23	-4
Chemicals	20	25	-5
Solid fuels	21	20	1
Motor vehicle parts, accessories	22	22	0
Electrical engineering	23	24	-1
Mechanical engineering	24	26	-2
Manufacturing office & duplicating machinery	25	17	8
Instrument engineering	26	19	7
Coefficient of rank correlation	$r_s = 0.72$		

Significant at the $\alpha = .01$ level

5. Comparison to existing trade data

There is no categorization of trade data directly comparable with the NACE categories. The closest is Eurostat's NACE-CLIO classification. By extracting the appropriate trade data from NACE-CLIO at the three digit level, however, a close approximation to 26 of the NACE two digit categories is possible. For example, the NACE-CLIO two digit branch 23, office and data processing machines; precision and optical instruments, does not have a NACE equivalent. At the three digit (NACE-CLIO group) level, this could be broken into the equivalents of NACE class 33, office and data processing machinery, and NACE class 37, instrument engineering.

The data on the 26 categories enable us to calculate the net exports of the main extractive and manufacturing industries in the peripheral countries. The industries are then rank-ordered in terms of net exports. This rank-ordering is compared to the rank-ordering of net exports calculated by means of the simple location quotient methodology. Results are presented in Table 4. Even with the extreme values for fishing products, the Spearman rank-order correlation coefficient of .72 is significant at the .01 level.

With such a high degree of correlation for the extractive and manufacturing industries, one can assume some viability of the location quotient-based estimates of

trade in services, for which trade data do not exist. Also, any distortion of traditional trade statistics by intrafirm trade and transfer pricing is not significant enough to prevent this correlation. "Because of the enforced change in collection methods it is not known how comparable current data for intra-EC trade are with figures for previous years" (Baker *et al.* 1993). Given the close correlation between LQ-based estimates of trade and the old trade data, the LQ-based method for some purposes may be a better way of estimating trade than the new, survey-based method. In future analyses we will compare location quotient-derived net exports to published trade data for individual countries at a more detailed industry level. Major discrepancies between the two sets of net exports for a given industry then may be interpreted as an initial indicator of aberrations in existing data.

6. Conclusions and directions for further research

In this study we modify and apply a simple location quotient procedure to identify the nature and direction of trade flows between core and periphery areas of the EU and between objective one and the remaining regions of the EU. By examining the location quotients and the changes in location quotients when the denominator is shifted, sectors are classified as residentiary, exporting, or importing.

The initial purpose of using this technique is to add some measure of trade in services to the analysis of core-periphery dualism. By using location quotients some of the data deficiencies arising from poor tracking of services can be bypassed. The core-periphery relationships found by traditional techniques are confirmed using employment-based comparisons. These relationships include agglomeration in core areas of high technology, large scale manufacturing, and producer services; specialization by peripheral countries in agriculture, extractives, low technology manufacturing, and standardized production; importation of producer services by the periphery; and provision of consumer and government services on a residentiary basis in both the periphery and the core. Similar findings are obtained in an analysis of objective one regions. The trade patterns of objective one regions vis-á-vis the remaining EU regions closely parallel the core-periphery patterns, both for manufacturing and services.

Comparison of the rank-ordering of net exports derived by this method to a rank-ordering of net exports obtained from extant data shows a strong correlation for extractive and manufacturing industries, the only industries for which traditional export data are available. The strength of this relationship implies that this is a viable means of estimating service industry exports.

This study sheds some light on the desirability of relying primarily upon the proposed convergence criteria associated with the Maastricht Treaty EMU as a primary mechanism leading to income convergence between core and periphery. These convergence criteria are based on the assumption that EMU will foster growth in core areas that will trickle down to lagging regions. We have shown that peripherality, defined either nationally or by subnational regions, is associated with an economic structure that emphasizes extractive industries and low technology manufacturing. Conversely, the core tends to specialize in high technology manufacturing and pro-

ducer services and exports these to the periphery. As these latter core specializations have been the primary sources of income growth over the past three decades, policies based upon trickle down effects will have less of a stimulative impact upon peripheral EU areas than will policies that are aimed at directly changing the structure of peripheral economies.

Accordingly, we find a continuing need for EU expenditures on structural development assistance; in particular, expenditures such as the European regional development fund and the European social fund foster infrastructure and human resource development that will make these peripheral areas more fertile beds for increased specialization in these high growth industries.

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