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Trade Links: Has Anything Occurred During 1990s in Baltic Europe? Trade liberalization and economic integration

Abstract

Global trade data for ten European countries located around the Baltic Sea (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Norway, Poland, Russia, Sweden) are analysed for the period between 1992 and 2000. Special attention is paid in this empirical analysis to the geographical aspect of the intra-Baltic trade. This means, on the one hand, the (hypothetical) existence of definite (sub)groups of countries and/or other spatial structures, defined by the strength of trade connections, and the relations of the individual countries and the entire region with the outer world. On the other hand, the observed changes in such structures over time are assessed. The analysis performed explicitly tries to accommodate a variety of technical assumptions concerning the methods of measuring trade relations between pairs of countries. The results obtained are partly comfortably conform to existing convictions and intuitions, and partly present important new matter, especially related to the transformations within the post-communist countries (like, in particular, the distinct integration of Poland into the intense trade structures of Europe). At the same time, broader conclusions can be drawn concerning the notions used in the analysis of geographical structures, as well as the methodology used (cluster analysis performed on the basis of absolute and relative directional trade indices).

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1. Introduction

The paper reports on the analysis of trade relations, in global terms, between ten countries located around the Baltic Sea. This analysis has three fundamental dimensions: (i) a check on the possible significance and interpretations of some of the commonly used, often apparently obvious notions, such as "integration", "region", etc.; (ii) assuming there is some sense to such notions – an interpretation is forwarded based upon the data analysed; and (iii) conclusions are presented concerning the main subject of trade links ("integration"?), and the dynamics thereof.

In (i) the instances of meanings of the apparently intuitively obvious definitions are given, with some of the arising structures analysed (*e.g.* what is a region? how are its definitions related to that of integration? what various definitions – "embedded regions", "hierarchical regions", "separate clusters", ... – can be read out of the hypothetical and actually identified data structures?). The latter are amply illustrated by – (ii) – the results obtained from the analysis. These results bear also on the interpretation of the degree of integration (seen through trade) and its changes over time, (iii): less or more, or – say, otherwise?

It is shown that certain geographical trade structures are very strong and persistent (*e.g.* the very strongly connected and relatively isolated pair of Finland-Estonia), while some other ones are more ambiguous, and do also undergo definite shifts over time. The authors pay a particular attention – no surprise – to the position of Poland within the framework considered, and to its changes. In fact, it is exactly the position of Poland that turns out to constitute one of the essential elements of change in the setting analysed. Although it is hard to draw more general justified conclusions on the direction of change observed, also in the context of "integration", in case of Poland the move towards integration within Europe as a whole is beyond doubt.

The paper takes also up some methodological points. First, it refers to the nature of data analysed. Then, it dwells upon the possibility of drawing conclusions concerning various issues from such data. The main body of the analysis is founded upon a simple, but general and powerful technique of cluster analysis, developed by the first two authors of the paper. Conclusions of the paper refer, therefore, also to the usefulness of such techniques and to their limitations.

The present paper reports on the consecutive stage in a small study carried out on the increasing set of trade data.[1]

[1] For the results from the previous stages see: A.B.Kisiel-Łowczyc, J.W.Owsiński, S.Zadrożny, *Trade relation structures in Baltic Europe*, "*Argumenta Oeconomica*", no. 2/1999; A.B.Kisiel-Łowczyc, J.W.Owsiński, S.Zadrożny, *Geographical structures of international trade in the Baltic Rim*, Proc. of the 1999 Conference of the Polish Classification Society, Wrocław University of Economics, Wrocław 2000, pp.11-26.

The following notation is used throughout the paper: t_{mn} – the value of trade flow from country *m* to country *n* (possibly with some superscripts), T_m – a trade sum for country *m*, the nature of the respective trade flows (exports, imports) being either explicitly denoted, or resulting from the context, s_{mn} – trade-wise proximity of the countries *m* and *n*, usually symmetric, *i.e.* s_{mn} = s_{nm}, its calculation being in principle based upon t_{mn} (d_{mn} analogously denoting distance or dissimilarity). The total number of countries is denoted *N*, and their set – ***N***.

2. Trade, affinity, and spatial structures

The magnitude of trade flows can be considered indicative of an economic affinity between two countries, with certain reservations, of which we will quote two:

(1) should we consider *absolute flows*, which tend to be proportionate to some GDP measure and to the inverse of geographical distance? the answer is usually a cautious "no", and a *relative indicator* of trade flow is used instead, so as to get rid of the proportionalities mentioned; once, however, we abandon the absolute flows we face the problems of choice (*what* relative indicator?) and interpretation (what the results obtained therefrom mean?); and

(2) while admitting that trade flows indicate economic affinity between two spatial units, we also ask for other factors (FDI, other capital, transport, tourism, labour force, migrations, etc.), and for relations between the trade-based affinity and the other ones.

Some of the respective variables are relatively easily observed (like trade), though with an error (to which we will yet return), while some other – hardly at all. We will assume, though, like in gravity models,[2] that there is a decent (non-negative) correlation between trade and FDI on the one hand,[3] and the other indicators treated as indicative of affinity in terms of economic ties, this being a justification for taking trade as a proxy for such kind of closeness, and an answer to (2) above.

That spatial elements may form coherent wholes called nominally *regions* is intuitively obvious. There are several simple intuitive definitions of the region.

[2] A.P.Cornett, S.P.Iversen, *The Baltic region in the European trade system*, Typescript, 1997; A.P.Cornett, S.P.Iversen, *The Baltic Rim region in the European trade system* in: J.W.Owsiński, A.Stępniak (eds.), *The Nordic-Baltic Europe: Integration Risks, Barriers and Opportunities,* The Interfaces Institute, Warsaw – Sopot 1997.

[3] K.Morita, *An economic analysis of foreign direct investment into Eastern Europe: the case of Japan's FDI into Poland* in: R.Kulikowski, Z.Nahorski and J.W.Owsiński (eds.), *Modelling of Economic Transition Phenomena*, University of Information Technology and Management, Warsaw 2001.

It is usually proposed that a region be composed of (spatial) units, which are more linked with each other than with the ones outside of the region.[4] This intuition supposedly leads to a simple and regular structure of well-separated subsets of the spatial units. Yet, this is generally not true, because of a variety of reasons.

Ambiguity

The quoted verbal definition, though formally correct, is ambiguous, and thus non-constructive, in several ways. First, we have to define the meaning of "more linked... than...", *i.e.*, the measure of internal and external linkage. The variety of such possible meanings constitutes the first aspect of ambiguity. Assume now that we measure internal linkage within a subset of spatial units with the average of s_{mn}'s within this subset, and the average of the outer s_{mn}'s measures the subset's external linkage. This is quite plausible. If so, every such pair of units *m*, *n* that s_{mn} attains its maximum over $\mathbf{N}\times\mathbf{N}$ simultaneously for both of them (*i.e.* at least one pair for which s_{mn} attains the maximum for the whole set of units) constitutes a region. Yet, within the same set ***N*** of spatial units there can be larger ("embracing") subsets of units, including the previously mentioned pair(s), which display the same feature and are therefore also "regions". In fact, the definition referred to allows certain *hierarchies of nested regions* to arise. Which of them should be treated as the proper "regions" (the second aspect of ambiguity)?

The case of the above definition of a region is well illustrated by the Example 1:

Example 1.

N=5, with values of symmetric s_{mn} given in the table:

n/m	1	2	3	4	5
1	-	**4**	**3**	**2**	**6**
2		-	**2**	**1**	**5**
3			-	**1**	**4**
4				-	**3**
5					-

[4] K.Peschel, *Perspectives of regional development around the Baltic Sea*, "*The Annals of Regional Science*", no. 32/1998, pp.299-320; K.Peschel, *The Baltic Sea region - an economically highly integrated area in future?,* paper for the 5th Nordic-Baltic Conference, Pärnu, Estonia, October 1998.

According to the definition cited, the pair $\{n,m\}$ = {1,5} is a region: its mean s_{mn}, $s_*(\{1,5\})=s_{15}=6$, while the average of the "outer" similarities, $s^*(\{1,5\},\{2,3,4\})=3.5$, and 6>3.5. If, now, we take the embracing set {1,2,5}, we obtain the "inner" average $s_*(\{1,2,5\})=5$, and the "outer" average $s^*(\{1,2,5\},\{3,4\})=2.5$, so, again, 5>2.5, and even the value of the difference, s_* - s^* = 2.5, is preserved. Moreover, when we take the yet bigger group of {1,2,3,5}, we get $s_*(\{1,2,3,5\})=4$, and $s^*(\{1,2,3,5\},\{4\})=1.75$. Thus, all three "nested" clusters:{{{1,5}2}3} are "regions". Whether we somehow cut or accept the hierarchy thus formed, we have to provide a plausible meaning to any such operation.

In our case the third kind of ambiguity results from the use of *relative* rather than *absolute* trade (or any other) flows. For relative flows, we face quite a choice of them and of their interpretations.

Asymmetry

In many cases (*e.g.* commuter flows) we deal with essentially asymmetric relations between pairs of units. If we wish to preserve this asymmetry in region building, the only way is by establishing hierarchical regions (for commuter flows: a hierarchy of centers). Hierarchy is based upon the asymmetric relation of "subordination" and "superordination" (*e.g.* "*n* belongs to the sphere [region] of influence of *m*"). Trade is also asymmetric, and so the gravity models, often used to explain trade, are in principle asymmetric, though asymmetry of trade, seen, *e.g.*, through $|t_{mn}-t_{nm}|/(t_{mn}+t_{nm})$, is not very significant. Further, in trade (and in similar flows) we are confronted with errors in data, which may easily exceed the above asymmetry indicator. If so, any exercise in asymmetry is devoid of sense.

There is, though, another aspect of asymmetry, which is important in analyzing spatial structures related to trade. If, namely, we use the relative s_{nm} indicators of trade-wise association in which the shares t_{mn}/T_m and t_{mn}/T_n appear, we encounter the pairs n,m of countries, for which one of these shares is high, and the other is low (differing even by an order of magnitude). If a ("small") country largely depends in its economy (and trade) upon another ("big neighbor") country, such a situation may easily arise, leading to high values of the resulting – symmetric – $s_{nm} = s_{mn}$. This fact can be uncovered by carrying out analyses with a variety of indicators, especially those insensitive to the phenomenon mentioned.

Definitions and methods

Within the analytic procedures applied there is a multiplicity of more "technical" definitions, of, *e.g.* turning t_{mn} into s_{mn}, and of the methods used to generate (spatial) structures, say regions (like the numerous algorithms of graph theory or cluster analysis). Without discussing these aspects of analysis we propose that it is possible to select for a given problem the definitions and methods reasonable both in terms of their interpretation (involving also the intuitions previously criticized) and the technical (mathematical) rigor and correctness. Thus, a well designed analysis, accounting for various points of view and the implied variability of results, should provide valuable insight, both as to existence of any structure and to its character.

3. The method and the spatial trade flow structure exercises

3.1. The data and some conclusions therefrom

The study was based on a general method of cluster analysis. Clustering exercises were carried out for data on trade and some other economic aspects of Baltic Europe in the years 1992-2000. We used country-wise trade data taken from various national or international sources and so, for each pair of countries *m*, *n* we dealt with four numbers (export-import/country *m*-country *n*). The differences are of little importance for the global image, but are crucial for more detailed analysis, casting an empirical light on the question of asymmetry. Thus, for Latvia and Sweden in 1996 we have, as in Table 1, an extreme case, with Latvian balance of either -72 or +179 million USD, the error closing on 100%.

There is definitely a wide margin of error or uncertainty, not only for the post-communist states, most important for the small ones. This margin tends to decrease over time as standard procedures are increasingly effective, but it persists due to other reasons. Thus, a lot of transactions go unregistered, both due to their character (*e.g.* Germans shopping in western Poland - more than 30 million daily visits a year until 1998, worth some 3 billion USD, or by Finns in Estonia, more precisely - in Tallinn), and to a variety of actual evasions (*e.g.* in the form of "tourist trade", or, in the wording of customs officers – „ant trade"). There are, as well, such semi- or il-legal phenomena as waste dumping in the post-communist countries (known from before 1990 through waste export from West to East Germany), leading often to increased pollution "on the way" (*e.g.* dropping of the waste tires in the Baltic Sea on their way to the East). Since, however, the margin is very difficult to estimate, and, at the same time, the unregistered flows are often held to be approximately proportional to the official trade flows (although the latter proposition seems shaky, see the case of Poland-Ukraine or Poland-Russia), we will not (be able to) account for it here.

The statistical material is too thin for a probabilistic treatment, and, anyway, no reasonable model-based hypothesis could be forwarded that would equally apply to the various cases encountered (involving western and eastern European countries, the flows being greater when seen by the importing or exporting country, etc.). The same applies to a potential application of the fuzzy set theoretical methods.

Note also that normalization and other consistency-ensuring procedures, including RAS, must account for the variety of reasons of the differences illustrated in Table 1, as well as for the differences in export/import gaps. If these reasons are not accounted for, along with the magnitude of the phenomena, the respective procedures can do harm to data, instead of improving them, especially if we want to draw far-reaching conclusions on the basis of the thus "corrected" data. Here, we try to counterbalance this effect by analyzing the data for a variety of assumptions.

Table 1. Data for trade between Latvia and Sweden in 1996 (in million USD)

Flow direction	Data from Latvia	Data from Sweden
Latvia → Sweden	94	386
Sweden → Latvia	166	207

Source: *Direction of Trade*, *Statistical Yearbook 1997*; Statistics Sweden 1997.

We will draw some conclusions already on the basis of the "raw" data, before passing to the more technical analyses. Thus, the shares of the Baltic trade of the ten countries in their world trade in consecutive years are shown in Table 2, and for three selected countries – in Table 3.

Table 2. Shares of Baltic trade of all the 10 countries in their global trade figures (in %)

Trade flow	1992	1993	1994	1995	1996	1997	1998	1999	2000
Exports	16.93	18.34	18.41	18.48	19.20	19.62	19.49	18.95	19.23
Imports	18.49	20.49	21.34	21.68	21.94	22.08	20.87	21.30	22.55

Source: Own calculations.

These figures indicate a very *clear and rather swift increase of the in-Baltic trade at the beginning of the 1990s, followed by a stabilization*. It must be kept in mind, though, also, that starting with 1998 the Russian crisis had a great impact on these shares (see: Table 3). The course of the process illustrated by Table 2 is essential for further analysis, as we will only marginally set the Baltic Rim against the global background, and will be primarily looking at the trade structures *within* this group of countries. Hence, the above result sets the – “moving horizon” for the analysis of intra-regional structures.

Table 3. Shares of Germany, Sweden and Finland in the Baltic and world trade of all the 10 Baltic countries (in %)

Country - flow	1992	1993	1994	1995	1996	1997	1998	1999	2000
Germany-Baltic exp/ imp	27.9/ 30.9	32.1/ 34.4	31.1/ 33.5	31.6/ 30.5	31.2/ 32.4	32.3/ 30.0	33.1/ 29.7	31.5/ 31.0	29.4/ 32.9
Germany-world exp/ imp	67.0/ 68.8	64.4/ 67.2	62.8/ 64.9	61.8/ 63.9	60.8/ 63.0	60.9/ 60.0	62.6/ 61.1	62.0/ 64.0	58.9/ 64.4
Sweden - Baltic exp/ imp	19.4/ 18.9	17.1/ 16.8	17.6/ 17.2	18.1/ 18.3	17.8/ 18.3	17.3/ 16.8	17.1/ 16.6	16.8/ 15.8	15.5/ 17.0
Sweden - world exp/ imp	8.9/ 8.4	8.8/ 8.6	9.1/ 9.0	9.7/ 9.3	10.0/ 9.4	9.9/ 8.9	9.8/ 8.9	9.8/ 8.6	9.1/ 8.9
Finland - Baltic exp/ imp	9.0/ 8.7	8.7/ 8.0	9.8/ 8.4	10.1/ 8.4	9.5/ 8.3	9.5/ 8.1	9.8/ 8.5	10.0/ 10.3	9.5/ 8.9
Finland - world exp/ imp	3.8/ 3.9	4.6/ 3.7	4.4/ 4.0	4.8/ 4.1	4.6/ 4.2	4.7/ 4.1	4.9/ 4.1	4.9/ 4.5	4.9/ 4.4

Source: Own calculations.

Note: the significant shifts between 1999 and 2000 are primarily caused by the tremendous shift in the Russian trade (a great increase of exports coupled with a collapse of imports).

Table 3 shows well the position of Germany. Although slightly declining, its share in the world trade of the Baltic countries is still at 60%. But the Germany’s share in the in-Baltic trade is twice smaller. This relation between the world and in-Baltic trade shares is opposite for Sweden and Finland (and for Denmark, not shown here): their in-Baltic shares are twice (or more) as big as those for the world trade.

These observations motivate us to note that even if such sub-units as provinces of Schleswig-Holstein and Meklemburgia-Antepomerania in Germany, or Kaliningrad and St.Petersburg in Russia were used in the study (the very difficult data problem put apart), their status being entirely different from that of the entire countries, the comparison or equal footing would not be feasible.

3.2. The method

The analyses carried out were performed with the cluster analytic technique developed by two of the present authors.[5] The technique, by virtue of the very definition of cluster analysis, finds "*the partition of a set of objects into subsets, such that the objects belonging to the same subsets are possibly similar or affine, while objects belonging to different cluster are possibly dissimilar or distant*". This avoids the apparently constructive formulation of Section 2, involving the comparison: "more... than". Thus, within the above framework we refer to an indirect definition of a region, being the result of the procedure (a "cluster") and not a directly definable entity. The above formulation is expressed in the method through the general form of a (objective) function that is being maximized or minimized, depending upon its particular shape.

The objective function, when maximized, is of the form:

$$Q_S^D(P) = Q_S(P) + Q^D(P), \qquad (1)$$

where P is a partition of the set of objects (here: the Baltic countries) into disjoint subsets, $Q_S(P)$ is the function of intra-cluster similarity over the entire partition P, and $Q^D(P)$ is the function of inter-cluster dissimilarity, or distance, over the entire partition P. In the simplest, and most common case,[6] $Q_S(P)$ and $Q^D(P)$ are sums over clusters forming partition, or their pairs, of the similarity or distance functions defined for individual clusters or their pairs. Thus, in this basic case:

$$Q_S(P) = \Sigma_q S(A_q) \quad \text{and} \quad Q^D(P) = \Sigma_{q<q'} D(A_q,A_{q'}), \qquad (2)$$

where $q=1,...,p$ are the indices of clusters A_q forming partition P, $\cup_q A_q = P$, $A_q \cap A_{q'} = \varnothing$, $q \neq q'$, $S(A_q)$ is a function of intra-cluster similarity (*e.g.* sum of similarities in the cluster A_q, the average similarity,...), and $D(A_q,A_{q'})$ is a function of distance between two clusters (*e.g.* sum of distances between objects in two clusters). The method requires $Q_S(P)$ and $Q^D(P)$ to be monotone in p, so that the parameterized form of (1) can be used for optimization, namely

$$Q_S^D(P,r) = (1-r)Q_S(P) + rQ^D(P), \qquad (1a)$$

with $r \in [0,1]$ being the parameter of the method. Certain, relatively mild conditions set on the functions appearing in the method allow for the effective (sub)optimization of (1a), leading to the near-to-optimum solution for (1).

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[5] J.W.Owsiński, *On a quasi-objective global clustering method* in: Edwin Diday et al. (eds.), *Data Analysis and Informatics*, North Holland, Amsterdam 1984; J.W.Owsiński, *On a new naturally indexed quick clustering method with a global objective function*, "*Applied Stochastic Modelling and Data Analysis*", no. 6/1990, pp.157-171.

[6] J.W.Owsiński, *On a new naturally indexed quick clustering method with a global objective function, "Applied Stochastic Modelling and Data Analysis"*, no. 6/1990, pp.157-171.

Without describing the method used in detail let us mention its most important features:

- it accommodates almost any definition of distance and/or proximity between objects;
- it is based on an explicit objective function, which is (sub)optimized, so that any partition can be evaluated in terms of this objective function, not only the partitions obtained with the method;
- it provides as solution both the composition of subsets (clusters) *and* their number;
- the (sub)optimal solution is obtained via a very simple aggregation algorithm, analogous to the classical progressive merger procedures, like the single linkage, average linkage, etc.;
- the progress of the procedure is accompanied by values of the merger parameter, r, which start from 1 (all objects being apart), and decrease for each consecutive merger; the (sub)optimal solution is attained for the merger occurring at the lowest $r \geq 0.5$ (which can also be interpreted as follows: mergers occurring for $r < 0.5$ associate objects less similar than dissimilar, and thus should not be included in the solution);
- owing to the simplicity of the procedure and the availability of the values of r we are capable of assessing the "strength" and "validity" of particular cluster structures obtained.

The clustering exercises carried out differed by the assumptions, reflected in the way in which, primarily, the distances/proximities were defined on the basis of the trade flow data.

3.3. The characteristics of the clustering exercises

We will give here only the characteristics of the exercises whose results are provided in the following section of the paper. In reality, several more analyses were performed.

The reference exercise used *bare flows*. We clustered countries on the basis of the previously mentioned four data items for each pairs of countries, *i.e.* the averaged and symmetrized flows. Thus, proximity s_{mn} between country m and n (and vice versa) was (we omit the year indices):

$$s_{mn} = \frac{1}{4}(t_{mn}^{\min} + t_{mn}^{\max} + t_{nm}^{\min} + t_{nm}^{\max}). \qquad (3)$$

The respective results are shown in Table 4. We also made an exercise, not shown here, where *adjustment for asymmetry* was introduced (decreasing the flow value for large asymmetry).

The proximities between countries were calculated for the first two *relative cases* as:

$$s_{mn} = \frac{1}{4}\left(\frac{t_{mn}^{\min}}{T_m^{\min}} + \frac{t_{mn}^{\max}}{T_m^{\max}} + \frac{t_{nm}^{\min}}{T_n^{\min}} + \frac{t_{nm}^{\max}}{T_n^{\max}}\right), \qquad (4)$$

a variant of the directional trade ratio[7] and used in the FDI context.[8] The *t*'s in (4) mean the same as before, while the *T'*s correspond to respective country-proper (*m* and *n*) sums of trade flows over the Baltic. The interpretation is that the s_{mn} will imply the structures *within* the Baltic region rather than against a broader background. The results are shown in Table 5.

In the second relative exercise formula (4) was also used, *T*'s being the trade sums for the whole world trade of the given countries. Thereby, the trade flows and the resulting similarities are perceived, in a sort of a global perspective. It must be emphasized, though, that this is not a full ("*quasi*-absolute") global perspective in the sense referred to in Section 2: the actual dispersion of trade flows in the global setting would hardly allow identification of the Baltic-proper structures. Thus, we again looked at the Baltic set of countries, though the background is the global one (see: Table 6 for results).

These two exercises were "verified" by the runs with the arithmetic mean from (4) replaced by the geometric one, so as to possibly get away from the asymmetric setting of a small-linked-to-big-economy.

Trade is often – and quite effectively – represented with the *gravity models,*[9] which are also used for future-oriented scenario generation. The scenarios are obtained for the changes in assumptions concerning the parameters of the model. The gravity model can be well illustrated by the following general form:

$$t_{mn} = a_0 + a_1 Y_m + a_2 Y_n + a_3 y_m + a_4 y_n - a_5 d_{mn} + a_6 \tau_{mn} \qquad (5)$$

[7] P.Smoker, *Trade, defense, and the Richardson theory of arms races: A seven nations study*, *"Journal of Peace Research"*, no. 2-4/1965.

[8] K.Morita, *An economic analysis of foreign direct investment into Eastern Europe: the case of Japan's FDI into Poland* in: R.Kulikowski, Z.Nahorski and J.W.Owsiński (eds.), *Modelling of Economic Transition Phenomena,* University of Information Technology and Management, Warsaw 2001.

[9] A.P.Cornett, S.P.Iversen, *The Baltic region in the European trade system*, Typescript, 1997; A.P.Cornett, S.P.Iversen, *The Baltic Rim region in the European trade system* in: , J.W.Owsiński, A.Stępniak (eds.), *The Nordic-Baltic Europe: Integration Risks, Barriers and Opportunities,* The Interfaces Institute, Warsaw – Sopot 1997; J.Fidrmuc, *Application of gravity models to commodity groups and trade projections between EU and Central-Eastern European countries* in: R.Kulikowski, Z.Nahorski and J.W.Owsiński (eds.), *Modelling of Economic Transition Phenomena,* University of Information Technology and Management, Warsaw 2001; T.Paas, *Gravity approach for exploring international trade flows of the Baltic Sea region*, Paper for the IAES Conference in Paris, March 2002.

$a_0,\ldots,a_6$ being model coefficients, obtained by regression, $Y_{m,n}$ are usually the GDPs of countries m and n, $y_{m,n}$ are the GDP *per capita* values for these countries, d_{mn} is a distance between them, and τ_{mn} is some variable (or variables) expressing additional relation(s) between the two countries (like membership in the same trade agreement structure).

The model is usually identified for a group of countries and a certain period. It is assumed that the coefficients $a_0,\ldots,a_6$ preserve validity over a broader spatial and temporal context, and so, by applying different values of Y's, y's, d and τ we can obtain trade estimates for various situations.

Gravity models are directional (asymmetric): the one for t_{mn} differs from that for t_{nm}, unless the respective coefficients are the same for the two models. Classical interpretations of these coefficients and respective variables refer to demand-supply push-and-pull, but once the GDPs and GDPs *per capita* appear on both sides of the models identified, the very clear initial tang of asymmetry is somewhat lost. Since in cluster analysis we refer to symmetric s_{mn}, we effectively overlook whatever asymmetry is left with the gravity models. In our study calculations were performed for two definitions of s_{mn}, *i.e.*:

$$s_{mn} = \frac{1}{4}\left(\frac{t_{mn}^{\min}}{T_m^{\min}} + \frac{t_{mn}^{\max}}{T_m^{\max}} + \frac{t_{nm}^{\min}}{T_n^{\min}} + \frac{t_{nm}^{\max}}{T_n^{\max}}\right)/(Y_m \cdot Y_n)^{1/2}, \quad \text{and} \tag{6}$$

$$s_{mn} = \frac{1}{4}\left(\frac{t_{mn}^{\min}}{T_m^{\min}} + \frac{t_{mn}^{\max}}{T_m^{\max}} + \frac{t_{nm}^{\min}}{T_n^{\min}} + \frac{t_{nm}^{\max}}{T_n^{\max}}\right)/(y_m \cdot y_n)^{1/2}. \tag{7}$$

The geometric averages in the denominator were meant to compensate for the wide disparities among the GDP and GDP *per capita* for the different countries, although did it with a very limited effectiveness. The differences reach, namely, even two orders of magnitude, and essentially twist the nature and interpretation of results (Tables 7 and 8). This issue is yet compounded by the shakiness of the very meaning of GDP, whether nominal or in the ppp form, and its actual relation to the phenomenon analysed, as well as by the variety of values provided by different sources (we used those from the reports of the Stockholm Chamber of Commerce).

We also tried to establish a comparative basis for the gravity background by inspecting the gravity model coefficients for various models known to us, especially with respect to the coefficients of the GDP and GDP *per capita* variables. No consistent relation between particular coefficient values (*e.g.* a_1/a_2 or a_3/a_4) was traced, though, in the models inspected (see, for instance, Table 11).

4. The results

The tables in this section show the aggregation steps (clusters appearing/changing at a given step) leading to formation of the (sub)optimal partition, and, at the bottom of each table, the partition corresponding to the (sub)optimal solution.

Note that the values of r^t for consecutive aggregation steps $t = 1,2,...$, may be regarded as *relative* measures of robustness of particular structures, since these values, $\in[0,1]$ (with the actually interesting interval being $[0.5,1]$), significantly depend upon definitions of the proximity used in particular calculations. Thus, if definitions for some exercises are very similar to each other (as in the calculations for the Baltic and the global horizons, Tables 5 and 6), then we can compare the results in terms of r^t. Otherwise, the comparisons of sheer values of r^t should be made very carefully, if at all.

We will also cite the values of an add-on (as opposed to the algorithmically natural r^t) indicator H, illustrating the degree of hierarchicity or "nestedness" of the structure. This indicator is defined as H = the maximum number of nested clusters formed through merging / (N – 1 – the number of objects still not clustered in the solution). Thus, if all objects clustered form a nested hierarchy and the remaining ones are isolated in the solution, then $H = 1$. If, on the other hand, N is even and all objects form $N/2$ pairs in the solution, then $H = 2/N$ (here: 0.2).

The results for the bare trade flows (Table 4) are characteristic in that there is a dominant cluster built gradually from the "core" outwards, the "core" being constituted by Germany and Sweden, to which other Scandinavian countries are linked, followed by Russia and Poland (the possibility of existence of the expanding "nested" structures of "regions" was mentioned in Section 2 – here $H = 1$). Estonia, Lithuania and Latvia are left outside of this cluster in view of the feeble trade flows to and from them, strictly connected with the magnitudes of these economies. It is highly interesting that since 1996 Poland replaces Finland as the fifth consecutive member of the dominant cluster, meaning that it has thereby moved much closer to the "core". In 1998 Poland indeed moved into the "core" itself.

Table 5 shows the results for trade flows divided by the respective Baltic totals. Thus, the structures obtained refer to the Baltic horizon. Now, in sharp distinction to the absolute flow image from Table 4, we get clear pair-wise linkages, which get then expanded and eventually linked. There are very few "outliers" (single-country clusters), not linked with other countries (for 1998 and 1999 $H = 5/9$). Attention is especially attracted to the strongest pairs of countries, which appear repeatedly. Such structures, often the very same, will yet be identified in several other exercises.

Analogous results, obtained for the "global horizon", appear in Table 6. The clusters are very similar, with, however, telling shifts along the value of *r*, and the similarly telling switches of sequence of formation of these clusters. In particular, the countries with trade more concentrated on the Baltic, are clustered now before some of the other ones. The value of *H* is equal 4/9 for all years except for 1999, when it jumps to 4/7.

The two final groups of results reported, Tables 7 and 8, show the structures obtained for the proximities based on trade flows related to the GDP and GDP *per capita* (for the respective pairs *m*,*n*). In Table 8 we see, again, a clear "outward" growth of the dominating cluster, resulting from the relatively weak influence of the GDP-*per capita*-defined denominator on the similarity measure, so that it is very much like the "bare flows" results of Table 4.

Table 4. Clustering of the Baltic countries for the average values of trade flows between them

Step	1993	1994	1995	1996	1997	1998	1999	2000
1. r^1 =	1.000 D-S	1.000 D-S	1.000 D-S	1.000 D-S	0.999 D-S	0.999 D-PL	0.999 D-PL	0.999 D-PL
2. r^2 =	0.922 DK-D-S	0.910 DK-D-S	0.914 DK-D-S	0.905 DK-D-S	0.918 DK-D-S	0.846 D-PL-S	0.839 D-PL-S	0.837 D-PL-S
3. r^3 =	0.787 DK-D-S-N	0.776 DK-D-S-N	0.775 DK-D-S-N	0.797 DK-D-S-N	0.790 DK-D-S-N	0.806 DK-D-PL-S	0.807 DK-D-PL-S	0.789 DK-D-PL-S
4. r^4 =	0.627 DK-D-S-N-FIN	0.640 DK-D-S-N-FIN	0.645 DK-D-S-N-FIN	0.642 DK-D-S-N-PL	0.662 DK-D-S-N-PL	0.690 DK-D-PL-S-N	0.687 DK-D-PL-S-N	0.685 DK-D-PL-S-N
5. r^5 =	0.601 DK-D-S-N-FIN-RUS	0.599 DK-D-S-N-FIN-RUS	0.575 DK-D-S-N-FIN-RUS	0.571 DK-D-S-N-PL-FIN	0.594 FIN-RUS	0.576 DK-D-PL-S-N-FIN	0.609 DK-D-PL-S-N-FIN	0.589 DK-D-PL-S-N-FIN
Sub-optimal partition	{DK,D,S, N,FIN,RUS,PL} {EST} {LT} {LV}	{DK,D,S, N,FIN,RUS,PL} {EST} {LT} {LV}	{DK,D,S, N,FIN,RUS,PL} {EST} {LT}{LV}	{DK,D,S, N,PL,FIN, RUS} {EST} {LT}{LV}	{DK,D,S, N,PL,FIN, RUS} {EST} {LT}{LV}	{DK,D,S,N, PL,FIN, RUS} {EST} {LT}{LV}	{DK,D,S, N,PL,FIN, RUS} {EST} {LT}{LV}	{DK,D,S, N,PL,FIN, RUS} {EST} {LT}{LV}

Source: Own calculations.

Note: DK – Denmark, EST – Estonia, FIN – Finland, D – Germany, LV – Latvia, LT – Lithuania, N – Norway, PL – Poland, RUS – Russia, S – Sweden. The same notation will be used in the remaining tables.

Table 5. Clustering of Baltic countries for the trade flows related to respective Baltic totals

Step	1993	1994	1995	1996	1997	1998	1999	2000
1. r^1 =	0.719 D-PL	0.709 D-PL	0.692 D-PL	0.732 D-PL	0.723 D-PL	0.730 D-PL	0.745 D-PL	0.743 D-PL
2. r^2 =	0.584 N-S	0.585 N-S	0.593 N-S	0.604 N-S	0.599 N-S	0.602 N-S	0.600 N-S	0.601 N-S
3. r^3 =	0.582 D-PL-RUS	0.570 LT-RUS	0.573 D-PL-RUS	0.579 LT-RUS	0.573 D-PL-RUS	0.567 D-PL-RUS	0.555 D-PL-RUS	0.571 EST-FIN
4. r^4 =	0.546 DK-N-S	0.557 D-PL-DK	0.545 DK-N-S	0.551 D-PL-DK	0.549 DK-N-S	0.547 DK-N-S	0.547 DK-N-S	0.559 D-PL-RUS
5. r^5 =	0.531 EST-FIN	0.539 D-PL-DK-N-S	0.536 EST-FIN	0.537 D-PL-DK-N-S	0.531 EST-FIN	0.540 EST-FIN	0.544 EST-FIN	0.549 DK-N-S
Sub-optimal partition	{D,PL,DK, RUS,N,S} {EST,FIN} {LT,LV}	{D,PL,DK, N,S} {EST,FIN} {LT,RUS, LV}	{D,PL,LT, RUS} {EST,FIN} {DK,N,S} {LV}	{D,PL,DK, N,S} {EST,FIN}{ LT,RUS, LV}	{D,PL,LT, RUS} {DK,N,S} {EST,FIN} {LV}	{DK,N,S,D ,PL,RUS} {EST,FIN} {LT,LV}	{DK,N,S,D ,PL,RUS} {EST,FIN} {LT,LV}	{DK,N,S,D ,PL,RUS} {EST,FIN} {LT,LV}

Source: Own calculations.

Table 6. Clustering of Baltic countries for trade flows related to respective trade totals

Step	1993	1994	1995	1996	1997	1998	1999	2000
1. r^1 =	0.581 D-PL	0.576 D-PL	0.553 D-PL	0.577 D-PL	0.582 D-PL	0.566 D-PL	0.581 D-PL	0.577 D-PL
2. r^2 =	0.530 EST-FIN	0.542 LV-RUS	0.550 LV-RUS	0.531 LT-RUS	0.529 DK-S	0.540 EST-FIN	0.537 EST-FIN	0.554 EST-FIN
3. r^3 =	0.527 LV-RUS	0.527 EST-FIN	0.534 EST-FIN	0.530 EST-FIN	0.525 LV-RUS	0.530 N-S	0.522 EST-FIN-S	0.523 EST-FIN-S
4. r^4 =	0.520 N-S	0.521 LT-LV-RUS	0.521 N-S	0.524 LT-RUS-LV	0.523 EST-FIN	0.529 LT-RUS	0.520 LT-LV	0.521 LT-LV
Subopti-mal par-tition	{D,PL,LT, LV,RUS} {DK,N,S} {EST,FIN}	{D,PL,DK, N,S} {EST,FIN} {RUS,LT, LV}	{DK,N,S,D ,PL} {EST,FIN} {LV,LT, RUS}	{D,PL,DK, N,S} {EST,FIN} {RUS,LT, LV}	{D,PL,DK, S,N} {EST,FIN} {LV,RUS, LT}	{D,PL,DK, N,S} {EST,FIN} {LV,RUS, LT}	{DK,D,PL, LT,LV} {EST,FIN, S}{RUS} {N}	{DK,D,PL, LT,LV} {EST,FIN, S}{RUS} {N}

Source: Own calculations.

Table 7. Clustering of Baltic countries for trade flows related to respective GDP's

Step	1993	1994	1995	1996	1997	1998	1999	2000
1. r^1 =	0.632 N-S	0.578 N-S	0.573 EST-FIN	0.572 EST-FIN	0.576 EST-FIN	0.577 EST-FIN	0.991 EST-FIN	0.994 EST-FIN
2. r^2 =	0.601 DK-N-S	0.568 EST-FIN	0.563 N-S	0.568 N-S	0.550 N-S	0.547 LT-LV	0.901 LT-LV	0.896 LT-LV
3. r^3 =	0.562 D-PL	0.555 DK-N-S	0.541 DK-N-S	0.553 LT-LV	0.531 LT-LV	0.540 N-S	0.866 N-S	0.820 N-S
4. r^4 =	0.560 LT-LV	0.542 LT-LV	0.533 LT-LV	0.538 DK-N-S	0.531 DK-N-S	0.531 D-PL	0.768 D-PL	0.716 D-PL
5. r^5 =	0.559 EST-FIN	0.532 D-PL	0.521 D-PL	0.527 D-PL	0.524 D-PL	0.542 DK-N-S	0.752 DK-N-S	0.712 DK-N-S
Sub-optimal partition	{DK,N,S, D,PL} {RUS} {LT,LV} {EST,FIN}	{DK,N,S, D,PL} {RUS} {EST,FIN} {LT,LV}	{DK,N,S, D,PL} {LT,LV, RUS} {EST,FIN}	{EST,FIN, LT,LV, RUS} {DK,N,S} {D,PL}	{EST,FIN, LT,LV} {DK,N,S} {RUS} {D,PL}	{EST,FIN, LT,LV} {DK,N,S} {RUS} {D,PL}	{EST,FIN, LT,LV} {DK,N,S} {RUS} {D,PL}	{EST,FIN, LT,LV, RUS} {DK,N,S} {D,PL}

Source: Own calculations.

Table 8. Clustering of Baltic countries for trade flows related to respective GDP's *per capita*

Step	1993	1994	1995	1996	1997	1998	1999	2000
1. r^1 =	1.000 D-RUS	1.000 D-RUS	0.999 D-RUS	0.999 D-PL	0.999 D-PL	0.999 D-PL	1.000 D-PL	0.999 D-PL
2. r^2 =	0.903 D-RUS-PL	0.893 D-RUS-PL	0.913 D-RUS-PL	0.881 D-PL-RUS	0.911 D-PL-RUS	0.872 D-PL-RUS	0.858 D-PL-RUS	0.912 D-PL-RUS
3. r^3 =	0.707 DK-S	0.701 DK-S	0.707 DK-S	0.716 N-S	0.690 DK-S	0.677 N-S	0.677 DK-S	0.661 DK-S
4. r^4 =	0.670 DK-S-D-RUS-PL	0.660 DK-S-D-RUS-PL	0.666 DK-S-D-PL-RUS	0.601 DK-D-PL-RUS	0.629 DK-S-D-PL-RUS	0.584 DK-D-PL-RUS	0.624 D-PL-RUS-DK-S	0.598 D-PL-RUS-DK-S
Sub-optimal Partition	{DK,S,D, RUS,PL, FIN,N} {EST} {LT}{LV}	{DK,S,D, RUS,PL, FIN}{EST} {N}{LT} {LV}	{DK,S,D,PL,RUS,FIN} {EST}{N} {LT}{LV}	{DK,D,PL, RUS,N,S, FIN}{LT} {LV} {EST}	{DK,S,D,PL,RUS,FIN}{N} {LT}{LV} {EST}	{DK,D,PL, RUS,N,S, FIN} {EST} {LT}{LV}	{DK,D,PL, RUS,S,FIN}{EST} {LT}{LV} {N}	{DK,D,PL, RUS,S,FIN}{EST} {LT}{LV} {N}

Source: Own calculations.

Table 9. Percentage shares of trade flows between Poland on the one hand, and Denmark and Sweden on the other, with respect to totals for the two sides of trade exchange, 1992-2000

Year	Sweden		Denmark	
	Imports from Poland: % of Swedish totals % of Polish totals	Exports to Poland: % of Swedish totals % of Polish totals	Imports from Poland: % of Danish totals % of Polish totals	Exports to Poland: % of Danish totals % of Polish totals
1992	0.86 3.22	0.67 2.46	1.33 3.34	1.28 3.29
1993	0.76 2.26	0.85 2.24	1.55 3.24	1.33 2.54
1994	0.90 2.68	0.98 2.77	1.80 3.49	1.44 2.64
1995	0.91 2.57	1.16 3.19	1.72 3.17	1.42 2.32
1996	0.89 2.42	1.26 2.88	1.82 3.04	1.78 2.26
1997	0.95 2.74	1.60 3.13	1.84 3.31	2.21 2.10
1998	1.11 2.39	1.58 2.89	1.76 2.81	1.98 1.98
1999	1.14 2.47	1.81 3.15	1.76 3.08	1.78 1.80
2000	1.37 1.60	1.70 2.87	1.78 2.71	1.62 1.60

Source: Own calculations on the basis of statistical data quoted.

Table 10. Evolution of the total trade shares between Poland and Denmark/Sweden

Items	Years								
	1992	1993	1994	1995	1996	1997	1998	1999	2000
A. Average % shares for Denmark/Sweden	1.04	1.12	1.28	1.30	1.44	1.65	1.61	1.62	1.62
B. Average % shares for Poland	3.08	2.57	2.90	2.81	2.65	2.82	2.52	2.63	2.20
Difference: B - A	2.04	1.45	1.62	1.51	1.21	1.17	0.91	1.01	0.58

Source: Own calculations.

Table 11. Coefficients of four exemplary gravity models

Model coefficients and corresponding variables	Model 1* year 1998	Model 2* year 2000	Model 3** year 1996	Model 4*** years 1992-4
a_0: constant	0.749	25.725	7.6315	- 19.50
a_1: GDP of country m	0.572	0.213	0.73354	1.43#
a_2: GDP of country n	0.633	0.164	0.75965	0.59#
a_3: GDP *per capita* of country m	- 0.007	- 0.377	n.a.	1.43
a_4: GDP *per capita* of country n	0.105	- 0.107	n.a.	0.59
a_5: distance between countries m and n	- 1.457	- 1.101	- 1.41816	- 0.87
a_7: barrier variable no. 1	0.641	0.025	2.0378	0.46##
a_8: barrier variable no. 2	- 0.309	- 0.589	0.8054	n.a.
a_9: barrier variable no. 3	- 0.061	n.a.	0.6106	n.a.

n.a. – not applicable (variable not appearing in the model)
* Paas (2002); ** Cornett and Iversen (1997a); *** Cornett and Iversen (1997b)
# DP reconstructed through the variable of population number
binary adjacency variable

5. The structures identified

This section is devoted to the analysis of results obtained via clustering and to drawing of respective conclusions, especially relative to the degree and dynamics of *integration*.

First, clustering, involving a variety of viewpoints – definitions of trade-related linkages – did not result in a complete chaos, as it might have been feared. Some resilient geographical trade structures emerged, present in the majority of results. In addition, some features of dynamics of these structures could also be identified, even if less visible. There is, of course, a definite difficulty in interpreting these structures, in view of several factors, of which we mention three:
(i) the very (intended) variety of assumptions behind particular calculations;
(ii) the decreasingly intuitive nature of results as the mergers form bigger clusters;
(iii) the sensitivity of (some) results to inherent errors (see: Table 1, for instance).

A certain interpretative difficulty, though, does not imply a lesser significance of results. The search for explanations can also lead to a deeper understanding of the system considered.

Further, the "technical" method applied proved to be effective in producing clear results of hierarchical form, accompanied by the values of the merger coefficient *r*, providing additional information on the validity and stability of the structures obtained.

In similar situations two kinds of sweeping reservations with respect to results obtained are usual: "*These results are trivial and do not require application of any refined methodology to obtain*" (when the results correspond to the commonly shared intuition), and/or "*These results disagree so much with the common opinion that there must be something wrong with them*" (in the opposite case). The results here presented are close enough to the midpoint between these opinions to be psychologically (if not substantially, which they also are) acceptable.

The strongest structures identified are the pairs of, first, {*Germany, Poland*} and then {*Estonia, Finland*}, followed, at a distance, by the weaker Scandinavian triangle {*Denmark, Sweden, Norway*}. In the latter case Sweden plays the "pivotal" role, since the first pair of countries clustered together within this triangle always involves Sweden. The strength of linkage between Germany and Poland is exceptional, although one should also stress the frequent creation of larger structures around this pair. The case is quite different with Estonia and Finland, whose pair enters much less frequently larger structures.

Thus, the strongest structures exclude Russia, Lithuania and Latvia, although the three countries form relatively pronounced linkages in some runs. In fact, Norway is in several cases also either left alone or enters into some structures at the later stages of the procedure.

The countries *never appearing alone* in the solutions obtained are Germany, Poland, Sweden and Denmark. On the other hand, the countries appearing most often alone (even neglecting the bare trade flows case in view of its very specific nature) are Latvia, Lithuania, Norway, and Russia. Thus, although we can hardly conclude within this study on the degree of integration of the whole region, we are entitled to forward justified conclusions on the degree of trade-wise integration of particular economies within the region. Similarly, we can cite the pairs that never occur in the same cluster in the solutions, *e.g.* Poland/Estonia, Poland/Latvia, Norway/Estonia, Norway/Latvia, Germany/Estonia. Note that we have here the very well trade-wise integrated economies versus the least integrated ones. These "breaks" indicate the shape of the larger, but definitely "weak", structures, that is, in the decreasing order of strength:

(i) the more pronounced Scandinavian-Southern structure, with three Scandinavian countries, Germany and Poland,
(ii) the definitely weaker Southern-Eastern structure, with Germany, Poland, Russia, sometimes Lithuania, and perhaps Latvia, and
(iii) the marginal Northern-Eastern structure, with Finland, the Baltic States, Russia, and often Sweden (see, in particular, Table 6).

The complete exercises concerned the period 1993-2000. This allows for a very initial comment on the dynamics of structures. In many cases we deal with two or three structures occurring intermittently in consecutive years, indicating that there is no, or perhaps very little, of an evolution from a given point of view. Indeed, it can be concluded that over the period analyzed the strong structures previously specified preserve their validity (the period of study being too short to speak of "stability"). Yet, we can forward certain propositions on more systematic changes. One of them concerns the definitely closer association of Poland with the Western-and-Scandinavian setting (and not just with Germany), see Table 4. On the other hand, a definite disassociation of Russia (Tables 7 and 8) is also noted. To a certain extent the same can be said of Finland and Norway. The appearance of the triangle Sweden-Finland-Estonia in 1999-2000 in Table 6 is also telling. The latter statements, though, should perhaps be seen against the background of a more general "flattening" of structures, causing that the larger structures go down along *r* below the threshold of optimality (*e.g*. Tables 7 and 8). This is equivalent, given the "moving horizon" of progressing regional integration, to a more uniform distribution of trade flows around the region (see the more detailed illustration for Poland vs. Denmark and Sweden in Tables 9 and 10). Essentially a very good phenomenon.

The closer association of Poland with Germany and Scandinavia (Denmark and Sweden, see also [Illeris, 2000][10]) and the flattening of structures mean that we deal with the "broadening of the area of positive economies of space" in the sense introduced in [Owsiński and Kałuszko (2000)],[11] involving larger trade and passenger flows, as well as investments.

In terms of methodological conclusions we can first consider the issue of the definition of a region. To what extent can the "strong" structures identified be treated as *sui generis* regions within Baltic Europe? A proper answer could be provided by a similar kind of analysis, conducted for a wider geographical environment, but even at this level we can attempt partial answers, such as those given before. This statement is valid in spite of the appearance in some runs (Tables 4 and 8) of the "nested" structures, for which it is definitely hard to establish a threshold of "regionality".

Quite a different problem is constituted by the very different economic settings observed in the countries subject to analysis. We can quote here two factors of essential difference, having a definite impact on the results: (i) the gap

[10] S.Illeris, *Outsourcing of textile and clothing industry from Denmark to Baltic transition countries* in: J.W.Owsiński and M.Johansson (eds.), *Global-Local Interplay in the Baltic Sea Region,* The Interfaces Institute, Warsaw 2000.

[11] J.W.Owsiński, A.Kałuszko, *Political and societal gradients across space vs. cooperation and competition* in: J.W.Owsiński and M.Johansson (eds.), *Global-Local Interplay in the Baltic Sea Region*, The Interfaces Institute, Warsaw 2000, pp.262-289.

in GDP (especially GDP *per capita*) values, of one or two orders of magnitudes, which is important in view of the existing connection between the GDP and the trade flow volumes, and (ii) the very different share of foreign trade in the economies of particular countries (it being usually much lower in the post-communist economies). If, however, we are able to observe the strong structures stretching across such differences, perhaps our indicators are good enough to deal with such situations, and the actual economic ties are important enough to form such solution structures irrespective of the differences.

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