STRUCTURAL FACTORS AND COMPETITIVENESS IN INTERNATIONAL TRADE: A NEW FORMULATION OF THE CONSTANT-MARKET-SHARES-ANALYSIS METHOD

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Abstract

The interpretation of a country's foreign trade performance requires a careful consideration of the role of structural factors. Interactions between changes in the distribution of world demand and international specialization patterns of single countries may significantly influence foreign trade aggregates. In order to study these connections, a statistical decomposition technique known as *constant-market-shares analysis* (CMS) has often been used.

This paper reviews the main methodological questions raised during the long debate on CMS analysis and presents a new formulation of this technique, integrating some recently proposed innovations with features of traditional specifications which are still valid.

The first set of problems which is examined concerns the accounting identity on which the decomposition is based. If it allows to distinguish more than one disaggregation criterion, the results of CMS analysis are sensitive to the order in which the decomposition is performed. To deal with this problem, the different disaggregation criteria may be used independently of each other, but in this case the formula must include "structural diversification indexes", which are related to the degree of statistical connection among the classification criteria. The most controversial methodological issue arising from CMS analysis concerns the choice of the decomposition formula, which is affected by an "index-number problem" in the selection of the weighting system. Recent developments in index-number theory provide arguments for choosing a specification similar to the Törnqvist price index. This approach however is based on the microeconomic theory of demand, whilst in CMS analysis no a priori theoretical relation may be assumed between market shares and the structure of demand. Moreover the descriptive power of specifications based on the Törnqvist weighting method appears weak, in comparison with traditional formulations incorporating interaction terms. The paper shows also that the contribution of trade specialization patterns to changes in market shares may be attributed to their conformity to demand trends and their polarization in strong and weak points. With all other things being equal, the more polarized is the specialization pattern of a country, the higher is the size of its market share changes.

JEL Classification**: F15, F21, F23.**

1. Introduction: Interpreting Foreign Trade Aggregate Performance

The analysis of a country's overall trade performance is often exclusively conducted in macroeconomic terms. Since, from an accounting point of view, the current account balance is equivalent to the difference between savings and investments (or between income and absorption), its behavior may thus be understood as the outcome of factors determining the accumulation of real and financial wealth in the economy. Even when the analysis is concentrated on foreign trade flows, the dynamics of export and import volumes is often explained by the behavior of other aggregate variables, such as real exchange rates and foreign or domestic income.

In many cases, however, these aggregate models prove to be inadequate in grasping the logic behind the phenomena observed. This occurs not only because, generally speaking, these models overlook important but difficult to quantify factors which help to determine foreign trade performance, such as product quality, or shifts in consumer tastes, as well as changes in international trade rules. A further reason for the inadequacy of these models is that even the influence of those variables which they most often do include, such as relative prices and income, cannot be fully captured in exclusively aggregate terms. It is therefore necessary to explicitly consider the role of structural factors, which are understood as being the whole set of characteristics defining the distribution of foreign trade by product or by country. For example, given the growth of world demand and all other circumstances being equal, the dynamics of a country's exports may be more or less sustained, according to the degree of conformity between the international specialization pattern of the country and the changes in the commodity structure of world demand. In other words, if the latter turns prevalently to products in which the country in question enjoys comparative advantages, the income elasticity of its exports shall be higher. In this sense we may speak of "macroeconomic" or "dynamic efficiency" of a country's international specialization pattern.

The influence of these structural factors - and in particular of those linked to the distribution of demand by product and by market - is more relevant than commonly believed and may sometimes go so far as to override the effect of aggregate variables, such as price competitiveness. Differences in foreign trade structures among countries are important even in order to explain differences in their growth rates. The characteristics of a country's international specialization pattern indeed have an impact on the income elasticities of its exports and imports, and hence on the intensity of the so-called external constraint to growth[1].

It is therefore clear that a proper macroeconomic analysis of a country's foreign trade performance cannot be done without complementing models based on aggregate variables with a correct evaluation of the role played by structural factors. These latter, indeed, and especially the interaction between the international specialization pattern of a country and the distribution of world demand, impart a significant impact on the very behavior of aggregate variables.

A frequently employed statistical method for evaluating the influence of structural factors on export growth and on the behavior of a country's international market share is known as *constant-market-shares* (or *CMS*) analysis. This is a decomposition technique, which owes its success both to the simplicity of its application and to its capacity to emphasize the particular relevance of structural factors that might otherwise be overlooked. However a great deal of questions have been put forward, not only as concerns the heuristic value of this method, but also because of the variability of the results generated by the different specifications available.

The first application of CMS analysis to the study of exports is usually attributed to Tyszynski (1951) and from then onwards the studies based on this method have been abundant. Among the most influential, we can cite those of Leamer and Stern (1970), Richardson (1971), Magee (1975), Fagerberg and Sollie (1987). With the contribution of Milana (1988), however, for the first time the methodological debate on CMS analysis was placed in the framework of the more recent developments in index-number theory, reaching a new specification of the formula of analysis, which was further perfected in Guerrieri and Milana (1990). In spite of all the criticism it has elicited, CMS analysis is still widely used, explicitly or implicitly, not only in academic research but also in policy-oriented analysis[2].

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1 The link between the income-elasticities of trade flows and the growth rate of an open economy was highlighted by Thirlwall (1979) and, with a different approach, by Krugman (1989). The hypothesis that international differences in such elasticities are essentially attributable to differences in the structure of foreign trade was advanced, among others, by Goldstein and Khan (1985).

2 An example is given by the table entitled *Export market growth and performance in manufactured goods*, which appears in each issue of the *OECD Economic Outlook* and is based on a very simple variant of CMS analysis. This statistical technique has been used also in economic history (see, e.g. Irwin, 1995).

In the following sections of this paper we will try to take stock of this long debate and present a reformulation of the CMS method, which combines features drawn from traditional and more recent specifications.

Section 2 is dedicated to a brief discussion of the significance of CMS analysis and the interpretive value of its results. Section 3 addresses the main problems arising from its application, laying the ground to Section 4, which presents a new specification of the decomposition formula.

2. The Nature of Constant-Market-Shares Analysis

The analytical method which has been dubbed *constant-market-shares analysis* (*CMS*) is a statistical technique which is predominantly used to study the aggregate behavior of a country's exports. With this kind of analysis, one seeks to evaluate to what degree the factors tied to the competitiveness of exported goods, as well as those connected to the structure of world demand and to the international specialization pattern of the country in question, contribute to such trends.

In practice, this involves breaking down the variations of a country's total exports or of her aggregate market share over time. The analysis is performed by starting from an accounting identity, to which a decomposition formula is applied. For this reason, it has often been emphasized that constant-market-shares analysis should not be employed for interpretive or forecasting ends, but understood as a method for the *ex-post* accounting measurement of the contribution of each specific elementary component to the behavior of an aggregate variable (see Milana, 1988, pp. 453-4)[3].

Given the accounting nature of the decomposition, it would be wrong to ascribe CMS analysis with an interpretive capability analogous to that of an econometric model. Nonetheless, the results of the decomposition may be used to orient the research into the explanations of exports behavior: for each one of the terms generated by the decomposition formula, a distinct economic meaning may indeed be found and therefore, a nexus with a set of explicative factors. For example, the so-called *competitiveness effect*, although it cannot be directly read as an indicator of the

[3] A new specification of CMS analysis, based on an econometric estimate of its elements, has recently been used by Cheptea, Gaulier and Zignago (2005).

competitiveness of exported goods, offers however an *ex-post* measurement of the impact brought about by the entire set of competitiveness factors on aggregate export performance.

The usefulness of CMS analysis arises from the fact that even if trends in competitiveness are equal, total exports of a country may record a different performance than those of other countries, as a consequence of the greater or lesser conformity of the international specialization pattern of each country with the structural tendencies of world demand. The statistical breakdown allows the identification of these structural factors and the measurement of their role in the aggregate change of exports. The terms generated by the decomposition can therefore be more easily evaluated through a proper interpretive model. The competitiveness effect, for example, could be traced back to the changes of real exchange rates or to other competitiveness factors, without the interference generated by the influx of structural factors.

As a method for decomposing the dynamics of aggregate variables, CMS analysis may be likened to other statistical techniques, and in particular to methods for breaking down the changes of an economic aggregate value into price and quantity indexes. As we shall see later, part of the problems encountered in the specification of the analytical formulas can be reduced down to an "index-number problem"[4].

More generally speaking, CMS analysis may be conceived as a particular case of a decomposition method, which is useful whenever one wishes to analyze the statistical link between the behavior of an aggregate entity and of the elementary variables which make it up. As a decomposition object, therefore, one may place whatever aggregate variable which can be represented as a weighted average of the corresponding elementary variables[5].

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4 See Richardson (1971), p. 234 and Milana (1988).

5 Actually, the CMS method can be seen as an application to international trade data of a technique, called *shift-and-share analysis*, widely used in regional economics and pioneered by Creamer (1943). Useful surveys of this field of research have been provided by Holden, Nairn and Swales (1989) and Loveridge and Selting (1998). An interesting application of the *shift-and-share* method to international trade data at sub-national level can be found in Coughlin and Pollard (2001).

3. Specification Problems

3.1 Introduction

A large part of the methodological debate on constant-market-shares analysis is focused on the problems posed by the specification of decomposition formulas, which sometimes appear of such a serious nature that they cast doubts upon the reliability of the results obtained with this statistical technique. However, as Guerrieri and Milana have noted (1990, p. 333), the criticisms addressed to the traditional approaches of CMS analysis are actually aimed at the particular formulas used rather than at the accounting breakdown in itself. The value of this breakdown does not, in fact, appear prejudiced by the variety of specifications available for the formula of analysis, but, as Magee had previously pointed out (1975, p. 222), "if we can dispose of the methodological problems, constant-market-shares analysis still stands or falls on whether, as an identity, it yields a useful organization of the data. If this identity, like the GNP identity, contains behavioral components that can be explained by other independent variables, and if this process gives expanded insight into the behavior of international trade flows, then more research is warranted, on both method and application."

Notwithstanding the conceptual simplicity of the operations to be performed, the formulations proposed for constant-market-shares analysis display considerable variety, deriving mainly from the diverse solutions adopted for the "index-number problem" inherent in the decomposition, but also from the different specifications of the base accounting identity. In the following sections, the main methodological problems posed by constant-market-shares analysis and the various specifications which have been proposed to resolve such problems, shall be reviewed.

Firstly, we shall explore two issues regarding the choice of the base accounting identity (the decomposition object and the number of criteria of disaggregation). In this context, the problem of the sensitivity of results to the order of the decomposition of structural terms shall also be examined.

Subsequently, the alternatives available for the decomposition formula of the base identity shall be examined, starting from the crucial theme of the weighting method, which remains perhaps the most debated issue in CMS analysis and which may be regarded as an aspect of the more general "index-number problem". To the latter, we may also trace the issue of the dependence of the decomposition results upon the time-path of the elementary data, raised by Milana (1988).

3.2 The Choice of the Base Accounting Identity

The starting point of constant-market-shares analysis is an accounting identity in which an aggregate variable (generally exports or market shares) is related to the elementary variables that make it up. To this identity, a decomposition formula is then applied which expresses the changes over time of the variables under study, as being the sum of two or more terms representing the effects of various factors which influence this variable.

The problems related to the specification of this decomposition formula shall be covered later in this paper (in Section 3.3). This section is solely addressed to the choice of the base accounting identity and is subdivided into two sub-sections, each corresponding to the two members of such an identity.

In the first sub-section, we shall examine the question of the choice of the variable to be decomposed, which appears on the left-hand side of the identity. In the second sub-section, we shall analyze some problems concerning the various possible criteria of data disaggregation, on which the specification of the right-hand side of the base identity depends.

3.2.1 The Decomposition Object

The selection of the aggregate variable appearing on the left-hand side of the base accounting identity depends mainly on the research aims, and affects even the choice of the decomposition formula. We will now illustrate the main options encountered in this regard in the studies undertaken with the CMS analysis method.

a) The Choice of the Trade Variable

As earlier mentioned in Section 2, the CMS method is generally used to analyze the foreign trade behavior of a country, in order to evaluate the relative contribution of competitiveness and of structural factors, to its trade performance. Normally, the variable chosen to represent such performance is export growth. However, there are also other aggregate variables which could be used. In an attempt to get a more complete evaluation of a country's position in international trade, its imports should be taken into consideration, for example by constructing decomposition formulas for the normalized trade balance or for the export-import cover ratio.

Another decision to be made regarding the decomposition object is how to express the trade flows which are to be analyzed. Many of the differences among specifications available in the literature depend on this choice. In some cases, the decomposition object is simply the absolute or relative change in a country's exports, without reference to any term of comparison, such as the change of world exports. In other specifications, trade performance is explicitly measured as the change in a country's market share, defined as the ratio between its exports and the exports of a reference area (the world or a more restricted set of competitors)[6]. Equivalently, trade performance can be measured as the difference between the growth rate of a country's exports and that of the reference area[7].

Actually, the above variants are substantially equivalent, since their ultimate target is to compare a country's trade performance with that of the reference area. If the

6 The choice of the data on which the formula is applied, raises an additional problem, which is particularly influenced by practical considerations. A country's exports toward the rest of the world may also be viewed as imports of the world from this same country and correspondingly, the market share may be calculated either as the ratio between a country's exports and those of the world, or as the ratio between the world's imports from that country and total world imports. If one actually had data for the whole matrix of world trade, this choice would be of marginal importance, since any divergence in the results could only be due to statistical discrepancies, for example the difference between F.O.B and C.I.F data. The issue becomes more crucial, when data referring to a more restricted set of countries (for example industrial countries) are available. In these cases, using export data allows you to regard the entire world as a market, but forces you to exclude among competitors, those countries for which export data is not available (for example developing countries). On the other hand, if import data is used, the analysis must be narrowed to a smaller market (industrial countries), but all competitors may be considered. The choice will thus be based on data availability and on the research target.

7 See, for example, European Central Bank (2005).

choice should fall on the simplest specifications based on changes in a country's exports, the decomposition formula will result as being slightly more complex, since beyond the terms representing the competitiveness effects and the structural factor effects, another appears which measures the effects of growth of world demand. This term disappears instead when market shares or differences in growth rates become the decomposition object.

b) *Data at Current or Constant Prices*

One significant and widely discussed issue regarding the object of analysis, is the choice among variables at current or constant prices[8]. The usefulness of data at constant prices appears greater when the effect of price competitiveness on export volumes is being evaluated. If on the other hand, competitiveness is understood in a wider sense, referring not only to prices but to the whole set of characteristics that can make a product more preferable compared to those of competitors (quality, image, organization of sales, etc.), data at current prices can be favoured, since they allow the measurement of the overall effect of such competitiveness factors on the export value. For example, the aggregate market share in value terms can improve, both in the case in which the higher price competitiveness of national products stimulates an adequate increase in export volumes, as well as in the case in which the qualitative characteristics of national products allow selling them at higher prices or successfully entering more lucrative segments of the foreign marketplace.

3.2.2 Disaggregation Criteria

In the definition of the base accounting identity, beyond the choice of the decomposition object, the second important aspect is the number of disaggregation criteria. Total exports (the aggregate market share) may be treated as the sum (weighted average) of the elementary export flows (of the elementary market shares) classified according to one or more criteria: by product, by destination country, by firm size category, by source region, etc.. The first studies based on constant-market-shares analysis used a sole disaggregation criterion (by product), but formulations were soon

8 See, for example, Richardson (1971) pp. 230-1.

elaborated which took into account both the commodity type criterion as well as that of destination markets.

In the case of a unique disaggregation criterion, choosing as decomposition object, for simplicity's sake, a country's aggregate share in a market's imports, defined as:

$$S^t \equiv \frac{\sum_k m_k^t}{\sum_k M_k^t} \qquad [1]$$

in which:

S^t: the target country's aggregate market share;

m_k^t: imports of the market from the target country in the k^th^ product (k = 1 ... p);

M_k^t: imports of the market from the world in the k^th^ product;

the base accounting identity is the following, which expresses the aggregate market share as the weighted ari^th^metic mean of the elementary shares recorded for each product:

$$S^t \equiv \sum_k s_k^t w_k^t \qquad [2]$$

in which:

$s_k^t \equiv \dfrac{m_k^t}{M_k^t}$: the target country's share of the market's imports in the k^th^ product;

$w_k^t \equiv \dfrac{M_k^t}{\sum_k M_k^t}$: weight of the k^th^ product over the market's total imports from the world.

If, on the other hand, there are two criteria of data classification (for example by product and importing country), as may happen when the market being contemplated is a geographic area or the world, the aggregate share of an exporting country on the imports of the market may be expressed as:

$$S^t \equiv \frac{\sum_i \sum_j m_{ij}^t}{\sum_i \sum_j M_{ij}^t} \qquad [\,3\,]$$

in which:

m_{ij}^t: imports of the j^th country (j = 1…m) from the target country in the i^th product (i = 1…n);

M_{ij}^t: imports of the j^th country from the world in the i^th product.

From definition [3] five alternative specifications of the base accounting identity can be derived:

$$S^t \equiv \sum_i \sum_j s_{ij}^t w_{ij}^t \qquad [\,4\,]$$

$$S^t \equiv \sum_i \sum_j s_{ij}^t g_{ij}^t p_{i.}^t \qquad [\,5\,]$$

$$S^t \equiv \sum_i \sum_j s_{ij}^t g_{.j}^t p_{ij}^t \qquad [\,6\,]$$

$$S^t \equiv \sum_i \sum_j s_{ij}^t g_{.j}^t p_{i.}^t d_{ij}^t \qquad [\,7\,]$$

$$S^t \equiv \sum_i \sum_j s_{ij}^t g_{ij}^t p_{ij}^t \frac{1}{d_{ij}^t} \qquad [\,8\,]$$

in which:

$s_{ij}^{t} \equiv \dfrac{m_{ij}^{t}}{M_{ij}^{t}}$: the target country's share of the jth country's imports from the world in the ith product;

$w_{ij}^{t} \equiv \dfrac{M_{ij}^{t}}{\sum_i \sum_j M_{ij}^{t}}$: weight of the jth country's imports from the world in the ith product over the market's total imports from the world;

$g_{ij}^{t} \equiv \dfrac{M_{ij}^{t}}{\sum_j M_{ij}^{t}}$: weight of the jth country's imports over the market's imports from the world in the ith product;

$g_{.j}^{t} \equiv \dfrac{\sum_i M_{ij}^{t}}{\sum_i \sum_j M_{ij}^{t}}$: weight of the jth country's imports over the market's total imports from the world;

$p_{ij}^{t} \equiv \dfrac{M_{ij}^{t}}{\sum_i M_{ij}^{t}}$: weight of the ith product over the jth country's total imports from the world;

$p_{i.}^{t} \equiv \dfrac{\sum_j M_{ij}^{t}}{\sum_i \sum_j M_{ij}^{t}}$: weight of the ith product over the market's total imports from the world;

$$d_{ij}^{t} \equiv \frac{M_{ij}^{t} \cdot \sum_i \sum_j M_{ij}^{t}}{\left(\sum_i M_{ij}^{t}\right)\left(\sum_j M_{ij}^{t}\right)} \equiv \frac{w_{ij}^{t}}{p_{i.}^{t}\, g_{.j}^{t}} :$$

structural diversification index (SDI): ratio between the weight of the jth country (of the ith product) over the market's imports in the ith product (over the jth country's total imports) and the weight of that country (of that product) over the market's total imports from the world.

Identity [4] is substantially equivalent to [2]: the two vectors of elementary market shares and of weights contain a number of elements (*m* x *n*) equal to that of the cells of a double-entry table in which the rows refer to the products and the columns to the importing countries. However in [4] it is not possible to distinguish the commodity from the geographic dimension of the disaggregation, since each weight is calculated as a ratio between the value of imports of each cell and the total value of the market's imports from the world. Such cells will henceforth be designated as "segments" of the importing market being considered.

Identities [5] and [6] have for a long time been the base identities most often used (explicitly or implicitly) in CMS analysis. In [5] the data on the market's imports are first disaggregated according to product type and then, for each one of these, the distribution by importing country is considered, whilst in [6] the opposite occurs. This appears evident if we consider that identity [5] can also be expressed as follows:

$$S^t \equiv \sum_i s^t_{i.} \, p^t_{i.} \qquad [\ 9\ ]$$

in which:

$$s^t_{i.} \equiv \frac{\sum_j m^t_{ij}}{\sum_j M^t_{ij}} \equiv \sum_j s^t_{ij} \, g^t_{ij} \qquad [\ 10\ ]$$

the target country's share of the market's imports from the world in the i^{th} product;

and similarly identity [6] may be written as follows:

$$S^t \equiv \sum_j s^t_{.j} \, g^t_{.j} \qquad [\ 11\ ]$$

in which:

$$s^t_{.j} \equiv \frac{\sum_i m^t_{ij}}{\sum_i M^t_{ij}} \equiv \sum_i s^t_{ij} \, p^t_{ij} \qquad [\ 12\ ]$$

the target country's share of the j^{th} country's total imports from the world.

In practice, identity [5] is obtained by constructing at two different levels of disaggregation identities similar to [2]; first the aggregate market share is expressed as the weighted average of market shares by product (identity [9]) and then each one of these latter is treated as the weighted average of the elementary market shares held for each product in each importing country (identity [10]). A similar statement is also valid for identity [6].

The internal asymmetry of identities [5] and [6] as concerns the degree of data disaggregation by product and by country affects the decomposition formulas, giving rise to one of the most discussed methodological problems of CMS analysis: the variability of results according to the order in which the decomposition is performed.

In order to solve this problem, Guerrieri and Milana (1990) have proposed accounting identities [7] and [8][9]. Their essential feature is that the product weights have been defined to the same degree of disaggregation as the geographic ones. In [7] the ones as well as the others are calculated at the margins of the double-entry table of the market's imports and therefore these latter distribution by product is determined independently of that by importing country[10]. In [8], on the other hand, all the weights are calculated within the double-entry table, which generates as many product distributions as there are importing countries and as many geographical distributions as there are products.

However, with this, the problem of the variability of results according to the order of disaggregation of data is not solved, as Guerrieri and Milana claimed (1990, p. 332), but it is simply presented in a different shape. The results of the decomposition are not independent of the order chosen for breaking down the data, but change according to the use of "internal" or "marginal" weights in the double-entry table, or, in other words, according to whether one chooses the base identity [7] or [8]. Between [7] and [8], there is essentially the same relation as between identities [5] and [6] in the traditional formulations[11].

In any case the symmetry in the level of disaggregation of geographic and sectorial weights is a characteristic of identities [7] and [8] which make them preferable when compared to the traditional ones. However, by confronting the two couples of accounting identities, it emerges that such an internal symmetry can only be achieved by introducing in the formulas a further element, which is the matrix of *structural*

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[9] An English version of this proposal can be found in Milana (2004).

[10] A similar approach has been followed in European Central Bank (2005).

[11] A different solution for this problem has been adopted by Cheptea, Gaulier and Zignago (2005), who derive the CMS effects from an econometric exercise, making the decomposition order not relevant for the results.

diversification indexes (SDIs). The interpretation of these indexes is nevertheless rather easy; they show to what degree the commodity structure of a market's imports is differentiated by passing from one importing country to another, or to what degree their distribution by importing country varies from one product to another. In other words, the SDIs reveal the degree of reciprocal dependence between the structure of the market by importing country and that by product, and show if the imports of the market are uniformly distributed among the various segments or instead tend to be concentrated in some of these. In the extreme case in which all the SDIs are equal to one, the commodity (or the geographic) distribution of imports would result as equal in all countries (for all products). There is therefore a precise relation between these indexes and Pearson's quadratic average contingency coefficient (**f**), calculated on the double-entry table showing the distribution of the market's imports by product and by importing country. In particular:

$$\left(\mathbf{f}^{t}\right)^{2} = \sum_{ij} d_{ij}^{t} w_{ij}^{t} - 1 \qquad [13]$$

Also from this expression, we can see that if all the diversification indexes were equal to one, there would be no statistical connection between the two criteria of import classification (by product and by importing country), while as the degree of interdependence among the two distributions grows, so such indexes depart from one.

3.3 The Choice of the Decomposition Formula

Once the base accounting identity of constant-market-shares analysis has been specified, there remain other options affecting the definition of the formulas for breaking down the changes over time of the variable being explored.

The most important issue concerns the shift from a continuous-time formulation to one in discrete time, and the subsequent choice of the weighting system to be used in the decomposition or, in other words, the *index-number problem* inherent in CMS analysis (see Richardson, 1971 and Milana, 1988). As far as this matter is concerned, in the next section, we shall survey the various alternatives proposed for the decomposition formula, whose differences stem from the choice of the weighting method.

In the subsequent section, we shall illustrate another issue linked to the preceding one: that of the dependence of the decomposition results upon the time-path of elementary data.

3.3.1 The weighting method and the index-number problem *in CMS analysis*

Referring to the base identity [2], the continuous-time decomposition of its variations generates:

$$\frac{dS^t}{dt} = \sum_k \frac{ds_k^t}{dt} w_k^t + \sum_k \frac{dw_k^t}{dt} s_k^t \qquad [\ 14\ ]$$

in which the rate of change of the aggregate market share results as equal to the sum of two terms, of which the first is the weighted average of the rates of change of the elementary shares and the second synthesizes the effects of changes in the structure of the market's imports. The first term is named the *competitiveness effect* (CE) since, given the demand structure, one can hold that changes in the elementary market shares mirror *ex-post* the effects of changes in relative prices and in the other factors of competitiveness. The second term is usually called the *structure effect* (SE) because it represents the variation that the aggregate market share would in any case have, because of the effect of changes in the structure of the market's imports, even if the elementary market shares do not change (*constant-market-shares*). It mirrors the conformity of a country's specialization pattern[12] to changes in the structure of demand.

The "index-number problem" of CMS analysis, concerns the variety of possible solutions to adapt identity [14], which was conceived for continuous time, to the discrete-time data available for empirical analysis. The existing alternatives, which differ among them for the choice of the weighting method, are the following:

12 The indicator of trade specialization which is implicitly used in CMS analysis is the Balassa (1965) *index of revealed comparative advantages*. However, if the object of the decomposition were the overall normalized trade balance, the appropriate specialization indicators would be expressed in terms of net trade.

$$S^t - S^0 = \sum_k \left(s_k^t - s_k^0\right) w_k^0 + \sum_k \left(w_k^t - w_k^0\right) s_k^t \qquad [\ 15\ ]$$

$$S^t - S^0 = \sum_k \left(s_k^t - s_k^0\right) w_k^t + \sum_k \left(w_k^t - w_k^0\right) s_k^0 \qquad [\ 16\ ]$$

$$S^t - S^0 = \sum_k \left(s_k^t - s_k^0\right)\left[\alpha\, w_k^t + (1-\alpha)\, w_k^0\right] + \sum_k \left(w_k^t - w_k^0\right)\left[(1-\alpha)\, s_k^t + \alpha\, s_k^0\right] \qquad [\ 17\ ]$$

$$S^t - S^0 = \sum_k \left(s_k^t - s_k^0\right) w_k^0 + \sum_k \left(w_k^t - w_k^0\right) s_k^0 + \sum_k \left(w_k^t - w_k^0\right)\left(s_k^t - s_k^0\right) \qquad [\ 18\ ]$$

$$S^t - S^0 = \sum_k \left(s_k^t - s_k^0\right) w_k^t + \sum_k \left(w_k^t - w_k^0\right) s_k^t - \sum_k \left(w_k^t - w_k^0\right)\left(s_k^t - s_k^0\right) \qquad [\ 19\ ]$$

For a long time, the most widely used formulas in CMS analysis have been based on identities [15] or [16], which have been chosen for their simplicity, or on [18], which offers the advantage of a coherent weighting method, in the sense that all the weights refer to the initial period, but requires the introduction of an added decomposition term.

A long debate has sprung up on the economic meaning of this term, which depends on the interaction between the variations of the market shares and of the demand structure. Richardson (1971) considered it as a “second measure of competitiveness", because it shows to what extent a country succeeds in concentrating positive trade performances (the increases in its market shares) in the most dynamic segments of the market’s imports.

Assuming another point of view, Fagerberg and Sollie (1987) defined the interaction term as a measure of the degree of flexibility of the international specialization pattern of a country in response to changes in the structure of demand and consequently dubbed it the *adaptation effect* (AE). In addition, they demonstrated that such a term could be decomposed in three elements according to the formula:

$$AE = r_A \sqrt{\sum_k \left(s_k^t - s_k^0 - \mu_s^t + \mu_s^0\right)^2}\sqrt{\sum_k \left(w_k^t - w_k^0\right)^2} \qquad [\ 20\ ]$$

in which:

r_A: linear correlation coefficient between changes of the elementary market shares and changes of the weights of the individual segments of the marketplace;

μ_s^t: unweighted arithmetic mean of the elementary market shares.

From this formula, it appears that the sign of the interaction term is established by that of the correlation coefficient r_A, while its value also depends on another two factors, which are respectively a measure of the degree of dispersion around the average of the variations of elementary shares and a measure of the variability of the structure of market demand[13].

Milana (1988) departs from all the traditional formulations of CMS analysis and criticizes the use of the interaction term, contending that the only specification which is coherent with the most recent developments of index-number theory is that of [17] with α = 0.5. This is equivalent to using as weights the averages between the initial period and the final one, analogous to the price index formula devised by Törnqvist (1936). Milana claims that this formulation is preferable to all the others, since it affords a better discrete-time approximation of the continuous-time decomposition formula. On the contrary, the interaction term appearing in equations [18] and [19] "is produced by the inability of the linear approximating formula to completely disentangle the component effects by tracing a non-linear function" (Milana 1988, p. 467)[14].

However the economic approach to index-number theory, which Milana refers to, concerns the splitting up of a variable value into its individual price and quantity components and assumes the existence of an aggregation function of such components based on the microeconomic theory of consumer behavior. In the case of CMS analysis,

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13 Similarly one may demonstrate that the structure effect is determined by:

$$SE = r_S\sqrt{\sum_k\left(s_k^0-\mu_s^0\right)^2}\sqrt{\sum_k\left(w_k^t-w_k^0\right)^2}$$

in which r_S is the linear correlation coefficient between the initial levels of the elementary market shares and the changes of the weights of the individual market segments and the other two factors represent respectively a measure of the dispersion of the elementary initial shares around their average (or, in other terms, an indicator of the degree of polarization of the target country's initial international specialization pattern) and a measure of the variability of the demand structure of the market.

14 Milana's approach has been followed, among the others, by Simonis (2000).

instead, it appears impossible to postulate a precise and theoretically founded functional relationship between the two elementary components (market shares and weights) and we consequently lack the continuous-time aggregation function on which we could select the best discrete-time approximations.

To this uncertainty on the theoretical advantages offered by formula [17], we can add the fact that, from a purely descriptive point of view, this appears to suffer from a drawback from which on the contrary the traditional formula [18] remains immune[15]. Using the averages between the initial and final periods as weights, formula [17] does not allow us to neatly disentangle the competitiveness effect from the structure effect. For example, the structure effect no longer represents, as in [18], the variation that the aggregate market share would undergo between period 0 and period t, had the elementary market shares remained equal to those at the outset, but is calculated as if such shares had remained constant on an intermediate level between the initial and the final one. By doing this however, the structure effect ends up by englobing a part of the changes of the elementary market shares, which should instead be captured by the competitiveness effect and vice versa.

It is true that equation [17] splits the entire change of the aggregate market share into only two components, without any residual, but by doing so it muddles their economic meaning. On the contrary, equation [18] does not accomplish an exact bipartition, but allows the structure effect to be clearly distinguished from the competitiveness effect. Moreover its residual interaction term, although signalling a less than complete decomposition, may be granted an economic interpretation (the adaptation effect).

Furthermore one could point out that in equation [17] the structure effect is static: it measures the influence of a country's international specialization pattern, defined in a certain period (halfway between 0 and t), on changes in its aggregate market share, but ignores the effects of mutations in the specialization pattern itself. In [18], on the other hand, it is possible to do both a static evaluation as well as a dynamic one; this latter is indeed supplied by the interaction term, that can also be interpreted as a measure of the effect of changes in a country's specialization pattern on its global export performance.

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15 Similar arguments, in a different context, may be found in a contribution by Menzler-Hokkanen and Langhammer (1994, pp. 311-312) on the bilateral index number technique for the measurement of the quality of imports and the substitution among trading partners.

3.3.2 The Dependence of the Results upon the Time Path of the Elementary Data

Another problem linked to the choice of the weighting method of the formula is that of the dependence of the decomposition results upon the time-path of the elementary data. Milana (1988) raised this issue in the context of his reformulation of CMS analysis, tying it to the issue of the approximation error which one will in anyway commit in representing a continuous aggregation function with an index number constructed in discrete time. To reduce this approximation error, the index-number theory referred to by Milana suggests building the index for a certain time span, subdividing it into the shortest possible intervals and chaining together the indexes calculated at those intervals.

Similarly in CMS analysis, by using the chain method, we may take into consideration the whole path followed by the data between the initial period and the final one. Consequently, the dimension and the sign of the detected effects come to strictly depend on such a path, in the sense that, with the initial and final levels of market shares and weights being equal, their intermediate levels determine the values assumed by the terms generated by the decomposition. In this sense, the problem of the dependence of the effects upon the time-path of the elementary data has not been solved - as Guerrieri and Milana claim (1990, pp. 332-3) - but indeed has been generated and highlighted by the chain method.

On the contrary in the traditional formulations the decomposition is performed by directly comparing the final period data with those of the initial period and thus one forgoes the opportunity to benefit from all the information contained in the intermediate data. On the other hand, it is precisely because of the effect of this choice, that the decomposition results, whatever formula is used, are however independent of the path followed by the elementary data in the intermediate periods.

However, the practice of subdividing the time span into short intervals can be useful to better understand the dynamics of the underlying variables, as well as to generate time series of the decomposition effects, which can be integrated into econometric models[16].

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[16] Recent applications of the *shift-and-share* analysis make wide use of this practice, advocated by Barff and Knight (1988). For an interesting example of how *shift-and-share* analysis can be integrated into econometric models, see Banasick and Hanham (2006).

4. A New Specification

In this section, we present a new decomposition formula for CMS analysis, taking into account the problems discussed in section 3. This formula may be used for analyzing data on import market shares, classified by importing country and by sector. The base accounting identity hence is [3], which is specified with [7]:

$$S^t \equiv \sum_i \sum_j s_{ij}^t g_{.j}^t p_{i.}^t d_{ij}^t$$

in which the symbols assume the same meaning as already indicated in Section 3.2.2.

The decomposition of the variations of [7] over time is performed with a formula similar to [18]. However the fact that in [7] each addend is the product of four elementary factors causes the number of terms generated by the decomposition to be not three, as in [18], but fifteen. Not all of these terms have a prominent informative value and lend themselves to an economic interpretation. For this reason we found it more useful to group together some of these terms and use a decomposition formula which picks out seven effects:

$$S^t - S^0 = \sum_i \sum_j \left(s_{ij}^t - s_{ij}^0\right) w_{ij}^0 +$$

[CE]

$$\sum_i \left(p_{i.}^t - p_{i.}^0\right) s_{i.}^0 +$$

[CSE]

$$\sum_j \left(g_{.j}^t - g_{.j}^0\right) s_{.j}^0 +$$

[GSE]

$$\sum_i \sum_j \left[\begin{array}{l} \left(d_{ij}^t - d_{ij}^0\right) s_{ij}^0\, p_{i.}^0\, g_{.j}^0 + \\ \left(p_{i.}^t - p_{i.}^0\right)\left(g_{.j}^t - g_{.j}^0\right) s_{ij}^0\, d_{ij}^0 + \\ \left(p_{i.}^t - p_{i.}^0\right)\left(d_{ij}^t - d_{ij}^0\right) s_{ij}^0\, g_{.j}^0 + \\ \left(g_{.j}^t - g_{.j}^0\right)\left(d_{ij}^t - d_{ij}^0\right) s_{ij}^0\, p_{i.}^0 + \\ \left(p_{i.}^t - p_{i.}^0\right)\left(g_{.j}^t - g_{.j}^0\right)\left(d_{ij}^t - d_{ij}^0\right) s_{ij}^0 \end{array}\right] + \qquad [\ 21\ ]$$

[SIE]

$$\sum_i \sum_j \left(s_{ij}^t - s_{ij}^0\right)\left(p_{i.}^t - p_{i.}^0\right) g_{.j}^0\, d_{ij}^0 +$$

[CAE]

$$\sum_i \sum_j \left(s_{ij}^t - s_{ij}^0\right)\left(g_{.j}^t - g_{.j}^0\right) p_{i.}^0\, d_{ij}^0 +$$

[GAE]

$$\sum_i \sum_j \left[\begin{array}{l} \left(s_{ij}^t - s_{ij}^0\right)\left(d_{ij}^t - d_{ij}^0\right) p_{i.}^0\, g_{.j}^0 + \\ \left(s_{ij}^t - s_{ij}^0\right)\left(p_{i.}^t - p_{i.}^0\right)\left(g_{.j}^t - g_{.j}^0\right) d_{ij}^0 + \\ \left(s_{ij}^t - s_{ij}^0\right)\left(p_{i.}^t - p_{i.}^0\right)\left(d_{ij}^t - d_{ij}^0\right) g_{.j}^0 + \\ \left(s_{ij}^t - s_{ij}^0\right)\left(g_{.j}^t - g_{.j}^0\right)\left(d_{ij}^t - d_{ij}^0\right) p_{i.}^0 + \\ \left(s_{ij}^t - s_{ij}^0\right)\left(p_{i.}^t - p_{i.}^0\right)\left(g_{.j}^t - g_{.j}^0\right)\left(d_{ij}^t - d_{ij}^0\right) \end{array}\right]$$

[RAE]

The first term is dubbed the *competitiveness effect* (CE) because it is the weighted average of the changes of an exporting country's elementary shares in each of the country-sector segments into which the import market is subdivided. The underlying idea is that such changes display the effects of variations in relative prices and in the other competitiveness factors (quality, image, distribution network, etc.) that render one country's products preferable to those of competitors. Essentially, the CE is not an *ex-ante* measure of the competitive strength of a country's products, but a synthetic *ex-post* indicator of their trade performance on the import market.

The subsequent three terms, when taken as a whole, are equivalent to the second term of [18], which is the *structure effect* (SE). Actually, they reveal how a country's aggregate market share would have changed because of the sole effect of changes in the structure of import demand, given the elementary market shares (hence the epithet *constant-market-shares*).

The commodity structure effect (CSE) measures the contribution imparted to the variation of a country's aggregate market share by changes in the sectorial composition of import demand. In fact its sign depends on the correlation between the changes in the relative importance of each sector in total imports of the market, and the shares that the target country holds in each sector in the initial period. In other words, the more the country's international specialization pattern (defined by the vector of its sectorial shares in the initial period) is oriented towards the most dynamic sectors of import demand, the more the CSE becomes favourable.

Similarly, the *geographic structure effect* (GSE) indicates to what degree the behavior of a country's aggregate share is influenced by changes in the distribution by importing country of total market demand. The better the geographical orientation of a country's exports to the market in the initial period corresponds to the trends in the distribution of total demand by importing country, the higher its GSE will be. In other words, the countries which achieve a positive and high GSE are those which hold the highest shares in exactly those import markets which turn out to be the most dynamic.

The *structural interaction effect* (SIE) depends on the way in which changes in the geographic and commodity structure of total imports influence each other. More exactly, the structural interaction effect is positive if such changes tend to increase the relative incidence of the market segments in which a country is specialized.

As we can see from the formula, the SIE is made up of the sum of five of the terms generated by the decomposition. The first of these, which could be named the *structural* *diversification effect* (SDE), depends on the way in which the SDIs of import demand change over time[17]. The sign of this effect is derived from the interaction between the changes of the SDIs and the initial levels of the elementary market shares as well as of the total country and sector weights. Actually, the greater the demand for imports concentrates in the segments in which an exporting country is specialized, or in other terms the more these segments increase their "specific weight" on total imports, the more the SDE becomes advantageous for that country. The SDE is substantially equivalent to the so-called "specific market-product effect" introduced for the first time in CMS analysis by Guerrieri and Milana (1990). Its usefulness derives from the fact that, as has already been mentioned in Section 3.2.2, the insertion of the SDIs into the decomposition formulas allows the use of homogeneous weights (at a similar degree of disaggregation) in the calculation of the other structural effects (CSE and GSE).

The other terms that make up the SIE arise from the interaction among the changes of the various kinds of weights used in the formula (sectorial weights, geographic weights and structural diversification indexes). The economic importance of these terms is not intuitive. For example, they tend to assume a positive sign for those countries which are specialized in market segments whose importance rises either because of increases in the total weight of the importing country - or of the sector - to which these segments belong, or still yet in the corresponding structural diversification indexes. But weight changes can play a favourable role also by combining themselves in other ways than that which was just described.

The last three terms of formula [21], taken as a whole, represent the *adaptation effect* (AE) and are exactly equal to the comparable term of [18].

The *commodity adaptation effect* (CAE) reflects the interaction between the competitiveness effects attained by a country in each sector[18] and the changes in the sectorial structure of total demand for imports. The CAE can be interpreted either as a "second competitiveness measure", in the sense that it reveals if a country succeeds in concentrating its best trade performances in the most dynamic sectors, or as an indicator of the degree of flexibility of the country's international specialization pattern, since it

17 The importance of the SDIs (*structural diversification indexes*) has been illustrated in section 3.2.2.

18 For each exporting country it is possible to calculate a set of *sectorial competitiveness effects*. Each one of those effects is equal to the weighted average of the share changes recorded for that sector in the various importing countries. Actually, these sectorial competitiveness effects, similarly to the global one (CE), indicate how the sectorial market shares of the target exporting country would have been altered, had the geographic structure (by importing country) of imports in individual sectors remained unchanged.

shows if such a pattern evolves in ways conforming to the tendencies of market demand. This ambivalence derives from the fact that the variations over time of the market shares can be read either as an effect of competitiveness factors (as in the CE), or as an outcome of changes in the specialization pattern, which is defined in fact by the distribution of the elementary shares around the average (as in the SE).

Similarly, the *geographic adaptation effect* (GAE) shows to what degree the market share increases attained by an exporting country in the individual market segments tend to be concentrated in the countries whose demand for imports has appeared to be the most dynamic. Its sign indeed depends on the correlation between changes in the geographic structure (by importing country) of total demand for imports and the competitiveness effects recorded by the exporting country in each one of the importing countries[19].

Finally the *residual adaptation effect* (RAE) encompasses a set of five interaction terms, whose dimensions are normally small. They capture the correlation among the changes of the elementary market shares, those of the structural diversification indexes or those of a combination of geographic and/or sectorial weights. Even the RAE, if it is positive, shows that the favourable trade performances attained by a country tend to be concentrated in the most dynamic segments of the market.

One of the main features of CMS analysis is its usefulness in illustrating the role played by structural factors in the evolution of market shares of the exporting countries. This role may be better understood by further decomposing the structural effects which appear in the formulas, using an approach similar to that proposed by Fagerberg and Sollie (1987) for the adaptation effect[20].

For instance we may express the commodity structure effect (CSE) as follows:

$$CSE = r_{SC}\sqrt{\sum_i\left(s_{i.}^{0}-\mu_{s}^{0}\right)^2}\sqrt{\sum_i\left(p_{i.}^{t}-p_{i.}^{0}\right)^2} \qquad [\ 22\ ]$$

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19 Each one of these competitiveness effects, measured in the individual importing countries, is equal to the weighted average of the share variations attained by the exporting country for the various sectors. In other words, they indicate how the market shares of the exporting country in each importing country would have been altered, had the sectorial structure of the importing country's demand remained unchanged.

20 See section 3.3.1.

in which: r_{sc} = linear correlation coefficient between an exporting country's initial sectorial market shares and the changes of the sector weights in total imports;

$s_{i.}^{0}$ = an exporting country's initial market shares of imports in individual sectors;

μ_{s}^{0} = unweighted arithmetic mean of an exporting country's initial sectorial market shares;

$p_{i.}^{t}$ = individual sector weights on total imports.

Equation [22] shows the commodity structure effect as the product of three factors:

a) the degree of correlation between the sectorial structure of the market shares of an exporting country, which defines its specialization pattern, and the changes in the sectorial structure of import demand;
b) an indicator of the variability of sectorial market shares around their mean or, in other terms, of the degree of polarization of the specialization pattern;
c) an indicator of the variability of the sectorial structure of import demand in the target period.

Since the third factor is common to all the exporting countries being considered, it is the first two which are decisive for the determination of the CSE. The sign of the CSE is established by the coefficient of correlation, while its size depends, both on the intensity of the correlation, and on the degree of polarization of the specialization pattern. In other words, at equal degrees of correlation between the exporting countries' specialization patterns and the changes in the structure of import demand, the countries which draw the major advantages (or disadvantages) of such changes are those characterized by a specialization pattern which is more differentiated between strong and weak points: the degree of polarization of the specialization pattern amplifies the magnitude of the structural effects.

5. SUMMARY AND CONCLUSIONS

The interpretation of a country's global foreign trade results requires careful consideration of the role played by structural factors. Interactions between changes in the distribution of world demand and international specialization patterns of single countries may significantly influence foreign trade aggregates.

In order to study these connections, a statistical decomposition technique known as *constant-market-shares* analysis has often been used. In this paper we have surveyed the main methodological questions raised during the long debate on CMS analysis, in order to devise a new formulation of this technique, integrating some recently proposed innovations with those features of traditional specifications which still appear to be valid.

The first set of problems which is examined concerns the accounting identity on which the decomposition is based. In theory a method similar to CMS analysis may be applied to any aggregate which can be defined as a weighted average of its elementary components. Hence the method could be dubbed "constant-elementary-variables". In practice the choice of the variable to be analysed depends on the research aims and on data availability.

Moreover if the base accounting identity allows to distinguish more than one disaggregation criterion, the results of CMS analysis are sensitive to the order in which the decomposition is performed. To deal with this problem, the different disaggregation criteria may be used independently of each other, but in this case the formula must include structural diversification indexes, which have been shown to be related to the degree of statistical connection among the classification criteria.

The most controversial methodological issue arising from CMS analysis however concerns the choice of the decomposition formula to be applied to the base identity. It has often been argued that CMS analysis faces an "index-number problem" in the selection of the weighting system for that formula. Recent developments in index-number theory provide arguments for choosing a specification without interaction terms, similar to the Törnqvist price index. This approach however is based on the microeconomic theory of demand, whilst in CMS analysis no *a priori* theoretical relation may be assumed between market shares and the structure of demand. Moreover the descriptive power of specifications based on the Törnqvist weighting method appears weak, in comparison with traditional formulations incorporating interaction terms, which have therefore been preferred in this research.

The decomposition formula proposed in this paper breaks down changes in aggregate market shares into seven terms: the competitiveness effect, three structural effects, measuring the influence of sectorial as well as geographic specialization patterns and three adaptation effects, which quantify the importance of the flexibility of those patterns in relation to changes in the structure of the market's imports demand.

Given its importance, the contribution of export sectorial specialization patterns to changes in market shares has been analyzed somewhat more thoroughly. This contribution has been shown to depend not only on the conformity of specialization patterns to changes in the structure of demand but also on the degree of their polarization in strong and weak points. With all other things being equal, the extent of changes in aggregate market shares is higher for countries whose comparative advantages are concentrated in few sectors than for countries characterised by a better-balanced specialization pattern.

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