I. SECTORAL STRUCTURE AND ECONOMIC GROWTH

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Abstract

The main goal of the present work is to reveal the advantages of introducing the so-called structural coefficient (SC) into economic analysis. SC is defined as an indicator of the similarity between a given sectoral structure and another, which is admitted as a referential. Consequently, the paper is organized as follows.

The first chapter is consecrated to computational formulas applicable to the estimation of such a measure. Ten possible algorithms are examined and five are retained as adequate for empirical investigations.

The second chapter discusses, by using WB Statistics for the World Economy, two important questions concerning the structural coefficient (SC): "Is SC an authentic "numeraire"? and "Can SC be rather considered as an "attractor"?". The paper inclines towards the second supposition.

In the third chapter, on the famous binomial "sectoral structure-economic growth", comments based on analytical valences of the structural coefficient (SC) are provided. With this aim, the Toda–Yamamoto version of Granger causality test is applied.

Several conclusions and further research lines end the paper. The necessary statistical appendices and references are included.

Keywords: structure, structural coefficient, economic growth, Granger causality test
JEL Classification: C13, Q10, Q41

I. Structural Coefficient (SC): Some Possible Computational Formulas

I.1. In the present paper, the notion of structure refers to the shares of different sectors (independently of the practiced classification) in an aggregate indicator such as production, employment, capital, consumption, foreign trade, etc. Since the attention is paid first to the relation between structure and economic growth, the global output is adopted as such an indicator. On this basis, the structural coefficient (SC) is conceived as a measure of the similarity between a given structure and another, admitted as a referential.

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Hence, there are two vectors of sectoral weights:

W_I= (W_1, W_2, W_n), representing the referential, and

w_i= (w_1, w_2,…w_n), characterizing the concrete structure which is submitted to evaluation.

Normally, in both vectors, each sector is marked by the same index. Other common features are:

- W_i and w_i contain identical number of elements (n);
- all these elements are non-negative ($W_i \geq 0$ and $w_i \geq 0$);
- $\Sigma W_i = \Sigma w_i = 1$.

I.2. The degree of similarity of compared sectoral vectors covers a broad spectrum of possible situations. Three classes are especially interesting for our research.

I.2.1. The respective structures can be considered as an identity when all w_i are

exactly equal to the corresponding W_i. In other words, the vector w_i is a copy of the sector W_i.

I.2.2. The incongruity is the opposite side. In this case, the components (w_i, W_i) can be grouped in three subsets.

I.2.2.a. In the first of them (I_1) all w_i are null, but W_i>0.

I.2.2.b. Conversely, in the second ($I_{2,}$) w_i>0 and W_i=0.

I.2.2.c. In the last (I_3) both w_i and W_i are null. I_3 can appear when:

- The nomenclature of sectors is given, for example, International Standard Industrial Classification of all economic activities (ISIC) of United Nations Statistics Division, Statistical Classification of Economic Activities in the European Union (CAEN), etc.
- The established referential leaves out one or more of the sectors recorded in the officially adopted nomenclature. Some of these omitted sectors are not present in the compared structure.

Although very low, the probability of such a situation cannot be completely ignored. Certainly, I_3 can be an empty subset.

A special form of incongruity is what could be named monosectoral disparity, when all the elements of compared structures are null, except two pairs (W_k, w_k) and (W_m, w_m), one being (0, 1) while the other is its anti-pole (0, 1).

I.2.3. The intersection occupies an intermediary position. The presence of a common subset of non-null values is its necessary feature.

I.3. Naturally, the quantitative estimation of the structural coefficient (SC) must take into account the mentioned circumstances. The variation of SC between 0 and 1 seems easy to understand, such a scale being familiar in frequent economic analyses. For this purpose, the following conditions are admitted:

- In case of identity, the structural coefficient ought to be equal to unity (identity rule).
- For incongruity, in all its forms, this coefficient is null (incongruity rule).
- If the values of two pairs of components – (w_o, W_o) and (w_q, W_q) – change position reciprocally, the structural coefficient does not change (permutation rule).

I.4. We studied ten algorithms which – as such or adequately transformed – could be used for estimating the similarity degree between two or more structural vectors:

- The first is Euclidean 1-norm distance, which is known also as the Manhattan distance, Finger–Kreinin dissimilarity index, Cityblock or L1 metric, Michaely or Stoikov index, variational distance (Finger and Kreinin 1979; Han and Kobayashi 2002; Tsai *et al*., 2004; Van Laerhoven 2004; Ho and Yeung 2007; Dietrich 2009; Memedovic and Iapadre 2010).
- Like the Euclidean 1-norm, the Canberra distance also involves the differences $|w_i\text{-}W_i|$. These are divided, however, by the sum of absolute values w_i and W_i (Wolda 1981; Androutsos *et al*., 1998; Van Laerhoven 2004; Jurman *et al*., 2009).
- The Euclidean 2-norm distance (named also L2 metric) was examined, which – under identity covariance matrix – is equivalent to the Mahalanobis distance (McLachlan 1999; Van Laerhoven 2004). A subsidiary form of this measure is represented by the Lilien index (Entorf 1996; Dietrich 2009; Dixon *et al*. 2010).
- Bhattacharyya coefficient approximates the difference between two discrete distributions using the roots of the product of corresponding elements (Thacker et al. 1997; Khalid et al. 2006; Thacker 2009; Nielsen and Boltz 2010; Nielsen et al., 2010).
- We have tried to adapt the famous Galton-Pearson correlation, estimated as a ratio of the covariance of respective series to the product of their standard deviations, for structural comparisons.
- Herfindahl–Hirschman or HH index (Economides and Skrzypacz 2004) also seemed adequate for the approximation of degree of similarity of two compared structures.
- With the same goal, Kullback–Leibler divergence or relative entropy (Garrido 2009; Weisstein 2011) was analyzed.
- The so-called Jaccard index (Karlsson 2007; den Besten *et al*., 2008) has not been avoided.
- Hellinger distance (Hazewinkel 2002; Pollard 2002; D'Ambrosio 2008) could be another possible solution.
- Finally, the Cosine similarity coefficient could not be ignored.

I.5. Five from these methods proved convenient for our target. They will be briefly commented upon using the symbols adopted in this paper. In some cases, the original formulas were slightly modified in order to comply with the above-adopted rules regarding the variation interval of SC.

I.5.1. Euclidean 1-norm structural coefficient (SCE) might represent the simplest way to compare two structures by involving only the absolute differences between their homologous elements. It is derived from the corresponding distance, which can vary between 0 and 2.

This is why, the structural coefficient based on such an algorithm is determined as follows:

$$SCE = 1 - \frac{\sum |w_i - W_i|}{2} \qquad [I.1]$$

In this estimation any form of incongruity (in which the numerator of the fraction becomes 2) gets evidently the score zero. On the contrary, the eventual equality of all w_i with W_i yields SCE=1. The permutation rule is also valid.

I.5.2. As a structural measurement, Bhattacharyya coefficient (SCB) is determined thus:

$$SCB = \sum \sqrt{w_i W_i} \qquad [I.2]$$

Clearly, if in each pair of elements at least one is zero, the structural coefficient is null; the imposed condition for incongruity, therefore, is covered. At the same time, SCB cannot exceed unity, which may appear when all $w_i=W_i=1/n$. Also, a possible rearrangement of the compared pairs does not change SCB.

I.5.3. The Hellinger structural coefficient (SCH) has been derived from the Hellinger distance as follows:

$$SCH = 1 - \frac{\sqrt{\sum (\sqrt{w_i} - \sqrt{W_i})^2}}{\sqrt{2}} \qquad [I.3]$$

If the compared vectors are identical, the expression $[\sum (\sqrt{w_i} - \sqrt{W_i})^2]^{0.5}$ is zero, while for the incongruity it equals $\sqrt{2}$. Therefore, the restriction 0<SCH<1 holds. And the permutation rule as well.

I.5.4. Another measure of similarity between two sectoral vectors is the Cosine structural coefficient (SCC).

It would be worth to outline that it is not possible to use only the dot product for such a purpose. Its minimal level (for incongruity) is zero. Concerning the identity, however, the results become ambiguous. Thus, if the vectors consist of one pair (1, 1), the rest being null, the dot product is $\Sigma w_i W_i=1$. In the case of $w_i=W_i=1/n$ (another form of identity) $\Sigma w_i W_i=1/n$. There are, obviously, many other intermediate combinations.

The expression for the angle between two vectors proved to be more adequate:

$$SCC = \frac{\sum w_i W_i}{\sqrt{\sum w_i^2}\sqrt{\sum W_i^2}} \qquad [I.4]$$

In such a determination, the limits of SCC are unequivocally 0 and 1. The result cannot be influenced, as well, by an eventual permutation of terms.

I.5.5. The Jaccard structural coefficient (SCJ) was deduced from the so-called Jaccard index, more specifically from its extended form. The following formula has been retained:

$$SCJ = \frac{\sum w_i W_i}{\sum w_i^2 + \sum W_i^2 - \sum w_i W_i} \qquad [I.5]$$

If in each pair of homologous elements at least one component is null (incongruity), evidently $\Sigma w_i W_i$ equals to zero. Conversely, if all these pairs are identical SCH=1. In other words, according to the relationship (I.5), the Jaccard structural coefficient also complies to the above-specified limits. Again, this determination does not depend on the terms' ordering.

I.6. The other five listed algorithms raise some problems.

I.6.1. As it was noticed, in the Canberra distance (D_{Can}) the absolute differences $|w_i - W_i|$ are divided by the sum of their absolute values. Since both w_i and W_i are non-negative, we have:

$$D_{Can} = \Sigma \frac{|w_i - W_i|}{(w_i + W_i)}$$

Obviously, if the ratio 0/0 appears in computations, it is interpreted as zero. It is not difficult to deduce that D_{Can} ranges from 0 to the number of elements included in the compared structural vectors. D_{Can} could also be transformed into the structural coefficient (SCCan) as follows:

$$SC_{Can} = 1 - \frac{\sum \frac{|w_i - W_i|}{(w_i + W_i)}}{n} \quad [I.6]$$

The permutation rule is observed. Also, if all w_i equal W_i, SC_{Can}=1.

There are, instead, some problems in the case of incongruity, under the presence of subset I_3. A simple assimilation of the fractions 0/0 to zero would induce $SC_{Can}>0$. In order to insure $SC_{Can}=0$ in all forms of incongruity, it would be necessary to eliminate such fractions, correspondingly reducing the denominator of expression [I.6].

Besides, unlike the Euclidean 1-norm, the Canberra distance can involve different weights for the same difference $|w_i - W_i|$. It would be difficult to find a rationale for such a circumstance. Consequently, this method has not been used.

I.6.2. Euclidean 2-norm structural coefficient (SC_{Eu2}) was also taken into consideration.

Due to the non-negativity of w_i and W_i, it can be determined as:

$$SC_{Eu2} = 1 - \frac{\sqrt{\sum (w_i - W_i)^2}}{\sqrt{2}} \quad [I.7]$$

The equality to unity in the case of identity is obvious. The rearrangement of pairs has also no effect. For the monosectoral disparity, really SC_{Eu2}=0. The rating of other forms of incongruity, however, could be over zero.

I.6.3. The classical linear correlation can vary from −1 to +1. Taking into account this interval and the properties of vectors w_i and W_i, the linear correlation could be also used as the Galton–Pearson structural coefficient (SC_{GP}):

$$SC_{GP} = \frac{1 + corr(w, W)}{2} = \frac{1 + \frac{n\sum w_i W_i - 1}{\sqrt{n\sum w_i^2 - 1}\sqrt{n\sum W_i^2 - 1}}}{2} \quad [I.8]$$

If all w_i are equal to W_i, $\Sigma w_i W_i = \Sigma w_i^2 = \Sigma W_i^2$ and finally SC_{GP}=(1+1)/2=1.

The ordering of components does not influence the result.

In the case of incongruity, however, there are problems beginning with the monosectoral disparity, in which $n\Sigma w_i W_i=0$ and $\Sigma w_i^2 = \Sigma W_i^2 = 1$. This means that SC_{GP}=[1−1/(n-1)]/2 which would be zero only for n=0.

I.6.4. In the analyzed case, two Herfindahl−Hirschman (HH) indexes may be determined: $HH_w=\Sigma w_i^2$ and $HH_W=\Sigma W_i^2$, each of them varying between 1 and 1/n. A possible Herfindahl−Hirschman structural coefficient (SC_{HH}) could be as follows:

$$SC_{HH} = 1 - \frac{|HH_w - HH_W|}{1-\frac{1}{n}} = 1 - \frac{\left|\sum w_i^2 - \sum W_i^2\right|}{1-\frac{1}{n}} = 1 - \frac{n\left|\sum w_i^2 - \sum W_i^2\right|}{n-1} \qquad [I.9]$$

The permutation rule does not raise problems.

Instead, the formula [I.9] can generate several maximal points. $SC_{HH}=1$ not only for the true identity ($w_i=W_i=1/n$), but whenever $HH_w=HH_W$. Even the monosectoral disparity would find itself in such a situation. Other forms of incongruity could also be associated with ambiguous results.

I.6.5. Concerning the Kullback−Leibler divergence or relative entropy, we must mention at least two questions.

I.6.5.a. The first arises from the possibility to calculate it in three variants (KLa, KLb, and KLc):

$$KLa=\Sigma wi*(log(wi/Wi) \qquad [I.10a]$$

$$KLb=\Sigma Wi*(log(Wi/wi) \qquad [I.10b]$$

$$KLc=(KLa+KLb)/2 \qquad [I.10c]$$

The last determination (arithmetic mean of KLa and KLb) avoids the asymmetry of Kullback-Leibler divergence, because of which Kla≠KLb.

In our specific case, all concrete structures are compared with the same structure (which is considered as a referential). It would be, therefore, acceptable to adopt the variant KLb.

Consequently, a Kullback–Leibler structural coefficient (SC_{KL}) could be as follows:

$$SC_{KL} = 1 - \sum W_i \log \frac{W_i}{w_i} \qquad [I.10]$$

Certainly, if the 0/log0 ratio appears in computations, it is interpreted as zero.

I.6.5.b. Now, the second series of comments. The formula [I.10] obeys the permutation rule. For identity, in which all $w_i/W_i=1$, the result is 1.

However, [I.10] is defined only if $w_i>0$ when $W_i>0$, which means that some forms of incongruity (beginning with the monosectoral disparity) are lost. On the other hand, the entropy Kullback–Leibler can exceed unity, SC_{KL} becoming negative.

I.7. Summarizing, due to the reported ambiguities, the formulas [I.6] − [I.10] are not retained as possible algorithms for estimating the structural coefficient (SC) in the interpretation promoted in this paper.

The others – I.1 to I.5 – are considered appropriate and will be used in our analysis. They are synthesized in Table 1.

Table 1

Computational formulas for the structural coefficient (SC)

Structural coefficient	Symbol	Formula
Euclidean 1-norm	SCE	$SCE = 1 - \frac{\sum \lvert w_i - W_i \rvert}{2}$
Bhattacharyya	SCB	$SCB = \sum \sqrt{w_i W_i}$
Hellinger	SCH	$SCH = 1 - \frac{\sqrt{\sum (\sqrt{w_i} - \sqrt{W_i})^2}}{\sqrt{2}}$
Cosine	SCC	$SCC = \frac{\sum w_i W_i}{\sqrt{\sum w_i^2}\sqrt{\sum W_i^2}}$
Jaccard	SCJ	$SCJ = \frac{\sum w_i W_i}{\sum w_i^2 + \sum W_i^2 - \sum w_i W_i}$

As already shown, all these determinations circumscribe the structural coefficient (SC) between two boundaries; 0 for all the forms of incongruity and 1 when the compared structures are identical.

The second chapter discusses the cognitive content of this measurement from other points of view.

II. Sensitivity of the Structural Coefficient (SC) to the Change of Adopted Referential

The previous chapter insisted on the main methodological requirement ($0<SC<1$) imposed to formulas for estimating the structural coefficient (SC) between the vectors w_i and W_i. These boundaries can be considered as a formal restriction for the respective computational techniques. Another important question is to identify the dependence of SC on the adopted referential structure. For the examination of this problem, an empirical analysis is to be preferred. For simplicity, the world economy's indicators will be examined.

II.1. Data Base

II.1.1. Our proposal will be applied to statistics provided by the World Bank, which covers almost four decades of the recent world economic development (1970–2008). This database (Statistical Appendix) seems to be more homogeneous from the methodological point of view than other similar sources. In any case, official institutions, according to the National Accounts System, deliver the data.

II.1.2. Regarding the structure of economy, the available possibilities are limited enough.

II.1.2.1. Systematically the World Bank statistics offer such information as weights in gross domestic product, only for three sectors:

- Agriculture,
- Industry, and
- Services.

The estimations are based on the value added, defined as follows: "Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of the value added is determined by the International Standard Industrial Classification (ISIC), revision 3. For VAB countries, the gross value added at factor cost is used as the denominator" (World Bank National Accounts Data, and OECD National Accounts Data Files).

The content of the above-mentioned sectors is the following:

II.1.2.1a. "Agriculture corresponds to ISIC divisions 1–5 and includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production."

II.1.2.1b. "Industry corresponds to ISIC divisions 10–45 and includes manufacturing (ISIC divisions 15–37). It comprises the value added in mining, manufacturing (also reported as a separate subgroup), construction, electricity, water, and gas."

II.1.2.1c. "Services correspond to ISIC divisions 50–99 and they include the value added in wholesale and retail trade (including hotels and restaurants), transport, and government, financial, professional, and personal services such as education, health care, and real estate services. Also included are imputed bank service charges, import duties, and any statistical discrepancies noted by national compilers as well as discrepancies arising from rescaling."

II.1.2.2. This classification is close (but not identical) to the well-known classical three-sector division:

- Primary,
- Secondary, and
- Tertiary.

The main differences concern, of course, the industry, which in a great measure belongs to the secondary sector, but includes also some branches of the primary one (first, mining).

It is worth noticing that the global trends sketched by the World Bank data are not far from those revealed by the classical three-sector nomenclature. In both cases, an increasing share of services is accompanied by the corresponding compression of industry and agriculture.

Briefly, we think that – due to their length (39 years) and to the fact that they represent the entire world economy – the WB series are relevant for testing the methodology proposed in this paper.

II.1.3. Based on these data, SC has been computed using the five formulas retained according to the criteria discussed in the first chapter. As a referential, we successively used the statistical structures registered at the beginning, middle and end of the period, more exactly the years 1970, 1983, 1996, and 2008. The sensitivity of SC to the change of referential can thus be easily identified.

The levels of SC are labeled by the corresponding symbols of computational methods used, followed by a digital suffix which indicates the adopted referential:

- 70 for the year 1970,
- 83 for the year 1983,
- 96 for the year 1996, and
- 08 for the year 2008.

Through the proposed sensitivity analysis, we attempt to clarify whether the referential plays the functions of a "numeraire" (a simple accounting unit), or its role is closer to that of a so-called "attractor" (interfering in the relative scores between the compared structures).

II.2. Is SC an Authentic "Numeraire"?

II.2.1. The crucial property of the "numeraire" as a measure is to be neutral with respect to relative evaluations of any other two compared elements. The Walrassian system is one of the most expressive examples. Independent of the merchandise whose price is adopted as a "numeraire" (=1), the relative prices of different products do not change (for a relevant discussion of such a property, see Reis and Watson 2007).

In our case, it means that the SCi/SCj (i≠j) ratios should remain stable irrespective of whether structural vector k or q is used as a referential. This condition could be easily translated into the usual statistical language. From the assumption

$$\frac{SC_{ki}}{SC_{kj}} = \frac{SC_{qi}}{SC_{qj}} \quad (i \neq j) \qquad \text{[II.B.1]}$$

automatically results

$$\frac{SC_{ki}}{SC_{qi}} = \frac{SC_{ki}}{SC_{qj}} = c \qquad \text{[II.2.1a]}$$

and

$$SC_{ki} = c * SC_{qi} \qquad \text{[II.2.1b]}$$

where: c is a constant.

The corresponding averages (noted by suffix m) of SC_{ki} and SC_{qi} are connected by the constant c thus:

$$SC_{qm} = \frac{1}{n}\sum SC_{qi} \qquad \text{[II.2.2]}$$

$$SC_{km} = \frac{1}{n}\sum SC_{ki} = \frac{c}{n}\sum SC_{qi} = c * SC_{qm} \qquad \text{[II.2.2a]}$$

The following algebraic transformations do not need commentaries:

$$cov_{kq} = \frac{1}{n}[\sum (SC_{ki} - SC_{km})(SC_{qi} - SC_{qm})] = \frac{c}{n}\sum (SC_{qi} - SC_{qm})^2 \qquad \text{[II.2.3a]}$$

$$var_k = \frac{1}{n}\sum (c * SC_{qi} - c * SC_{qm})^2 = \frac{c^2}{n}\sum (SC_{qi} - SC_{qm})^2 \qquad \text{[II.2.3b]}$$

$$var_q = \frac{1}{n}\sum(SC_{qi} - SC_{qm})^2 \qquad [II.2.3c]$$

$$cor_{kq} = \frac{cov_{kq}}{\sqrt{var_k\ var_q}} = \frac{\dfrac{c\sum(SC_{qi} - SC_{qm})^2}{n}}{\dfrac{c\sum(SC_{qi} - SC_{qm})^2}{n}} = 1 \qquad [II.2.3]$$

Therefore, SC could be admitted as a “numeraire” only if the ordinary correlation coefficient (Galtung–Pearson) between the estimations that resulted from two different referentials would be close to +1. Evidently, the same condition is necessary in the case of a rank correlation (Spearman, for instance).

II.2.2. Table 2 presents the ordinary (Galtung–Pearson) and rank-order (Spearman) correlation coefficients characterizing the estimations that resulted from four different referentials (mentioned above), using the same computational formula. The regular figures refer to ordinary correlation, while the italic ones indicate the rank-order correlation.

Table 2

Correlation coefficients (ordinary and rank-order) among estimations of SC calculated using different reference structures

	SC70E	SC83E	SC96E	SC08E
SC70E	1	***0.695142***	***-0.80972***	***-1***
SC83E	0.766777	1	***-0.48745***	***-0.69514***
SC96E	-0.86217	-0.44871	1	***0.809717***
SC08E	-0.99999	-0.76596	0.862493	1
	SC70B	SC83B	SC96B	SC08B
SC70B	1	***0.660931***	***-0.7664***	***-0.9998***
SC83B	0.912561	1	***-0.36802***	***-0.66073***
SC96B	-0.69059	-0.33495	1	***0.766599***
SC08B	-0.8772	-0.60442	0.953024	1
	SC70H	SC83H	SC96H	SC08H
SC70H	1	***0.660729***	***-0.77955***	***-0.9998***
SC83H	0.717971	1	***-0.38927***	***-0.66053***
SC96H	-0.82622	-0.3362	1	***0.779757***
SC08H	-0.99985	-0.7192	0.828858	1
	SC70C	SC83C	SC96C	SC08C
SC70C	1	***0.695142***	***-0.817***	***-1***
SC83C	0.923075	1	***-0.49838***	***-0.69514***
SC96C	-0.76783	-0.46247	1	***0.817004***
SC08C	-0.88999	-0.64623	0.975487	1
	SC70J	SC83J	SC96J	SC08J
SC70J	1	***0.695344***	***-0.817***	***-1***
SC83J	0.92166	1	***-0.49858***	***-0.69534***
SC96J	-0.76196	-0.45107	1	***0.817004***
SC08J	-0.89813	-0.65721	0.969116	1

Even a quick examination of this table shows that, in all the formulas, a change in the referential modifies – sometimes substantially – the relative evaluations of SC. As a rule, the correlation coefficient is farther from +1 for longer temporal distances between the structures admitted as referentials.

This means that the structural coefficient (SC) – as it was defined in the first chapter – cannot play the role of an authentic "numeraire". On its basis, the relative evaluations among different compared structures are not independent of the adopted referential.

II.3. Can SC be considered rather as an "attractor"?

Since SC does not accomplish the role of a "numeraire", it is almost a matter of course to put the question formulated in the title of this section. "Roughly speaking, an attracting set for a dynamical system is a closed subset A of its phase space such that for <many> choices of initial point the system will evolve towards A." (Milnor 2006; a similar definition appears also in WolframMathWorld 2011). Two sub-questions arise.

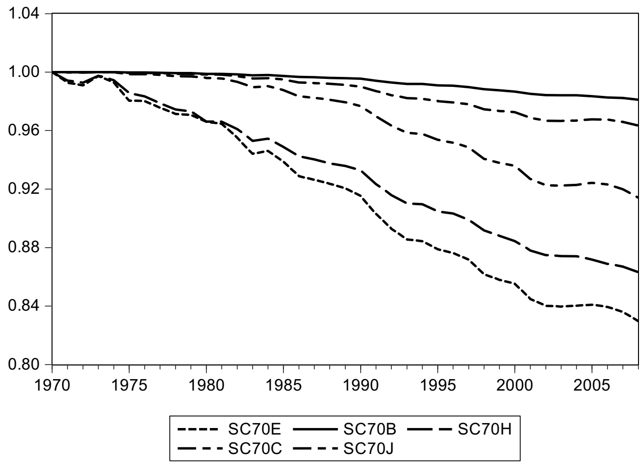
II.3.1. Could a given sectoral distribution of labor force and capital represent a possible target for economies? The answer is unequivocally affirmative. If a structure allows, comparatively to the other, to better satisfy the demand preferences of society through a more efficient utilization (under the dominant technological system) of available resources, then a movement towards this structure becomes natural. In other words, the referential used in formulas of SC can exert the "attractor" role, under the condition that it faithfully reflects the trends in economic development.

II.3.2. The other question is more technical. Admitting that the referential is correctly determined, do the above computational formulas accomplish the "attractor" attributes adequately? The following simulations show that all the proposed formulas give higher scores for the structures positioned closer to the referential.

II.3.2.1. The estimations provided by using as a referential the data for 1970 are presented in Figure 1.

Figure 1

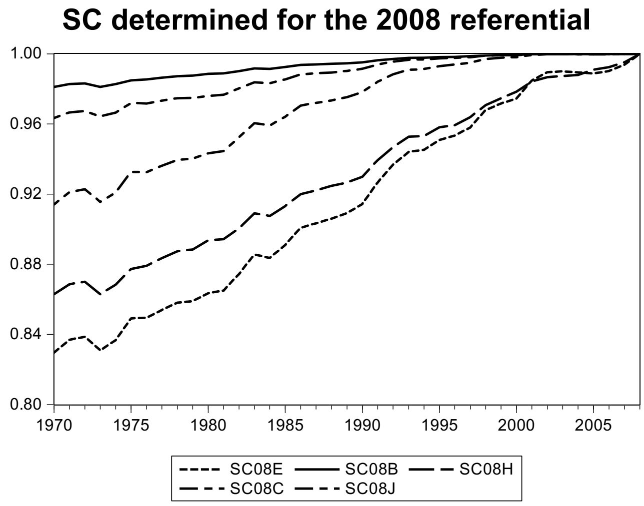
SC determined for the 1970 referential



The referential 1970 induces, therefore, a continuous compression of SC; differences appear only in the velocity of this trend. In other words, adopting such a reference structure, the early structures get higher scores against the later ones.

II.3.2.2. The picture is *vice versa* if the data for 2008 are adopted as referential – Figure 2.

Figure 2



In this case, the more recent structures benefit by higher scores in comparison with the earlier ones.

II.3.2.3. The following two figures show the simulations for the referentials 1983 and 1996, respectively.

Figure 3

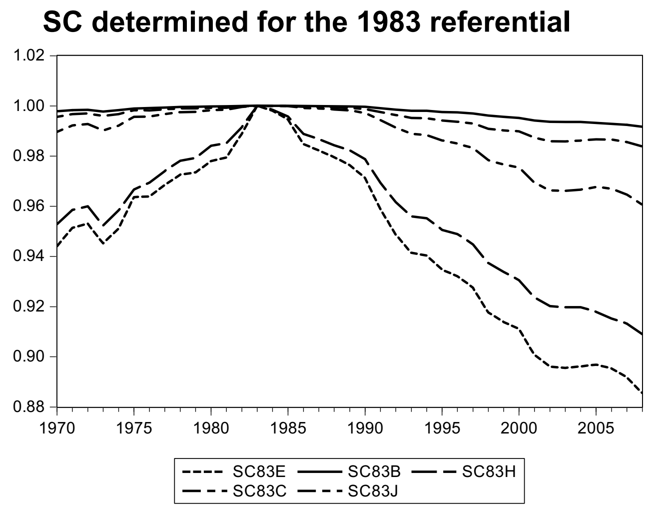
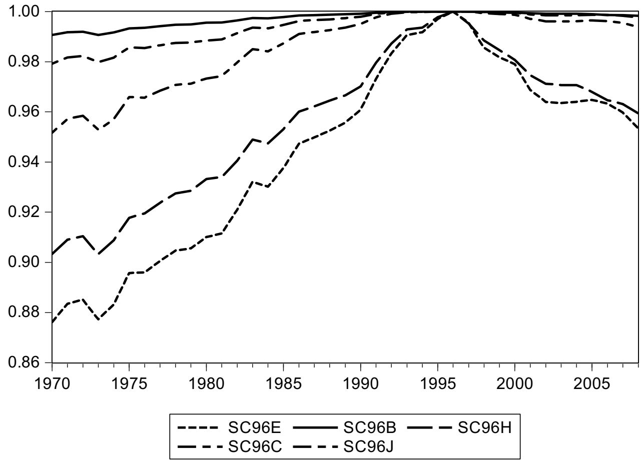


Figure 4

SC determined for the 1996 referential



The referentials 1983 and 1996, therefore, provide similar trajectories consisting of an initial increasing trend, inverted afterwards.

II.3.3. Concluding, the referential plays an "attractor" role. As a matter of fact, this behavior derives intrinsically from the congenital condition of SC estimation, namely to reach maximal level (+1) only when a given concrete structure coincides with the referential one.

The most important difference between the applied methods is related to the limits within which SC changes. Table 3 presents the coefficient of variation registered by SC in all five computational formulas.

Table 3

Coefficient of variation of SC

Formula	SC70	SC83	SC96	SC08
E	0.062276	0.036474	0.040625	0.062279
B	0.0064	0.002589	0.002975	0.006382
H	0.047865	0.028267	0.030634	0.047999
C	0.013124	0.005258	0.006813	0.012743
J	0.031235	0.012867	0.015987	0.030571

The formulas E, H, and J, therefore, generate larger variations in SC, while in the case of methods B and C they are more restrained.

II.3.4. The interpretation of referential as an "attractor" does not contradict some generally accepted conjectures of economics. It is well known that each historical age – depending on the state of technology, material and human capital endowment, social preferences, institutional framework – was characterized by a dominant sectoral structure, as a specific matrix of preferable allocation of resources. In this field, there are major contributions (Fisher, 1939; Clark, 1957; Rostow, 1960; Kuznets, 1966; Chenery and Syrquin, 1975; Williamson, 1979; Pasinetti, 1981; North, 1981; Kravis *et al*., 1983; Baumol, 1967; Baumol *et al*., 1985; Wallis and North, 1986). From the more recent literature (huge in terms of dimensions and diversity), we mention several titles, only as illustrations: Nordhaus, 2006; Acemoglu, 2007; Tamm and Kaldaru, 2008; Dietrich, 2009; Sepp *et al*., 2009; Memedovic and Iapadre, 2010; Paas, 2010.

Three "attractor" structures have been intensively investigated:

- Agrarian economy characterized by the preponderance of agriculture, accompanied by a low share of manufacturing activities and services;
- Industrial economy, in which the industry – first of all its manufacturing branches – become leading;
- Service economy, dominated by the tertiary sector.

The evolution from agrarian to industrial and, afterwards, service economy has been terminologically consecrated as the so-called three-sector paradigm. It really reflects the historical trend manifested in the global development of world economy and represents a fundamental pillar of modern economics.

Connected to the development of "new economy", at present there are attempts to extend the three-sector hypothesis to a four-sector one. However, the theory of quarterization is not sufficiently elaborated, especially from the perspective of quantitative analysis.

III. Structural Coefficient (SC) and Economic Development

Almost the entire literature dedicated to the economic development has treated the growth in strong connection with the structural (especially sectoral) reallocations of productive factors. The inclusion of SC allows to approach in a somehow new manner, this long debated question.

As the previous chapter has already demonstrated, the structural coefficient (SC) depends significantly on the adopted referential. Its numerical determination becomes, therefore, the first step of such an analysis.

III.1. Approximating the Referential for the World Economy

III.1.1. Generally, we could imagine three ways to solve this problem.

III.1.1.1. One of them – named hereinafter statistical – consists in filtering the historical series in order to identify the trends that dominate the sectoral changes in economy during the respective period. As a result, the structure to which the economy tends, as a steady-state system is quantitatively configured.

Certainly, this does not mean a simple mechanical computational procedure. As it is well known, different econometric techniques can provide different estimations, sometimes contradictory. In his final option, the modeler is frequently obliged to involve many collateral considerations. However, the available data remain the decisive support of this approach.

III.1.1.2. The second way could be named normative, the referential being deliberately defined as an explicit target. In this case, not only statistical information, but especially forecasting searches concerning highly expectable changes in productive infrastructure, technologies, human capital, disposable natural resources, demographic behaviors, social preferences, international (commercial and financial) flows, institutions, and so on are taken into consideration. In such a demarche, the prospective inferences are, therefore, preponderant.

III.1.1.3. Obviously, a large variety of combinations – between the above-mentioned approaches (statistical and normative) – are also conceivable. Representing such a mixture, the third way can be called as a hybrid one.

III.1.2. The solutions III.1.1.2. and III.1.1.3. are too complex to be experimented in our work. They would need laborious and interdisciplinary research, highly representative international debates, and long interactive professional communications in order to reach a large scientific adherence.

Therefore, the first way will be illustrated. To this aim, the series for the evolution of the world economy are preferred, because of their superior representativeness. The data for different countries or zones can hide deviations from the real “attractor” structure, equilibrated by symmetrical imbalances (international commercial and financial flows).

Our attempt assumes that the weights of delimitated sectors – agriculture (w_a), industry (w_{in}), and services (w_s) – tend towards long-run stable levels. For simplicity, all processes pushing the existing sectoral economic distribution towards the “attractor” are imputed to the factor-time (t). Therefore, the differences between the actual structure and its steady-state level are adjusted step-by-step, depending on t. The present application adopts an elementary specification:

$$wa=c(11)+c(12)/t+\varepsilon_{at} \quad [III.1.1]$$

$$win=c(21)+c(22)/t+\varepsilon_{it} \quad [III.1.2]$$

$$ws=c(31)+c(32)/t+\varepsilon_{st} \quad [III.1.3]$$

$$c(11)+c(21)+c(31)=1 \quad [III.1.4]$$

Taking into account that the real structure stabilizes around its long-run configuration, for large values of t, we admit the approximation W_a=c(11), W_{in}=c(21), and W_s=c(31). In other words, W_a, W_{in}, and W_s will be adopted as a referential structure of the modern world economy.

Under the specification [III.1.1-III.1.4] the coefficients c(12) and c(22) have to be positive (the weights of agriculture and industry are decreasing), while the coefficient c(32) will be negative (the services sector being in expansion). We do not expect, of course, a normal distribution of residuals and high coefficients of determination.

The referential deduced from this econometric estimation shows as follows:

$$W_a=0.04774 \quad [III.1.5]$$

$$W_{in}=0.31598 \quad [III.1.6], \text{ and}$$

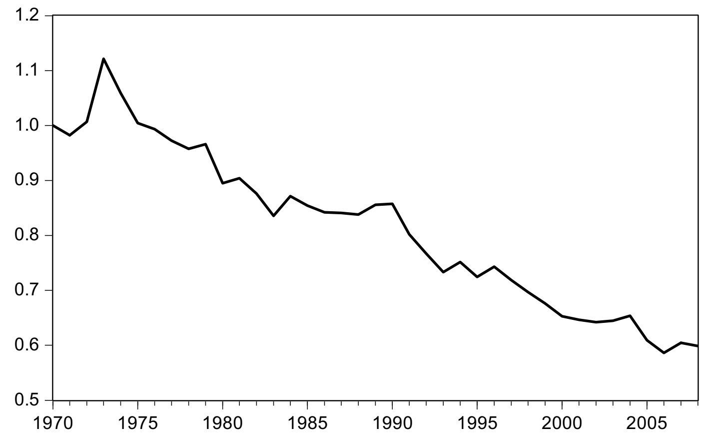
$$W_s=0.63628 \quad [III.1.7]$$

III.1.3. These results seem plausible, except maybe for the weight of agriculture, which has been situated during the last 15–16 years at lower levels. The Hodrick-

Prescott filter also indicates a trend close to statistical data. Nevertheless, the presented estimation for W_a can be advocated by some important economic arguments. If the statistical weights of agriculture are transformed into volume indicators (AGout) and, subsequently, into per capita data (AGcap), the corresponding indices (against 1970, denoted by prefix I70) are given in Figure 5.

Figure 5

Index (base 1970 =1) of the agricultural output per capita



It is difficult to admit that an almost continuous decline in the per capita agricultural production could be considered as a long-run equilibrium trend. The recent world food problems (including the rising prices of these products) contradict such a hypothesis. It is rather a consequence of a possible "overtertiarization" phenomenon. Due to these considerations, the estimated level of W_a (respectively 0.04774) as a component of referential will be maintained.

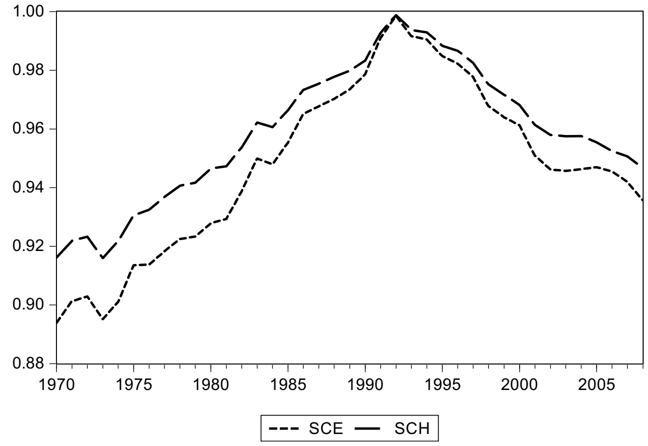
It would be ridiculous to pretend that the above specification is infallible. As we already mentioned, besides econometric estimations, there are also perfectly admissible normative and hybrid algorithms. In the case of econometric methods, different computational techniques can be used. Despite these reserves, the referential obtained from the system [III.1.1-III.1.4] seems credible.

III.1.4. Consequently, the structural coefficient (SC) characterizing the evolution of world economy has been determined on the basis of estimations [III.1.5-III.1.7]. All five formulas – finally retained as relevant (Chapter II) – have been applied (Statistical Appendix). The results are placed between not very large boundaries: the minimum is equal to 0.893951 (obtained by method E) and the maximum over 0.99 (obtained by all methods). This reveals that – during the later decades – the structure of the world economy did not register spectacular modifications (data concerning the national economies show, normally, another picture). Obviously the differences between the extreme values of SC vary as a function of the used computational algorithm.

In the case of formulas E and H it is the most accentuated.

Figure 6

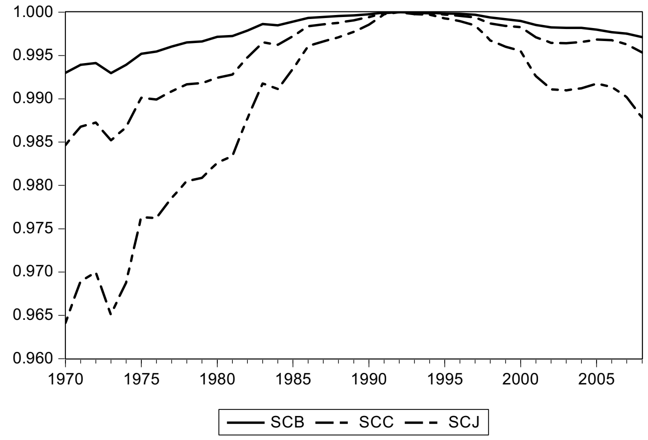
SCE and SCH for the statistically determined referential



A small variation appears if SC is estimated using the formulas B, C, and J.

Figure 7

SCB, SCC and SCJ for the statistically determined referential



III.2. Using SC in the Analysis of the "Sectoral Structure-Economic Growth" Binomial

III.2.1. The problems concerning this binomial occupied the first scene of economic and social thinking beginning with physiocrats and exponents of the classical English school. From relatively recent studies about these issues, it can be seen, for example, in Echevarria, 1997; Montobbio, 2002; Dietrich, 2009; Memedovic and Iapadre, 2010; Grinin, Korotayev and Malkov, 2010.

During the history, practically, nobody contested the connection between the rising trend of the GDP and the changing distribution of resources among productive branches. Beyond this agreement, however, there were intensive controversies concerning the causal factors that induce periodically deep sectoral restructuring of employment and capital. Such debates also continue nowadays.

Most opinions, promoted in socio-economic literature, center around three main conceptual schemes.

III.2.1.1. One of them is demand-side explanation. It insists on structural shifts of demand, induced – according to Engel's laws and Maslow's scale of needs – by the increasing income per capita, which accompanies the economic growth.

III.2.1.2. At anti-pole, there is the supply-side explanation. Relating to the sectoral mutations developed along history, this second approach invokes preponderantly the so-called "productivity hypothesis". More concretely, it puts on first explicative plan the manifold effects of technical progress in different segments of economy.

III.2.1.3. Some complex explanations were expected to appear, which would appeal to determinants situated on both demand and supply sides. Involved are also institutional and other factors.

A detailed examination of these theories exceeds the intended problematical perimeter of the present paper.

III.2.2. The enounced (in the title of this section) binomial has generated another question. In fact, it is a problem of the kind "the chicken or the egg causality dilemma". What has priority (as a leading impulse): "sectoral structure" or "economic growth"?

III.2.2.1. Within the conceptual framework of explanations III.2.1.1.- III.2.1.3., practically no possible answer can be rejected.

- So, it would be difficult to imagine a consistent reallocation of productive factors without a previous big accumulation. It is understood that such a vision attributes a leading position to the economic growth, which allows increasing savings and, subsequently, new investments.
- On the other hand, a major change of the consumer preferences – sooner or later – blocks up the supply. Thus, a restructuring of output becomes a *sine qua non* condition of economic growth.
- Based on complex explanations, it is easy to argue inherent interdependence between the sectoral shifts and output expansion.

III.2.2.2. Unfortunately, the empirical researches also were not trenchant, at least until now. Dietrich examined carefully many such attempts, referring to the works of Pelka, 2005; Kongsamut *et al.*, 2001; Meckl, 2002; Aiginger, 2001; Echevarria, 1997; Stamer, 1998, 1999, which proved contradictory. His conclusion also was not univocal: "This paper investigated the causal relationship between economic growth and structural change measured in terms of employment as well as in terms of real value added by the aid of a Granger causality test in a panel framework for seven OECD countries. The main finding is that the causality relationships are heterogeneous across the investigated countries. We found evidence that aggregate economic growth is causing structural change as well as the other way round" (Dietrich, 2009, p.32).

Table 4

Unit Root Tests – Synthesis

Augmented Dickey-Fuller test statistic (ADF)								
	t-Statistic	Prob.*		t-Statistic	Prob.*		t-Statistic	Prob.*
Exogenous: None			Exogenous: Constant			Exogenous: Constant, Lin. Trend		
Null Hypothesis: **GDP has a unit root**								
ADF test statistic	16.985	1	ADF test statistic	4.459	1	ADF test statistic	0.580	0.999
Null Hypothesis: **SCE has a unit root**								
ADF test statistic	0.341	0.779	ADF test statistic	-1.485	0.530	ADF test statistic	0.156	0.997
Null Hypothesis: **SCB has a unit root**								
ADF test statistic	-2.767	0.007	ADF test statistic	-2.823	0.067	ADF test statistic	-0.749	0.960
Null Hypothesis: **SCH has a unit root**								
ADF test statistic	0.306	0.769	ADF test statistic	-2.839	0.063	ADF test statistic	0.270	0.998
Null Hypothesis: **SCC has a unit root**								
ADF test statistic	-1.329	0.166	ADF test statistic	-1.970	0.298	ADF test statistic	-1.479	0.815
Null Hypothesis: **SCJ has a unit root**								
ADF test statistic	-1.580	0.106	ADF test statistic	-2.195	0.212	ADF test statistic	-1.667	0.742
Phillips-Perron test statistic (PP)								
	Adj. t-Stat	Prob.*		Adj. t-Stat	Prob.*		Adj. t-Stat	Prob.*
Exogenous: None			Exogenous: Constant			Exogenous: Constant, Lin. Trend		
Null Hypothesis: **GDP has a unit root**								
PP test statistic	23.462	1.000	PP test statistic	6.522	1.000	PP test Statistic	1.425	1.000
Null Hypothesis: **SCE has a unit root**								
PP test statistic	0.672	0.857	PP test statistic	-1.815	0.368	PP test statistic	-0.114	0.993
Null Hypothesis: **SCB has a unit root**								
PP test statistic	1.094	0.926	PP test statistic	-2.711	0.082	PP test statistic	0.039	0.995
Null Hypothesis: **SCH has a unit root**								
PP test statistic	0.617	0.845	PP test statistic	-1.790	0.380	PP test statistic	0.014	0.995
Null Hypothesis: **SCC has a unit root**								
PP test statistic	1.432	0.960	PP test statistic	-2.911	0.053	PP test statistic	-0.313	0.987
Null Hypothesis: **SCJ has a unit root**								
PP test statistic	1.308	0.949	PP test statistic	-2.938	0.050	PP test statistic	-0.159	0.992

*MacKinnon (1996) one-sided p-values.

III.2.2.3. In our opinion, further analysis of this problem is not useless. A clearer answer would help us to better understand the economic development, either globally or structurally. It would also contribute to a more efficient construction of macroeconomic policies. Actually, if the structural changes precede economic growth, the government's efforts must be directed towards forecasting and stimulating these presumed mutations. This would involve great financial resources, more or less complex regulating legislation, in other words an increasing state intervention. In an opposite situation – when the causal relationship is produced from economic growth to structural changes – a converse behavior of macroeconomic management seems to be adequate.

III.2.3. As it was determined in the present paper, the structural coefficient (SC) could facilitate the analysis of the here debated binomial. Due to such a synthetic measure, we can easily use modern statistical techniques concerning the relationship between dynamics of sectoral structure and economic growth.

However, the classical Granger causality test cannot be directly applied on data for GDP and SC, since not all of them are stationary. The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, for GDP and all five variants of SC are presented in the following table.

27 (9x3) pairs ADF-PP tests were calculated. In 19 cases, the probability exceeds 0.1 in both tests. Only in 2 situations either ADF or PP indicates lower probabilities. In other cases (6), the results are ambiguous (one test shows a probability higher than 0.1, while another contrarily). A reasonable conclusion is to accept that the series of GDP and structural coefficients (five formulas) are not stationary. Therefore, the Granger causality test as such cannot be considered relevant.

III.2.4. Under these conditions, the Toda–Yamamoto version of the Granger test (TYG) has been used (Toda and Yamamoto, 1995; Sinha and Sinha, 2007; Lin, 2008; Yalama and Çelik, 2008). This has been computed in two variants:

- without trend, which better clarifies the short-run interaction growth-structure and
- with trend, more relevant to characterize such an interaction on long term.

III.2.4.1. The first application is described synthetically in Table 5.

Table 5

Toda–Yamamoto version of the Granger test (TYG) – without trend

SCE does not Granger Cause GDP			**GDP does not Granger Cause SCE**		
Test Statistic	Value	Probability	Test Statistic	Value	Probability
F-statistic	0.765689	0.387878	F-statistic	0.600445	0.443925
Chi-square	0.765689	0.381554	Chi-square	0.600445	0.438408
SCB does not Granger Cause GDP			**GDP does not Granger Cause SCB**		
Test Statistic	Value	Probability	Test Statistic	Value	Probability
F-statistic	3.032747	0.091207	F-statistic	2.175417	0.150003
Chi-square	3.032747	0.0816	Chi-square	2.175417	0.140231
SCJ does not Granger Cause GDP			**GDP does not Granger Cause SCJ**		
Test Statistic	Value	Probability	Test Statistic	Value	Probability
F-statistic	0.942565	0.43628	F-statistic	0.147131	0.930471
Chi-square	2.827695	0.418961	Chi-square	0.441392	0.931565

SCH does not Granger Cause GDP			GDP does not Granger Cause SCH		
Test Statistic	Value	Probability	Test Statistic	Value	Probability
F-statistic	0.363959	0.550568	F-statistic	0.83593	0.367401
Chi-square	0.363959	0.546316	Chi-square	0.83593	0.360563
SCC does not Granger Cause GDP			**GDP does not Granger Cause SCC**		
Test Statistic	Value	Probability	Test Statistic	Value	Probability
F-statistic	0.924123	0.444842	F-statistic	0.154139	0.925952
Chi-square	2.772369	0.428069	Chi-square	0.462418	0.927067

Practically, F-statistic and Chi-square in all the five computed SC indicate that both null hypotheses – "SC does not Granger Cause GDP" and "GDP does not Granger Cause SC" – cannot be rejected. Only in one case – "SCB does not Granger Cause GDP" – the probability is under 10%. We interpret such a result in the sense that on a short-run, a possible causal relationship between economic growth and structural changes does not exist or, at least, cannot be revealed.

III.2.4.2. The second application of the Toda–Yamamoto version of the Granger test (TYG) is described briefly in Table 6.

Table 6

Toda–Yamamoto version of the Granger test (TYG) – with trend

SCE does not Granger Cause GDP			GDP does not Granger Cause SCE		
Test Statistic	Value	Probability	Test Statistic	Value	Probability
F-statistic	2.107773	0.14106	F-statistic	1.376103	0.269713
Chi-square	4.215546	0.121508	Chi-square	2.752206	0.252561
SCB does not Granger Cause GDP			GDP does not Granger Cause SCB		
Test Statistic	Value	Probability	Test Statistic	Value	Probability
F-statistic	6.033001	0.020048	F-statistic	0.345405	0.561124
Chi-square	6.033001	0.014041	Chi-square	0.345405	0.556726
SCJ does not Granger Cause GDP			GDP does not Granger Cause SCJ		
Test Statistic	Value	Probability	Test Statistic	Value	Probability
F-statistic	4.112721	0.029117	F-statistic	0.013923	0.986181
Chi-square	8.225441	0.016363	Chi-square	0.027847	0.986173
SCH does not Granger Cause GDP			GDP does not Granger Cause SCH		
Test Statistic	Value	Probability	Test Statistic	Value	Probability
F-statistic	2.030662	0.150814	F-statistic	1.600888	0.220279
Chi-square	4.061324	0.131249	Chi-square	3.201776	0.201717
SCC does not Granger Cause GDP			GDP does not Granger Cause SCC		
Test Statistic	Value	Probability	Test Statistic	Value	Probability
F-statistic	4.004158	0.031578	F-statistic	0.006889	0.993136
Chi-square	8.008316	0.01824	Chi-square	0.013779	0.993134

This application seems to be more explicit. The null hypothesis "GDP does not Granger Cause SC" is accepted clearly in all 5 determinations of the structural coefficient. Instead the null hypothesis "SC does not Granger Cause GDP" is rejected unequivocally in three cases (SCB, SCJ and SCC) and with high probability in the other two (SCE and SCH with approximately 85%). In other words, in "Granger acceptation", the causality relationship seems to come rather from the structural changes towards the economic growth, and not *vice versa*. Besides, such an interaction is plausible preponderantly on a long run.

III.2.5. Until now, this dilemma has been contradictorily commented.

III.2.5.1. Arguments in both possible directions were formulated. Some theorems insisted on priority of structural changes, while others outlined the leading role of economic growth. Several attempts were made to reconcile these big engines of social development (Kongsamut *et al*., 1997; Laitner, 2000; van Zon and Muysken, 2003; Pugno, 2003; Ngai and Pissarides, 2004; Foellmi and Zweimüller, 2005; Acemoglu and Guerrieri, 2008; Gomes and Teixeira, 2009). The question, nevertheless, remains a cobweb.

The results of empirical analysis were also ambiguous (see, as a recent example, Hartwig 2010). But in most statistical applications either partial measures of structural changes or insufficiently representative samples were used.

III.2.5.2. Our approach tried to surpass both impediments, introducing a synthetic indicator (structural coefficient) and using world economy's series. Its main result – the long-run causal relationship from structural changes towards economic growth – is consistent with two crucial premises of the modern civilization. Some circumstances – as accumulated capital, existent labor force's expertise, dominant characteristics of the management, available natural resources, etc. – confer to the sectoral structure of economy a relatively pronounced inertia. On the contrary, the consumer preferences and productive technologies show a higher dynamism. At a certain level of development, the outmoded structure becomes more and more a drawback for the output's expansion. The reallocation of resources (including redistribution of employment and capital among different branches) imposes as a condition a further economic growth. Due to the relative sluggishness of the factors influencing this complicated matrix, the true relationship between structural changes and economic growth cannot manifest itself instantaneously. Its symptoms become statistically identifiable only at medium-long temporal horizons.

IV. Several Conclusions

1. The estimation of structural coefficient (SC) as a synthetical measure of the degree of similarity of a given concrete structure with another adopted as a referential may be useful at least for the international economics. Through this measurement different structures become comparable among themselves. The methodology developed in the present paper facilitates the explanation of inter-country disparities. It can also reveal, for different regions, the reserves of growth available from the structural point of view.

2. Obviously, the most important question in such an approach is to define the referential structure. Any simplified vision would be in this case dangerous. The determination of a four-level graph would be probably the preferable solution.

- The highest level could be represented by a corresponding scheme for the world economy as a whole (our empirical analysis is such an illustration).

- The following one would comprise the referentials for the main economic zones, which – depending on many circumstances – may differ from the global one.
- In such a case, a set of national structures ought to be approximated, taking into consideration their natural resources, capital (physic and human) endowment, and other possible comparative advantages.
- Finally, these national structures could be disaggregated for different regions within each country.

Obviously, it is essential to insure the necessary coherence at each level and among all of them.

3. In terms of technical tools, both available ways – normative and statistical – can be applied.

3.1. The first will need complex and laborious interdisciplinary researches (demographic, technological, axiologic-institutional, and so on), highly representative international debates, and long interactive professional communications in order to reach a large scientific adherence. National authorities' and international organizations' involvement in such a great project would be vital.

3.2. The statistical procedures are evidently more accessible. For estimation of SC, the paper has examined ten possible computational algorithms.

Five of them proved acceptable. We refer to the formulas deduced from Euclidean 1-norm distance (SCE), Bhattacharyya coefficient (SCB), Hellinger distance (SCH), Cosine coefficient (SCC), and Jaccard index (SCJ), which were used in our statistical applications.

The other five – Canberra distance, Euclidean 2-norm, Galton–Pearson correlation, Herfindahl–Hirschman index, and Kullback–Leibler divergence – raise some problems and have not been retained.

4. Each of the applied algorithms in our paper is distinguished by pluses and minuses. Their comparative analysis, of course, must be deepened. Such new methods could be found. Their combinations must be also taken into account. One of the simplest of such possibilities is the arithmetic average of all estimations (SCM). It is presented in Figure 8.

In this case, the Toda–Yamamoto version of the Granger test looks like in Table 7.

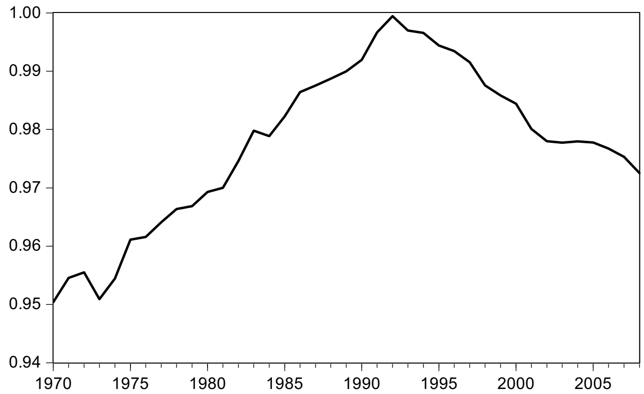
Table 7

Toda–Yamamoto version of the Granger test (TYG)

Without trend					
SCM does not Granger Cause GDP			**GDP does not Granger Cause SCM**		
Test Statistic	Value	Probability	Test Statistic	Value	Probability
F-statistic	1.203202	0.280869	F-statistic	1.094408	0.303335
Chi-square	1.203202	0.272683	Chi-square	1.094408	0.295497
With trend					
SCM does not Granger Cause GDP			**GDP does not Granger Cause SCM**		
Test Statistic	Value	Probability	Test Statistic	Value	Probability
F-statistic	2.749105	0.081905	F-statistic	1.107174	0.345034
Chi-square	5.49821	0.063985	Chi-square	2.214349	0.330492

Figure 8

Arithmetic average of all estimations (SCM)



As expected, the mean values of SC do not change the previous remarks concerning the relationship of economic growth and sectoral structure of output. It is clear that such “consensual” methodological solutions can be more robust than every separate algorithm.

5. Undoubtedly, our attempt is incomplete and maybe disputable. Supplementary and extended studies are necessary, doubled by intensive scientific debates, in order to outline a largely accepted methodology of quantitative evaluation for the sectoral economic structures.

Acknowledgements

The author is grateful to David Harvey (The Granger Centre for Time Series Econometrics) for the suggestion to use the Toda–Yamamoto test in our empirical research. Thanks, also, to Corina Saman (Centre for Macroeconomic Modelling of the Romanian Academy) for her computational assistance in this application.

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Statistical Appendix

Table 8

Data for the World Economy*

Year	Agriculture, value added (ratio to GDP)	Industry, value added (ratio to GDP)	Services, value added (ratio to GDP)	GDP (constant 2000 billion US$)	Population, total, billion	t
1970	0.088045	0.381748	0.530251	12150.33	3.686779	1
1971	0.084897	0.377599	0.537551	12643.13	3.765568	2
1972	0.084013	0.376785	0.539247	13365.88	3.842803	3
1973	0.089573	0.379025	0.53145	14238.58	3.919222	4
1974	0.084936	0.377787	0.537352	14460.27	3.99617	5
1975	0.081331	0.368939	0.54979	14593.57	4.0714	6
1976	0.078016	0.371967	0.550059	15314.79	4.144645	7
1977	0.074667	0.370761	0.55462	15940.03	4.217882	8
1978	0.071681	0.369615	0.558744	16638.98	4.292203	9
1979	0.070681	0.369713	0.559647	17325.44	4.368026	10
1980	0.065403	0.370473	0.564165	17647.64	4.444643	11
1981	0.065812	0.368637	0.565589	18028.15	4.522608	12
1982	0.064648	0.360305	0.575076	18103.9	4.602867	13
1983	0.06102	0.352885	0.586194	18608.3	4.683379	14
1984	0.061733	0.35412	0.584217	19506.92	4.763281	15
1985	0.059244	0.349202	0.591632	20270.77	4.844674	16
1986	0.057499	0.341153	0.601437	20950.69	4.929429	17
1987	0.056396	0.339716	0.603986	21698.84	5.016017	18
1988	0.054619	0.33884	0.606624	22723.94	5.103373	19
1989	0.054651	0.335589	0.60984	23578.32	5.190608	20
1990	0.054093	0.331011	0.614959	24279.62	5.278933	21
1991	0.050616	0.322149	0.62723	24657.04	5.363293	22
1992	0.048123	0.314516	0.637356	25178.55	5.444311	23
1993	0.045894	0.309434	0.644647	25625.26	5.526087	24
1994	0.046195	0.307962	0.645821	26471.29	5.606785	25
1995	0.043922	0.304649	0.651416	27238.21	5.689054	26
1996	0.044168	0.301752	0.654066	28161.6	5.769199	27
1997	0.041764	0.299625	0.6586	29204.83	5.84934	28
1998	0.040106	0.29138	0.668505	29896.58	5.928479	29
1999	0.038155	0.289516	0.67232	30886.2	6.00701	30
2000	0.035791	0.289166	0.675034	32209.31	6.084959	31
2001	0.035332	0.279287	0.68537	32725.52	6.162194	32
2002	0.03484	0.275002	0.690145	33365.57	6.238739	33
2003	0.034501	0.274907	0.690581	34256.9	6.315161	34
2004	0.034002	0.275966	0.69002	35655.09	6.391312	35
2005	0.030951	0.279704	0.68926	36929.93	6.467321	36
2006	0.028969	0.280146	0.690771	38412.43	6.543713	37
2007	0.029098	0.276533	0.694284	39922.8	6.6205	38
2008	0.028703	0.270658	0.700571	40541.99	6.697799	39

** World Data Bank – World Development Indicators (WDI) & Global Development Finance (GDF), http://databank.worldbank.org/ddp/editReport?REQUEST_SOURCE=search&CNO=2&topic=3. [Accessed at 14 January 2011].*

Table 9

Structural Coefficient (SC) for the World Economy

Computational method	Euclidean 1-norm	Battacharyya	Hellinger	Cosine	Jaccard	Mean	
Year	SCE	SCB	SCH	SCC	SCJ	SCM	T
1970	0.893951	0.992996	0.916172	0.984651	0.96414	0.950382	1
1971	0.901249	0.993919	0.921858	0.98679	0.968928	0.954549	2
1972	0.902946	0.994136	0.923266	0.987248	0.96998	0.955515	3
1973	0.895148	0.992971	0.916015	0.985197	0.9651	0.950886	4
1974	0.901036	0.993911	0.92172	0.986725	0.968792	0.954437	5
1975	0.913482	0.995203	0.930519	0.990112	0.976306	0.961124	6
1976	0.913759	0.995463	0.932481	0.989919	0.976209	0.961566	7
1977	0.918318	0.99603	0.936796	0.990862	0.978525	0.964106	8
1978	0.922445	0.9965	0.940657	0.991665	0.980499	0.966353	9
1979	0.923349	0.996617	0.941651	0.991801	0.980877	0.966859	10
1980	0.927866	0.99716	0.946516	0.992409	0.982606	0.969311	11
1981	0.929292	0.997242	0.947295	0.992794	0.983396	0.970004	12
1982	0.938783	0.997875	0.95374	0.99477	0.987734	0.974581	13
1983	0.949866	0.998621	0.962192	0.996507	0.991766	0.97979	14
1984	0.947904	0.998489	0.960662	0.996232	0.991117	0.978881	15
1985	0.955315	0.998909	0.966369	0.997226	0.993448	0.982253	16
1986	0.965115	0.999332	0.973298	0.998368	0.996077	0.986438	17
1987	0.967659	0.999445	0.975399	0.998586	0.996611	0.98754	18
1988	0.970305	0.99955	0.977816	0.998768	0.997085	0.988705	19
1989	0.973522	0.999636	0.979888	0.999054	0.997728	0.989965	20
1990	0.978649	0.999755	0.983349	0.999411	0.998556	0.991944	21
1991	0.990954	0.999947	0.992781	0.999898	0.999745	0.996665	22
1992	0.998538	0.999997	0.998792	0.999997	0.999993	0.999463	23
1993	0.991619	0.999949	0.993682	0.999906	0.999772	0.996986	24
1994	0.990446	0.99994	0.992937	0.99987	0.999691	0.996577	25
1995	0.984856	0.999859	0.988338	0.999707	0.999275	0.994407	26
1996	0.982205	0.999816	0.986658	0.999573	0.998966	0.993444	27
1997	0.977672	0.999691	0.982542	0.999381	0.998448	0.991547	28
1998	0.967769	0.999382	0.975212	0.998686	0.996733	0.987557	29
1999	0.963954	0.99919	0.971612	0.998418	0.996003	0.985835	30
2000	0.961239	0.998983	0.968168	0.998257	0.995497	0.984429	31
2001	0.950903	0.998508	0.961425	0.997086	0.992621	0.980109	32
2002	0.946127	0.99823	0.957984	0.996467	0.991084	0.977978	33
2003	0.945692	0.998188	0.957492	0.99643	0.990969	0.977754	34
2004	0.946252	0.998192	0.957537	0.996546	0.991216	0.977948	35
2005	0.946976	0.99797	0.955407	0.99684	0.991733	0.977785	36
2006	0.94545	0.99768	0.95241	0.99675	0.991375	0.976733	37
2007	0.941951	0.997521	0.950626	0.996262	0.990167	0.975305	38
2008	0.935673	0.997113	0.946573	0.995343	0.987852	0.972511	39