Methodological considerations on the size of Coefficient of Intensity of Structural Changes (CISC)

Dr. Florin Marius PAVELESCU (pavelescu.florin@yahoo.com)
Institute of National Economy

ABSTRACT

The paper brings arguments in favour of emphasizing the modeling factors of the Coefficient of Intensity of Structural Changes (CISC) in order to obtain a better interpretation of the significance of the respective method of structural change measurement. Also, it is highlighted the impact of characteristic features of structural changes on differentiation of the size of CISC computed at economic branch level and sectorial level respectively. There are identified all possible situations of structural changes from a sectorial point of view. At the end of the paper, there is presented a numerical example related to structural changes of Romania's employed population during the period 2008-2011. The above-mentioned example offers an opportunity to review all the necessary steps for identification of CISC modeling factors, when economic branches approach is considered, and a comparison with CISC computed in a sectorial vision is made. **The respective steps were made by using R Software.**

Key-words*: transfer of weights, informational energy, main and secondary sense of sectorial structural change, intrasectorial structural changes*

JEL Classification*: C02, C18, O11*

Economic development is accompanied as a rule by structural changes. Consequently, it is important to define and use methods of measurement, which permit to reveal the features of respective changes. Among the methods of measurement built in order to attain the above-mentioned objective we may consider the Coefficient of Intensity of Structural Changes (CISC). Therefore, CISC was used in papers, such as E. Dobrescu (1968) and E. Dobrescu (2009), in order to analyze the behaviour of leading indicators during periods which are defined by fast economic growth or by ample transformations of economic mechanism. It is important to note that the size of CISC depends on the level of aggregation of data, in other words on the number of considered economic branches or sectors. Therefore, it is very important to review some algebraic properties of CISC and explain the relationship between above-mentioned coefficient computed at economic branch level and sectorial level respectively.

1. ALGEBRAIC PROPERTIES OF COEFFICIENT OF INTENSITY OF STRUCTURAL CHANGES

Usually, the Coefficient of Intensity of Structural Changes (CISCr) is computed with the help of formula:

$$CISCr = \sqrt{\sum_{i=1}^{r} (g_{i1} - gi_0)^2} \quad (1)$$

where:

r = number of considered economic branches

g_{i1}, g_{i0}= the weight of economic branch i in the analyzed indicator in year 1 and year 0, respectively.

We may observe that there are economic branches, which are faced with an increase of their weights, while there are economic branches, which experience a decrease of their weights.

Because we have: $\sum_{i=1}^{n} g_{i0} = \sum_{i=1}^{n} g_{i1} = 1$, we may observe that sum of the gains in weights is equal with the sum of absolute values of the losses in weights. We may define the sum of gains registered by weights of some economic branches during the analyzed period as "transfer of weights" (Twr).

If we divide the considered economic branches in 'winners" and "losers" of weights, we are able to write the formula of CISCr such as:

$$CISCr = Twr \cdot \sqrt{\frac{\sum_{j=1}^{p} (g_{j1} - g_{j0})^2}{Twr^2} + \frac{\sum_{k=1}^{q} (g_{k1} - g_{k0})^2}{Twr^2}} \quad (2),$$

where:

p= the number of economic branches which register gains in their weights

q= the number of economic branches which register losses in their weights

We may notice that expressions $IEp = \frac{\sum_{j=1}^{p}(g_{j1} - g_{j0})^2}{Twr^2}$ (3) and $IEq = \frac{\sum_{k=1}^{q}(g_{k1} - g_{k0})^2}{Twr^2}$ (4) are in fact informational energies if we consider O.Onicescu and M. Botez (1985).

The maximum value of IEp is equal with 1 and occurs if only one of the differences $(g_{j1} - g_{j0})$ is equal with Twr, the rest of the respective differences being equal with 0. Analogously, maximum value of IEq is 1 and is observed when only one of the differences $(g_{j1} - g_{j0})$ is equal with Twr, the rest of the respective differences being equal with 0.

Consequently, we may write: $CISCr = Twr \cdot \sqrt{IEp + IEq}$ (5)

The maximum value of the expression $\sqrt{IEp + IEq}$ is $\sqrt{2}$.

The minimum value of IEp is equal with (1/p) and is obtained when all the differences $(g_{j1} - g_{j0})$ are equal with (Twr/p). Analogously, the minimum value of IEq is equal with (1/q) and is obtained when all the differences $(g_{j1} - g_{j0})$ are equal with (TWr/q).

Because r = p+q, the absolute minimum of expression $\sqrt{IEp + IEq}$ is obtained if p=q and is equal with $\sqrt{\frac{4}{r}}$, equivalent with $\sqrt{\frac{2}{p}}$

If r=2p-1, the absolute minimum of the expression $\sqrt{IEp + IEq}$ is equal with $\sqrt{\frac{2 \cdot p - 1}{p \cdot (p-1)}}$, equivalent with $\sqrt{\frac{r}{p \cdot (r-p)}}$.

The ratio between the minimum and maximum value of the expression $\sqrt{IEp + IEq}$, respectively ($RIE_{min/max}$) is equal with $\sqrt{\frac{r}{2p \cdot (r-p)}}$. If p = q, we have $RIE_{min/max} = \sqrt{\frac{1}{p}}$ (6)

In these conditions, we may write: $$CISCr = Tw \cdot \sqrt{2} \cdot \sqrt{\frac{IE_p + IE_q}{2}} \quad (7)$$

The expression $DCSC_r = \sqrt{\frac{IE_p + IE_q}{2}}$ (8) may be considered as **degree of concentration of structural changes in the context of an economy with r branches,** because it represents the ratio between the registered concentration of the structural changes both from point of view of gaining and loosing of relative importance and the maximum value of the respective concentration.

In other words, we are able to express CISCr as:

$$CISCr = Twr \cdot \sqrt{2} \cdot DCSCr \quad (9)$$

2. PARTICULAR FEATURES OF CISC COMPUTED IN CONDITIONS OF A TRISECTORIAL VISION

If the vision initiated by Colin Clark (1960) and consacrated in Y.Sabolo, I. Gaude and R. Wery (1974) is adopted, economic branches may be grouped in three economic sectors, i.e. primary sector (agriculture, forestry, hunting and fishing), secondary (industrial) sector (mining and quarrying, manufacturing, electricity, gas, steam and air conditioning production and supply) and tertiary sector (services).

In these conditions, it is possible to identify six types of sectorial structural changes, respectively:

a) **re-agrarization**, if the weight of primary sector increased during analyzed period
b) **de-agrarization**, if the weight of primary sector decreased during analyzed period
c) **re-industrialization** if the weight of primary sector increased during analyzed period
d) **de-industrialization** if the weight of secondary sector decreased during analyzed period
e) **tertialization** if the weight of tertiary sector increased during analyzed period
f) **de-tertialization** if the weight of tertiary sector decreased during analyzed period

If only three sectors are considered, the computation of coefficient of intensity of sectorial structural changes (CISCs) is a particular case

of CISC. In order to compute CISCs, the following formula may be used: $CISCs = Tws \cdot \sqrt{IEu + IEv}$ (10), equivalent with:

$$CISCs = Tws \cdot \sqrt{2} \cdot DCSCs \quad (11)$$

where Tws, IEu, IEv and DCSCs have analogous significance as in case of CISCr.

Also, it is to note that u= number of sectors experiencing gains in their relative importance and v= number of sectors experiencing loses in their relative importance.

The minimum value of CISCs in conditions of a fixed transfer of weights ($CISCs_{min}$) is $CISCs = Tws \cdot \sqrt{\frac{3}{2}}$

The maximum value of the above-mentioned indicator in conditions of fixed transfer of weights ($CISC_{smax}$) is: $CISCs = Tws \cdot \sqrt{2}$

Because we deal with only three sectors, the transfer of weights is entirely located in one of the considered sectors. Also, we are able to make a hierarchy of the sectors from the point of view of absolute value changes of weights registered in the analyzed period and determine the main and secondary sense of the structural changes.

Therefore, we consider as the main sense of structural change the type of change which occurred in the sector where modification of weight is maximum from the point of view of absolute value. The secondary sense of structural change is considered the type of change that happened in the sector where the modification of weight is placed as the second one from the point of view of absolute value.

It is possible to identify twelve situations from the point of view of senses of sectorial structural changes, respectively:

A) Main sense = re-agrarization, Secondary sense de-industrialization
A) Main sense = re-agrarization, Secondary sense de-tertialization
A) Main sense = de-agrarization, Secondary sense re-industrialization
A) Main sense = de –agrarization, Secondary sense tertialization
A) Main sense = re-industrialization, Secondary sense de-agrarization
A) Main sense = re-industrialization, Secondary sense de-tertialization
A) Main sense = de-industrialization, Secondary sense re-agrarization
A) Main sense = de-industrialization, Secondary sense tertialization
A) Main sense = tertialization, Secondary sense de-agrarization
A) Main sense = tertialization, Secondary sense de-industrialization
A) Main sense = de-tertialization, Secondary sense= re-agrarization
A) Main sense = de-tertialization, Secondary sense= re-industrialization

It is to note that in practice the main sense of sectorial structural changes are determinated by the features of the stages of development of the analyzed economy. Therefore, if we consider the hypothesis presented in J. Fourastie (1989) and A Toefler (1980), in the long run, the main sense of structural change in general and especially in case of employed population is de-agrarization during the period of building the base industrial structure[1] and tertialization during the transition to a post-industrial society[2].

3. IDENTIFICATION OF MODELING FACTORS OF DIFFERENTIATION OF THE COEFFICIENTS OF INTENSITY OF STRUCTURAL CHANGES AT SECTORIAL AND ECONOMIC BRANCH LEVEL

The Coefficient of Intensity of Structural Change computed at sectorial level (CISCs) differs from CISC computed at the level of economic branches (CISCr). The respective differentiation is determinated not only the considered level of aggregation of data, but also by the features of intrasectorial structural changes.

If we consider the economic branches grouped within the three sectors CISCr may be written as:

$$CISCr = \sqrt{\sum_{s=1}^{3}(g_{s1}-g_{s0})^2}\cdot\frac{\sum_{m=1}^{m} abs(g_{m1}-g_{m0})^2}{\sum_{s=1}^{3}(g_{s1}-g_{s0})^2}\cdot\frac{\sum_{i=1}^{r}(g_{i1}-g_{i0})^2}{\sum_{m=1}^{m} abs(g_{m1}-g_{m0})^2} \qquad (12)$$

1 The period of building the base industrial structure is considered by A Toefler as the second wave of the development of economy and society. The above-mentioned author considered that the second wave of economic and social development of mankind has begun with the industrial revolution and ended during 1950's in the most developed western countries, being characterized by the tendency to create and develop mass production within industrial firms. Also, it is to observe that during the second wave period, an important transfer of population from rural areas to urban areas took place. It is to observe that the respective structural change was replicated in the other countries during the periods when their industrial base was created and developed.

2 According to Toefler the Third Wave of economic and social development of the mankind became manifest in the most developed market economies during the late 1950's. The is a period of transition to a post industrial society where generation and use of informational –communicational technologies plays a role which become bigger and bigger for economic activities. Consequently, there are stimulated the de-massification of the industrial activities and descentralization of the decisions taken by economic and social actors. In these cnditions, services sector supplies the most important part of the jobs, while the weights of primary and secondary sectors in the employed population consanly decrease.

where:

g_{s1}, g_{so}= weights registered by sectors in year 1 and year 0 respectively.

g_{ms1}, g_{mso}= weights registered by economic branch m, which is grouped within sector s in year 1 and year 0 respectively.

abs (g_{ms1}-g_{ms0})= absolute value of the difference between the weights registered by economic branch m, which is grouped within sector s in year 1 and year 0 respectively.

In these conditions, we may define the **index of intrasectorial structural change (IIaS)** by using the formula:

$$IIaS = \sqrt{\frac{\sum_{s=1}^{3}(\sum_{m=1}^{ms} abs(g_{ms1} - g_{ms0}))^2}{\sum_{s=1}^{3}(g_{s1} - g_{s0})^2}} \tag{13}$$

It is to note that there are two situations detected by IIaS, namely:

a) when all the structural changes registered at the level of branches are in accordance with the sense of structural changes registered at sectorial level. In this case IIaS=1
b) when the sense of at least one of structural changes registered at the level of branches is in contradiction with the sense of structural change registered at sectorial level. In this case IIaS>1.

Also, we may define the **index of concentration of structural changes within sectors (**ICsect), by considering the formula:

$$IC\sec t = \sqrt{\frac{\sum_{i=1}^{r}(g_{i1} - g_{i0})^2}{\sum_{s=1}^{3}(\sum_{m=1}^{ms} abs(g_{ms1} - g_{ms0}))^2}} \tag{14}$$

If we consider IIaS and ICsect, we may also compute CISCr by using the formula:

$$CISCr = CISCs \cdot IIaS \cdot IC\sec t \tag{15}$$

4. A NUMERICAL EXAMPLE. COMPUTATION OF CISC IN CASE OF EMPLOYED POPULATION AT ECONOMIC BRANCH AND SECTORIAL LEVEL DURING THE PERIOD 2008-2011

In order to illustrate the proposed improvement methodology for the interpretation of Coefficient of Intensity of Structural Changes, there were identified the modeling factors of differentiation of CISCs and CISCr in case of employed population during period 2008-2011, considering data from Romania's Statistical Yearbook for 2012.

There are taken into account a number of 10 economic branches, which are grouped into three sectors, namely:

a) **Primary sector** with a single economic branch, Agriculture, forestry and fishing, respectively

b) **Secondary (industrial) sector** with four economic branches, namely: 1) Mining and quarrying, 2) Manufacturing, 3) Energy, gas and water production and supply and waste management, 4) Constructions

c) **Tertiary (services) sector** with five economic branches, namely: 1) Wholesale and retail, repair of motor vehicles, hotels and restaurants, 2) Transport, storage, information and communication activities, 3) Financial intermediation, insurance, real estate activities, professional, scientific and technical activities, 4) Social infrastructure services (public administration, education, health), 5) Shows, culture and recreation activities and other services activities.

The structural changes of employed population during the period 2008-2011 at the level of economic branches and sectors respectively are shown in table no.1 and table no.2, respectively.

Structural changes of employed population at level of economic branches in Romania during the period 2008-2011

Table no.1

%

Economic branch	Weight in 2008	Weight in 2011	Differences of weights
Economy as a whole	100,00	100,00	0,00
Agriculture, forestry, fisheries	27,52	29,19	1,67
Mining and quarrying	0,93	0,78	-0,15
Manufacturing	19,33	17,87	-1,46
Energy, gas, water	2,39	2,32	-0,07
Constructions	7,91	7,30	-0,61
Wholesale and retail, Hotels and restaurants	15,21	15,48	0,27
Transportations, Comunications	6,33	6,81	0,48
Financial intermediation and professional services	6,25	6,56	0,31
Social services	12,05	11,43	-0,62
Culture and recreation services and other services	2,08	2,26	0,18

Structural changes of employed population at sectorial level in Romania during the period 2008-2011

Table no.2

%

Economic branch	Weight in 2008	Weight in 2011	Differences of weights
Economy as a whole	100,00	100,00	0,00
Primary sector	27.52	29.19	1.67
Secondary sector	30.56	28.27	-2.29
Tertiary sector	41.92	42.54	0.62

The computation of indicators related to proposed methodology for CISC computation at economic branch and sectorial level with the help of R Software (Annex no.1) led to following results:

CISCr= 2.48%. Twr= 2.91%, IEp= 0.3806, IEq= 0.3448, DCSCr= 0.6021
CISCs= 2.90%. Tws= 2.29%, IEu= 0.6058, IEv= 1.000, DCSCs= 0.8960

We may observe that size of CISCr is relatively small one, i.e. 2.48%. The respective indicator is obtained in conditions of a transfer of weights of 2.91% and of a moderate degree of concentration of structural changes, 0.6021, respectively.

CISCs is equal with 2.90%. During the analyzed period, the main sense of sectorial structural change was de-industrialization, while the secondary

sense was re-agrarization. At a first sight, the sense of sectorial structural change appears to be in contradiction with the trend of the long run mutations of the employment model during the transition to a service economy. But the respective structural change of employed population is recommendable to be seen related to the situation of Romania's economy during the analyzed period. It is important to note that during 2009-2010 Romania faced an economic recession, which led to the loss of jobs especially in the secondary (industrial) sector. In the same time, due to the fact that the demand for labour decreased relatively slowly in the services sectors, their weight in total employed population increased. But during the analyzed period the employed persons in the primary sector have registered a growth. Therefore, the secondary sense of employment structural change was the re-agrarization.

The size of CISCs is greater than the size of CISCr, although the sectorial transfer of weights (2.29%) is smaller than the transfer of weights registered when the economic branches are considered (2.91%). The explanation of the respective situation is the sensibly higher degree of concentration of sectorial structural change in comparison with the situation registered at economic branch level.

The respective explanation is confirmed by computation of IIaS and ICsect. Therefore, we obtained IIaS= 1.1692 and ICsect= 0.7309. In these conditions, ratio between CISCr and CISCs is equal with 0.8546.

It is to note that supraunitary value of IIaS is a consequence of the fact that the sense of change of relative importance registered by social services is in contradiction with the sense of change of relative importance registered by tertiary sector as a whole related to employed population.

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Annex no.1

The instructions used in R Software in order to compute CISCr and CISCs and their modeling factors

```
#import data
ramuri2008 <- read.table(file.choose())
ramuri2011 <- read.table(file.choose())

sectoare2008 <- read.table(file.choose())
sectoare2011 <- read.table(file.choose())

## Computation of CISCr
#Computation of weights of economic branches
gi0 <- round((ramuri2008$V1/sum(ramuri2008$V1)*100),4)
gi1 <- round((ramuri2011$V1/sum(ramuri2011$V1)*100),4)

#Computation of differences gi1-gi0
dif_gi <- gi1-gi0

##Computation of CISCr with classical method (CISCr1)
CISCr1 <- round((sum(dif_gi^2)^0.5), 4)

##Computation CISCr with proposed method
#A) Selection of positive values of dif_gi
dif_poz_gj <- dif_gi[dif_gi>0 & !is.nan(dif_gi)]
```

```
#B) Selection of negative values of dif_gi
dif_neg_gk <- dif_gi[dif_gi<0 & !is.nan(dif_gi)]

#C) Computation of transfer of weights considering r economic branches
(Twr)
Twr <- sum(dif_poz_gj)

#D) Computation of informational energy of positive dif_gj (IEp)
IEp <- round((sum(dif_poz_gj^2)/Twr^2), 4)

#E) Computation of informational energy of negative dif_gk (IEq)
IEq <- round((sum(dif_neg_gk^2)/Twr^2), 4)

#F) Computation of degree of concentration of structural change considering
r economic branches (DCSCr)
DCSCr <- round((((IEp+IEq)/2)^0.5), 4)

#G) Computation of CISCr with formula issued from proposed methodology
(CISCr2)
CISCr2 <- round((Twr*2^0.5*DCSCr), 4)

##Computation of CISCs

# Computation of sectorial weights
gs0 <- round((sectoare2008$V1/sum(sectoare2008$V1)*100),4)
gs1 <- round((sectoare2011$V1/sum(sectoare2011$V1)*100),4)

# Computation of differences gs1-gs0
dif_gs <- gs1-gs0

## Computation of CISCs with clasical method (CISCs1)
CISCs1 <- round((sum(dif_gs^2)^0.5), 4)

## Computation of CISCs with proposed method (CISCs2)
# A) Selection of positive values of dif_gs
dif_poz_gu <- dif_gs[dif_gs>0 & !is.nan(dif_gs)]

# B) Selection of negative values of dif_gs
dif_neg_gv <- dif_gs[dif_gs<0 & !is.nan(dif_gs)]
```

```
# C) Computation of sectorial transfer of weights (Tws)
Tws <- sum(dif_poz_gu)

# D) Computation of informational energy of positive dif_gu (IEu)
IEu <- round((sum(dif_poz_gu^2)/Tws^2), 4)

# E) Computation of informational energy of negative dif_gv (IEv)
IEv <- round((sum(dif_neg_gv^2)/Tws^2), 4)

# F) Computation of degree of concentration of sectorial structural change
(DCSCs)
DCSCs <- round((((IEu+IEv)/2)^0.5), 4)

# G) Computation of CISCs with formula issued from proposed methodology
(CISCs2)
CISCs2 <- round((Tws*2^0.5*DCSCs), 4)
```

Identification of modeling factors of Coefficients of Intensity of Structural Changes differentiation at sectorial and economic branch level

```
#A) Computation of sum of absolute values of differences (gi1-gi0) within
sectors
dif_abs_s1 <- abs(dif_gi[1])
dif_abs_s2 <- sum(abs(dif_gi[2:5]))
dif_abs_s3 <- sum(abs(dif_gi[6:10]))

#B) Computation of sqabs_uv
sqabs_uv <- (sum(dif_abs_s1^2,dif_abs_s2^2,dif_abs_s3^2)^0.5)

#C) Computation of IIas
IIas <- sqabs_uv/CISCs2

#D) Computation of ICsect
ICsect <- CISCr2/sqabs_uv

#E) Computation of ratio between CISCr and CISCs (ratio_CISCr_CISCs)
ratio_CISCr_CISCs <- CISCr2/CISCs2
```