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Essentials aspects on macroeconomic variables and their correlations

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Abstract. *The measurement of the correlations between macroeconomic variables, including the cause-effect links, provide useful information for policy makers in the government and public agencies. Especially important is the system of relationships that reveals the influence of certain factors on the Gross Domestic Product. This paper outlines the influence of the unemployment, measured through the unemployment rate, the inflation. Also, the authors discuss the correlations of the economic growth.*

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1. General aspects

Any economic program consists in a policy measures set intended to achieve the main objectives of the macroeconomic policy, which usually means economic growing, employment, prices stability and external balance improvement.

These objectives are quantified by four main variables named macroeconomic key-variables, which measure, correlate and analyze any economy performance, namely:

- GDP growing pace;
- unemployment rate measured either as registered level at the end of each year, or as medium level per year;
- inflation rate measured either by the growing rate of the gross domestic product deflator – D , or the monthly medium growing of the consumer prices;
- current account payment balance.

The four variables make possible the evaluation of the main domestic and external macroeconomic imbalances, monitoring the changes in economy and the corresponding policy making aiming at future objective realization.

Between the four variables important macroeconomic correlations are settled as well as with strong correlations between them and other macroeconomic indicators.

Anghelache, Mitruț and Voineagu (2013) develop on the national accounts and macroeconomic indicators, describing the correlations of the high level economy, while Anghelache (2008a) is a reference work in statistics. Anghelache and Anghelache (2013) focus on the structural analysis of GDP, based on macroeconomic models. Iordache et al. (2011) have introduced an econometrical model for GDP calculation. Necșulescu and Șerbănescu (2014) characterize the correlation between main macroeconomic indicators and the final consumption. Bekerman (1968) treats some aspects regarding the analysis of the national income. Anghelache (2009) describes the macroeconomic indicators used for international comparisons. Diamond (2013) reviews some characteristics of the unemployment. Anghelache (2008b) presents the interconnections between external balance and macroeconomic outcome aggregates. Dinu (2012) describes some aspects on macroeconomics.

2. The significance of the correlation GDP growing rate and unemployment rate

Theoretically, this correlation is obvious: a recessive economy characterized by a GDP (RPIB) decreasing rate of growth, unemployment rate (RS) is growing; when the economy is increasing, the GDP (RPIB) is increasing, while the unemployment rate (RS) is decreasing. This inverted (negative) correlation is known as Okun's law. Analyzed by US economic conditions, the law has the following mathematical relation:

$$RPIB_{t/t-1} = 3\% - 2(RS_t - RS_{t-1}), \quad (1)$$

where:

$RPIB_{t/t-1}$ – GDP growth rate in t time period compared to t-1 time period;

3% – GDP growth trend (trend relative to time);

$RS_{t,t-1}$ – unemployment rate in t time period, respectively in t-1 time period.

So, if the unemployment rate does not change, the GDP will have a 3% growth. For each growth percentage point of the unemployment rate, the GDP growing rate will decrease by 3%. For example, if the RS increases from 6% to 8% in the current period, than real RPIB will be –1%.

$$RPIB = 3 - 2(8\text{-}6) = -1\%. \quad (2)$$

This relation may be written as:

$$RS_{t+1} = RS_t - 0{,}5(RPIB_{t/t-1} - 3). \quad (3)$$

It follows that the unemployment rate in the current period will increase or decrease compared to the one from the previous period, as well as RPIB will be bigger or smaller than the growth trend (3%). In other words if the decrease of unemployment rate will decrease by 1%, RPIB must reach 5%:

$$RS_{t+1} - RS_t - 0{,}5(5 - 3 = -1). \quad (4)$$

This relation is statistical, unavailable for any country, only for the USA and only for the stage which was researched by Okun. Such statistical relation may be concluded separately for each country, with regard to conditions specific to the developmental stage.

For the latter years of the Romanian economy, the statistical data analysis led us to the conclusion that Okun's law is valid but only in a specific manner.

Firstly, the economic growth trend was considered the annual medium GDP growth rate for the 1980-1989 period calculated at 1.4%.

Secondly, between 1990 and 1993, no stable statistic relation can be determined between the GDP growth rate and unemployment rate even if the inverse correlation between the two variables is obvious.

Thirdly, starting with 1994, an Okun type relation between unemployment rate change and GDP growth rate change according to the trend may be settled, precisely for a delayed relation: GDP growth in t time period, over the registered trend (1.4%) led to an unemployment decrease for the t +1 time period.

The deduced relation is:

$$RS_{t+1} = RS_t + \alpha(RPIB_{t/t-1} - 1{,}4), \quad (5)$$

where:

$$\alpha \in (-0,4;-0,45). \quad (6)$$

In other words, the 1% GDP growth rate in the t year over the trend level ensured a decrease of the unemployment rate in t +1 year with about 0.4%.

Otherwise, the GDP change only partially explains the unemployment rate evolution.

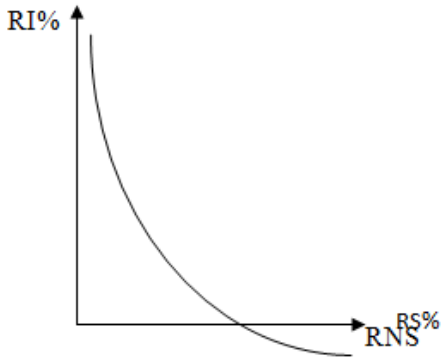
The medium credit interest rate for economic agent loans had a more important effect on the unemployment rate.

An intense direct correlation between the two variables was identified.

3. The correlation between the inflation rate and unemployment rate

The statistical data series analysis – especially the developed countries, until the "oil price shock" year, 1973 – underlined an inverse correlation, simple and stable, between inflation rate and unemployment rate. In other words, a relation of compensation between inflation and unemployment could be consisting of either a smaller unemployment obtained by a bigger inflation or the inflation may be reduced by an increased unemployment. This inverse correlation finds an expression in Philips curve.

Phillips curve on short term



The compensation relation corresponding to this graph is available only on short term is the following:

$$RI_t = RI_{t-1} + \alpha(RS_t - RNS).$$

Thus, the actual inflation rate (RI) depends on two factors:

- the inertial element, defined by the expected inflation, which can be replaced by the previous inflation (RI_{t-1});
- the cyclic element, defined by the deviation of the actual unemployment (RS_t) as to the natural rate of unemployment (RNS).

Following this formula, it is obvious that as much as unemployment is maintained at its natural level, the inflation rate does not change. Accordingly, if the unemployment rate increase over its natural level, the inflation rate will register a certain decrease depending on the α parameter (decreasing segment of Phillips curve).

After the oil price shock in the 70s, it was an awareness regarding the complexity of inflation – unemployment relation. The inflation rate is influenced by a third factor also (ε), namely the shocks of the aggregate offer (the nominal owed GDP changes, for exemple, the stressed price increases for certain products).

$$RI_t = RI_{t-1} - \alpha(RS - RNS) + \varepsilon. \tag{8}$$

It follows that there is a possibility that, on the long run, Phillips duduced inverse correlation between inflation and unemployment should not manifest. The evolution of the two variables will find an expression on a series of Phillips curves mapped on subperiods (on short term).

The medium levels registered on the inflation and unemployment rate in Romania may be analyzed by Phillips curve use.

4. Main aspects regarding the correlation between GDP growth rate and inflation rate

As GDP is calculated in current prices or in comparable prices, the nominal or real evolution of this indicator can be assumed.

The nominal evolution is indicated by the following relations:

$$IPIB_n = \frac{PIB_1^{crt}}{PIB_0^{crt}} \tag{9}$$

$$RPIB_n = IPIB_n - 1 \tag{10}$$

The real evolution refers to the fresh calculation in comparable prices (to the start period) of the GDP of the current period, by using the GDP deflator (D):

$$PIB_1^{comp} = \frac{PIB_1^{crt}}{D}, \tag{11}$$

where:
D = RI+1;
RI – inflation rate calculated based on deflator.

The real evolution is expressed by the following relations:

$$IPIB_r = \frac{PIB_1^{comp}}{PIB_0^{comp}} \frac{PIB_1^{comp}}{PIB_0^{crt}}$$
$$RPIB_r = IPIB_r - 1 \quad (13)$$

The relation between nominal GDP, real GDP and the inflation rate is:

$$IPIB_n = IPIB_r \times D \quad (14)$$

or transfer in rates:

$$RPIB_n = RPIB_r + RI + RPIB_r \times RI \ . \quad (15)$$

As the last product registers a significant value – in case of a reduced inflation rate, in many cases it is used the following relation:

$$RPIB_n = RPIB_r + RI \ . \quad (16)$$

Under the current conditions of the Romanian economy, this last relation cannot be used, as the product $RPIB_r \times RI$ has a value big enough.

5. Basic correlations of the economic increase

The total or *per capita* GDP is the synthetic indicator characterizing the economic increase expressed by increase its volume and rate. It follows that, the economic growth is based on direct production factors combination and use: fix capital, employment and the consumptions of the material circulating means.

As to the theory of economic growth, its factors, their interdependence and effectiveness and the statistic and analytic macroeconomic methods used are discussed.

A balanced development of the economy should comply with three conditions at macroeconomic and branch level:

- First of all, the GDP size is relative to the labour capacity, at national economy level through the working population $(\Sigma T)^3$, also by the quality and intensity of labour, measured by social productivity of labour $(\overline{W})$.

$PIB = \overline{W \times \Sigma T -}$ at national economy level. (17)

Based on the same indicators per branch the relation becomes:

$VAB = W \times T -$ per branch

where:
VAB = Gross Added Value

Dynamically expressed, the first relations will be:

$$IPIB = \overline{IW} \times I\Sigma T \tag{18}$$

or

$$RPIB + 1^* = \left(R\overline{W} + 1\right) \times \left(R\Sigma T + 1\right), \tag{19}$$

where:
I – increase index for each indicator;
R – increase rate for each indicator.

The last relation can be re-written as a correlation between increase rates:

$$RPIB = \underset{\substack{\text{influence}\\ \text{of intensive}\\ \text{factor}}}{R\overline{W}} + \underset{\substack{\text{influence}\\ \text{of extensive}\\ \text{factor}}}{R\Sigma T} + \underset{\substack{\text{common}\\ \text{influence}}}{R\overline{W \times R\Sigma T}}. \tag{20}$$

This relation can be used in many forms, depending on the way the common influence is approached:

- the common influence can be set aside when at least one of the increase rates registers a significant value;
- the common influence can be assigned to one factor, either quantitative or calitative;

$$RPIB = R\overline{W} + R\overline{W} \times R\Sigma T + R\Sigma T = R\overline{W}\left(1 + R\Sigma T\right) + R\Sigma T$$

$$= \underset{\substack{\text{intensive}\\ \text{factor}\\ \text{influence}}}{R\overline{W} \times I\Sigma T} + \underset{\substack{\text{extensive}\\ \text{factor}\\ \text{influence}}}{R\Sigma T}$$

or

$$RPIB = R\overline{W} + R\Sigma T + R\overline{W} \times R\Sigma T = R\overline{W} + R\Sigma T\left(1 + R\overline{W}\right) =$$

$$= \underset{\substack{\text{intensive}\\ \text{factor}\\ \text{influence}}}{R\overline{W} \times R\Sigma T} \times \underset{\substack{\text{extensive}\\ \text{factor}\\ \text{influence}}}{I\overline{W}} \tag{22}$$

- the common influence of each factor can be parted either equally or proportionally to the independent influences.

Secondly, the GDP is analyzed with regard to the main element of the national wealth – fixed funds $\left(\Sigma F\right)$ - and the average use efficiency $\left(\overline{E}\right)$.

$$PIB = \overline{E} \times \Sigma F - \text{national economy level;} \tag{23}$$

$$VAB = E \times F - \text{branch level.} \tag{24}$$

Similarly to A, increase rates correlation between GDP and influence factors is:

$$RPIB = \underset{\substack{\text{intensive}\\\text{factor}\\\text{influence}}}{R\overline{E}} + \underset{\substack{\text{extensive}\\\text{factor}\\\text{influence}}}{R\Sigma F} + \underset{\substack{\text{common}\\\text{influence}}}{R\overline{E} \times R\Sigma F} \quad (25)$$

Thirdly, GDP size depends on volume of consumed circulating material means $(\Sigma C)^4$ and their average use efficiency $(\overline{M})$

$PIB = \overline{M} \times \Sigma C -$ national economy level;

$VAB = M \times C -$ branch level.

Correlation between increase rates is:

$$RPIB = \underset{\substack{\text{intensive}\\\text{factor}\\\text{influence}}}{R\overline{M}} + \underset{\substack{\text{extensive}\\\text{factor}\\\text{influence}}}{R\Sigma C} + \underset{\substack{\text{common}\\\text{influence}}}{R\overline{M} \times R\Sigma C}. \quad (26)$$

The correlations refer to a single element of the production process: either employment or fixed capital or material consumption. Thus, GDP change is completely owed to one of these three factors. As the three resources act simultaneously in the production process, that means the GDP change to be the result of their correlated action. We cannot simply add the intensive influences from each element and then the extensive influences, because the total will be the same in size, with the relative GDP addition.

As a result, there have been a series of calculus methods which allow to settle the extent of the national economy development to be accomplished intensively or extensively, with regard to the three resources altogether.

The existent correlations between relative changes of GDP and the factor increase rates for each resource, represents the peak of these demonstration.

$$RPIB = R\Sigma T + R\overline{W} \times I\Sigma T \quad (27)$$

$$RPIB = R\Sigma F + R\overline{E} \times I\Sigma F \quad (28)$$

$$RPIB = \underset{\substack{\text{extensive}\\\text{factor}\\\text{influence}}}{R\Sigma C} + \underset{\substack{\text{intensive}\\\text{factor}\\\text{influence}}}{R\overline{M} \times I\Sigma C}$$

In order to have a displayed formula cumulating extensive and intensive influences of the three factor altogether, each influence of each element will be corrected with coefficient: GT for employment, GF for fixed capital, GC for material consumption, so as:

$$GT + GF + GC = 1(100). \quad (29)$$

These could be:

- the value definition of each factor share in the total factors cost, which can be expressed by net added value share (VAN), of economic return (A) and of materials consumption (or intermediary consumption, CI) in the gross production total (PB).

$$GT = GF = GC = 33.3\% ; \tag{30}$$

- calculated shares based on each factor elasticity (E) as to production, the elasticity expressed by the ratio between GDP relative increase and each resource relative increase:

$$ET = \frac{RPIB}{RT} \qquad EF = \frac{RPIB}{RF} \qquad EC = \frac{RPIB}{RC} \tag{31}$$

$$GT = \frac{ET}{\Sigma E} \qquad GF = \frac{EF}{\Sigma E} \qquad GC = \frac{EC}{\Sigma E},$$

where:

$\Sigma E =$ the three resources elasticity sum.

This shows the disadvantage of not being able to apply to negative elasticities.

A relation may be written with the result of the intensive and extensive contribution of the three resources to GDP increase:

$$RPIB = \underbrace{\left(R\Sigma T + R\overline{W} \times I\Sigma T\right)}_{\text{employment influence}} \times GT + \underbrace{\left(R\Sigma F + R\overline{E} \times I\Sigma F\right)}_{\text{fixed capital influence}} \times GF +$$

$$+ \underbrace{\left(R\Sigma C + R\overline{M} \times I\Sigma C\right)}_{\text{materials consumption influence}} \times GC = \tag{32}$$

$$= \underbrace{\left(R\Sigma T \times GT + R\Sigma F \times GF + R\Sigma C \times GC\right)}_{\text{total extensive influence}} +$$

$$+ \underbrace{\left(R\overline{W} \times I\Sigma T \times GT + R\overline{E} \times I\Sigma F \times GF + R\overline{M} \times I\Sigma C \times GC\right)}_{\text{total intensive influence}}.$$

The previous relations can be used to analyze the GDP dynamics starting with the the influence factors which can be viewed as medium and total indicators. The use of this version – in the first phase of the macroeconomical analyses – supposes to consider the homogeneity of the economy by the medium representativity respectively by time view quality factors at a next level. The homogeneity verification is made by analyzing the variation coefficient (v) calculated as the ratio between the average square deviation (σ) and the medium level of the respective indicator. For example, in the case of labour productivity, we use:

$$v = \frac{\sigma_w}{\overline{W}} = \frac{\sqrt{\frac{\Sigma\left(W - \overline{W}\right)^2 \times T}{\Sigma T}}}{\overline{W}} \times 100, \quad (33)$$

where:
W, T – workforce productivity and working population at branch level.

When the variation coefficient is above 35-40%, the average is not representative, and the factor contribution to GDP increase will be inaccurate as the calculated average will bring about the value equalization at branch level. Thus, in the second stage of the macroeconomic analysis, we need to determine the contribution of all factors at branch level, following that their influence on GDP growth to result from contribution aggregation at branch level.

It follows that the three basic correlations can be analyzed based on:

$$PIB = \Sigma W \times T \quad (34)$$

$$PIB = \Sigma E \times F \quad (35)$$

$$PIB = \Sigma M \times C \quad (36)$$

There are two influence factors:
- quality factor (intensive) at branch level (W, E, M);
- quantity factor (extensive) at branch level (T, F, C).

The previous relations may be studied also based on factors systems implying the influence of changes in the branch structure for each resource.

$$PIB = \overline{W} \times \Sigma T = \Sigma\left(W \times YT\right) \times \Sigma T \quad (37)$$

$$PIB = \overline{E} \times \Sigma F = \Sigma\left(E \times YF\right) \times \Sigma F \quad (38)$$

$$PIB = \overline{M} \times \Sigma C = \Sigma\left(M \times YM\right) \times \Sigma C \quad (39)$$

The three influence factors are:
- quality factor (intensive) at branch level (W, E, M);
- structural factor (YT, YF, YM);
- quantity factor (extensive) at national economy level $\left(\Sigma T, \Sigma F, \Sigma C\right)$.

We can deepen the analysis considering the correlation between work productivity and fixed capital efficiency:

$\overline{W} = \overline{E} \times \overline{Z}$ – national economy level; (40)

$W = E \times Z$ – branch level; (41)

where:
Z – fixed funds labour endowment.

Starting with these relations, GDP size can be determined by:

$$PIB = \Sigma W \times T = OE \times Z \times T ; \quad (42)$$

$$PIB = \overline{W} \times \Sigma T = \overline{E} \times \overline{Z} \times \Sigma T = \Sigma\left(E \times YF\right) \times \Sigma\left(YT \times Z\right) \times \Sigma T \quad (43)$$

Based on research objectives and the quality of the available statistic data, when analyzing GDP increase, any of these factorial relations can be used. Obviously, the most complex – by number and importance of the considered factors and as well as by the correlation between efficiency indicators – is the last relation. It is used in order to determine the contribution of each element to GDP change.

Conclusions

The correlations between macroeconomic variables, together with the equations that represent their mathematical expression, form a relevant toolbox for analysts. As it is known that data processing methodology is one of the key issues of the data analysis procedure, the presented correlations represent a solution, at least partial, to that issue.

The intensive development of an economy needs the increase of GDP by a more effective use of the existent employment, fix and material resources. Instead, the extensive development refers to an increase of the three resources.

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