STUDY OF THE RELATIONSHIP BETWEEN ECONOMIC GROWTH, VOLATILITY AND INNOVATION FOR THE EU-27 AND CEEC COUNTRIES

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Abstract

The present study applies, along general lines, the methodology used in Ramey&Ramey (1995), and Kroft, Lloyd-Ellis (2002), respectively, to analyze the dependencies between growth, volatility and innovation in the case of the EU-27 and CEEC (new member states from Central and Eastern Europe) countries, respectively. Unlike the above-mentioned papers, which use human capital as proxy for innovation, we use as indicator of innovation the Summary Innovation Index(SII), proposed by the European Innovation Scoreboard (EIS). Using the EVIEWS econometric software, we estimate regressions of the GDP growth rate on its total volatility, as well as on its partial volatilities, split with respect to the phases of the economic cycle. We also estimate regressions of the innovation rate on the GDP growth rate volatilities, as well as regressions of the GDP growth rate on the rate of innovation and the split volatility of the GDP growth rate. We find positive dependencies of the GDP growth rate on its own volatility, as well as on the innovation rate. The sources of the data are EUROSTAT, the National Statistical Institute of Romania (INS), and the European Innovation Scoreboard.

Keywords: growth, volatility, innovation

Introduction

Given the current conditions of global economic crisis, when economies contract and we are faced with the largest recession of the last seventy years, the main objective is to stabilize the economy and re-launch economic growth. In this context, innovation becomes a vital element for survival and development. Every state must innovate, either to remain competitive or to recover the gaps which separate it from the more developed ones.

On the other hand, the extensive discussions concerning the crisis point out to the crucial influence of volatility, as a measure of uncertainty, on economic growth, on economic cycles, in particular.

Recent theoretical and empirical research demonstrated the existence of a relationship between volatility and economic growth. Although it is frequently assumed that

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uncertainty affects negatively investment, hence growth, theoretical literature suggests that the impact can be positive or negative.

The present paper examines the relationships between economic growth, innovation and volatility, with special reference to the EU countries and, among these, the new member states from Central and Eastern Europe (CEEC).

1. Recent results concerning the relationship between economic growth and volatility

Although it is often presumed that uncertainty will have adverse consequence for investment and hence growth, the theoretical literature in fact suggests that the impact may be positive or negative.

For example, while *Abel (1983)* shows that with symmetric costs of adjustment, a mean—preserving spread in price volatility will tend to raise investment, *Pindyck (1988)* shows that the opposite may be true when adjustment costs are asymmetric (e.g. if investments are irreversible).

Cabellero (1991) demonstrates that perfect competition and constant returns in production is likely to result in a positive relationship, whereas imperfect competition and decreasing returns to scale will yield a negative one.

Aizenman and Marion (1993) construct an endogenous growth model, in which investors face a random tax on capital that can take on two values, high or low, and investments that are irreversible. This setup creates an option value of postponing an investment, since by delaying the decision to invest, one can learn more about future tax regimes. The model shows that an increase in policy uncertainty can reduce investment, and therefore growth, in some circumstances.

A second class of theories focus on the structural relationship between fluctuations and growth—promoting activities that may arise, even in a deterministic environment. Some emphasize the causal impacts of business cycle fluctuations on long—run productivity growth. For example *Sakellaris and Spilimbergo (1999)* find that education enrollment is counter-cyclical for OECD countries. Similarly, by lowering wages, recessions may reduce the opportunity costs of innovative effort and induce greater productivity improvements (*Aghion and Saint Paul, 1998*).

Schumpeter (1927) emphasizes causality in the other direction – the advances that generate long—run growth can cause cyclical fluctuations. This may be because new innovations require reorganization and restructuring before they can be used in practice thereby drawing resources out of production. Recently, *Helpman and Trajtenberg (1998)* formalizes these “Schumpeterian cycles” and find that the size of recessions are positively correlated with average growth.

Francois and Lloyd-Ellis (2002) develop a theory of growth and cycles in which fluctuations arise because of strategic clustering of implementation across sectors. They find that growth and volatility are negatively related across economies.

In all these theories the impact of fluctuations does not arise through the affects of aggregate uncertainty, but rather through a structural relationship between business cycles and growth.

Several papers have attempted to estimate the empirical relationship between volatility and growth across countries. In most cases these involve regressions of the average growth rate over a given sample period on the standard deviation of the growth rate or some other measure of uncertainty. Both *Komendi and Meguire (1985)* and *Grier and Tullock (1989)*, for example, find a positive relationship between mean growth and its standard deviation. In contrast *Aizenman and Marion (1993)* find a negative relationship between growth and policy uncertainty.

Ramey and Ramey (1995) go beyond this approach by constructing an econometric model in which the volatility measure is interpreted as forecast uncertainty. Using pooled time series, cross—country data, and controlling for other growth correlates, they uncover a significant and robust partial correlation between growth and volatility.

Kroft, Lloyd-Ellis (2002) build on Ramey and Ramey's analysis by developing an econometric specification that decomposes aggregate volatility into structural, business cycle fluctuations and residual forecast uncertainty. This allows them to consider the hypothesis that it is business cycle shifts that generate the negative relationship between growth and volatility, rather than year—to—year uncertainty. Their specification hinges on the assumption that economic actors can condition on which phase (recession or boom) of the business cycle they are in. The estimates that they obtain indicate a significant and robust, negative correlation between growth and between—phase volatility – the component of volatility associated with medium term shifts between recessions and booms. In contrast growth appears to be positively correlated with within—phase volatility – the average standard deviation within recessions and booms. These results are robust to the inclusion of other growth correlates and hold true in both a 92 country sample and an OECD country sample.

2. The relationship between economic growth and its overall volatility

Based on the *Ramey&Ramey* methodology, simple regressions are estimated for two country samples: a sample of the EU 27 countries and a sample of the 10 CEEC countries, for the period 1996 – 2010. In both regressions, the dependent variable is the average GPD growth rate, and the explanatory variable is its volatility. The data concerning GDP growth rate are provided by EUROSTAT.

Volatility is measured through the standard deviation (square root of the variance) of the growth rate $\sigma_i = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(g_{it} - \overline{g}_i\right)^2}$ where g_{it} is the growth rate of country *i* in year *t*, *T* is the number of years (in our case, T =15), and the average growth rate is given by: $\bar{g}_i = \frac{1}{T}\sum_{t=1}^{T} g_{it}$

The data were processed by using the EVIEWS econometric software. The regression equations are:

$$\bar{g}_i = 1.004 \quad + 0.547\sigma_i \tag{1}$$

with $R^2 = 0.65$ for EU 27 countries and

$$\bar{g}_i = 2.767 \quad + 0.187\sigma_i \tag{2}$$

with $R^2 = 0.14$ for CEEC countries.

These equations indicate a simple positive correlation between the economic growth rate and volatility in both samples. We can notice that, for regression (1), the indicator R^2 reflects a good data adjustment. For the second regression equation, the value 0.14 is low; however, it is better than the R^2 values of analogous regressions in *Ramey&Ramey* (0.057 for the sample of 92 countries, and 0.02 for OECD countries, respectively). Comparing the signs of the volatility-related coefficients, we note that the positive sign in equations (1) and (2) is compliant with the result obtained in *Ramey&Ramey* regarding the OECD countries.

3. The relationship between growth, economic cycle and volatility

Following the methodology used in *Kroft*, *Lloyd-Ellis (2002)*, we identify the phases of expansion (noted by *e*) and recession (noted *r*) for each country and we decompose the overall volatility into "within—phase" volatility (within the two phases), denoted σ_{iw}, and "between—phase" volatility (between the two phases), denoted σ_{ib}.

They are calculated using the formulas $\sigma_{iw} = \sqrt{\frac{1}{T}\left(\sum_{t\in r}\left(g_{it} - \bar{g}_{ir}\right)^2 + \sum_{t\in e}\left(g_{it} - \bar{g}_{ie}\right)^2\right)}$ for within—phase volatility and $\sigma_{ib} = \sqrt{\frac{T_{ir}}{T}(\bar{g}_{ir} - \bar{g}_i)^2 + \frac{T_{ie}}{T}(\bar{g}_{ie} - \bar{g}_i)^2}$ for between—phase volatility, where T_{ir} and T_{ie} are the numbers of years when country *i* is in recession or in expansion, respectively, and $\bar{g}_{ir} = \frac{1}{T_{ir}}\sum_{t\in r} g_{it}$ and $\bar{g}_{ie} = \frac{1}{T_{ie}}\sum_{t\in e} g_{ie}$ are the average growth rates during recession and expansion, respectively. We have: $\sigma_i^2 = \sigma_{iw}^2 + \sigma_{ib}^2$.

It can be noted that 29.4% of overall volatility is represented by within-phases volatility and 70.6% of the total volatility is represented by between-phases volatility for the EU 27 countries; for the CEEC countries, 28% of overall volatility is represented by within-

phases volatility, and 72% of the total volatility is represented by between-phases volatility.
The following conclusions can be inferred:

- the behavior of the CEEC countries is similar to that of all EU-27 countries;
- between-phases volatility is approximately 70% of overall volatility, whereas within-phases volatility is approximately 30%.

In order to estimate the regression equations of the GDP growth rate on the "split" volatilities. The corresponding regression equations are:

$$\overline{g}_i = 0.846 \quad +0.827\sigma_{iw} + 0.175\sigma_{ib} \tag{3}$$

with $R^2 = 0.67$, for the EU 27 countries and

$$\overline{g}_i = 1.788 \quad +1.229\sigma_{iw} - 0.311\sigma_{ib} \tag{4}$$

with $R^2 = 0.71$, for the CEEC countries.

The values of R^2 indicate a good data adjustment for both regressions. These values are far better than the similar ones obtained in *Kroft, Lloyd-Ellis (2002)*) (0.114 for the sample of 92 countries, and 0.02 for the OECD sample). Both regression equations indicate a partial positive correlation between within-phases volatility and average growth rate. This result coincides with the conclusion of *Kroft, Lloyd-Ellis (2002).* As regards the relationship between the average growth rate and between-phases volatility, a partial positive correlation can be noted for the EU 27 countries (in the first regression equation), and a partial negative correlation for CEEC countries (in the second regression equation), respectively. As concerns the regression equation (4) for the CEEC, the result coincides with the one obtained in *Kroft, Lloyd-Ellis (2002)* for both regressions. On the other hand, comparing this result with the one in the regression equation (2), where the dependence of the GDP average growth rate on the total volatility is positive, we can conclude that the positive coefficient of within-phases volatility dominates the negative coefficient of between-phases volatility. As for the regression equation (3) for EU-27, where both coefficients are positive, the result coincides with the one in equation (1), where the coefficient of total volatility is positive.

4. The relationship between innovation and its volatility for the EU and CEEC countries

Based on the data of the European Innovation Scoreboard (EIS), regressions of the SII growth rate were estimated on its own total volatility, as well as on the "split" volatilities (both of the SII growth rate, and of the GDP growth rate) for the EU and CEEC countries, using the methodology described in sections 1 and 2.
i) Regressions of the SII index on its own total volatility
Based on the methodology described in section1 (for GDP), regression equations were estimated for the growth rate of the SII innovation index.
Unfortunately, we were able to obtain data on SII for all EU countries only for the period 2003-2009, which means that, for the growth rates, we only have five data. Because of the shortness of the data series, the results of estimations referring to this index are questionable.

The corresponding regression equations are:

$$\bar{s}_i = -0.019 + 0.647 v_i \qquad (5)$$

with $R^2 = 0.64$, for the EU 27 countries, and

$$\bar{s}_i = 0.017 + 0.379 v_i \qquad (6)$$

with $R^2 = 0.52$, for the CEEC countries.

For both samples, these equations indicate a positive relation between the SII growth rate and its volatility.

ii) Regressions of the SII index on its "split" volatility

Based on the methodology described in section 2 (for GDP), we estimated regression equations of the growth rate of the SII innovation index on its within-and between-phases volatilities.

Comparing the total volatilities of the innovation growth rate with the split volatilities, we note that the within-phases aggregated volatility is 12% of the aggregated total volatility, whereas the between-phases volatility is 88%, for the UE 27 countries. For CEEC, the aggregated within-phases volatility is 11% of the aggregated total volatility, whereas the aggregated between-phases volatility represents 89%. The following conclusions can be drawn:

- the behavior of the CEEC is similar to the general behavior of the EU-27 ;
- the largest part of the aggregated total volatility of the innovation rate is represented by the aggregated between-phases volatility.

The corresponding regression equations are:

$$\bar{s}_i = -0.018 + 0.401 v_{iw} + 0.504 v_{ib} \qquad (7)$$

with $R^2 = 0.52$, for the EU 27 countries,

and

$$\bar{s}_i = 0.015 + 0.771 v_{iw} - 0.575 v_{ib} \qquad (8)$$

with $R^2 = 0.88$, for the CEEC countries.

Both regression equations indicate partial positive correlations between the innovations average growth rate and its within-phases volatility. A partial positive correlation is noted, although, between the innovation average growth rate and its between-phases volatility for the EU 27 countries (in the regression equation (7)) and a partial negative correlation between the innovation average growth rate and its between-phases volatility for the CEEC countries (in the regression equation (8)).

iii) Regressions of the SII growth rate on the split volatility of the GDP growth rate

The corresponding regression equation is:

$$\bar{s}_i = -0.017 \quad - 0.006 \sigma_{iw} + 0.010 \sigma_{ib} \qquad (9)$$

for the EU 27 countries, and

$$\overline{s}_i = 0.027 \quad + 0.016\sigma_{iw} - 0.001\sigma_{ib} \qquad (10)$$

for the CEEC countries.

In the regression equations (9) and (10), the coefficients referring to the volatilities of the GDP growth rate are not significant, unlike in the equations (7) and (8), where the coefficients of volatilities (of the innovation growth rate) are significant. We can conclude that the volatility of the GDP growth rate does not influence the innovation growth rate.

5. The relationship between the GDP growth rate, innovation and volatility for the EU and CEEC countries

In what follows, multiple regressions of the GDP growth rate are estimated, based on the innovation rate and on the split volatilities of the GDP growth rate.

The corresponding regression equation is:

$$\overline{g}_i = 2.380 \quad + 46.848\overline{s}_i - 1.421\sigma_{iw} + 0.242\sigma_{ib} \qquad (11)$$

for the EU 27 countries, and

$$\overline{g}_i = 1.394 \quad + 46.227\overline{s}_i - 1.754\sigma_{iw} + 0.469\sigma_{ib} \qquad (12)$$

for the CEEC countries.

The analysis of equations (11) and (12) reveals a great similarity between the behaviors of the countries in the two samples (EU 27 and CEEC).

Thus,

a) there is a positive and significant partial correlation between the GDP growth rate and the SII growth rate;

b) there is a positive and significant partial correlation between the GDP growth rate and its between-phases volatility, and a negative and significant partial correlation between the GDP growth rate and its within-phases volatility.

6. Conclusions

The present study applies, along general lines, the methodology used in *Ramey&Ramey (1995)*, and *Kroft, Lloyd-Ellis (2002)*, respectively, to analyze the dependencies between growth, volatility and innovation in the case of the EU-27 and CEEC (new member states from Central and Eastern Europe) countries, respectively. Unlike the above-mentioned papers, which use human capital as proxy for innovation, we use as indicator of innovation the Summary Innovation Index(SII), proposed by the European Innovation Scoreboard (EIS). Using the EVIEWS econometric software, we estimated regressions of the GDP growth rate on its total volatility, as well as on its partial volatilities, split with respect to the phases of the economic cycle. We also estimated regressions of the innovation rate on the GDP growth rate volatilities, as well as regressions of the GDP growth rate on the rate of innovation and the split volatility of the GDP growth rate.

We found positive dependencies of the GDP growth rate on its own volatility, as well as on the innovation rate. The positive dependence of GDP growth rate on its own total volatility may seem counterintuitive, but it is in accordance with the findings in *Komendi and Meguire (1985), Grier and Tullock (1989), Ramey&Ramey (1995)* (for the OECD sample), etc. Further analysis would be useful to explain this kind of dependence. We also have explored in more detail the empirical cross-country relationship between average growth and fluctuations in growth rates. In particular, using the methodology developed in *Kroft, Lloyd-Ellis (2002)*, we distinguished between fluctuations that may be interpreted as year—to—year uncertainty (within-phases volatility) and fluctuations that reflect structural business cycle shifts between recessions and expansions(between-phases volatility).Overall, we found a significant positive correlation between growth and short—term, year—to year fluctuations. As concerns the correlation between growth and medium—term business—cycle fluctuations, we found that it is significant and positive for EU27, but negative (and significant) for CEEC. We also considered the possibility that innovation may act as a conduit in the relationships between volatility and growth. We found no systematic correlation between the innovation rate and the two measures of GDP volatility. On the other hand, the multiple regressions in section 5 exhibit a positive and significant partial correlation between the GDP growth rate and the innovation growth rate, alongside with a positive and significant partial correlation between the GDP growth rate and its between-phases volatility, and a negative and significant partial correlation between the GDP growth rate and its within-phases volatility, for both samples. The reason why we singled out the group of the 10 new member states within the 27 EU countries was to find out whether their specific historical background involves major behavioral differences with respect to the group of more developed EU countries.

We found no such major differences; the simple regressions in section 2 are similar for both samples, not only regarding the signs, but also the absolute values of the coefficients. The same conclusion holds for the multiple regressions in section 5.

The only notable difference appears in the multiple regressions in section 3: as we mentioned above, we found that the correlation between growth and medium—term business—cycle fluctuations is significant and positive for EU27, but negative (and significant) for CEEC. The reason for this difference can be that the present recession affected more severely the new member states.

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