The effect of economic crisis upon convergence and cohesion in the European Union

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Abstract

In the summer of 2007 the U.S. economy began to deteriorate, once the Lehman Brothers episode unraveled, despite numerous government interventions, U.S.A. and the European Union entered the recession. This study uses Markov chains to study the effects of the global economic crisis on European Union member states, taking into account the aspect of convergence. The first stage of the analysis is based on the indicator GDP/capita and we came to the conclusion that it cannot provide a comprehensive understanding of the crisis. This led to extending the analysis by including the following terms: Corruption Perceptions Index, Index of Economic Freedom, the government's external debt and FDI. Results of the analysis showed that the real growth was higher than the estimates made. Markov chain analysis also proved to be effective in revealing the trend of probability of belonging to groups meaning it can estimate a good trend for considered variables. European economic convergence has suffered from the economic crisis especially in financial terms.

Keywords: Markov chain analysis; convergence; cohesion; economic crisis;

1. Introduction

In the economic literature, the term convergence (and his antonym, divergence) has a common use and occupies a central role in describing the evolution of various systems or economic entities, in relation to the medium or the more successful entities. The study of convergence describes the way in which various factors and economic, social and political mechanisms act or compete for the diminishing of differences or delays between these entities. The study of convergence represents the attempt of leveling the economic, social, monetary, financial and performance
indicators, the assurance of reducing the gaps between the levels of development, the assurance of monetary and
financial stability in all countries, as well as reducing the gap or reaching a level of compatibility between
institutional and administrative structures and mechanisms of different countries/regions.

Since its first steps the European Union has been faced with gaps of convergence. These differences have
widened considerably in the context of the global economic crisis, leading to dramatic ruptures regarding the
development of real economy (GDP per capita and other level indicators) between developed and emerging
countries. Since currently there are a variety of approaches and studies of cohesion and a high diversity of
computational methodologies, we aim to present this introductory material regarding cohesion within the UE using
Markov chains.

2. Markov Chains

In mathematics, a Markov process or a Markov chain is a stochastic process which has the property that, given its
present state, future states are independent of the past. The current status of such a process holds all information
about the whole evolution process.

A Markov chain is a multistage experiment consisting of a sequence of trials in which the state, or outcome, of
each trial depends on the state of the trial that immediately precedes it. The goal in a typical problem involving
Markov chain is to compute the probability that the system will be in a particular state at a specified time.

A finite Markov chain is a process which moves among the elements of a finite set \( \Omega \) in the following manner:
when at \( x \in \Omega \), the next position is chosen according to a fixed probability distribution \( P(x, \cdot) \). A discrete time
process \( \{X_n, n = 0, 1, 2, \ldots \} \) with discrete state space \( X_n \in \{0, 1, 2, \ldots \} \) is a Markov chain if it has the Markov
property:
\[
P[X_{n+1} = j | X_n = i, X_{n-1} = i_{n-1}, \ldots, X_0 = i_0] = P[X_{n+1} = j | X_n = i].
\] (1)

Equation (1), often called the Markov property, means that the conditional probability of transition from state \( i \)
to state \( j \) is the same, no matter what sequence \( x_0, x_1, \ldots, x_{t-1} \) of states precedes the current state \( x \). This is exactly why the
\( |\Omega| \times |\Omega| \) matrix \( P \) suffices to describe the transitions.
The Markov property is common in probability models because, by assumption, one supposes that the important
variables for the system being modeled are all included in the state space.

We consider homogeneous Markov chains for which:
\[
P[X_{n+1} = j | X_n = i] = P[X_1 = j | X_0 = i].
\] (2)

We define
\[
P_{ji} = P \{X_{n+1} = j | X_n = x\}
\] (3)

Let \( P = [P_{ij}] \) denote the (possibly infinite) transition matrix of the one-step transition probabilities. Let
\[
P^n = \sum_{k} P_{ik} P_{kj}
\]
be the operator of standard matrix multiplication. Then we expand the analysis via the Markov
property (1):
\[
P^n_{ij} = \sum_{k} P[X_{n+1} = k | X_n = i] P[X_{n+2} = j | X_{n+1} = k] = \sum_{k} P[X_{n+2} = j, X_{n+1} = k | X_n = i]
\]
\[
= P \{U \{X_{n+2} = j, X_{n+1} = k \} | X_n = i\} = P[X_{n+2} = j | X_n = i]
\] (4)

Generalizing this calculation:
The matrix power \( P^n \) gives the n-step transition probabilities.

Classification of states:
State \( j \) is accessible from \( i \) if \( P^n_{ij} > 0 \) for some \( k \geq 0 \). The transition matrix can be represented as a directed graph
with arrows corresponding to positive one-step transition probabilities \( j \) is accessible from \( i \) if there is a path from \( i \)
to \( j \).
For example:

![Directed graph illustrating a transition phase Markov chains](image)

Figure 1. Directed graph illustrating a transition phase Markov chains


I and j communicate if they are accessible from each other. This is written \( i \leftrightarrow j \), and is an equivalence relation, meaning that:

- \( i \leftrightarrow i \) [reflexivity]
- If \( i \leftrightarrow j \) then \( j \leftrightarrow i \) [symmetry]
- If \( i \leftrightarrow j \) and \( j \leftrightarrow k \) then \( i \leftrightarrow k \) [transitivity].

3. World Economic Crisis in the European Union based on GDP/capita using Markov Chains

In the first phase we analysed GDP/capita in EU27 1995-2007. The final transition matrix (1995-2007) is shown in the following table. There were used a number of eight intervals, calculated using the Sturges formula \( k = \frac{x_{\text{max}} - x_{\text{min}}}{1 + 3.322 \log N} \).

<table>
<thead>
<tr>
<th>Year/Group</th>
<th>Group</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
<th>G6</th>
<th>G7</th>
<th>G8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>G1</td>
<td>115</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>G2</td>
<td>1</td>
<td>63</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>G3</td>
<td></td>
<td>82</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>G4</td>
<td></td>
<td>28</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>G5</td>
<td></td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>G6</td>
<td></td>
<td>3</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>G7</td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>G8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>2007</td>
<td>116</td>
<td>70</td>
<td>88</td>
<td>36</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>324</td>
</tr>
<tr>
<td>2008</td>
<td>35.802</td>
<td>21.605</td>
<td>27.16049</td>
<td>11.111111</td>
<td>1.851852</td>
<td>1.234568</td>
<td>0.617284</td>
<td>0.617284</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>34.057</td>
<td>21.499</td>
<td>26.59808</td>
<td>12.45011</td>
<td>2.464158</td>
<td>1.388889</td>
<td>0.617284</td>
<td>0.925926</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>32.41</td>
<td>21.303</td>
<td>26.07655</td>
<td>13.60953</td>
<td>3.052967</td>
<td>1.657706</td>
<td>0.658586</td>
<td>1.234568</td>
<td></td>
</tr>
</tbody>
</table>

To fully understand the broad effects of the economic crisis on European convergence and cohesion we compared real data with predictions made with the help of Markov chains for 2008 and 2009.

We can observe that in figure 2, EU27 real group affiliation is dramatically different from the predicted one. For example, using Markov chains prediction we can state that 34% of the EU countries, those that belong in G1, have a GDP/capita between [800-10450] euros, whereas in reality only 14.8% belong there. These differences continue to
manifest in all the groups, showing how hard it can be to predict during a crisis and how it can affect convergence between EU members.

Figure 2. Comparison for year 2008 between real and predicted percentages

![Figure 2](image1)

Figure 3. Comparison for year 2009 between real and predicted percentages

![Figure 3](image2)

In 2009 (Figure 3) differences begin to fade between the predicted percentages and the real one. There are massive migrations from one group to another, from 2008 to 2009. Perhaps most relevant to the crisis is the percentage of G1 (2008) = 14.81% compared to G1 (2009) = 32.4%. The number of countries belonging to Group 1 doubled, in perhaps the most difficult year of the crisis, showing major decline in GDP/capita.

The second stage of our analysis was performed for the interval 1995-2010, based on GDP/capita in the EU27. The same number of groups and frequency were used. If in the first phase we analyzed 2008 and 2009 as the early stages of crisis, we continued by showing the differences between predictions and reality in recent years, namely 2011, 2012.
It should be noted that in the graph for 2011 there is a similar trend across groups. There still are differences between predictions and reality, but the predictions for EU27 in 2012 show a relatively evenly distributed number of countries in the first four groups.

Given the major differences between actual and forecast data we continued our analysis with other indicators relevant to the effects of the crisis on economic convergence and cohesion. These new indicators were studied for the 2000-2010 interval.

4. Markov analysis based on the Corruption Perceptions Index

The first variable considered is the corruption perception index. The CPI index is a ranking of countries according to the extent to which corruption is believed to exist. It shows the level of transparency and it’s generally sensitive to economic changes, domestic or global.

Although the trend is similar, in Figure 6, we can see that the values suffer changes in the first years of crisis. Imbalance led to countries transitioning into lower groups with lower index values. This indicates a potent and growing presence of corruption in the European Union.

Tables 5 and 6 indicates a problem in terms of corruption today. Although one would expect a constant evolution based on predictions, corruption levels continue to fluctuate, increasing divergences between states.
Table 5. Predicted percentages for CPI 2011, 2012

<table>
<thead>
<tr>
<th></th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
<th>G6</th>
<th>G7</th>
<th>G8</th>
</tr>
</thead>
</table>

Table 6. Real percentages for CPI 2011, 2012

<table>
<thead>
<tr>
<th></th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
<th>G6</th>
<th>G7</th>
<th>G8</th>
</tr>
</thead>
</table>

5. Markov Analysis based on the Economic Freedom Index

The link between economic freedom and prosperity is obvious when it comes to the Economic Freedom Index. In the first years of this study (Table 7), the evolution of EFI had a similar trend in both the case of the predictions and the real percentages. Groups 4, 5 and 6 contain most of the states with an aggregate percentage of 62-68%. For this indicator we can say that the notion of European convergence and cohesion is a fact. In 2011, 2012 (Table 8) we can see a trend similarity between predicted and actual percentages but also there is a smooth transition occurring towards higher groups.

Table 7. Predicted and real percentages for Economic Freedom Index 2008, 2009

<table>
<thead>
<tr>
<th></th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
<th>G6</th>
<th>G7</th>
<th>G8</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>1.6931</td>
<td>0.6878</td>
<td>12</td>
<td>19.531</td>
<td>22.505</td>
<td>21.628</td>
<td>12.971</td>
<td>8.9855</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
<th>G6</th>
<th>G7</th>
<th>G8</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>0</td>
<td>0</td>
<td>7.4074</td>
<td>22.222</td>
<td>18.519</td>
<td>25.926</td>
<td>14.815</td>
<td>11.111</td>
</tr>
</tbody>
</table>

Table 8. Predicted and real percentages for Economic Freedom Index 2011, 2012

<table>
<thead>
<tr>
<th></th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
<th>G6</th>
<th>G7</th>
<th>G8</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0.9481</td>
<td>0.3574</td>
<td>7.407</td>
<td>21.049</td>
<td>18.984</td>
<td>26.859</td>
<td>15.767</td>
<td>8.6285</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
<th>G6</th>
<th>G7</th>
<th>G8</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>0</td>
<td>0</td>
<td>7.4074</td>
<td>22.222</td>
<td>11.111</td>
<td>33.333</td>
<td>18.519</td>
<td>7.4074</td>
</tr>
<tr>
<td>2012</td>
<td>0</td>
<td>3.7037</td>
<td>3.7037</td>
<td>22.222</td>
<td>22.222</td>
<td>33.333</td>
<td>11.111</td>
<td>3.7037</td>
</tr>
</tbody>
</table>
6. Markov analysis based on government gross external debt

In the current economic situation, external debt as a percentage of GDP can be of extreme relevance in decomposing effects of the crisis on economic convergence. In Figure 7 we clearly see the effectiveness of Markov chains in appreciating the evolution of a trend. As with other indicators actual percentages exceed those predicted but the trend is correct. From an economic point of view, real data shows evidence of states migrating in superior groups with larger external debt. This has contributed to the economic downturn by increasing government debt. In 2011 there is a shift from G5 to G6, which shows that countries with considerable debt have increased it even further.

Figure 7. Comparison for the year 2008, 2009 between real and predicted percentages of External Debt

7. Markov analysis based of Foreign Direct Investments

This index is the basis for many states, especially European ones, coming out of the crisis or maintaining stability. FDI are defined as being the net entry investments of a foreign entity in the economy of the respective country. In this study FDI have been expressed as a percentage in relation to the GDP. The values start from -10%, which represent higher exits than entries in investments, and can reach up to an amazing 172% in the case of Luxemburg. Regarding the probabilities which give its group, the estimated ones show the same trend as the real ones, with a higher real concentration in the group with the lowest FDI level. The situation is the same for 2011.

Table 9. Predicted and real percentages for Gross External Debt in 2011

<table>
<thead>
<tr>
<th>Predicted percentages</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
<th>G6</th>
<th>G7</th>
<th>G8</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Real percentages</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
<th>G6</th>
<th>G7</th>
<th>G8</th>
</tr>
</thead>
</table>

Table 10. Predicted and real percentages for FDI in 2008, 2009

<table>
<thead>
<tr>
<th>Predicted percentage</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
<th>G6</th>
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</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>84.43</td>
<td>12.773</td>
<td>0</td>
<td>1.159</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.5795</td>
</tr>
<tr>
<td>2009</td>
<td>82.818</td>
<td>13.14</td>
<td>0</td>
<td>1.2165</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.6083</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Real percentages</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
<th>G6</th>
<th>G7</th>
<th>G8</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>85.185</td>
<td>3.7037</td>
<td>7.4074</td>
<td>0</td>
<td>3.7037</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2009</td>
<td>92.593</td>
<td>7.4074</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
8. Conclusions

This paper has highlighted the effect of the economic crisis on EU27, in the context of economic convergence and cohesion. One of the objectives was a review of convergence in terms of GDP/capita. Another objective was to show the limited capacity when it comes to measuring discrepancies between EU member states. Preliminary results have shown that the analysis based on GDP/capita is not sufficient so other indicators were included in this analysis.

With all the indicators it has been observed that the analysis with the help of Markov chains is reliable with regards to the trend identification, but incapable to give a clear estimate of group affiliation. Furthermore, with all the factors considered we can still notice the active existence of the crisis effects which contribute to the continuous increase in divergence between the EU27 states.

A positive surprise is the economic freedom index showing a concentration of values, which implies a stronger convergence in this area and also, we can see that it was minimally affected by the crisis. It should however be noted that no relevant conclusions can be drawn about convergence policy in EU. For this and for explaining the present crisis, the analysis should be developed to include more variables in a broader econometric analysis.

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