Spatial Econometric Analysis of Inflation Convergence

Mehmet Özmen, Fatma İdil Baktemur
Cukurova University
mozmen@cu.edu.tr

In the study, it has been aimed to estimate CPI inflation convergence between the periods of 1992-2013 among European countries with spatial econometric models. Conducted analyses show the existence of spatial interaction.

Keywords: Inflation, CPI, Convergence, Spatial Econometrics

Introduction

The issue of inflation convergence has become an important topic in both domestic and international macroeconomics. Inflation convergence in a group of similar countries indicates the integration of goods markets. In integrated markets, inflation rates generally exhibit convergence in the long run. (Anoruo and Murthy, 2014, pp. 1)

Rogers et al (2001) present direct evidence on price level convergence in Europe, using a unique data set. They then investigate how much of the recent differences in national inflation rates in the euro area can be explained by faster rising prices in the low-cost euro countries. Between 1990 and 1999, prices became less dispersed in the euro area. Convergence was especially evident for traded goods, more in the first half of the 1990s than the second half. For tradables, price dispersion in the euro area has fallen into the range found in the United States. While price level convergence contributed to observed inflation differences within the euro area, other forces explain most of the current cross-country differences in euro area inflation.

Busetti et al (2006) study the convergence properties of inflation rates among the countries of the European Monetary Union over the period 1980-2004. They split the sample into two parts, before and after the birth of the euro. They study convergence in the first sub-sample by means of univariate and multivariate unit root tests on inflation differentials, arguing that the power of the tests is considerably increased if the Dickey-Fuller regressions are run without an intercept term. Overall, they are able to accept the convergence hypothesis over the period 1980-1997. They then investigate whether the second sub-sample is characterized by stable inflation rates across the European countries. Using stationarity tests on inflation differentials, they find evidence of diverging behaviour. In particular, they can statistically detect two separate clusters, or convergence clubs: a lower inflation group that comprises Germany, France, Belgium, Austria, Finland and a higher inflation one with Spain, Netherlands, Greece, Portugal and Ireland. Italy appears to form a cluster of its own, standing in between the other two.
Egert (2007) provides a comprehensive review of the factors that can cause price levels to diverge and which are at the root of different inflation rates in Europe including the EU-27. Their estimation results provide the obituary notice for the Balassa-Samuelson effect. Nevertheless, they show that other factors related to economic convergence may push up inflation rates in transition economies. Cyclical effects and regulated prices are found to be important drivers of inflation rates in an enlarged Europe. House prices matter to some extent in the euro area, whereas the exchange rate plays a prominent (but declining) role in transition economies.

The aim of the study of Tunay and Silpagar (2007) is to analyse inflation convergence phenomenon across different geographical regions in Turkey. Also, another aim is to estimate the speed of inflation convergence and the importance of dispersion or spill-over effect among regions. The empirical findings point out the existence of a serious inflation convergence phenomenon and rather fast convergence process among different geographical regions.

In the study of Spiru (2008) the degree of convergence of inflation rates of Central and East European economies to a variety of measures of European norm inflation is assessed using a range of econometric techniques. The results suggest that while convergence can be revealed in a number of cases, there is some sensitivity associated with the testing framework, in particular whether time series or panel methods are used. Furthermore, the inflation convergence performance of the Central and Eastern European countries is conditional on the chosen inflation benchmark, the composition of the panel and the correlations among members. Moreover, by conducting a battery of linearity tests, it is found that nonlinear inflation convergence is virtually ubiquitous for the period that includes the accession of the Central and Eastern European former transition economies into the EU.

Lopez and Papell (2011) study the behavior of inflation rates among the 12 initial Euro countries in order to test whether and when the group convergence initially dictated by the Maastricht treaty and now by the ECB, occurs. They find strong and lasting evidence of convergence among the inflation rates soon after the implementation of the Maastricht treaty and a dramatic decrease in the persistence of the differential after the occurrence of the single currency.

Yesilyurt (2014) investigates the convergence of the regional inflation rates for Turkey at NUTS 2 level over the period of 2004:1 to 2011:12. She used pair-wise approach to examine the regional inflation convergence. The results reveals that in the case of structural break there is a strong convergence among the regions of Turkey.

Anoruo and Murthy (2014) use nonlinear unit root testing procedures to examine the issue of inflation convergence for the Central African Economic and Monetary Community (CEMAC) member states including Cameroon, Central African Republic, Chad, Equatorial Guinea, Gabon and the Republic of Congo. The results from nonlinear STAR unit root tests suggest that inflation differentials for the sample countries are nonlinear and mean reverting processes. These results provide evidence of inflation convergence among countries within CEMAC. The finding of inflation convergence indicates the feasibility of a common monetary policy and/or inflation targeting regime within CEMAC.

Method

In recent years, the spatial econometrics literature has exhibited a growing interest in the specification and estimation of econometric relationships based on spatial panels. Spatial panels typically refer to data containing time series observations of a number of spatial units (zip codes, municipalities, regions, states, jurisdictions, countries, etc.). This interest can be explained by the fact that panel data offer researchers extended modeling possibilities as
compared to the single equation cross-sectional setting, which was the primary focus of the spatial econometrics literature for a long time. Panel data are generally more informative, and they contain more variation and less collinearity among the variables. The use of panel data results in a greater availability of degrees of freedom, and hence increases efficiency in the estimation. Panel data also allow for the specification of more complicated behavioral hypotheses, including effects that cannot be addressed using pure cross-sectional data. (Elhorst, 2010, pp. 377)

**Fixed Effects Spatial Error and Lag Model**

The log likelihood function of spatially correlated error model is below. (Elhorst, 2003, pp. 249-250)

\[
-\frac{NT}{2} \ln(2\pi\sigma^2) + \frac{1}{2\sigma^2} \sum_{i=1}^{N} (Y_i - \hat{Y}_i) = \frac{1}{2\sigma^2} \sum_{i=1}^{T} e_i' e_i = (I - \delta W)(Y_i - \hat{Y}_i - (X_i - \bar{X})\beta)
\]

With a spatially lagged dependent variable

\[
-\frac{NT}{2} \ln(2\pi\sigma^2) + \frac{1}{2\sigma^2} \sum_{i=1}^{N} (Y_i - \hat{Y}_i) = \frac{1}{2\sigma^2} \sum_{i=1}^{T} e_i' e_i = (I - \delta W)(Y_i - \hat{Y}_i - (X_i - \bar{X})\beta)
\]

**Random Effects Spatial Error and Lag Model**

Random Effects Spatial Error: (Elhorst, 2003, pp. 251-256)

The log likelihood function is

\[
\log L = \frac{-NT}{2} \ln(2\pi\sigma^2) - \frac{1}{2\sigma^2} \sum_{i=1}^{N} \sum_{j=1}^{T} (y_i - \hat{y}_i)'(1 - \delta\vartheta_i)^2 + T\sum_{i=1}^{N} \ln(1 - \delta\vartheta_i) - \frac{T}{2\sigma^2} \sum_{i=1}^{T} e_i' e_i + \beta Y_i = (I_N - \delta W)Y_i - (P - (I_N - \delta W))\bar{Y}
\]

\[
X_i^* = (I_N - \delta W)X_i - (P - (I_N - \delta W))\bar{X}
\]

\[
\beta \text{ and } \sigma^2 \text{ can be solved from their first order maximizing conditions:}
\]

\[
\hat{\beta} = (x' x^*)^{-1} (x' y^*)
\]

\[
\hat{\sigma}^2 = \frac{\sum_{i=1}^{T} e_i' e_i}{NT}
\]

\[
x^* = \left[ \begin{array}{c}
X_i^* \\
X_i^*
\end{array} \right],
\]

\[
y^* = \left[ \begin{array}{c}
Y_i^* \\
Y_i^*
\end{array} \right]
\]
Upon substituting these values in the log likelihood function, the concentrated log likelihood function of $\delta$ and $\theta^2$ is obtained:

$$
\log L = C - \frac{NT}{2} \log(\sum_{i=1}^{T} e_i') - \frac{1}{2} \sum_{i=1}^{N} \log(1 + \theta^2 (1 - \delta \omega_i)^2) \\
+ T \sum_{i=1}^{N} \log(1 - \delta \omega_i) \\
C = -NT/2x\log(2\pi) - NT/2 + NT/2x\log(NT)
$$

Random Effects Spatial Lag Model: (Elhorst, 2003, pp. 251-256)

The log likelihood function is

$$
\log L = -\frac{NT}{2} \log(2\pi\sigma^2) + \frac{N}{2} \log \theta^2 + T \sum_{i=1}^{N} \log(1 - \delta \omega_i) - \frac{1}{2\sigma^2} \sum_{i=1}^{N} e_i'^{*} e_i^*
$$

where $e_i^* = Y_i - X_i^* \beta$ 

\[ Y_i^* = (I_N - \delta W)Y_i - (1 - \theta)X_i \]

$\beta$ and $\sigma^2$ can be solved from their first order maximizing conditions:

$$
\hat{\beta} = (x^* x^*)^{-1} (x^* y^*) \\
\hat{\sigma}^2 = \frac{\sum_{i=1}^{T} e_i'^{*} e_i^*}{NT}
$$

$X^*$

\[
\begin{bmatrix}
X_{i1}^* \\
\vdots \\
X_{iT}^*
\end{bmatrix}
\]

$Y^*$

\[
\begin{bmatrix}
Y_{i1}^* \\
\vdots \\
Y_{iT}^*
\end{bmatrix}
\]

Upon substituting these values in the log likelihood function, the concentrated log likelihood function of $\delta$ and $\theta^2$ is obtained:

$$
\log L = C - \frac{NT}{2} \log(\sum_{i=1}^{T} e_i') + \frac{N}{2} \log \theta^2 + T \sum_{i=1}^{N} \log(1 - \delta \omega_i) \\
C = -NT/2x\log(2\pi) - NT/2 + NT/2x\log(NT)
$$

**Empirical Estimation**

In the study, it has been aimed to estimate inflation convergence between the periods of 1992-2013 among founder European countries with spatial econometric models. Model is represented below:

$$
\Delta \pi_{ij} = \mu_i + \beta \pi_{ij} + \phi \Delta \pi_{i,j-1} + \rho W \Delta \pi_{ij}^* + \epsilon_{ij}
$$

In the equation; $\Delta \pi_{ij}$ represents first difference of inflation, $\Delta$ represents difference operator, $\rho W \Delta \pi_{ij}^*$ represents spatial lags of inflation, $W$ represents spatial weight matrix, $\beta \pi_{ij}$
represents inflation of current period, \( \Delta \pi_{t-1} \) represents first difference of inflation in the previous period and \( \varepsilon_{it} \) represents error term. In the model, \( \mu, \beta, \phi, \rho \) are coefficients and have special meanings in the sense of convergence analysis. The coefficient of \( \beta \) measures speed of convergence and it is known in the literature as \( \beta \) convergence coefficient. The coefficient of \( \phi \) measures the effect of inflation in the previous period. The coefficient of \( \rho \) measures spillover effects (the effect of inflation of neighboring regions to the inflation of related region).

Spatial weight matrix is created in two ways. In the first type, it is created by dividing weights equally among each units neighbors. So the sum of weights in each row is equal to one. The countries are Germany, Belgium, Netherlands, Luxemburg, France and Italy, respectively.

\[
W_1 = 
\begin{bmatrix}
0 & 0.25 & 0.25 & 0.25 & 0.25 & 0 \\
0.25 & 0 & 0.25 & 0.25 & 0.25 & 0 \\
0.5 & 0.5 & 0 & 0 & 0 & 0 \\
0.33 & 0.33 & 0 & 0 & 0.33 & 0 \\
0.25 & 0.25 & 0 & 0.25 & 0 & 0.25 \\
0 & 0 & 0 & 0 & 1 & 0
\end{bmatrix}
\]

Table 1
Hausman Test

<table>
<thead>
<tr>
<th>Model</th>
<th>Probability Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAR</td>
<td>0.2730</td>
</tr>
</tbody>
</table>

Stata 12.0 is used.

The Hausman test says that the appropriate model is random effects.

Table 2
Estimation of The Model With the First Matrix Type

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>z statistics</th>
<th>probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \hat{\mu} )</td>
<td>-.9927651</td>
<td>.1499158</td>
<td>-6.62</td>
<td>0.000</td>
</tr>
<tr>
<td>( \hat{\beta} )</td>
<td>.4623912</td>
<td>.064619</td>
<td>7.16</td>
<td>0.000</td>
</tr>
<tr>
<td>( \hat{\phi} )</td>
<td>-.2816644</td>
<td>.0554615</td>
<td>-5.08</td>
<td>0.000</td>
</tr>
<tr>
<td>( \hat{\rho} )</td>
<td>.4832005</td>
<td>.0602728</td>
<td>8.02</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Number of observations: 132
Number of groups: 6
Number of observations in groups: 22
Log Likelihood: -135.8176

Stata 12.0 is used.

The lagged value of inflation is found statistically significant. Because of its negative value, it can be said that the effect of previous inflation increase rate is negative on current inflation.
increase rate or negative interaction between each other. The coefficient value of spatial explanatory variable is positive and significant, and this shows that current inflation is positively related with neighboring regions. Inflation increase rate in each region is affected by its first degree neighbors at a %48 rate. The speed of convergence from one region to another is %46.

The second matrix type is obtained by putting the value of most neighborly relations of equal weights except 0.

\[
W_2 = \begin{bmatrix}
0 & 0.25 & 0.25 & 0.25 & 0.25 & 0 \\
0.25 & 0 & 0.25 & 0.25 & 0.25 & 0 \\
0.25 & 0.25 & 0 & 0 & 0 & 0 \\
0.25 & 0.25 & 0 & 0 & 0.25 & 0 \\
0.25 & 0.25 & 0 & 0.25 & 0 & 0.25 \\
0 & 0 & 0 & 0 & 0.25 & 0
\end{bmatrix}
\]

Table 3
Hausman Test

<table>
<thead>
<tr>
<th>Model</th>
<th>Probability Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAR</td>
<td>0.2243</td>
</tr>
</tbody>
</table>

Stata 12.0 is used.

The Hausman test says that the appropriate model is random effects.

Table 4
Estimation of The Model With the Second Matrix Type

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>z statistics</th>
<th>probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \hat{\mu} )</td>
<td>-1.035233</td>
<td>.1547652</td>
<td>-6.69</td>
<td>0.000</td>
</tr>
<tr>
<td>( \hat{\beta} )</td>
<td>.479934</td>
<td>.0667756</td>
<td>7.19</td>
<td>0.000</td>
</tr>
<tr>
<td>( \hat{\phi} )</td>
<td>-.3070941</td>
<td>.0567562</td>
<td>-5.41</td>
<td>0.000</td>
</tr>
<tr>
<td>( \hat{\rho} )</td>
<td>.5542923</td>
<td>.076528</td>
<td>7.24</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Number of observations: 132
Number of groups: 6
Number of observations in groups: 22
Log Likelihood: -139.4087

Stata 12.0 is used.

The lagged value of inflation is found statistically significant. Because of its negative value, it can be said that the effect of previous inflation increase rate is negative on current inflation increase rate or negative interaction between each other. The coefficient value of spatial explanatory variable is positive and significant, and this shows that current inflation is positively related with neighboring regions. Inflation increase rate in each region is affected by its first degree neighbors at a %55 rate. The speed of convergence from one region to another is %48.
Conclusion

In the study, it has been aimed to estimate inflation convergence between the periods of 1992-2013 among founder European countries with spatial econometric models. Spatial weight matrix is created in two ways. In the first type, it is created by dividing weights equally among each units neighbors. So the sum of weights in each row is equal to one. The lagged value of inflation is found statistically significant. Because of its negative value, it can be said that the effect of previous inflation increase rate is negative on current inflation increase rate or negative interaction between each other. The coefficient value of spatial explanatory variable is positive and significant, and this shows that current inflation is positively related with neighboring regions. Inflation increase rate in each region is affected by its first degree neighbors at a %48 rate. The speed of convergence from one region to another is %46.

The second matrix type is obtained by putting the value of most neighborly relations of equal weights except 0. The lagged value of inflation is found statistically significant. Because of its negative value, it can be said that the effect of previous inflation increase rate is negative on current inflation increase rate or negative interaction between each other. The coefficient value of spatial explanatory variable is positive and significant, and this shows that current inflation is positively related with neighboring regions. Inflation increase rate in each region is affected by its first degree neighbors at a %55 rate. The speed of convergence from one region to another is %48.

The more capital, labor and goods markets mobilize, the more interest, wage and price differences decrease. Convergence is expected in this situation. Our results show strong convergence and spatial relation. This holds with Tunay and Silpagar (spatial econometrics) study.

References


