

# Analysing Economic Growth Using Panel Data and Markov Chains

Guido Pellegrini

*Department of Statistics, University of Bologna*

*Via Belle Arti, 41*

*40126 Bologna, Italy*

*pellegrini@stat.unibo.it*

## 1. Empirical techniques for the analysis of regional economic growth

The statistical models for the analysis of economic development have received new attention in the last years, due to the blooming of studies about economic growth. Up to now, the state of application of statistical models for the analysis of regional economic development is not completely satisfactory. One of the reasons is the lack of an analysis of the development distribution dynamics. Actually, the neo-classical approach forecasts convergence among areas, and therefore excludes the presence of mechanisms of polarizations, stratifications and clusters of areas with similar patterns of growth. (Quah, 1997). These aspects of growth require methodological instruments that allow to analyse the distribution dynamics of development among areas. Recently, Quah (1993, 1997) and others (Magrini, 1996, Fingleton, 1998) proposed a new methodological approach based on non parametric analysis and the application of Markov chains. This paper provides an empirical analysis of the development of Italian sub-regional areas over the period 1952-1995, using the Markov chains approach. The emphasis is on the existence of convergence and/or divergence processes among areas. The analysis is based on the updating of a newly compiled database on the gross product and population of Italian provinces (corresponding to the NUTS 3 level in the official UE classification), described in Fabiani and Pellegrini (1997).

## 2. Markov chains and regional economic growth

If the cross-sectional distribution of provincial output per capita is discretised into a finite number  $n$  of classes, it is possible to construct a  $n \times n$  transition matrix  $P$  where the element  $p_{ij}$  indicates the probability that a province classified in class  $i$  in one period will be in class  $j$  in the following period. Let  $d^t = (d^t_1, \dots, d^t_n)$  be the vector of "population proportion" at time  $t$ . The evolution of its distribution can be described by the equation:

$$(1) \quad d^{t+1} = P d^t$$

If equation (1) satisfies the Markov property for a homogeneous chain, then equation (1) can be analysed as a time-homogeneous Markov chain. The matrix  $P$ , which defines the probability of transition within a single time period, can be generalised to consider the probabilities of transition in  $(k+h)$  periods. In general:

$$(2) \quad P(k+h) = P(h) P(k)$$

The asymptotic behaviour of  $P(k)$  can be analysed using the analytical tools developed for the study of Markov chains. If the classes are ergodic and the set of all classes is not closed then the Markov chain is ergodic and it is possible to show that the limits exist and are independent of the initial class  $i$ . For an ergodic Markov chain there always exists a stationary, ergodic distribution,

independent of time, which is the limiting distribution of the chain and can be computed from the eigenvalues of the transition matrix. Note that not all the matrices  $P$  have an ergodic distribution.

In this paper provincial GDP per capita relative to the country average has been discretised into 7 intervals so that the observed sample is approximately divided into equal categories. The transition matrix for the period 1952-1995 suggests a quite strong dynamism of Italian provinces:

**Table 1. Transition matrix (1952-1995).**

Initial year	Final year						
	State 1	State 2	State 3	State 4	State 5	State 6	State 7
State 1	0.40	0.24	0.32	0.04	0.00	0.00	0.00
State 2	0.09	0.45	0.09	0.22	0.09	0.00	0.00
State 3	0.08	0.08	0.23	0.15	0.08	0.20	0.15
State 4	0.00	0.00	0.00	0.09	0.27	0.36	0.27
State 5	0.00	0.00	0.22	0.11	0.33	0.33	0.00
State 6	0.00	0.00	0.20	0.00	0.40	0.20	0.20
State 7	0.00	0.00	0.06	0.11	0.11	0.39	0.33

The ergotic distribution shows the well know 'twin peaks' distribution, that have a natural interpretation in terms of polarization. The raise of two peaks appears only after 1970:

**Table 2. Ergotic distributions.**

Period	State 1	State 2	State 3	State 4	State 5	State 6	State 7
1952-1995	0.03	0.04	0.17	0.09	0.25	0.25	0.16
1952-1970	0.00	0.00	0.00	0.00	0.48	0.52	0.00
1970-1995	0.26	0.13	0.15	0.13	0.10	0.11	0.11

## REFERENCES

Fabiani, S., Pellegrini, G., (1997) Education, Infrastructure, Geograpy and Growth: An Empirical Analysis of the Development of Italian Provinces, Temi di discussione, Banca d'Italia, n. 323.

Fingleton Bernard (1998) Specification and Testing of Markov Chain Models: an Application to Convergence in the European Union, Oxford Bulletin of Economics and Statistics, 59, n.3

Magrini S. (1996) Income Disparities in the European Union: An Empirical Analysis, presented at the VII Conferenza di Scienze Regionali, Sondrio, Italy.

Quah D. (1993) Empirical Cross-Section Dynamics in Economic Growth, European Economic Review, 37, n. 2-3, April.

Quah D. (1997) Empirics for Growth and Distribution: Polarization, Stratification and Convergence Clubs, Journal of Economic Growth, 2, March.

## FRENCH RÉSUMÉ

*Ce travail presente l'analyse de la convergence du PIB pro capite des provinces italiennes dans la période 1952-1995 à travers les chaines de Markov.*