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Abstract

The Effects of Space on Inter-State Growth Dynamics and Income Disparities in India –
Modeling the Simultaneous Growth of a System of Spatial Units
by
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This dissertation examines the effects of spatial-specific conditions on trends in inter-state disparities in a sample of 17 Indian states. It employs an extended Lotka-Volterra model to estimate the magnitude and direction of inter-state growth dynamics and the long run collective behavior of this system of states. An evaluation of estimates of growth effects or inter-state growth dynamics is conducted and meaningful insights into their association with the varying levels and rates of growth of income per capita of states in the sample derived.

Executive Summary

The Effects of Space on Inter-State Growth Dynamics and Income Disparities in India – Modeling the Simultaneous Growth of a System of Spatial Units

by
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Data on levels and rates of growth of income per capita of states in India over time suggest sustained and in some cases deepening disparities notwithstanding the commitment articulated by the Government of India since Independence to balance growth. The problem of deepening disparities is not unique to Indian states or to India. Evidence of increasing disparities at all spatial scales – city, district and other functional regions – has been found in over 50 developing countries (Kanbur and Venables 2005a, b).

The disparity measured in terms of income per capita growth has typically been attributed to differences in key determinants including levels of education and health, investment to GDP ratio, fertility rates and the ratio of government consumption spending to GDP (Barro and Sala-i-Martin 2004). Others have noted that values in one location depend on values in another location and incorporated this notion of spatial dependence into studies of regional economic convergence (Rey 2004; Abreu et al. 2005). In one such operationalization, the stock of knowledge in a region and the region's ability to catch-up to the technological leader have been found to be subject to distance decay effects and hierarchical interactions at least in the case of US counties (Pede et al. 2006). However, following a number of studies concerned with how inter-regional dynamics contribute to the small differences in growth rate's behind today's differentials

in levels of income per capita, there is growing recognition that the direction and magnitude of spillover effects impact the growth paths of regional economies that are economically divergent (Arbia and Paelinck 2003a, b; Piras et al. 2005, 2006).

The insight that spatial dynamics are bound to dominate trends in income in the very long run motivates this dissertation. A parallel motivation is the lack of progress in efforts to address disparities in the case of Indian states. At the core of this study is a conceptual framework in which inter-state growth dynamics are a product of factors that are location-specific and of the interactions of locations or functional regions, and in which two or more locations interact because of geographic proximity and/or structural complementarities. The conceptual framework takes into account as well factors that are likely to facilitate or deter interactions between functional regions such as road infrastructure, existence of million plus cities, to name few. The dissertation examines three sets of questions: Does the simultaneous growth of a system of spatial units, in this case a system of Indian states, exhibit a distinct pattern? If such a pattern exists, is it one of convergence or divergence?[1] Second, are the growth dynamics of spatial units that are geographically proximate similar to the growth dynamics of spatial units that are structurally equivalent? And third, what may be some of the factors dominating space-specific dynamics in the long run? Are certain determinants of growth shared by spatial units with particular growth dynamics?

The study keeps track of the structure of spatial dependence among 17 states in India and of the collective behavior that results from the micro-level interactions of the states in the sample with an extended Lotka-Volterra model (Samuelson 1971; Arbia and Paelinck 2003b; Paelinck 2004). It evaluates the estimates of growth effects or inter-state growth

[1] Divergence and convergence have a mathematical meaning and an economic meaning.

dynamics to gain a better understanding of their association with the varying levels and rates of growth of income per capita characteristic of the 17 Indian states. It also assesses the differences in the nature of growth effects that are driven by geographical proximity from those that are driven by structures that are equivalent and the effects on the simultaneous growth of the system comprising 17 states.

A limitation of this analysis is the use of a sample of 17 states instead of the population of 28 states and 7 union territories. The decision to work with a sample was made largely because of differences in the quality and availability of the data particularly of smaller states and union territories. The sample includes three administrative divisions – Bihar, Madhya Pradesh and Uttar Pradesh – before other states were carved out from them in 2000. The states in the sample in 2000-01 accounted for more than 94 percent of all-India net domestic product and over 97 of the country's population. The study period is from 1980-81 to 2000-01.

Consistent with spatial theory and spatial econometrics, the extended Lotka-Volterra model treats the growth of every state as a function of its own level of per capita income (*a*), the level of per capita income of first order or contiguous neighbors (*b*) the level of per capita income of higher order or non-contiguous states (*c*), and an autonomous growth rate (*d*). Per capita income is a proxy for a state's location-specific factors. The simultaneous and in a sense cumulative effect of the growth experiences of all relevant units thus captured is incorporated in as one more factor in the growth patterns observed in the long run both for individual states and as a system. The extended Lotka-Volterra model is as follow:

$$y_{rt} = y_{r,t-1} \bullet \exp[a_r * y_{r,t-1} + b_r * \sum y^*_{r,t-1} + c_r * \sum y^{**}_{r,t-1} + d_r] \quad (1)$$

where,
$y_{r,t-1}$ and y_{rt} = endogenously estimated variables for region r at time $t-1$ and t
a_r = own growth effect
b_r = growth effect from first order neighbors
c_r = growth effect from higher order neighbors
d_r = constant representing each spatial unit's residual rate of growth
$\sum y^*_{r,t-1}$ = sum of endogenously estimated values of contiguous spatial units
$\sum y^{**}_{r,t-1}$ = sum of endogenously estimated values of higher order spatial units

For each state's equation, first order neighbors and higher order neighbors have the same estimated b_r and c_r, respectively. This imposition to keep the number of parameters to be estimated manageable "controls for the presence of spillover effects" albeit with the risk of bias in the estimates of these spillovers and "other coefficients" (Piras et al. 2006: 7), although in this study the results are used in line with the possible uses appropriate to the particular estimator (simultaneous dynamic least square) chosen here (see below).

An important step in the dissertation is to define the matrices of first order and higher order neighbors. The study uses three different approaches. One is based on queen type contiguity. A second is based on average location quotients between 1993-94 and 2000-01. Location quotients are a measure of over concentration in an industry or sector so that states with similar over concentration may complement or compete with each other. A third approach conducts a factor analysis using standardized annual shares of total NSDP at factor cost by industry of origin between 1980-81and 1995-96. The purpose is to allow variance in the data to define contiguity and avoid adopting an arbitrary cutting point as in the case of the definition of contiguity according to location quotients.

Model coefficients are estimated with simultaneous dynamic least squares (Paelinck 1990, 2004; Griffith and Paelinck 2007). This estimator method is appropriate for

projections, policy simulations and mathematical programming, among others. Adjusted R-squares above 0.9 indicate goodness of fit.

Varied in nature and intensity the interactions among states with different levels and rates of growth of income per capita as captured by the extended Lotka-Volterra model indicate possible mathematical and economic divergence of the system.

Despite complex inter-linkages between economy-based and geography-based spillovers the extended Lotka-Volterra model enables the exploration of the influence of different economic structures or geographical neighbors on the dynamics of income per capita. The study does indeed identify varied interdependencies among states according to geographical proximity and/or structural equivalence. To some extent growth effects from structurally equivalent states are found to be stronger in absolute values than growth effects from geographically proximate states. Although this is somewhat contingent on how different is the composition of the three sets of contiguity matrices in particular for some states who appear to have first order neighbors that are both geographically proximate and structurally equivalent.

The analysis of model estimates suggests that to some extent lagging states have positive growth effects from first order neighbors (b) while better off states have negative growth effects from first order neighbors (b). The study also finds that growth effects from first order neighbors (b) are for the most part stronger in absolute values than from higher order neighbors (c), and that better off states appear to experience a stronger growth effect from higher order neighbors (c) than their lagging counterparts.

Better off states that are surrounded by lagging states do not seem to capture growth effects that are as strong as when surrounded by a more diverse mix of first order

neighbors (*b*). For lagging states to have better off states as first order neighbors (*b*) does not seem to engender stronger growth effects, an indication that not only can a distance decay effect be expected in the case of lagging states but also that hierarchical or asymmetrical interactions are less conducive to strong growth dynamics in this system. Other instances of weak growth effects are found among states that are strongly interdependent with other states not included in the sample, as well as states with lopsided economic structures where a region plugged into the world economy (Bangalore and Hyderabad) is the engine of growth and the rest of the economy is characterized by slow growth.

Of the factors considered to be associated with growth effects either as conduits or as aides, five in particular – the existence of million plus cities in 1980, higher road length in 1981-82, higher per capita tax exportation, being the recipient of less than 3 percent of the total amount of foreign direct investment between 1991 and 2004, and more religious diversity – are associated with stronger average growth effects from first and higher order neighbors in absolute terms. The dissertation recommends incorporating these factors into future studies to attain more meaningful definitions of contiguity or *in lieu* of per capita state domestic product data to estimate model coefficients.

The study finds that a thorough analysis of estimated growth effects or structures of spatial dependence on a state by state basis can provide information and knowledge that can help structure policy for pairs of states, a state and its first order neighbors and/or for a complex of a state and its first order neighbors.

A relevant policy implication of this dissertation and the proposed methodology is that policies to enable states to interact more intensively with other geographically proximate

states may be misguided as well as hinder the emergence of strong positive growth effects. For some states to expand opportunities and areas of interactions with other structurally equivalent states could yield more significant results. If so, to obtain accelerated benefits policies need to be flexible enough for states to adapt them to the unique or relatively unique patterning of neighbor types. In this context, finding new and innovative ways to transform institutions, resist inertia and imbue in actors a commitment to promote positive interdependencies requires sustained leadership.

There are several significant contributions of this dissertation. First, it develops a new methodology that makes it possible to detect spatial and structural dynamic spillover effects among states in India. Second, it provides new insight into the relationship between divergent tendencies in the Indian economy (despite a long history of India's attempt to deploy a generally balanced growth policy) and both their spatial and structural relations. And third, the empirical findings show that the methodology enables a deeper insight into potential policy prescriptions for the nation, its states and a combination of states which are nearest neighbors.

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