Inertia and Endogenous Factors, Spatial Dynamics and Regional Economic Development — Drawing on the India and China Cases

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Abstract

Evidence of income divergence at various scales provides the motivation for examining the role of selected inertia and endogenous factors in the development process with particular emphasis on the role of interregional dynamics and policy. A body of work on interregional dynamics that relies on an extended Lotka-Volterra model to keep track of the structure of spatial dependence among regions is briefly considered. It offers a promising starting point for an improved understanding of the factors behind trends in income and for expanding policy options. Examples from China and India but with a greater emphasis on India are provided.

JEL Classification : C13, R11

Keywords : Regional Economic Development, Spatial Dynamics, Lotka-Volterra Model, India, China

1. Introduction

The purpose of this paper is to illustrate the relevance and importance of various inertia and endogenous factors in the development process with particular emphasis on the role of interregional dynamics and policy.

There has been considerable progress in the modeling of economic growth during the past two decades but this progress often fails to incorporate the role that interregional dynamics play in the economic growth and development process.¹ For example, cross national studies of income convergence or divergence tend to mask the considerable variance in these processes at the sub-national level and the related structure of spatial dependence (see for example Barro and Sala-i-Martin 1992) and thus run the risk of distortion. At the same time, one of the core concerns or controversies in the field of development planning and policy is whether balanced or unbalanced growth schemes are most appropriate as these are likely to result in some form of inertia factors (more below). The core of the controversy lies with the fact that at the national level growth usually occurs most rapidly with unbalanced strategies [34], e.g., the recent coastal investment oriented strategy of China resulted in huge growth in these target areas and also produced considerable growth for the nation. However, it also resulted in an imbalance in geographic benefit distribution which became a

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¹ For a survey of the literature on space and growth see for example, Abreu et al. [1].

major policy issue as the non- or lesser-participating regions became impatient for the day they would participate. This is the dilemma of an unbalanced but apparently effective aggregate national strategy: more rapid growth will occur but its geographic unevenness is perceived by marginal participants and becomes a major political problem.

That both geography and planning, and policy give rise to inertia factors has been recognized by institutional economics [38] [39], new economic geography [29] [30] and evolutionary growth theory [36] [37], to name a few, with path dependency a key notion in these schools of thought. However, so-called endogenous factors, which include leadership and entrepreneurship, have been known to counteract negative inertia factors in some regions [50]. In this context, an examination of factors such as planning and policy as further illustrated below in the context of balanced/unbalanced growth strategies can provide insights into regional economic development and divergent/convergent trends in income. In the presence of persisting inequalities among interacting regions an analysis of interregional growth effects can also contribute to a better understanding of the observed differentials in economic growth and development.

The paper proceeds with the following structure. First is a brief discussion about how development tends to ensue over time and space and how this influences income convergence/divergence and the distribution of development benefits. Then some empirical evidence on convergence and divergence is considered. The conclusion of this discussion focuses on the important role of space and sub-national regional economies in income dynamics. Next, the discussion moves back to a focus on India showing at the national level that there is evidence that regional income disparities since Independence in 1947 either worsened or did not change. Inertia and endogenous factors responsible for this are then considered with particular attention to interregional dynamics, the focus of the final part of the paper. Conclusions are then presented.

2. Space and Time in Regional Economic Development

Zhao [56] in a study of the U.S. space economy showed that the center of gravity of the economy measured by output, led temporally and spatially the spread of economic inputs. In short, the diffusion of inputs spatially and temporally lagged the locus of growth in output. This implies that the spillover effects of previous development and endogenous factors drive the development process, at least in the aggregate and in the U.S. (and probably in most developed economies). It is likely that this relationship persists in developing economies also. That is to say that existing centers of economic activity spill their benefits over into adjacent areas as argued in the classical spatial models of Cristaller (also see Richardson 1979; King 1984; Higgins and Savoie 1995; Losch 1938; and Perroux 1950) and thus inertia in the space economy plays a strong role in development and, *ceteris paribus*, development will be uneven (unbalanced) unless there are powerful counteracting forces such as exceptionally strong government intervention policies.

There is a growing body of literature and evidence that income divergence is ironically increasing in many countries [23] [25]. The reason, at least in part, is that the long run is only a theoretical construct [9] [10] [11]. The reality is that the economic growth and development process is highly impacted by nodal drivers at the sub-national level such as fast

growing (and lagging) regions [31] [22] and/or so called leading sectors. Further, endogenous processes create differential performance that does not conform to outcomes that would result if only influenced by factor cost differentials [46] [51] — for the regional case – as implied by neo-classical economics. Consequently, the long run is never achieved because of inertia and endogenous forces that produce technological innovation and other processes (e.g., entrepreneurship) that convert this knowledge into viable commercial operations. Such dynamics are only partially (at best) driven by comparative advantage defined in terms of factor cost differentials.

3. Income (or Benefit) Convergence at the Sub-National Level in India

India, following adoption of a menu of liberalization policies and practices in the early 1990s, has produced quite significant and increasing national growth. This experience is well documented, (for example, Desai 1999; Bussolo and Whalley 2003; and The World Bank 2003) and can be traced from an annual GDP growth rate of about 3 percent in the early 1990s to annual rates of 8 percent or greater more recently. In many ways India's experience is as remarkable as China's given that both have huge populations in excess of one billion persons. Heretofore it was almost a conclusion that such giants could not and would not be able to advance their economies significantly. However, both India and China are on the road to achieving just that, albeit with China having started earlier and thus nearing this goal more rapidly.

However, long term regional income differentials in India have worsened or remained unchanged [48]. This is corroborated by other studies during the period between 1968 and the late 1990s [43] [18].² Table 1 lists levels and growth rates per annum in per capita net state domestic product (NSDP) in constant 1993-94 prices for a sample of 17 states in India that illustrate these regional differentials.

In light of the above we can ask what is responsible for the continuing income disparities. Inertial and endogenous forces were claimed to be the broad categories of these factors.³ But it is important to be more specific than this so as to add substance to these claims. First, is a discussion of the inertial factors which often are not mutually exclusive of endogenous factors. Inertial factors include capital accumulation (it is more concentrated in some places than others), transport costs (efficiency of transport connectivity is a product at any given time of past investments), public policy especially at the national level that tends to support past patterns and amplifies the perpetuity effects (defined below) of government failures and successes in the locus of such investments, market fit, infrastructure, technology and urbanization differentials. Table 2 offers an example of the latter with data on million plus cities and information on percent of main workers by sector where available for a sample of 17 states in India.

However, not all elements of these factors are inertial: endogenous forces such as

² However, it is important to note that at the sub-national level some studies of long run trends in income for Indian states report instead evidence of absolute convergence (e.g., Cashin and Sahay 1996a, b) and also of conditional convergence (e.g., Nagaraj et al. 1998; Aiyar 2001).

³ Certainly macro economic forces such as changing cyclical conditions and international trade may impact disparities or the failure to reverse them but for the sake of this argument we are setting these aside for now.

Table 1. Growth Rates per Annum in Per Capita NSDP in Constant (1993-94) Prices

State	NSDP per capita (1980-81), Rupees	1980-81 to 1985-86	1985-86 to 1990-91	1990-91 to 1995-96	1995-96 to 2000-01	1980-81 to 1990-91	1990-91 to 2000-01	1980-81 to 2000-01
Andhra Pradesh	4,604	0.016	0.070	0.033	0.046	0.034	0.040	0.038
Assam	4,636	0.027	0.007	0.006	0.004	0.011	0.004	0.009
Bihar	3,427	0.036	0.017	-0.031	0.043	0.026	0.008	0.008
Gujarat	6,455	0.030	0.050	0.074	0.012	0.028	0.050	0.040
Haryana	7,514	0.033	0.046	0.010	0.032	0.040	0.024	0.032
Himachal Pradesh	5,793	-0.002	0.053	0.032	0.052	0.030	0.044	0.036
Jammu and Kashmir	6,244	0.008	-0.005	0.016	0.019	-0.004	0.019	0.009
Karnataka	4,943	0.008	0.047	0.044	0.072	0.031	0.056	0.043
Kerala	5,692	-0.001	0.044	0.060	0.041	0.017	0.048	0.038
Madhya Pradesh	5,084	0.004	0.019	0.019	0.019	0.017	0.024	0.022
Maharashtra	7,102	0.020	0.061	0.059	0.022	0.036	0.042	0.044
Orissa	4,085	0.020	0.013	0.035	0.026	0.021	0.025	0.017
Punjab	8,442	0.034	0.032	0.020	0.029	0.034	0.025	0.028
Rajasthan	4,254	0.034	0.081	0.020	0.026	0.039	0.035	0.038
Tamil Nadu	5,266	0.034	0.050	0.059	0.050	0.038	0.053	0.047
Uttar Pradesh	4,133	0.016	0.041	-0.011	0.014	0.026	0.009	0.016
West Bengal	4,952	0.025	0.021	0.044	0.056	0.023	0.051	0.036
Sample	5,449	0.021	0.044	0.030	0.033	0.029	0.034	0.032
All-India	5,126	0.021	0.044	0.047	0.039	0.029	0.046	0.038

Note : As suggested in Ahluwalia [4] [5], the growth rate is based on a loglinear trend where $\log Y = a + bt$ and $b = \log(1+r)$ so that $r = (\text{antilog } b) - 1$. For the purpose of this analysis a loglinear trend which takes into consideration all observations is a more adequate estimate than say the average growth rate per annum as suggested by Dasgupta et al. [18]; that is, $1/T (\ln(Y_T/Y_0))$, where T =length of period, Y_0 and Y_T initial and final per capita incomes.

Source : EPW Foundation [21], *EPW Domestic Product of India*, NSDP at Constant (1993-94) Prices : Back Series, Rupees, crore; supplemented with data from CSO and from the Ministry of Statistics and Program Implementation (MOSPI).

effective but flexible institutions, leadership and entrepreneurship, especially historical, as well as current [50] determine whether these elements remain relatively ineffective in the face of change. In such cases inertia constrains a region's ability to adjust to change. When positive endogenous forces are in play inertia defined conditions are reinterpreted and fitted to changing conditions (market, ideological, technological or political). For example, the state of Rajasthan was able to improve literacy rates enormously in both rural and urban areas until the early 1990s when this successful strategy was modified (see Table 3 for state level data on literacy rates). This is one example of the challenge of sustaining successful programs but also of the possibility of change happening over the course of several decades if there is commitment by the stakeholders and lead actors. Thus, it is necessary to recognize that the inertia from the past may counteract endogenous forces that are moving a system positively. Another example perhaps is the huge push to improve the delivery of public services in India that has been preceded by extensive assessment of very poor implementation of policies nation-wide, a forerunner of exceptionally strong government interven-

Table 2. Million Plus Cities and Main Workers by Sector, Selected Years

	Urbanization rate			Population in Urban Agglomerations > 1 million			% of Main Workers by Sector in 1991*				
	1980-81	1990-91	2000-01*	1980	1991	2001	Pr Act	Ind.	Trade & Commerce	Transport & Commun.	Serv
ANDHRA PRADESH	23.32	26.89	27.08								
Hyderabad				2,545,836	4,344,437	5,533,640	4	32	24	11	29
Vishakhapatnam				603,630	1,057,118	1,329,472	7	28	15	15	35
Vijayvada				543,008	845,756	1,011,152	11	24	24	18	22
ASSAM	9.88	11.1	12.72								
BIHAR	12.47	13.14									
Patna				918,903	1,099,647	1,707,429	14	12	20	5	48
Jamshedpur				669,580	829,171	1,101,804	3	52	16	6	24
Dhanbād				678,069	815,005	1,064,357	43	13	17	8	19
GUJARAT	31.10	34.49	37.35								
Ahmedabad				2,548,057	3,312,216	4,519,278	2	42	25	9	22
Surat				913,806	1,518,950	2,811,466	2	61	19	5	13
Vadodara				744,881	1,126,824	1,492,398	5	38	20	9	28
Rajkot				445,076	654,490	1,002,160					
HARYANA	21.88	24.63	29.00								
Faridābād				330,864	617,717	1,054,981					
HIMACHAL PRADESH		8.69	9.79								
JAMMU & KASHMIR	21.05	23.83	24.88								
KARNATAKA	28.89	30.92	33.98								
Bangalore				2,921,751	4,130,288	5,686,844	3	43	22	8	24
KERALA	18.74	26.39	25.97								
Kochi				685,836	1,140,605	1,355,406	10	31	21	14	23
MADHYA PRADESH	20.29	23.18									
Indore				829,327	1,109,056	1,639,044	3	33	26	9	28
Bopal				671,018	1,062,771	1,454,830	5	30	20	9	35
Jabalpur				757,303	888,916	1,117,200	5	35	19	9	31
MAHARASHTRA	35.03	38.69	42.40								
Mumbai				8,243,405	12,596,243	16,368,084	1	42	24	11	22
Pune				1,686,109	2,493,987	3,755,525	3	43	18	8	27
Nagpur				1,302,066	1,664,006	2,122,965	4	33	23	13	27
Nashik				429,034	725,341	1,152,048	13	36	16	7	27
ORISSA	11.79	13.38	14.97								
PUNJAB	27.68	29.55	33.95								
Ludhiana				607,052	1,042,740	1,395,053	8	51	20	6	14
Amritsar				594,844	708,835	1,011,327	9	32	30	7	22
RAJASTHAN	21.05	22.88	23.38								
Jaipur				1,015,160	1,518,235	2,324,319	4	33	24	8	32
TAMIL NADU	32.95	34.15	43.86								
Chennai				4,289,347	5,421,985	6,424,624	3	34	23	10	30
Coimbatore				920,355	1,100,746	1,446,034	7	45	20	7	20
Madurai				907,732	1,085,914	1,194,665	6	35	29	9	21
UTTAR PRADESH	17.95	19.84									
Kanpur				1,639,064	2,029,889	2,690,486	4	31	27	8	31
Lucknow				1,007,604	1,669,204	2,266,933	7	21	23	8	41
Varanasi				791,162	1,030,863	1,211,749	4	42	27	6	21
Agra				747,318	948,063	1,321,410	4	37	24	6	29
Meerut				536,615	849,799	1,167,399	10	31	21	7	30
Allahabad				650,070	844,546	1,049,579	5	18	26	8	43
WEST BENGAL	26.47	27.48	28.03								
Kolkata				9,194,018	11,021,918	13,216,546	2	39	25	10	23
Asansol				366,424	763,939	1,090,171	24	30	20	10	16
All India *	23.73	25.72	27.78								

Note :Urbanization rate refers to the percentage of urban population to total population.

*Main workers are those who have worked at least 183 days or in the previous year. These data are only available for cities that crossed the 1 million population threshold by the 1991 Census.

*The last census conducted before Chhattisgarh, Jharkhand and Uttaranchal were carved out from Bihar, Madhya Pradesh and Uttar Pradesh, respectively is 1991.

Sources : Data from indiastat.com, National Human Development Report 2001, and own computations using India census data. Functional Classification of Urban Agglomerations/Towns of India 1991, Ministry of Home Affairs, Govt. of India.

Data on population by city also from: Thomas Brinkhoff: City Population, <http://www.citypopulation.de>.

The share of urban population to total population for 2001 is from 3iNetwork (2006), *India Infrastructure Report*, New Delhi:Oxford University Press.

Table 3. Literacy by State

State	Literacy (7+ years) in Percent											
	Rural						Urban					
	1981			2001			1981			2001		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
Andhra Pradesh	38.7	16.8	27.9	66.1	44.4	55.3	72.6	48.7	61.0	83.2	69.3	76.4
Assam*	58.7	39.2	49.3	69.0	52.3	60.9	84.4	73.3	79.4	89.9	81.0	85.8
Bihar*	42.4	12.4	27.7	48.3	18.0	33.8	73.2	47.5	61.8	77.7	55.9	67.9
Gujarat	57.8	28.8	43.6	70.7	45.8	58.5	80.7	60.2	71.0	85.5	72.2	79.2
Haryana	53.4	18.8	37.3	76.1	49.8	63.8	76.1	55.8	66.8	86.6	72.1	79.9
Himachal Pradesh	62.4	35.3	48.9	83.6	65.2	74.4	83.7	70.1	77.8	92.5	85.9	89.6
Jammu & Kashmir	39.0	13.1	26.9	60.3	35.1	48.2	62.7	43.0	53.6	80.3	62.2	72.2
Karnataka	51.1	23.8	37.6	70.6	48.5	59.7	76.5	56.4	66.9	86.9	74.9	81.1
Kerala	86.7	74.2	80.3	93.5	86.8	90.1	92.0	82.0	86.9	96.1	90.9	93.4
Madhya Pradesh*	40.8	17.3	29.3	51.0	19.7	35.9	76.4	50.8	64.6	81.3	58.9	70.8
Maharashtra	61.7	29.5	45.7	82.2	59.1	70.8	82.9	63.9	74.3	91.4	79.3	85.8
Orissa	53.5	22.0	37.8	73.6	47.2	60.4	76.4	51.0	64.8	88.3	72.7	81.0
Punjab	49.6	32.7	41.7	71.7	57.9	65.2	70.8	58.1	65.0	83.0	74.6	79.1
Rajasthan	37.0	6.8	22.5	73.0	37.7	55.9	72.3	41.5	58.1	87.1	65.4	76.9
Tamil Nadu	60.1	29.8	45.0	77.5	55.8	66.7	83.8	62.2	73.3	88.4	75.6	82.1
Uttar Pradesh*	43.4	11.7	28.5	52.1	19.0	36.7	64.8	42.7	54.9	70.0	50.4	61.0
West Bengal	52.8	26.8	40.2	73.8	53.8	64.1	77.2	62.5	70.7	86.5	76.1	81.6
India	49.6	21.7	36.0	71.2	46.6	59.2	—	—	—	86.4	73.0	80.1

Notes : Literacy rates refer to the proportion of literates to the population in the age group 7+.

*1981 data for Assam is from 1991. 2001 data for Bihar, Madhya Pradesh and Uttar Pradesh are from 1991 before Jharkhand, Chhattisgarh and Uttaranchal were carved out.

Sources : Planning Commission, *National Human Development Report 2001*, Government of India and indiastat.com

tion policies there.

In terms of endogenous effects it may be argued that past development may be driven by the resource base (but resources are more than just natural ones as was considered to be the case in earlier times but also include institutions, human capital and associated productivity levels and entrepreneurial capacity and leadership), technological innovation, knowledge production and its transfer (while part of this is extra-local in nature), the conversion of innovations and related knowledge production and transfer into commercial products is a highly local process [2]. In short, endogenous factors are those that enable a region to counter inertial effects when they push or fail to reverse the drift of a region toward a poor market fit in the face of change. However, it follows, that in most cases growth will be unbalanced despite government efforts to the contrary unless such policies are extreme. China is a good example of this today in that it has adopted strong policies to channel investment and development to the interior but with only some success—inertia of past development in coastal areas continues to influence the locus of development. Whether this has changed the income dynamics in China from divergence [23] to convergence is yet to be seen.

Consequently, even though India appears to be concerned with and aiming toward a

⁴ India has a long history of pre-occupation with the condition of the poor and the development of

balanced development strategy (see below)⁴ [3] [14] [54] it is faced with the fact that its most advanced industry and thus nodes of highest growth potential are concentrated in a few places. As such India faces the task and the opportunity of how to embed the products and services of this industry in the other regions and sectors of its economy as a way to spread or distribute the associated benefits and higher wage jobs to a broader range of the population. For example, productivity and wages will rise faster in sectors such as retail, wholesale, transport, manufacturing and so on the sooner IT is adapted to enhance production and output in those sectors. This is the way trickle down may occur in the leapfrog model. For sure one might argue that India's extensive 'unskilled' labor may not fit well into the leapfrog model considering that India has a record of privileging skill-intensive manufacturing over labor-intensive endeavours [27]. Also, it is already facing shortages of 'skilled' labor, particularly in ICT. Nonetheless, the dynamism in the India economy is coming mostly from the ICT sector and the diffusion of its application to other sectors will likely stimulate skill development to meet that demand. The great increase in management and engineering education programs in the private sector of India is an indicator that this is probably already occurring.

In this context, there is another factor that is important and that is interregional dynamics or spillover effects which itself is in part inertial in nature but also may have additional impacts on maintenance or change in income differential patterns. Further, it is a context where policy intervention may be capable of influencing positive development at the national, state and local levels. For example, incentive policies can be developed to induce lagging regions to better adjust their economies to changing market and technological conditions *in tandem* with other neighboring or non neighboring regions with whom they might share positive spillovers. But only if accurate measurement and modeling are achieved will such policies be devised and adjusted to achieve such outcomes.

4. Interregional Spillover Effects and Policy

Events in one place can influence events in other places through direct, indirect and induced spillover effects. This is in fact what interregional input-output models attempt to measure. These effects are in part inertial in what some economists call perpetuity effects, i.e., the effect of all of the inertial effects at one location including historical dependency relationships, which may be described as long term build up effects. Finally, there may also be demonstration effects that are passed along from one place to another through either contagion or hierarchical diffusion. To illustrate, India experienced the development of an information and computer technology (ICT) industry in the 1980s through a coincident set of policies including special tax holiday provisions to large scale educational and human capital investments [52]. This industry grew up around a geographic concentration in the Bengalooru region where investments in the Indian Institute of Science and other related human capital producing investments were made. Today high technology industry (ICT) is well developed, specializes in technology services and has spread to other parts of India including Hyderabad and Pune as well as to major urban areas such as Delhi, Chennai and Mumbai.

policies to increase their participation in the development process. This national concern continues and will most likely persist in the future thus keeping a national focus on balanced development.

This diffusion was hierarchical not contagion in nature resulting in the above referenced nodes of concentration. While such diffusion may be more difficult to achieve in other parts of India in the future given the high costs of the infrastructure investments and subsidies required, the experience of Hyderabad and Pune suggests there may still be an opportunity for other technology intense development centers to be created. More recently knowledge continues to flow as part of the federalist system of governance although not exclusively as evidenced by policy papers by industry organizations, research institutes and international organizations.⁵

All in all, many of these effects are proximal in nature, i.e., nearness increases the potential for stronger spillover effects, but not in all cases as sometimes non-spatial network effects are stronger than proximal ones. For example, countries may adopt one of two development plans and strategies: develop an investment and policy strategy that is balanced at the outset with the realization that success at the aggregate level may be a long time coming or may never reach a critical level; or, develop an unbalanced strategy and try to find a way to manage benefit differentials until they can be channelled to or trickle down to non-target regions and/or groups. While China's experience during its take-off to extended development is a classic case of the latter, it appears that India is more oriented toward the former with of course the caveat that India's rhetoric and planning has emphasized balanced development but there have been a number of factors such as the logic of industrialization and the associated system of industrial licenses and import controls which have generated extensive corruption, reinforcing inequality not only economically but of opportunity and capability. So despite its rhetorical and seeming desire to create a balanced growth strategy and plan India still faces a real and potential benefit distribution problem.⁶

The interregional dynamics of development and spillover effects, such as income differentials, are not well understood. A better understanding of these would enable formulation of more appropriately targeted policies at the national level as well as at the state and local level. For example, the interregional literature in India [32] [12] [13] [53] provides us with only a limited understanding of how such spillover effects are threaded through the multi-regional Indian economy over time.

The methodology for measuring interregional dynamics and development spillover

⁵ China's strategy on the other hand in addition to being initially unbalanced was also traditional as it chose to transition its economy from agriculture dependence to initially low level consumer manufactured products and then up the product (and services) sophistication ladder. Eventually it expects to become competitive in the production of high end services and products under-girded with internal innovation processes leading to creation of advanced goods and services. Its current large investment in government sponsored venture capital firms like the Innofund and in technology incubation are examples of the leading edge of its aim to compete at the highest level in the next generation.

⁶ Still, India's development experience has been viewed as a potentially different model than the traditional stage theoretic one (e.g. Rostow 1971) that has dominated development policy for the past 50 years or so. It has been envisioned that India has the possibility of leapfrogging the normal stage dependent process, in whole or part, that begins with moving labor from agriculture and resource based endeavors to low level manufacturing to mid-level and eventually higher level and higher value manufactured products and services [52]. In short, it may be possible to leapfrog stages in the traditional sequence and thereby speed up the development process because its one high end industry (ICT) is well developed and globally competitive and thus could be the major lever of development.

effects is not well developed. While point in time estimates can be made using interregional input-output models or computable general equilibrium models such models have rarely been developed with panel data and never with annual panels over a sufficiently long period. In short, the estimation of interregional spillover effects could be improved. Consequently, a methodology is needed to more adequately model these effects in order to better inform policy at all levels aimed at addressing the income divergence problem. One such method has been developed by Arbia and Paelinck [7] and is being adapted and tested with data from the Indian States by Kocornik-Mina [28]. For background, Samuelson [49] proposed the Lotka-Volterra (LV) model of dynamic interdependence between predators and prey for use in economic analysis⁷, which Arbia and Paelinck [7] extended and applied⁸ to model the inter-regional dynamics of European Union as follows:

The two-equation basic LV model

$$\dot{x}_1 = x_1(a_1 - a_{12}x_2) \quad (1)$$

$$\dot{x}_2 = -x_2(a_2 - a_{21}x_1) \quad (2)$$

where:

$\dot{x}_1$ is the time derivative of the prey species (e.g., the change in the number of deer)

$\dot{x}_2$ is the time derivative of the predator species (e.g., the change in the number of tigers)

x_1 is the number of individuals of the prey species

x_2 is the number of individuals of the predator species

a_1 is the constant rate that the prey species develops at

a_{12} is the rate preyed upon by the predator species

a_2 is the rate the predator species fades in the absence of prey

a_{21} is the rate that predator species encounters (feeds upon) its prey

is extended to n 'species' (spatial units) by introducing a first order contiguity matrix (nearest neighbors), and a second matrix of higher orders of contiguity (all other spatial units in the system):

$$y_{rt} = y_{r,t-1} \cdot \exp[a_r * y_{r,t-1} + b_r * \sum y_{r,t-1}^* + c_r^* \sum y_{r,t-1}^{**} + d_r] \quad (3)$$

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 first order spatial units

$\sum y_{r,t-1}^{**}$ = sum of endogenously estimated values of higher order spatial units

⁷ Dendrinos and Mullaly [19] used a modified Lotka-Volterra to model inter-urban dynamics. They noted that changes in technology and/or comparative advantage, among other factors, would transform the inter-urban dynamics.

⁸ The Arbia and Paelinck nonlinear continuous-time econometric framework [7] [8] was used by Piras et al. [41] to compare estimation procedures of spillover effects or interactions of output per worker and capital per worker in agriculture, manufacturing and services in three regions in France and their contiguous neighbors. A subsequent paper by the same authors extended further the Arbia and Paelinck framework [7] [8] to consider the interdependent behavior of three sectors and the spillover effects on spatial neighbors in five Italian regions between 1980 and 2003 (see Piras et al. 2006).

In this model the cyclicity of the original LV model is removed so that it is no longer a non-convergent predator-prey model assuming constant predator-preying rates but one that describes 'a different convergence path and a different steady-state level for each region, as well as the conditions for the long-term equilibrium for the entire area' ([8], p. 359).

In her study of a sample of 17 states in India⁹, Kocornik-Mina [28] finds support for considering in the analysis of long run trends in income the simultaneous growth of the system of regions itself and of the structure of spatial dependence among states in India. This suggests a potential method for considering the patterns of interregional dynamics of individual pairs or groups of regions in the context of the whole interregional system in a way that federal and state policy may be better targeted and coordinated to enhance development especially at the local regional level. Her initial modelling results show that these interregional dynamics are quite complex but some shared traits by regions with similar patterns of interregional dynamics are a promising start and a solid foundation for efforts to translate this knowledge into concrete policies. The study does indeed identify varied interdependencies among states according to geographical proximity and/or structural equivalence.¹⁰ 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 sets of contiguity matrices in particular for some states that 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 (e.g., Bangalore and Hyderabad) is the engine of growth and

⁹ The seventeen states in the sample in alphabetical order are Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. The data used to estimate the model coefficients *a*, *b*, *c* and *d* are NSDP per capita published by the EPW Research Foundation (2003, [21]) and supplemented with data from the Government of India's Central Statistical Organization. The period of analysis is from fiscal year 1980-81 to fiscal year 2000-01.

¹⁰ Structural equivalence is defined according to 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.

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 exportation¹¹, 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.

5. Conclusions

This paper has been broad in scope and vision and thus enhances the odds of becoming superficial. For sure there is some superficiality in the structure of the argument and the depth of the evidence presented. This of course stems from the problem of limited space that denies the presentation of a large volume of supporting evidence and detail. So the first shortcoming of the paper is just this. But beyond that the goal has been to outline the argument presented and to illustrate it with examples from both China and India, albeit with a greater emphasis on India.

The evidence shows that income disparities are increasing in many parts of the world and as well in China and India. The paper also argues that most countries' development strategies are unbalanced either by design (China) or by default despite their intent (India) and that policies to counteract the associated fairness or equity issues must be developed and implemented notwithstanding that such policies may be marginally effective unless they are very strong and thus sufficient enough to counteract inertial forces.

The paper also attempts to argue that countries even when they lean toward balanced growth strategies cannot easily overcome inertial and local regional endogenous forces that tend to maintain prior unevenness in incomes and development (unless of course the endogenous forces include strong leadership and are sufficiently flexible to enable a region to adjust to change). Examples of inertial and endogenous forces are given and used to explain on the one hand that weak endogenous forces will not be sufficient to counteract inertial forces and when left unattended will likely drive a region into retarded development and a lagging region status in the face of market and/or technology change. On the other hand strong endogenous forces enable a region to adjust to changing conditions producing a good market and technology fit, and leading region status [50]. Such endogenous forces are leadership, institutional thickness, entrepreneurship, regulations and informal attributes such as values and accepted practices.

From a policy perspective this all means that national policies to address regional income disparities will at best be only partly effective unless they also include policies to influence the distribution of interregional economic spillover effects. Such interregional

¹¹ Interstate sales of goods are subject to taxes. According to Rao and Singh [44], these sales taxes are applied 'predominantly on the basis of origin, at the stage of manufacture or import. Taxes are also levied on raw materials, intermediate inputs, and capital goods' (p.215). As affluent states (tax exporters) tend to produce more goods that are exported to other less affluent states (tax importers), consumers in the latter end up paying sales taxes that are much higher than those paid by consumers in producing states. This is referred to as tax exportation and it is difficult to measure because data on interstate trade are not available. See Rao and Singh (2005).

effects are also driven by inertia (resources, scale, history and infrastructure) and local endogenous factors and if there are not strong policies to address lagging region problems the outcome over time will be in terms of the interaction between inertial and local regional endogenous forces. However, for effective interregional policies to be formulated improved information and modelling methods are needed. The current techniques for measuring interregional dynamics are limited and thus beg for innovation. One such innovation is a Lotka-Volterra based approach that takes into consideration individual growth effects in the modelling of the simultaneous growth of a system of spatial units.

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