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Pulapre Balakrishnan
Ashoka University, New Delhi
&
IIM Kozhikode

Mausumi Das
Email: mausumi@econdse.org
Department of Economics
Delhi School of Economics

M Parameswaran
Centre for Development Studies
Thiruvananthapuram, India

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CENTRE FOR DEVELOPMENT ECONOMICS
DELHI SCHOOL OF ECONOMICS
DELHI 110007

The internal dynamic of Indian economic growth*

Pulapre Balakrishnan
Ashoka University, New Delhi, India and IIM Kozhikode, India

Mausumi Das
Delhi School of Economics, New Delhi, India

M Parameswaran
Centre for Development Studies, Thiruvananthapuram, India

Abstract

A stylised fact of Indian economic history since 1950 is that the rate of growth of the economy has accelerated periodically and across policy regimes. In this paper we present a theoretical framework that can generate such a pattern due to cumulative causation through positive feedback. The growth process is then investigated using cointegration analysis. We are able to establish the existence of positive feedback which is at the centre of cumulative causation. We are also able to date the onset of this mechanism which has driven growth in India for close to half a century by now. This leads us to conclude that the internal dynamics are at least as important as the policy regimes to understand growth over the long term in this country.

Keywords: economic growth, India, cumulative causation, increasing returns, producer services

JEL Classification: O11, O41, O47

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1 Introduction

A stylised fact of the Indian economy since 1950 is that the rate of growth of the economy has accelerated, by which we mean it has increased periodically. During this period there have been two distinct policy regimes in place. The mid-50s had witnessed the launch of what has been referred to as the Nehru-Mahalanobis Strategy[1] which aimed at industrialisation within a regime characterised by investment licensing and restrictions on international trade and capital movements. This had lasted more or less unchanged till 1991 when a substantial liberalisation of the policy regime took place. The main aspects of this change were the ending of the licensing of private investment and the rescinding of many of the controls on international trade and payments. In the interim there had been policy changes, some even significant, but in our view these did not amount to what may be considered a regime change. While there has certainly been an acceleration of growth since the liberalisation of the policy regime in 1991 the growth rate of the economy had actually accelerated at least once before that date. This feature has been remarked upon as requiring explanation.[2] Actually, economists have not only pointed out that the accelerations have taken place while the policy regime had remained more or less unchanged but that they have taken place without an upward shift in the variables usually identified as likely to matter for growth transitions, such as the savings rate, foreign direct investment or exports.[3]. In a comment that has a bearing on the issue of growth accelerating without any significant change in the policy regime the authors have observed that the acceleration that they date to the seventies occurred at a time when "... India had acquired a reputation as one of the most protected and heavily regulated economies in the world." In this paper we propose a model of growth based on cumulative causation that generates accelerating growth in the economy once it crosses a threshold size. Next, we test for the presence of such a mechanism in the data. We are able to detect its presence and date its initiation.

2 History of growth in India

The history of growth in the Indian economy since 1950 is that the growth rate has increased over time. This pattern of acceleration may be seen in Figure 1

[1] See Chakravarty (1987).

[2] The economist who first proposed that growth acceleration in India happened before 1991, and therefore did not coincide with a change in the policy regime, was DeLong (2003).

[3] See Kotwal, Ramaswami, and Wadhwa (2011)

below which depicts the different growth phases of the economy. These have been identified using the Bai and Perron (1998) procedure.[4] From Figure 1 it may be noted that, except for one phase, the rate of growth of the economy has accelerated periodically. Two observations are in order here. First, the slight decline in the rate of growth after 1964-65 is arguably related to two consecutive years of exceptional drought, with a direct impact on agricultural production, and a severely reduced growth of public capital formation which lasted for a whole decade. Both are in the nature of exogenous shocks and may reasonably be assumed to be unrelated to the internal dynamic of the growth process.[5]. When the Bai-Perron procedure is repeated with the outliers, namely the level of GDP in the years 1965-66 and 1979-80, excluded we find a continuous acceleration of the economy.[6] The repeated acceleration of the Indian economy is therefore established as a stylised fact. Secondly, Figure 1 does not reveal an acceleration that had occurred in the first half of the nineteen fifties. The Bai-Perron exercise requires a trimming of the data at both ends of the sample as a regime switch is required to last a certain length of time to be counted as one. In the underlying exercise we have followed the established convention of allowing for a 15 percent trimming, implying a data stretch of approximately eight years given our sample size. Thus an acceleration in the first half of the 1950s could not have been identified, as sample begins with 1950. On the other hand, when data for the entire twentieth century is considered, an acceleration is evident in the first half of the nineteen fifties. So the acceleration of growth in India had actually commenced even earlier than reflected in Figure 1. Note that these accelerations occurred even before any overhauling of the policy regime which had remained more or less unchanged since the 1950s till 1991 when significant trade and industrial policy reforms were initiated. These reforms assigned a larger role to the market and took the Indian economy in the direction of greater integration with the rest of the world. We take the observed behaviour to imply that the internal dynamics of the growth process, which may be understood as the mechanism of growth, have been at least as important for the acceleration as shifts in the policy regime. We do not interpret this as implying that economic policy does not matter, only that we would need to recognise a possible role for internal dynamics. To run ahead a little, we might say that economic policy is most effective when it serves to quicken

[4] All details relevant to this estimation may be found in Balakrishnan and Parameswaran (2007).

[5] These events and their impact on the economy have been documented in Balakrishnan (2010). How exogenous shocks can affect the internal dynamics is discussed in Section 3.

[6] The breakpoints however alter. The estimates may be had from the authors upon request.

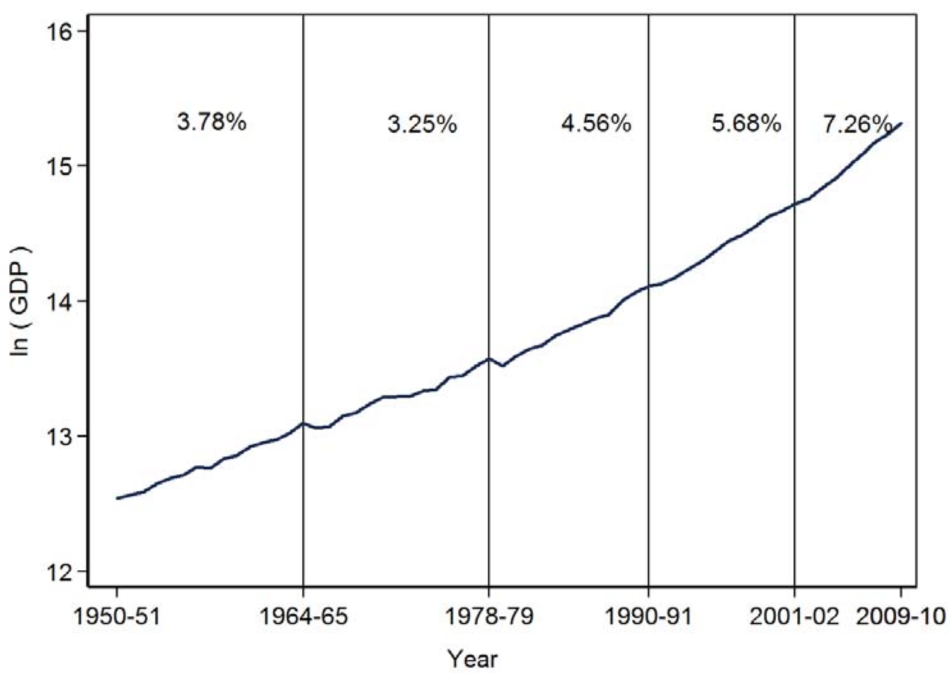

Figure 1: Growth transitions in India 1950–2010

these dynamics. The evidence thus far suggests that there is a case for more nuanced understanding of the growth process in India.

Table 1: Sectoral Growth Rates (in %)

Series	First Period	Second Period	Third Period	Fourth Period
Primary	2.42 [1950-51 to 1986-87]	3.31 [1987-88 to 2009-10]		
Manufacturing	6.23 [1950-51 to 1964-65]	4.34 [1965-66 to 1984-85]	5.90 [1985-86 to 1998-99]	7.12 [1999-00 to 2009-10]
Services	4.47 [1950-51 to 1959-60]	4.29 [1960-61 to 1979-80]	6.17 [1980-81to 1996-97]	8.24 [1997-98 to 2009-10]

Note: Brackets contain the period of the reported growth rate.

3 Existing Literature

In a recent survey Basu and Maertens (2007) have identified two contending views explaining the contemporary growth surge in India: the conventional view that argues that the policy reforms of the early 1990s had played a major role in the growth acceleration; and a countering view, which argues that the surge in growth rate in India happened around 1980 and could therefore not be attributed entirely to the new economic policies of the early 1990s. However, much of the research surveyed in the article may be seen as addressing the issue that growth in India may have accelerated before the liberalising reforms of 1991. The feature that growth has accelerated periodically since 1950, including more than once post 1991 - as established in Figure 1 - is not, however, addressed.

Two papers that address the question of growth accelerating before the liberalisation of the economy in 1991 merit attention. It is of interest that they approach the problem from radically opposing angles. The first authors to attempt an explanation of DeLong's observation that the growth transition occurred before any major shift in the economic policy regime had taken place were Rodrik and Subramanian (2005). They argued that the growth transition of *circa* 1980 followed the "pro business" (note not "pro market") tilt in economic policy in the final stage of the Indira Gandhi regime. Rodrik and Subramanian believe that the impact of this shift may be seen in the rise of productivity growth around that time. Prima facie the thesis appears problematic as the share of manufacturing itself is small. Unless of course the multipliers/spillover effects are very large. By way of criticism of the Rodrik and Subramanian argument, Agarwal and Whalley (2013) state that the share of private corporate investment did not rise in the 1980s leaving unspecified the mechanism whereby the alleged pro-business tilt led to faster growth. Actually, for most of the 1980s private investment remained steady, except in the last 3 years of the decade when it rose sharply, which DeLong (2003) explains in terms of the positive expectation following Rajiv Gandhi's rise to power.

Terming the Rodrik and Subramanian explanation as a "supply side" account, Nell (2013), provides an exclusively demand-side explanation of the transition of 1980. First, he contests their test of a demand-based explanation of the transition. Rodrik and Subramanian had rejected a demand-based explanation of the growth turnaround on grounds of an insignificant increase in capacity utilisation. Nell's case is that when the natural rate of growth is endogenous to demand no increase in capacity utilisation is necessary to accommodate growing demand. It is based on the idea that the natural rate of growth rises in response to the growth of autonomous demand, inducing faster growth of labour productivity. This view harks back to Verdoon's Law which is based on the productivity growth experience of European economies. Nell identifies the relevant demand shock of the 1980s in India as the step-up in the fiscal deficit as a share of GDP. This shift in the fiscal stance, it is argued, contributed to a growth acceleration.

The Rodrik and Subramanian and Nell accounts share some features which leave them of limited use in an investigation of long-term growth in India, a prominent feature of which is the periodic acceleration of the growth rate. For instance after the increase in the 1980s highlighted by Nell the fiscal deficit has declined steadily since 1991 once fiscal consolidation became an explicit objective of economic policy (see: De, 2012). However, as seen in Figure 1, growth accelerated twice during this period of fiscal consolidation. Both sets of authors identify some elements of the growth transition of *circa* 1980, but implicitly confine themselves to a single sector namely manufacturing. Sectoral focus robs these explanations of economy-wide scope. As seen in Table 1 there is at least much dynamism in the service sector as there is in manufacturing. Some reflection based on the information in Table 1 suggests that a proper explanation of the growth transitions observed should be based on a continued - and possibly linked - acceleration of the growth rates of both manufacturing and services.

There is also another strand in the literature which may be characterised as studying the sources of growth. Papers by Madsen, Saxena, and Ang (2010); Banerjee and Sinharoy (2014) would fall within this category, with the former set of authors proposing that India's growth is consistent with at least one version of endogenous growth theory and the latter set identifying education and trade as central to long-term growth. But none of them address the repeated acceleration of the growth rate, which is the concern of this paper.

We conclude our brief survey of the literature by observing that a key feature of growth in India i.e., its continued acceleration is not addressed by existing papers that have either provided episodic explanations – focussing on phases of fast growth – or tried to identify the sources of growth. In this paper we aim to isolate the internal dynamics of growth that can account for its continued acceleration across policy regimes.

4 Cumulative Causation and Accelerating Growth

First, we seek a theoretical framework capable of accommodating the Indian growth experience. Such a framework should be able to explain the experience which, as shown above, is one of a continuously accelerating rate of growth of the economy across policy regimes. From a study of growth by principal sectors, displayed in Table 1, we observe the following pattern.[7] The primary sector has displayed steady growth since the late 1980s while both manufacturing and services display steady acceleration even after that date. Therefore an explanation of the growth history of the economy would have to give a significant role for its non-primary segments. This leads us to explore an explanation that grants a role to a dynamism resulting from interaction between these two sectors. It may be noted that they account for over 80% of GDP currently.

An important feature of modern production processes is the use of a variety of specialised intermediate inputs to produce the final good. These specialised inputs themselves are produced using yet another set of specialised inputs. Thus production of a commodity involves a number sequences, each using a variety of specialised inputs. This process of specialisation increases productivity at every stage of the production process, resulting in higher productivity of the final-goods sector. These specialised inputs are more costly to produce in the presence of a small market. The production of a larger variety of specialised intermediate inputs, or a deeper division of labour, is dependent upon a large final-goods sector the demand generated by which makes production of a greater variety of intermediate inputs economically viable. Increased productivity of the final-goods sector, due to greater variety of inputs, stimulates its expansion which in turn leads to further division of labour.

An economy characterised by this kind of complementarity between final-goods production and specialised inputs will typically exhibit economy-wide increasing returns, which results in either expectation-driven multiple equilibria (each with self-fulfilling expectations) or history-driven multiple steady states (or equilibrium growth trajectories). When labour and/or production of various specialised inputs can be adjusted instantaneously, expectation plays a crucial role in determining the actual scale of operation. Expectation of high (low) demand stimulates a higher (lower) scale of operation, which indeed results in high (low) demand for each product, sustaining the initial belief. Thus there are two equilibria - high and low - each sustained by a self-fulfilling belief or expectation.

When labour and other inputs are slow to adjust, history becomes crucial in determining the subsequent growth trajectory of the economy. If the economy historically starts with a low size of the manufacturing sector and/or fewer varieties of intermediate inputs, then the corresponding scale

[7]The phases of growth in each sector were also identified by applying the very same Bai-Perron method.

of manufacturing remains low and the economy gets stuck to a low steady state (with limited range of intermediate inputs, a 'shallow' division of labour and persistent low productivity of the final goods sector) quite independent of agents' expectations. Conversely, a manufacturing sector and/or larger varieties of intermediate inputs allows the economy to enjoy perpetual growth in income and output along an equilibrium path, characterised by increased degree of specialisation and concomitant rise in productivity[8].

Here we follow the history-based mechanism to explain the growth trajectory of the Indian economy. An implication is that in an economy of the above type, once growth has been initiated, the interaction between the sectors causes the growth rate of the economy to accelerate. However a sufficiently strong negative shock can cause a slowing of its momentum precisely because of the mechanism outlined above. We can imagine such shocks in the form of events external to the economy such as shocks to the balance of payments or agricultural-supply fluctuations. Exogenous shocks can also come in the form of public investment cycles.

As stated above, in the presence of a complementarity between the sectors of an economy, history matters, i.e., the economy could be in either of the two equilibria depending upon where it was to start with. But exactly as shocks can alter its growth rate, a stagnant economy can also be 'shocked' into the preferred equilibrium, with a high level of income, by deliberate policy, including co-ordinated public investment. Rosenstein-Rodan's conception of the Big Push refers precisely to such pre-meditated shocking of an economy stuck in a 'low-level equilibrium trap'[9], though he was not so directly concerned with growth as we are here. In the theory of growth, the earliest statement of a process propelled by specialisation is due to Young (1928). Young had identified specialisation as a source of economy-wide increasing returns driving growth. Of course, the idea was already in Adam Smith except that the specialisation in 'The Wealth of Nations' was contained within the pin-factory and did not extend to the dynamics of the economy as a whole. Later Stigler (1951) had identified the cheapening of purchased services due to their specialised production as the source of a downward-shifting cost curve for the manufacturing firm. It may be mentioned that the Young process is truly

[8]For a review of the literature on the interrelationship between the division of labour and economic development resulting in expectation-driven multiple equilibria see Matsuyama (1991); Ciccone and Matsuyama (1996); Rodríguez-Clare (1996, 1997). History-driven growth trajectories based on increased specialisation have been analysed by Romer (1987, 1990); Benassy (1998). The relative importance of history vis-a-vis expectations in the process of economic development have been analysed by Krugman (1991) and Adserá and Ray (1998).

[9]The idea has been formalised by Murphy, Shleifer, and Vishny (1989).

endogenous, leading Kaldor (1972) to term such growth as "cumulative and endogenous change".

4.1 Producer Services in Modern Economies

We have suggested above that viewing long term growth in India as an interaction between the manufacturing and services sectors is helpful to understanding the recent history of the Indian economy. Here we single out that part of services production that is most likely to contribute to accelerating growth as result of this interaction. It has been argued in the literature that industrialising economies rely substantially on producer services[10]. This has been suggested on the basis of data on the size of the producer services sector in these economies and also the large share of employment accounted by these services there. Moreover, it has been argued that these services are produced under conditions of increasing returns to scale (IRS) due the presence of significant start-up costs. The "specialised inputs" of our discussion above may be considered to refer to such producer services. Interestingly, increasing returns to scale in manufacturing has been widely recognised in the theory but not in the production of services[11]. Before turning to our theoretical model and the empirical investigation based on it, it would be useful to list the producer services likely to matter, and to review the evidence on the presence of IRS in the provision of producer services.

In a pioneering study for the United States (Greenfield, 1966) the following have been listed as producer services: Transportation, Communications, Wholesale trade, Finance Insurance and Real Estate (FIRE), Business services, Legal services, Engineering and Government. Two points about this list may be noted. First, this more or less exhausts much of what constitutes the 'Tertiary sector' in India's National Accounts. Secondly, the inclusion by Greenfield of government as a producer service is interesting in that it conveys a non-ideological assessment of what the state can do in principle. It appears to be based on a realistic assessment of the role of government in the US economy in the middle of the second half of the 20th century. Greenfield's estimate of the share producer services in GDP for the USA in 1960 is 22%. In our empirical investigation that follows we use both a broad and a narrow definition of producer services, the latter being designated 'core producer services' which are defined in Section 5. Here it may be noted that in the year 1980-81 in India producer services accounted for 46% of GDP and core producer services for 28%. By the year 2000-01 these had increased to 59%

[10] SeeRodríguez-Clare (1997); Faini (1984); Greenfield (1966).

[11] For instance, while Young (1928) had conceived of an endogenous growth process driven by increasing returns in production he had confined his story to manufacturing.

and 37%, respectively. It is equally relevant that along with the rise in the share of producer services in the national income there has been a concomitant increase in the share of private provision of these. Our estimates show that public provision of producer services broadly defined fell from 31 percent in 1980 to 25 percent in 2010. With respect to the so-called "core" producer services, the figure fell from 22 percent to 16 percent over this period. Thus we find that for over half the sample period in our study the provision of producer services has been overwhelmingly by the private sector. This gives a somewhat aggregative picture of course. While it suffices given our purpose, we draw attention to a snapshot of the distribution between public and private sectors across categories within India's services sector provided in Nayyar (2013).

Finally, onto the evidence for increasing returns to scale in the production of producer services. Much of the evidence is from studies of western economies. This has been collected in Faini (1984). There, evidence for IRS is cited in sectors as wide-ranging as banking, trade, and advisory services apart from the obvious ones such as roads and transportation. For India, evidence is presented by Elhance and Lakshmanan (1988) of decreasing cost of inputs to manufacturing following the expansion of "infrastructure", both social and physical. Their's admittedly is a set wider than our own 'producer services'. Recent research on Indian manufacturing identify the productivity enhancing effect of producer services (see: Banga and Goldar (2007); Arnold, Javorcik, Lipscomb, and Mattoo (2016))[12].

We now present a theoretical model of interaction between manufacturing and producer services that generates accelerating growth.

5 A Model

In this section we draw upon an endogenous growth model with specialised intermediate inputs (a la Romer (1990)) and combine it with a Lewisian labour migration story to provide a model of accelerating growth.[13] These specialised inputs can be interpretated as the producer services which we would focus on in our subsequent empirical analysis. The profit dynamics in the intermediate inputs sector together with the labour dynamics in final

[12]For an early recognition of the importance of producer services in understanding the growth process in India see Kotwal and Ramaswami (1998).

[13]Labour migration from agriculture to non-agricultural sector is consistent with the Indian growth experience. As Papola and Sahu (2012) show, the employment share of agriculture has been falling steadily while that of non-agriculture (manufacturing and services) has been rising consistently since 1970-71.

goods production generates a process of cumulative causation, resulting in accelerating rate of growth for the model.[14]

The model presented here is close in spirit to that of Eswaran and Kotwal (2002) who explore the role of service sector in the process of industrialisation. However theirs is not a story of growth. They only consider whether a one-shot increase in agricultural productivity can lead to emergence of a viable industrial sector working through the services sector. In our model on the other hand, the virtuous cycle of positive externalities from the services sector to manufacturing and from manufacturing back to services again work continuously to generate an accelerating growth rate for the economy. Unlike Eswaran and Kotwal, the agricultural sector in our model (which we model only implicitly) is Lewisian in nature, characterized by surplus labour and a constant marginal product of labour.

The underlying production structure is as follows. There is a perfectly competitive manufacturing sector that uses labour and a variety of specialised inputs, namely producer services, to produce the final output (along the lines of Dixit and Stiglitz (1977); Ethier (1982), Romer (1990)).[15] The final commodity, which is also the numeraire, is used for consumption and investment purposes. The specialised inputs of different varieties are on the other hand provided by monopolist firms who set their own prices and use manufacturing output as an input of production.

At any point of time the total supply of labour (L_t) to manufacturing and the number of varieties of specialised inputs (n_t) are given. The supply of labour in manufacturing changes over time in response to the existing wage differential between manufacturing and the alternative occupation (say, agriculture). The number of specialised inputs on the other hand goes up due to investment in the production of newer varieties. We shall assume that all wages are consumed while all profits are invested. Thus the number of new varieties produced depends positively on the amount of profits earned in the previous period.

In this set up, the process of cumulative causation works in the following way. Suppose at the beginning the economy is at a steady state with a constant supply of labour and a constant number of varieties being employed period after period. Now suppose there is an exogenous one-time positive

[14] This is a stylised model which naturally cannot explain every possible feature of the Indian growth story. As mentioned earlier, the purpose here is to highlight a mechanism that links the manufacturing output and producers' services together in generating accelerating growth.

[15] We use term 'labour' here in a generic sense and do not differentiate between skilled and unskilled labour. Adding skilled labour as a separate input would not change any of the results of the model.

shock that raises the profitability of intermediate goods production. In the next period, all the extra profits are invested, which increases the number of varieties of specialised inputs available in the next period. Increased variety in our Dixit-Stiglitz specification increases productivity of labour in manufacturing. Thus due to the increase in the number of specialised inputs in the next period, the wage rate in manufacturing also goes up, which draws more labour from agriculture to manufacturing. This results in further increase in manufacturing output - with a concomitant increase in demand and corresponding supply of all the existing specialised inputs (including the new ones that have just come up). Once again, the increased sales contributes to increased profits - which, when invested, yet again generates newer varieties of specialised inputs in the subsequent period. This chain of events continues, resulting in an accelerating rate of growth for manufacturing.

A similar complementarity between inputs in the production process have been explored in Ciccone and Matsuyama (1996) and Rodríguez-Clare (1996). However Rodriguez-Clare's is a static model which does not allow for growth. In Ciccone-Matsuyama on the other hand labour remains constant. Thus even though the economy exhibits growth, there is no necessary mechanism to explain 'accelerating growth'. Moreover in both these models, there are multiple equilibrium trajectories for the economy - driven by expectations. In our model, there is no multiple equilibria. Given history, growth trajectory of the economy is uniquely defined. History also determines whether an economy at all takes off or stagnates. Thus an external big push is required to initiate the process of growth. But once it takes off, its subsequent acceleration is driven entirely by its internal dynamics.[16] We now present our basic model.

5.1 The Static Model (L_t and n_t given)

In manufacturing, output is produced using labour (L_t) and n_t varieties of producer services. This good is used for consumption and investment. In the model it is treated as the numeraire, and all prices and factor returns are measured in units of manufacturing. Manufacturing production technology is as follows:

$$Y_t = (L_t)^{1-\alpha} \int_{j=0}^{n_t} (x_{jt})^{\alpha}\, dj; \qquad 0 < \alpha < 1. \tag{1}$$

The manufacturing sector is consists of competitive firms who take the input prices (w_t and p_js for all j) as given and equate these with the corre-

[16] Bose and Chattopadhyay (2010) presents examples of growth models which are similar in spirit to ours, although the underlying mechanisms are quite different.

sponding marginal products. Thus

$$w_t = \frac{\partial Y}{\partial L} = (1-\alpha)(L_t)^{-\alpha} \int_{j=0}^{n_t} (x_{jt})^{\alpha} dj; \tag{2}$$

and,

$$p_{jt} = \frac{\partial Y}{\partial x_j} = \alpha (L_t)^{1-\alpha} (x_{jt})^{\alpha-1} \text{ for all} j. \tag{3}$$

Notice that equation (3) represents the inverse demand function for each specialised input j, being a producer service, coming from the manufacturing sector.

5.1.1 Production technology for specialised inputs:

Each specialised input can be potentially produced by a monopolist who has a patent for producing the specialised input for one period. Production of a variety requires the manufacturing good as an input[17]. There are two kinds of costs the patent-holding monopolist has to incur in order to produce the specialised input j. First, it requires a fixed set-up cost, K, which must be incurred *before* production takes place. Hence It must be financed by borrowing and/or from past savings which involves an imputed interest rate of r. Thus the fixed cost incurred by each monopolist producer of the j^{th} variety is:

$$F = rK \tag{4}$$

After the fixed set-up cost has been incurred, production of the specialised input also require manufacturing goods as inputs. Let us assume that production of one unit specialised input of any variety requires one unit of the manufacturing good, which is the variable cost associated with the production of specialised inputs. Thus, profit of the monopolist producer of specialised input j is given by:

$$\pi_{jt} = p_{jt} x_{jt} - x_{jt} - F. \tag{5}$$

Following Acemoglu, Zilibotti, and Aghion (2006); Klasing (2014), we further assume that there exits a large number of competitive firms which can imitate the technology available to the monopolist and produce the same variety without incurring any fixed cost, but incurring a higher variable cost. Let us assume that the unit cost (in terms of manufacturing good) of imitating

[17] This specification has been borrowed from Aghion and Howitt (2008), Chapter 3, Section 3.2.1.

any particular variety of intermediate input is given by $\eta > 1$. Thus the price that would be charged by the competitive fringe would be given by η. This sets an upper bound on the price that can be charged by the monopolist.

Using the inverse demand function (3) for the monopolist producer of intermediate input j, we can write his profit function as:

$$\pi_{jt} = \alpha \left(L_t\right)^{1-\alpha} \left(x_{jt}\right)^{\alpha} - x_{jt} - F. \tag{6}$$

The monopolist maximises (6) with respect to x_j, which gives us the optimal quantity produced by the monopolist as:

$$\begin{aligned} x^*_{jt} \quad &: \quad \frac{d\pi_j}{dx_j} = 0 \Rightarrow \alpha^2 \left(L_t\right)^{1-\alpha} \left(x_{jt}\right)^{\alpha-1} - 1 = 0 \\ &\Rightarrow \quad x^*_{jt} = \alpha^{\frac{2}{1-\alpha}} L_t \end{aligned} \tag{7}$$

Hence, the profit maximising price for the monopolist producer of variety j is given by:

$$\begin{aligned} p_{jt} \quad &= \quad \alpha \left(L_t\right)^{1-\alpha} \left(x^*_{jt}\right)^{\alpha-1} \\ &\Rightarrow \quad p_{jt} = \frac{1}{\alpha}. \end{aligned} \tag{8}$$

Notice that in the absence of the competitive fringe, the monopolist would charge a price equal to $\frac{1}{\alpha}$. We shall assume that $\frac{1}{\alpha} > \eta$, so that monopolist producer is compelled to charge a price equal to η. At this price, profit of the monopolist producer of variety j is given by:

$$\begin{aligned} \pi^*_{jt} \quad &= \quad \eta x^*_{jt} - x^*_{jt} - F \\ &\Rightarrow \quad \pi^*_{jt} = (\eta - 1)\alpha^{\frac{2}{1-\alpha}}.L_t - F \end{aligned} \tag{9}$$

Notice that all the specialised input producers charge the same price and optimally produce the same amount. Thus in this *symmetric equilibrium* ,

$$\left. \begin{aligned} x^*_{jt} = x^*_{it} = x^*_t = \alpha^{\frac{2}{1-\alpha}}.L_t; \\ p^*_{jt} = p^*_{it} = p^* = \eta. \\ \pi^*_{jt} = \pi^*_{it} = \pi^*_t = (\eta - 1)\alpha^{\frac{2}{1-\alpha}}.L_t - F \end{aligned} \right\} \text{for all specialized inputs } i \text{ and } j. \tag{10}$$

Recall that the patent right for the monopolist producer of a variety lasts only for one period. Thus, if he operates, the monopolist producers earns profit only for one period. Thereafter production of that particular variety is taken over by the competitive fringe. Moreover, if for some reason the monopolist firm decides not to operate in any period (under circumstances to be specified later), then again production is taken over by the competitive fringe. This implies that the prices charged for any specialised input (whether produced by the monopolist or by the competitive fringe) remain constant at η. Moreover, there is always some non-zero number specialised inputs available for manufacturing production. Growth however can happen if and only if either the number of specialised inputs or the labour force employed in manufacturing goes up over time.

The gross output produced in the manufacturing sector at time t (using the symmetric equilibrium condition) is given by:

$$\begin{aligned} Y_t &= (L_t)^{1-\alpha} \int_{j=0}^{n_t} (x_{jt})^{\alpha} \, dj = (L_t)^{1-\alpha} \int_{j=0}^{n_t} (x_t^*)^{\alpha} \, dj = (L_t)^{1-\alpha} (x_t^*)^{\alpha} \int_{j=0}^{n_t} dj \\ &\Rightarrow Y_t = (L_t)^{1-\alpha} (x_t^*)^{\alpha} \; n_t. \end{aligned} \tag{11}$$

Recall however that part of the manufacturing output is used as input in the production of specialised inputs. Thus net output or value-addition in manufacturing in period t :

$$V_t \equiv Y_t - n_t x_t^* = (L_t)^{1-\alpha} (x_t^*)^{\alpha} \; n_t - n_t x_t^*.$$

Plugging the equilibrium value of x_t^* :

$$\begin{aligned} V_t &= (L_t)^{1-\alpha} \left(\alpha^{\frac{2}{1-\alpha}} \; L_t\right)^{\alpha} \; n_t - n_t \, \alpha^{\frac{2}{1-\alpha}} \; L_t \\ &\Rightarrow V_t = \alpha^{\frac{2\alpha}{1-\alpha}} \; n_t L_t \; - \; \alpha^{\frac{2}{1-\alpha}} \; n_t L_t \\ &\Rightarrow V_t = \alpha^{\frac{2}{1-\alpha}}. \left(\frac{1}{\alpha^2} - 1\right) \; n_t L_t > 0. \end{aligned} \tag{12}$$

Finally, the manufacturing wage rate in the symmetric equilibrium is given by:

$$\begin{aligned} w_t &= (1-\alpha)\,(L_t)^{-\alpha} \int_{j=0}^{n_t} (x_t^*)^{\alpha} \, dj = (1-\alpha)\,(L_t)^{-\alpha} \, n_t \, (x_t^*)^{\alpha} \\ &\Rightarrow w_t = (1-\alpha)\,(L_t)^{-\alpha} \left(\alpha^{\frac{2}{1-\alpha}} \; L_t\right)^{\alpha} n_t \\ &\Rightarrow w_t = (1-\alpha)\alpha^{\frac{2\alpha}{1-\alpha}} \; n_t \end{aligned} \tag{13}$$

It is clear from the above equation (equation (12)) that rate of growth of value addition in manufacturing is directly related to the rate of growth of n_t

and L_t, i.e.,

$$\frac{\dot{V}}{V} = \frac{\dot{n}}{n} + \frac{\dot{L}}{L}.$$

In the next section we trace the dynamics of n_t and L_t and show that this model is capable of generating accelerating rate of growth of manufacturing. However, before we go to the dynamics, there are two important points that need to be mentioned here. First, note that due to presence of the fixed cost, the monopolist producers of specialised inputs earn non-negative profits if and only if (from equation (6)):

$$L_t \geqq \frac{F}{(\eta - 1)} \alpha^{-\frac{2}{1-\alpha}} \equiv \bar{L} \text{ (say)}.$$

As we have just noted above (in equation (12), the value addition in manufacturing depends linearly on labour employed in manufacturing and on the number of varieties of specialised inputs. Thus given $\bar{L}$, we can find a corresponding level of *net output per unit of designs*, represented by

$$\bar{v} : v_t \equiv \frac{V_t}{n_t} = \alpha^{\frac{2}{1-\alpha}}. \left(\frac{1}{\alpha^2} - 1\right) \bar{L},$$

such that manufacturing production takes off if and only if

$$v_t \geqq \bar{v}.$$

We could interpret this $\bar{v}$ as a scale effect, i.e., a minimum size of the manufacturing sector (relative to the number of varieties of specialised inputs existing) is necessary for it to take off. To put it differently, the 'share' of each intermediary input in the manufacturing output, as captured by the $\frac{V_t}{n_t}$ ratio, should be sufficiently high. If the scale of operation in manufacturing falls below this level, then the mopolist

Secondly, notice from equation (12) that

$$V_t = \alpha^{\frac{2}{1-\alpha}}. \left(\frac{1}{\alpha^2} - 1\right) n_t L_t.$$

At the same time, from equation (7),

$$x_t^* = \alpha^{\frac{2}{1-\alpha}} L_t.$$

Using these two relationship, we can write the equilibrium net output in manufacturing as:

$$V_t = \left(\frac{1}{\alpha^2} - 1\right) n_t \left(\alpha^{\frac{2}{1-\alpha}}.L_t\right) = \left(\frac{1}{\alpha^2} - 1\right) n_t x_t^* = \left(\frac{1}{\alpha^2} - 1\right) X_t,$$

where $X_t \equiv n_t x_t^*$ is the total amount of specialised inputs that is provided to manufacturing in equilibrium. Written this way, it is clear that

$$\frac{\dot{X}}{X} = \frac{\dot{V}}{V} = \frac{\dot{n}}{n} + \frac{\dot{L}}{L}.$$

In other words, the dynamic behaviour that we are going to capture in the next section in terms of n_t and L_t will be *equivalent* to the dynamic behaviour of X_t. Thus the empirical specification where $\frac{\dot{V}}{V}$ has been linked to $\frac{\dot{X}}{X}$ derives from the dynamics of the present model.

5.2 Dynamics

Recall from equation (12) that

$$\frac{\dot{V}}{V} = \frac{\dot{n}}{n} + \frac{\dot{L}}{L}.$$

In this section we are going to specify the economic principles that govern the movements of n_t and L_t over time. In the process we also show that these economic principles working through n_t and L_t are capable of generating accelerating rate of growth for V_t.

5.2.1 Dynamics of L_t

We postulate that labour supply in manufacturing corresponds to a Lewis-Harris-Todaro type migration story, such that the rate of movement of labour from agriculture to manufacturing is linked to the wage differential between the two sectors. Let us assume that there is surplus labour in agriculture so that the real wage rate in agriculture is constant at some level $\bar{A}$ and moving some people away from agriculture does not affect this wage rate - at least no immediately. Then labour supply in manufacturing obeys the following dynamic equation:

$$\frac{\dot{L}}{L} = f(w_t - \bar{A}); f(0) = 0; f' > 0.$$

This equation implies that labour keeps moving from agriculture to manufacturing as long as $w_t > \bar{A}$ (the opposite happens $w_t < \bar{A}$) and the labour movement across sectors stops when the wages across sectors are equalised. Without any loss of generality, let us assume that f is a linear function such that

$$\frac{\dot{L}}{L} = \lambda. \left[w_t - \bar{A} \right]; \ \lambda > 0.$$

Further, plugging back the equilibrium value manufacturing wage (from equation (13)):

$$\dot{L} = \lambda \cdot L_t \cdot \left[(1-\alpha)\alpha^{\frac{2\alpha}{1-\alpha}} n_t - \bar{A}\right] \tag{14}$$

5.2.2 Dynamics of n_t:

Recall that the producers of specialised inputs earn non-negative profits provided $L_t \geqq \bar{L}$. Let us assume that all these profits are invested in coming up with newer ways of production organization which enhances the variety of specialised inputs over time, such that

$$\dot{n} = g(\Pi_t); \;\; g(0) = 0; \;\; g' > 0,$$

where $\Pi_t \equiv n_t \pi_t^*$ is the aggregate profit earned in period t.[18] Again, without any loss of generality, let us assume that g is a linear function such that

$$\dot{n} = \mu.\Pi_t; \;\; \mu > 0$$

Further, plugging back the equilibrium value of profit for each specialised-input producer (from equation (10)):

$$\begin{aligned} \dot{n} &= \mu.n_t \pi_t^* \\ &\Rightarrow \; \dot{n} = \mu.n_t \left[(\eta - 1)\alpha^{\frac{2}{1-\alpha}}.L_t - F\right] \end{aligned} \tag{15}$$

5.2.3 Phase Diagram:

Equations (14) and (15) represent a 2×2 system of differential equations in L_t and n_t. We analyse the dynamics in terms of the following phase diagram.

Notice that from (14),

$$\dot{L} \;=\; 0 \Rightarrow \lambda.L_t \,.\, \left[(1-\alpha)\alpha^{\frac{2\alpha}{1-\alpha}} \; n_t - \bar{A}\right] = 0$$

$$\Rightarrow \begin{array}{l} \text{either } L_t = 0 \\ \text{or } \; n_t = \frac{\bar{A}}{1-\alpha}\alpha^{-\frac{2\alpha}{1-\alpha}} \equiv \bar{n} \text{ (say).} \end{array}$$

Also for any positive value of $L_t$whenever $n_t > \bar{n}$, $\dot{L} > 0$; and whenever $n_t < \bar{n}$, $\dot{L} < 0$.

[18] Notice that this dynamic equation is relevant if and only if $L_t \geqq \bar{L}$. Otherwise it is not profitable to supply specialised inputs to manufacturing; hence the manufacturing production collapses.

Again, from (15),

$$\dot{n} \;=\; 0 \Rightarrow \mu.n_t\left[(\eta-1)\alpha^{\frac{2}{1-\alpha}}.L_t - F\right] = 0$$

$$\Rightarrow \begin{array}{c} \text{either } n_t = 0 \\ \text{or } L_t = \frac{F}{(\eta-1)}\alpha^{-\frac{2}{1-\alpha}} \equiv \bar{L} \end{array}$$

Also for any positive value of n_t,whenever $L_t > \bar{L}$, $\dot{n} > 0$. On the other hand, whenever $L_t < \bar{L}$, the potential profit of the monopolists turn negative; hence they refrain from production. In this case, intermediate goods production is carried out only by the competitive fringe and there is no investment in increasing the variety of specialized inputs. Thus $\dot{n} = 0$.

We summarise all these information in the following phase diagram:

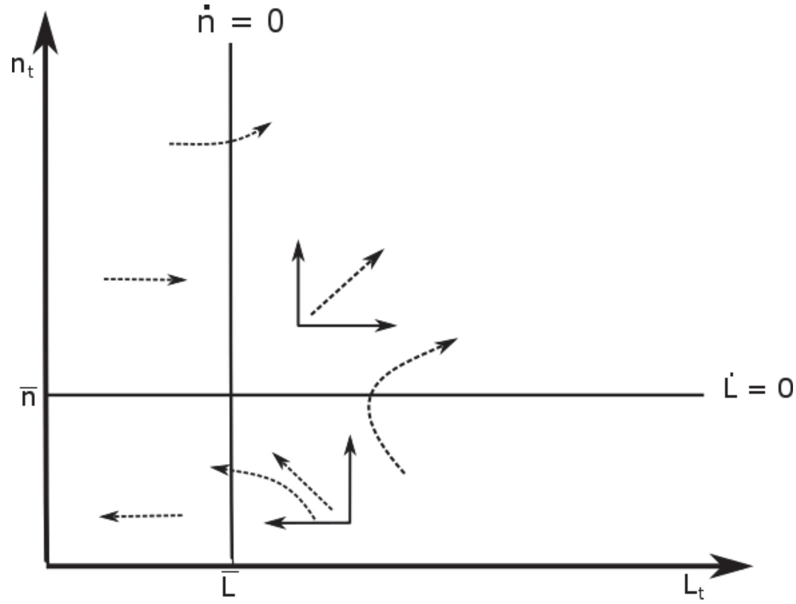

Figure 2: Dynamics of the Economy

From the phase diagram it is clear that there exits a trap (represented by the south-west corner of the diagram where $n_t < \bar{n}$ and $L_t < \bar{L}$) such that if the economy starts in this region then manufacturing sector does not take off - unless there is an external push. To put it differently, the internal dynamics fails to generate growth if the economy gets stuck in this region.

On the other hand, in the region where $n_t > \bar{n}$ and $L_t > \bar{L}$, both n_t and L_t are perpetually growing. It fact, in this region both n_t and L_t are increasing at an *increasing* rate. To see this, notice that from (15),

$$\frac{\dot{n}}{n} = \mu. \left[\left(\frac{1-\alpha}{\alpha} \right) \alpha^{\frac{2}{1-\alpha}} .L_t - F \right] \equiv \gamma_n \text{ (say)}.$$

Now, $\dfrac{d\gamma_n}{dL} > 0$. Thus in the region where L is increasing over time, γ_n will be increasing too.

Next, note that from (14),

$$\frac{\dot{L}}{L} = \lambda. \left[(1-\alpha)\alpha^{\frac{2\alpha}{1-\alpha}} \; n_t - \bar{A} \right] \equiv \gamma_L \text{ (say)}.$$

Again, $\dfrac{d\gamma_L}{dn} > 0$. Thus in the region where n is increasing over time, γ_n will be increasing too.

It therefore follows that in the region where both n_t and L_t are increasing, manufacturing output also increases at an increasing (accelerating) rate. This result arises due to the fact that $\dfrac{\dot{V}}{V} = \dfrac{\dot{n}}{n} + \dfrac{\dot{L}}{L}$, and hence, $\dfrac{d\left(\frac{\dot{V}}{V}\right)}{dt} = \dfrac{d\gamma_n}{dL}.\dfrac{dL}{dt} + \dfrac{d\gamma_L}{dn}.\dfrac{dn}{dt} > 0$.

5.2.4 Dynamics in the Long Run

In our model the accelerating rate of growth of manufacturing stems from the complementarity between the two manufacturing inputs - labour and producer services. This complementarity generates a mutually reinforcing feedback mechanism such that increased employment of labour leads to increased demand for producer services and increased usage of producer services leads to higher demand of labour. This in turn generates higher wages in manufacturing as well as higher profits for the producers of the producer services. Needless to say, this process can continue as long as there is continued supply of labour coming from the agricultural sector. In the long run, as more and more labour move to manufacturing, the wage rate in the agricultural sector is also likely to rise, closing the wage gap and reducing the inflow of labour to the manufacturing sector. Thus growth in manufacturing would eventually taper off in the long run.

The above model has the clear implication that once growth is initiated it accelerates due to cumulative causation based on the interaction between market size and production technology. The obverse of this is that prior to the economy crossing a threshold equilibrium growth is zero. However, as seen in

Figure 1 in India there has been a positive growth even before an acceleration is observed. Reconciling this history of the Indian economy with the prediction of the model is not difficult. Growth as generated in our theoretical model is market driven. However, in reality other drivers of growth exist at the same time, principal among them being government. In the nineteen fifties public policy in India had aimed to industrialise. The strategy was to revive a stagnant economy via a co-ordinated public investment programme which had included producer services. This, termed the Nehru-Mahalanobis Strategy, initiated growth in the economy[19]. Private investment had responded as the market expanded.

6 Empirical Investigation

The theoretical model that we have presented implies accelerating growth driven by an interaction between the manufacturing and producer-services sectors. It also implies that this will set in only after the crossing of a threshold scale by the economy. We have already presented evidence of an acceleration in the rate to growth of the Indian economy since 1950 in Figure 1. We now test for the existence of a mutual feedback between the non-agricultural sectors of economy. This is done using the methodology of cointegration analysis.

Cointegration among a set of variables implies the presence of a long run 'equilibrium' relationship binding them. If a set of variables are cointegrated, they cannot move "too far" away from each other. (Dickey, Jansen, and Thornton, 1991). Further, cointegration implies that short run changes in these variables also include responses that correct for any deviation from the long run relationship. In our model, once the size of the producer services and manufacturing industries crosses a threshold, a positive feedback mechanism linking the two sectors begins to operate. In this mechanism, expansion in one sector stimulates expansion of the other sector, so that both sectors move together. In econometric terms the two sectors are co-integrated.

We use GDP data in 2004-05 prices obtained from the 'National Accounts Statistics' of India's Central Statistical Organisation published by the EPW Research Foundation. Clarification is needed with respect to the representation of producer services. Two definitions have been used, namely, 'Producer services' and 'Core Producer Services'. Producer Services (PS) comprises All Services, Electricity, Gas and Water Supply, and Construction. Core Producer Services (CPS) comprises Electricity, Gas and Water Supply, Trade, Transport by other means, Storage, Railways, Communication, Banking and

[19] See Chakravarty (1987).

Insurance, and Business Services. In the econometric results presented below the lower case stands for the logarithm of a variable.

Prior to undertaking the cointegration test, we conducted unit root tests for detecting the order of integration of the time series of manufacturing (m) and producer services (ps). We use four different tests for the presence of a unit root in each series, namely the Augmented Dickey Fuller (ADF), Philips-Perron, Kwiatkowski-Philips-Schmidt-Shin (KPSS) and the Zivot and Andrews tests. Of these, Zivot and Andrews test allows for a break in either trend or level or in both while testing for a unit root. The details of the tests and the results are given in Section A of Supplementary Material. The results of the unit root tests show that time series for producer services (ps) and manufacturing are $I(1)$. We next implements the Engle-Granger two-step procedure of cointegration analysis. Accordingly, we first test for cointegration between these two series. The results presented in Table 2 show absence of cointegration between producer services and manufacturing for the period 1950-51 to 2009-10.

Table 2: Testing for Cointegration (Period: 1950-51 to 2009-10)

Cointegration Regression	ADF test statistic	Critical value (5%)
$m_t = \underset{(6.39)}{0.45} + \underset{(81.88)}{0.95}\, ps_t$	-2.73	-3.44
$m_t = \underset{(7.66)}{0.68} + \underset{(62.66)}{0.91}\, cps_t$	-2.50	-3.44

Note: (1) t values are reported below the coefficients. (2) ADF critical value is obtained from MacKinnon (2010).

There can be several reasons for the failure to reject the null of no cointegration including structural breaks in the underlying relationship (Stock and Watson, 1996) and segmented cointegration (Kim, 2003; Fukuda, 2008). Segmented cointegration means presence of cointegration in a segment of the sample period and its absence in the remaining portion(Kim, 2003). We consider both these possibilities.[20] First, we conduct the test of cointegration with a structural break using the test developed by Carrion-i-Silvestre and Sansó (2006). This LM-type test tests the null of cointegration allowing for a structural break in both the deterministic and the cointegration vectors with and without a time trend. The test also allows for endogenous regressors. The break point may be known or unknown. In the latter case, it needs

[20]Other reasons for the failure to reject the the null of no cointegration discussed in the literature include incorrect choice of lags in testing equation (Banerjee, Dolado, Galbraith, and Hendry, 1993), and threshold effects in a possible cointegration relation (Balke and Fomby, 1997).

to be estimated by minimising the sum of residual squares over all possible break points as given in Bai and Perron (1998). We implement the test using estimated breakpoints and the results are presented in the Table 3. The test is performed using the upper tail of the distribution, implying that the null hypothesis of cointegration is rejected when the value of the test statistic exceeds the critical value. In all cases the null hypothesis of cointegration was rejected.

Table 3: Testing for the null of cointegration with one break (Period: 1950-51 to 2009-10)

Model: $m_t = \alpha + \beta ps_t + u_t$			
Break in	Break Year	Test statistic	Critical Value(99%)
both α and β	1963-64	3.05	0.3449
only α	1960-61	4.85	0.3543
Model: $m_t = \gamma + \theta cps_t + \epsilon_t$			
Break in	Break Year	Test Statistic	Critical Value(99%)
both γ and θ	1968-69	1.46	0.2699
only γ	1960-61	6.09	0.3543

Notes: Critical values, which are 99% points of the distribution, are obtained from the Carrion-i-Silvestre and Sansó (2006).

Next we tested for the possibility of segmented cointegration. We use the Fukuda (2008) method for detecting segmented cointegration. In this method, the period of cointegration is identified by minimising a modified Bayesian Information Criterion over all possible partition of the series. The details of the methodology and its advantage compared to an alternative procedure is given in section B of the Supplementary Material. Results, presented in Table 4, show that in all the cases cointegration is detected for the period 1965-66 to 2009-10. In order to confirm absence of cointegration prior to 1965-66, we conducted the 'cointegration breakdown' test proposed by Andrews and Kim (2006). Andrews and Kim proposes two tests, termed P and R, to test for cointegration breakdown in a segment of a time series[21]. The breakdown in cointegration can be due to a shift in the parameters of the cointegrating vector and/or a shift in the errors from being stationary to being integrated. The results, presented in Table 5, show that the null hypothesis of no breakdown in cointegration during the first 15 years of the data period is rejected by both the tests.

[21]Implementation requires that this be the smaller segment, which holds in our case.

Table 4: Segmented cointegration: Results

Model	Period of Cointegration
$m_t = \alpha + \beta ps_t + u_t$	1965-66 to 2009-10
$ps_t = \lambda + \delta m_t + e_t$	1965-66 to 2009-10
$m_t = \gamma + \theta cps_t + \epsilon_t$	1965-66 to 2009-10
$cps_t = \mu + \phi m_t + \nu_t$	1965-66 to 2009-10

Table 5: Testing for cointegration breakdown during 1950-51 to 1964-65

Model: $m_t = \alpha + \beta ps_t + u_t$		
Test	Value of the test statistic	P-value
P	0.219	0.00
R	2.679	0.05
Model: $m_t = \gamma + \theta cps_t + \epsilon_t$		
P	0.394	0.00
R	6.710	0.00

Note: p-values are computed using sub-sampling method.

We now interpret the econometric results in terms of our theoretical model. The absence of cointegration during the first fifteen years of the sample period is not surprising. Our theoretical model implies that the scale of the economy in terms of both producer services and manufacturing must cross a threshold for the positive feedback mechanism and the consequent cumulative causation to start operating. The results imply that it took fifteen years for this to happen. Viewed in terms of size of the economy, GDP in 1965-66 was close to 70% higher than in 1950-51. Notice that from Figure 1 that economy-wide growth had slowed for a while from around this date. However, there is no contradiction in the finding of onset of cumulative causation at a time when the rate of growth of the economy declined marginally. As pointed out in Section 2 above the growth rate of the economy is subject to deviation from its long term trajectory due to exogenous shock. The shocks pertaining to the Indian economy in the mid 1960s have been discussed in the passage referred to.

Table 6 presents results of the cointegration test undertaken for the period 1965-66 to 2009-10. In the cointegration testing procedure, any y series could be made the regressand of the cointegrating regression. As a result the value (but not the distribution) of the test statistic will differ depending on which series is used as the regressand. Therefore, it is advised that the procedure be repeated having replaced the regressand with the regressor and vice versa, particularly if the test statistic obtained from the first one is near to the chosen critical value (see MacKinnon (2010, p.3)). Following this we undertake the cointegration test with m_t, ps_t and cps_t as regressand in alternative regressions. The results points to the existence of cointegration during this period[22].

Table 6: Cointegrating Regression: 1965-66 to 2009-10

Cointegration Regression	Value of ADF test statistic	Critical value (5%)
$m_t = \underset{(17.62)}{0.89} + \underset{(113.52)}{0.88}\, ps_t$	-3.72	-3.48
$ps_t = \underset{(-14.94)}{-0.98} + \underset{(113.52)}{1.13}\, m_t$	-3.65	-3.48
$m_t = \underset{(28.16)}{1.249} + \underset{120.99}{0.83} cps_t$	-3.76	-3.48
$cps_t = \underset{(-22.59)}{-1.48} + \underset{(120.90)}{1.20}\, m_t$	-3.72	-3.48

Note: Critical values for ADF test are taken from MacKinnon (2010). t values of estimated coefficients are given below the coefficients in parenthesis.

Given the length of the time series, from 1965-66 to 2009-10, during which we observe cointegration between producer services and manufacturing, it is quite possible that structural change takes place in the cointegration relation. Incorporation of the structural change, if any, in the cointegrating regression is essential for correct estimation of the error term, the lagged value of which appears in the second step of the Engle-Granger procedure, namely, the estimation of the error-correction model. We estimate the breaks in the cointegrating vectors by minimizing the sum of residual squares (see: Kejriwal and Perron, 2010, 2008) and the number of breaks is determined on the basis of the Bayesian Information Criterion. Residuals from co-integrating regressions incorporating the breaks thus identified are used in the estimation of the dynamic specification, i.e., error-correction model.

As per the Engle-Granger procedure, we next estimate the dynamic specification relating manufacturing to producer services. The dynamic specification is estimated for the period 1965-66 to 2009-10, for which cointegration has been detected. In our theoretical model, manufacturing production and that

[22]We also conducted the cointegration test using Johansen's procedure which validated cointegration.

of producer services are expected to affect one another contemporaneously because the supply and consumption of services occur at the same time implying simultaneity from the econometric point of view. Therefore, instrumental variable method (GMM-IV) is used for estimation. The instruments used are the lags of the endogenous explanatory variables.[23]. In our empirical investigation we adopt the general-to-specific modelling strategy. The general model included lags of the explanatory variables and, based on the length of the series, allowed for one structural break. The Moment and Model Selection Criterion-BIC proposed by Andrews and Lu (2001) was used to choose the lag length and validate the break in coefficients.[24] The model thus arrived at is reported in Table 7. Note that all the models include an intercept dummy. The generalized R-squared (GR^2) appropriate to IV estimation proposed by Pesaran and Smith (1994) is also reported.

In all the regressions manufacturing production directly impacts producer services and vice versa, indicating the existence of the positive feedback mechanism intrinsic to cumulative causation. Moreover, the coefficient on the ECM is negative and significant in all the regressions, indicating the existence of a long-run equilibrium relationship between the two sectors, as envisaged in our theoretical model. Note that the growth of primary production is not

[23]Instruments used for Δm_t are Δm_{t-2} Δm_{t-3} Δrm_{t-3} Δurm_{t-4}, where rm and urm respectively denote the registered and unregistered part of total manufacturing. Instruments used for Δps_t and Δcps_t are Δps_{t-2} δps_{t-3} $\delta cps_{t-2} \delta cps_{t-3}$. The instruments were selected on the basis of the strength of correlation between current dated endogenous explanatory variable and potential instruments as suggested in Reed (2013). The first lag of the endogenous variables were excluded from the set of potential instruments to ensure their exogeneity

[24]Given the length of the sample period, i.e., forty five years, one break either in all the coefficients or in intercept alone was considered. Breakpoints were estimated by minimising the sum of squared residuals. For estimating breakpoints in an instrumental variable regression see Perron and Yamamoto (2013).

significant in these regressions, implying that it is not part of the feedback mechanism driving long-term growth.

Table 7: Dynamic Specification: GMM-IV Estimates

Explanatory Variables	Dependent Variable			
	Δps_t	Δm_t	Δm_t	Δcps_t
Δm_t	0.216*			0.219**
	(2.26)			(6.18)
Δps_{t-1}	0.218			
	(1.92)			
ECM	-0.139*	-0.791**	-0.685**	-0.0758**
	(-2.34)	(-13.30)	(-17.40)	(-4.19)
Δps_t		0.870**		
		(8.20)		
Δm_{t-1}		0.428**	0.322**	
		(6.68)	(5.32)	
Δcps_t			1.037**	
			(11.58)	
Δcps_{t-1}				0.0967
				(1.54)
D	0.0209**	-0.0234**	-0.0237**	0.0285**
	(17.51)	(-6.85)	(-9.95)	(16.15)
Constant	0.0226**	-0.0158*	-0.0131**	0.0287**
	(13.11)	(-2.41)	(-4.05)	(10.03)
GR^2	0.59	0.49	0.51	0.58
Hansen's J (χ^2)	1.16 (0.56)	1.39 (0.71)	1.40 (0.70)	1.46 (0.69)
Observations	44	44	44	44

Notes: (1) z values robust to heteroskedasticity and autocorrelation are in parenthesis, except for Hansen's J where p-values are reported. ** and * indicates significance at 1 and 5% level respectively. (2) ECM denotes the error-correction mechanism. (3) D is a dummy variable to capture intercept shift, location of which is different in each model.

The regressions show an asymmetry in that the response of producer services to manufacturing is less strong than the response of manufacturing to the growth of producer services as reflected by the regression coefficients. There could be two possible explanations of this. First, though, as reported above, the share is declining, a part of the producer services in India continued to be provided by government. For a variety of reasons the response of the public sector may be expected to be less immediate than that of the private. We can see this from the following. When a restricted definition of producer services, i.e. 'core producer services' is used, which excludes public administration and defence, both of which are provided by the public sector, it is found that the response of this variable is more than twice that of 'producer services' as a whole. Equally, the coefficient on the ECM in the case of 'core producer services' is twice that of 'producer services'. However, even with this evidence of greater response of producer services when a more restricted version is used the response of manufacturing to the growth of producer services remains higher than that of producer services to the growth of manufacturing. This leads to the second reason for a greater observed response of manufacturing relative to producer services in the feedback mechanism. While manufacturing production requires producer services, a part of the production of producer services serves activity elsewhere in the economy.

7 Conclusion

In studies of economic growth in India there has been a tendency to over emphasise the policy regime, and not enough of an effort to understand the production process and its implications. We believe that there is a case for redressing the balance. Our approach to growth in this paper has been to take cognisance of the importance of the internal dynamics of the growth process.

We have demonstrated here that the growth rate of the Indian economy has accelerated more or less continuously over the past sixty years. This has occurred across the policy regimes that have been in place during this period. These policy regimes may be seen, broadly, as having been one of government activism in a relatively closed economy for about four decades and a more liberal regime that followed the economic reforms launched in 1991. The acceleration of the economy even during the first phase has already been recognised in the literature. However, no satisfactory explanation has been provided thus far[25]. Here, we have presented a model that generates a growth trajectory as observed in India. The model draws upon the literature on economic development that highlights the existence of a positive feedback between sectors and the consequent cumulative causation that causes accelerating growth.

Our model has interacting manufacturing and service sectors. Drawing upon a widely noted feature of modern industrial economies we have imagined these services to be predominantly producer services involving start-up costs. The model demonstrates that feedback between the sectors generates

[25]See DeLong (2003).

accelerating growth via cumulative causation once the economy has crossed a threshold in terms of scale. Two testable propositions follow, namely, the absence of a feedback mechanism till a threshold scale is crossed and its presence afterward. We have tested this hypothesis econometrically using the methodology of cointegration. We found evidence of segmented cointegration, i.e., cointegration from 1965-1966 onwards and its absence prior to that date. In terms of our theoretical model, this date may be taken to represent the crossing of the threshold scale by the Indian economy. In the estimate of the dynamic specification of the econometric model we found evidence of the positive feedback mechanism underlying cumulative causation and of the error-correction mechanism that it implies.

The recent history of India suggests that the services sector may be considered as having been an engine of growth. Incredulousness on this score is to be traced to the focus on consumer services which are not inputs into the manufacturing. The timing of the growth transitions in India, i.e., that they occurred even as the economy was relatively closed to foreign trade, suggests that in the mainstream discourse the role of the trade regime as a determinant of the growth path may have been exaggerated, and that of the economy's capacity to provide a variety of producer services may have been underrated. It is vital to this account that most producer services are, under present technological possibilities, non-traded and therefore need not materialise merely as a result of the rescinding of trade restrictions. What we have just stated with respect to the trade regime may be extended to the policy regime more generally, i.e., whether it is more or less liberal may have mattered less for growth than the internal dynamics. Public investment very likely made a difference in the early stages of growth in India to take the economy out of a low level equilibrium trap and to cross the threshold scale that we have identified in our model. The internal dynamics are likely to have taken over subsequently.

We conclude by making two points. The first is regarding the significance of our findings. First, it is historically consistent in that it can account for the growth path of the economy in terms of the policies pursued. We believe that we have demonstrated the relevance of the development strategy initiated in India in the nineteen fifties which administered a positive shock to the economy. It is this that gave rise to the internal dynamics which continue into the present. Secondly, how do we see the relative roles of internal dynamics and economic policy, especially following the liberalising reforms of 1991? We believe that these reforms have contributed to growth by enabling private participation to respond to the opportunities arising in the form of a growing demand for producer services. So far this has mainly been confined to roads, ports, airports and telecommunications. Arguably the private sector's response is not independent of the internal dynamics of the growth process whereby an increasing scale expands the market. This has the implication that just freeing an economy need not ensure that the private sector will invest in producer services. The private sector may not have been willing to invest in producer services at an earlier stage of development as the scale would have been unviable. Internal dynamics matter here in that the pre-existing growth would have provided the incentive for private provision of these services. This is a case in which "growth begets growth". The reforms implemented since 1991 of course ensured that legal barriers to entry have been removed, but it may be noted that the economy had already accelerated. This places the success of the reforms of 1991 in perspective. At the same time, our findings have the implication that the policies pursued in India in its early stages of development, notably the building by the public sector of infrastructure providing producer services may well have had a role in the subsequent acceleration of its economy. We believe that this conclusion has implications for the study of economic growth and development beyond India. There has been theoretical speculation in the literature on the importance of the process of cumulative causation via positive feedback as a generic mechanism of growth. The results presented here attest that.

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Supplementary Material

This supplementary material contains the followings. Section A gives the details of the unit root testing procedure and test results and section B explains the estimation of segmented cointegration.

A Unit root testing strategy

Unit root tests have been conducted using four alternative tests, (1) Augmented Dickey Fuller (ADF) test, (2) Phillips-Perron (PP) test, (3) KPSS test and (4) Zivot-Andrews test.

Augmented Dickey Fuller (ADF) Test: As plots of all the series against time show an increasing trend (see Figure 3), unit root tests were conducted with the alternative hypothesis of trend stationarity and the null of unit root[26]. The actual lag length of ADF test regressions was determined through a sequential test procedure, in which number of lags was decided by testing for the significance of the coefficient of the additional lag.[27] In this, we started with a maximum lag of four and in all the cases the actual lag length was found to be less than four. Critical values for the tests were obtained using the response surface regressions given by MacKinnon (2010).

While testing for the stationarity of the first differences of the manufacturing, we considered alternative of level stationarity, as its plot against time is not showing any particular trend. However, the plot of the first difference of producer services has revealed an increasing trend, therefore while testing for the stationarity of its first difference, the alternative of trend stationarity is assumed.

Phillips-Perron (PP) Test: This test, proposed by Philips and Perron (1988)[28], is a non-parametric test with the null hypothesis of *unit root* that explicitly allows for weak dependence and heterogeneity of the error process. The test procedure involves computation of the long run variance of the process, requiring the researcher to specify the lag length to be used. We used a lag length equal to the integer value of $12(T/100)^{0.25}$, where T is the

[26]See: Elder J and P.E. Kennedy (2001) "Testing unit roots: What should students be taught?", *Journal of Economic Education*, 32(2), pp: 137-146

[27]See: Ng, S. and Perron, P. (1995)"Unit root test ARMA models with data dependent methods for the selection of truncation lag" *Journal of Americal Statistical Association*, 90(429), pp.268-281.

[28]Phillips P.C.B and P. Perron (1988) "Testing for unit root in time series regression", *Biométrika*, 75(2), 335-46.

total length of the time series[29]. We use Z_t statistics and critical values were computed using the response surface regressions given in MacKinnon (2010).

Kwiatkowski-Phillips - Schmidt - Shin Test (KPSS test): This test, proposed by Kwiatkowski, Phillips, Schmidt, and Shin (1992)[30], is an LM test for testing the null of stationarity against the alternative of unit root. The test needs computation of the long run variance of the error term and for this we used a lag length of $4(T/100)^{0.25}$. Simulation results reported in Kwiatkowski, Phillips, Schmidt, and Shin (1992) showed that this lag length was performing well for a sample size of 60 in terms of power and size properties. In our testing procedure for the level series, the null hypothesis is trend stationarity. And for first difference series, the null hypothesis is level stationarity, except in the case of producer services in this case trend stationarity is assumed.

Zivot and Andrews Test: It is possible that unit root tests discussed above wrongly diagnose a stationary time series having one or more trend break or level break as a unit root process. In order to guard against this possibility, we employ unit root test proposed by Zivot and Andrews (1992).[31] This test allows for one break either in trend or in intercept or in both while testing for the null of unit root. The break point is identified endogenously. While implementing this test, we allowed breaks in both time trend and intercept. Lag length of the endogenous variable included in the test regression is determined on the basis of a sequential test procedure, with a maximum lag of four.

[29]The results are invariant to use of short lags.

[30]Kwiatkowski, D., P. C. Phillips, P. Schmidt, and Y. Shin (1992) 'Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root?," *Journal of Econometrics*, 54(13), 159-178.

[31]Zivot, E., and D. W. K. Andrews (1992)"Further evidence on the great crash, the oil price shock, and the unit-root hypothesis," *Journal of Business & Economic Statistics*, 10(3), 251-270.

The results of the unit root tests are presented in Table S1 and Table S2.

Table S1: Testing for the order of Integration (Level series)

Test	Value of the test statistic	Critical Value (5%)
Primary Sector (p)		
ADF	-2.61	-3.49
Philips-Perron	-4.75	-3.49
KPSS	0.32	0.15
Zivot-Andrews	-7.35	-5.08
Manufacturing(m)		
ADF	-1.48	-3.49
Philips-Perron	-0.69	-3.49
KPSS	0.25	0.15
Zivot-Andrews	-3.92	-5.08
Producer Services (ps)		
ADF	1.45	-3.49
Philips-Perron	2.29	-3.49
KPSS	0.39	0.15
Zivot-Andrews	-1.92	-5.08
Core Producer Services (cps)		
ADF	1.32	-3.49
Philips-Perron	1.60	-3.49
KPSS	0.40	0.15
Zivot-Andrews	-1.99	-5.08

Notes: 1.For ADF, Philips-Perron and Zivot-Andrews tests the null-hypothesis is non-stationarity and for KPSS test the null-hypothesis is stationarity

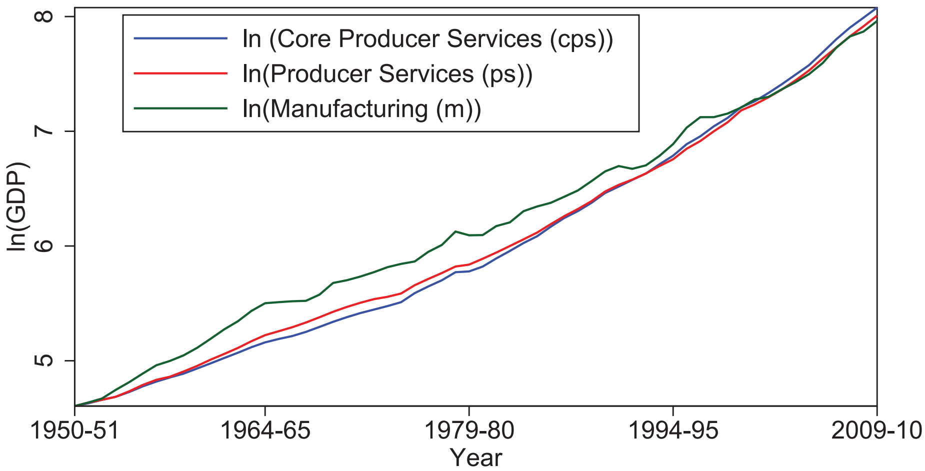

Figure 3: Log of Manufacturing and Producer Services GDP

Table S2: Testing for the order of integration (First differences)

Manufacturing(m)

Test	Value of the test statistic	Critical Value (5%)
ADF	-5.65	-2.91
Philips-Perron	-5.53	-2.91
KPSS	0.24	0.46
	Producer Services (ps)	
ADF	-5.29	-3.49
Philips-Perron	-5.29	-3.49
KPSS	0.13	0.15
	Core Producer Services (cps)	
ADF	-6.06	-3.49
Philips-Perron	-6.05	-3.49
KPSS	0.11	0.15

Note: 1.For ADF, and Philips-Perron tests the null-hypothesis is non-stationarity and for KPSS test the null-hypothesis is stationarity

B Estimation of Segmented Cointegration

The procedure proposed by Fukuda (2008) allows detection of regime switches between cointegration and non-cointegration at unknown time points. Consider the following cointegration regression and ADF testing regression with m breaks ($m+1$ regimes) and T observations.

$$y_t = \alpha_j + x_t^T \beta_j + u_{jt} \qquad (t = T_{j-1}+1, \ldots, T) \tag{16}$$

where x_t is a k vector.

$$\Delta u_{jt} = \rho_j u_{jt-1} + \sum_{i=1}^{p} \phi_{ji} \Delta u_{jt-i} + \epsilon_{jt} \tag{17}$$

for $j = 1, \ldots, m+1$ and $T_0 = 0$ and $T_{m+1} = T$. The disturbance term ϵ_{jt} is generated from $NID(0, \sigma_j^2)$ and $\rho_j = 0$ implies absence of cointegration in j^{th} segment. The set of switch points $(T_1, \ldots, T_m)$ are explicitly treated as unknown. The purpose is to identify the time points at which cointegration relationship is switching. Let $T_i - T_{i-1} \geq h$, be the minimum length of a segment. The method involve estimating the cointegration regression and testing for cointegration in each $m+1$ segment. Lag length in ADF regression in each segment is chosen on the basis of BIC. The segmentation chosen is the one that minimises the following Modified Bayesian Information Criteria (MBIC), BIC2, over all possible $m+1$ segmentations allowed by h.

$$BIC2 = \sum_{j=1}^{m+1} (T_j - T_{j-1}) \ln \hat{\sigma}_j^2 + \ln(T) \left(m + \sum_{j=1}^{m+1} \theta_j \right) \tag{18}$$

where $\theta_j = k + p_j + 2$ if the u_t has a unit root in the j^{th} segment, and $\theta_j = k + p_j + 4$ if cointegration exists in j^{th} segment.

The simulation results reported in Fukuda (2008) show that BIC2 outperforms many other information criteria and has the test size of about 5% in the terminology of hypothesis testing. Simulations are also conducted to compare the performance of this method with that proposed by Kim (2003). It shows that this method strictly outperforms, in terms of size and power, the procedure suggested by Kim (2003). In our implementation of Fukuda's method, given the sixty year time series, we considered a maximum of one break point (or two segments), and we started with $h = 15$. Since $h = 15$, resulted in a corner solution, we used a lower value 10 for h and in both cases results are the same.