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THE MECHANISM OF LONG-TERM GROWTH IN INDIA

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Abstract

A stylized 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 mechanism that can account for this behaviour in terms of cumulative causation through positive feedback. We write down a theoretical model incorporating start-up costs and pecuniary externalities that generates the behaviour observed, i.e., periodic acceleration. The model's implications are tested using the methodology of co-integration analysis. We find evidence of positive feedback and error correction which are at the centre of cumulative causation. Further, we are also able to date the initiation of this process, which has remained the mechanism of growth in India for close to half a century by now. This leads us to conclude that the internal dynamics of the growth process are at least as important as changes in the policy regime to understand growth over the long term in the country. The article has a relevance beyond the context of its investigation. There has been speculation in the theoretical literature on growth and development on the importance of cumulative causation as a generic mechanism of growth. The results presented here attest that.

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1 Introduction

Accounts of India's economic growth over the past six decades have tended to rely on predilection. In particular, there has been a tendency to identify India's growth trajectory with changes in the policy regime. This approach can come up against a divergence from the historical record, though this has not by itself deterred some authors. Now, it would be agreed that any explanation would have to be consonant with data. It would also be agreed that an explanation would have to be parsimonious and not appear as a shopping list of factors underlying the process. In this paper we aim to provide such an account of growth in India based on its internal dynamics. This helps place the relative roles of policy, shocks, and internal dynamics. We see this as re-instating the role of economic mechanisms in understanding growth in India, a programme that has been sidelined somewhat by explanations that rely excessively on changes in the policy regime[1].

2 What is to be explained

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 below which depicts the different growth phases of the economy. These have been identified using the Bai and Perron (1998, 2003) procedure. All details relevant to this estimation may be found in Balakrishnan and Parameswaran (2007). In that paper the year 1979-80 had been identified as a breakpoint. Following the observation by Basu (2008) that this was a year of exceptional decline in output, and therefore an outlier, we have checked for outliers in the GDP annual growth series. The growth rates in 1965-66 and 1979-80 were found to be outliers[2]. Accordingly, the break dates were now identified by excluding these years from the date set. The resulting phases of growth and corresponding growth rates may be seen in Figure 1. The growth rates have been estimated using the kinked-exponential model of

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[1] The explanation provided here may be seen in light of the observation in Kotwal, Ramaswami, and Wadhwa (2011) that India's growth acceleration has taken place without any major shift in the savings rate, a spurt in exports or greater foreign direct investment, suggesting that an explanation is in order. The model we present here and our findings based on it amount to providing an explanation that does not rely on these factors.

[2] A resistant rule was adopted for detecting outliers. The rule consists of an upper fence (UF) and a lower fence (LF) defined as $UF = Q_3 + 1.5 \times (IQR)$ and $LF = Q_1 - 1.5 \times (IQR)$, where Q_i and IQR respectively denote the i^{th} quartile and inter-quartile range of annual growth rates. Growth rates lying beyond UF and LF are considered as outliers. See Hoaglin, Iglewicz, and Tukey (1986).

Boyce (1986), which imposes continuity of the trend at the breakpoint. The growth rates have been estimated using all data points in the sample period.

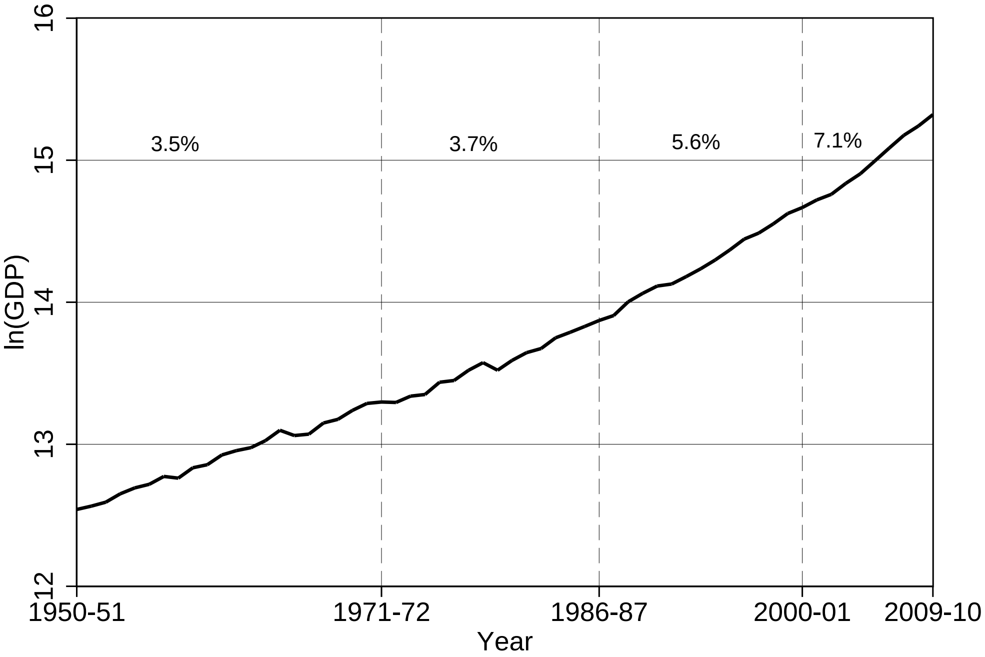

Figure 1: Growth transitions in India 1950–2010

Two observations may be made regarding the trajectory of growth. First, the growth rate has increased over time. Secondly, accelerations have 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[3]. These reforms assigned a larger role to the market and took Indian economy in the direction of greater integration with the global economy. We take the observed behaviour to imply that the internal dynamics of the growth process, which may be understood as the workings of the economy, have been at least as important as shifts in the policy regime for growth. We do not interpret this as implying that economic policy does not matter, only that we would need to give importance to these dynamics. To run ahead a little, we might say that economic policy is most effective with respect to growth when it serves to quicken the dynamics. The evidence thus far suggests that there is a case for more nuanced approach to the interpretation of the growth process in India.

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[3] This feature of the growth path in India has been recognized in the literature, for which see DeLong (2003). In our view, however, no satisfactory explanation of the development has been provided.

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]

3 A theoretical approach to the Indian experience

3.1 The role of increasing returns

First, we seek to relate the Indian experience to an appropriate theoretical framework.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. Further, from a study of growth by principal sectors, displayed in Table 1. We observe the following pattern[4]. 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 the growth of these sectors. This is elaborated upon below.

An account of accelerating economy-wide growth as the outcome of an interaction between the manufacturing and services sectors would be as follows: consider a 2-sector economy with a manufacturing sector and a services sector producing inputs into manufacturing. These services, it is assumed, are produced under increasing returns to scale (IRS) given the existence of fixed costs in their production. It is well known that in the presence of a fixed cost the average cost of production declines with its scale. This implies that the viability of services production is related to the scale of manufacturing which constitutes the market for services.

An important feature of modern production processes is its roundaboutedness, that 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

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

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 the use of variety of inputs stimulates an expansion of the intermediate goods sector which in turn stimulates further division of labour.

An economy characterized 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 specialized 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. In the low-level equilibrium, scale of the final goods sector is low, making production of only a very limited range of intermediate inputs viable or a 'shallow' division of labour. This results in lower productivity of the final goods sector, in turn contributing to a low scale of operation. On the other hand, the high-level equilibrium is characterised by greater size of the final goods sector and production of a large variety of intermediate inputs or a 'deeper' division of labour.

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 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, an historically high size of the manufacturing sector and/or fewer varieties of intermediate inputs allows the economy to escape this low steady state and enjoy perpetual growth in income and output along an equilibrium path, characterized by increased degree of specialization and concomitant rise in productivity [5].

Here we follow the history-based mechanism instead of the expectation-based mechanism to explain the growth trajectory of the Indian economy. An implication is that in the 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 static economy can also be 'shocked' into the preferred equilibrium, with a high level of income, by deliberate policy, including co-ordinated public investment. Though he was not so directly concerned with growth as we are here, Rosenstein-Rodan's conception of the Big Push refers precisely to such meditated shocking of an economy stuck in a 'low-level equilibrium trap'[6]. In the theory of growth, the earliest statement of a process propelled by specialization 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 specialization 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 a source of a downward-shifting cost curve for the manufacturing firm.It may be mentioned that the Young process is truly endogenous, leading Kaldor (1972) to term such growth as "cumulative and endogenous change". However, Kaldor, while appreciative of its thrust, had thought of Young's account as being somewhat sanguine about demand and went on to provide the conditions under which it would hold. We do not pursue this development here. Moreover, Kaldor had emphatically confined

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[5] 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); Rodriguez-Clare (1996, 1997). History-driven growth trajectories based on increased specialization 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), Adserá and Ray (1998).

[6] The idea has been formalized byMurphy, Shleifer, and Vishny (1989).

increasing returns to scale to manufacturing. We believe that such a position would be a restrictive one to take today as there is by now substantial evidence that some services are produced under increasing returns to scale and that they have been essential to the development of the industrialised economies.

3.2 Producer Services in Modern Economies

We have suggested above that viewing 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[7]. This has been suggested on the basis of data on the growth size of the producer services sector inn 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. The intermediate 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[8]. Before turning to our theoretical model and 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 20^{th} century.

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

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[7] See Rodriguez-Clare (1997); Faini (1984); Greenfield (1966).

[8] 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.

presented by Elhance and Lakshmanan (1988) of decreasing cost of inputs to manufacturing following the expansion of “infrastructure”, both social and physical. Theirs admittedly is a set wider than our own ‘producer services’, but, it may be noted, the mechanism envisaged by the authors is the same, namely, declining input cost for manufacturing due to increasing scale of provision. Though without explicit recognition of the existence of increasing returns recent research on Indian manufacturing identify an impact of the development of producer services on manufacturing productivity[9]. This may be seen as another route by which the growth of producer services stimulates manufacturing growth.

We now present a theoretical model that generates accelerating growth, a feature of the Indian economy as observed.

4 A Model of Cumulative Causation with Increasing Returns

Here we build an endogenous growth model which generates accelerating rate of growth through the process of cumulative causation. The underlying 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)). 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 to labour to manufacturing and the number of of varieties of specialised inputs are given. The labour supply 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

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[9] For an early recognition of the importance of producer services in understanding the growth process in India see Kotwal and Ramswami. (1998). For empirical investigation in the context of Indian manufacturing see Banga and Goldar (2007); Arnold, Javorcik, Lipscomb, and Mattoo (2012).

period after period. Now suppose there is an exogenous one-time demand shock, which raises the demand for manufacturing output. To accommodate this demand, producers seek to produce more, which raises the demand for both the factors - labour as well as the specialised inputs. Labour supply can be increased only gradually (in the next period). Hence the immediate effect of this demand shock (at unchanged L_t and n_t) is realized in the form of an increased 'amount' used of each of the existing specialised inputs. In other words, demand for each of the existing specialised inputs and the corresponding supply goes up, resulting in higher sales and therefore higher profits (at constant prices and per unit variable cost) for the existing producers of the specialised inputs.

This first round effect then sets in motion the dynamics of L_t and n_t which further augments the manufacturing output over time is the following way. 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 specialized inputs in the subsequent period. This chain of events continues resulting in an accelerating rate of growth for manufacturing.

Similar complementarity between inputs in the production process have been explored in Ciccone and Matsuyama (1996) and Rodriguez-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, it subsequently accelerates driven entirely by its internal dynamics. We now present the basic model.

4.1 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:

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

The manufacturing sector is operated by competitive firms who take the input prices (w_t and p_js for all j) as given and equate these with the corresponding marginal products. Thus

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

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.

Production technology for specialised inputs: Each specialised input is produced by a monopolist. Production of a variety requires the manufacturing good as an input[10]. There are two kinds of costs involved in production of specialised inputs 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

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

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:

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

Using the inverse demand function (3) for this monopolist, we can write the profit function as:

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

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

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

Correspondingly, the optimal price charged by the monopolist producer of variety j is:

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

Notice that $\frac{1}{\alpha} > 1$, so that production of the specialised inputs is viable to begin with. Finally in equilibrium, profit of the monopolist producer of variety j is given by:

$$\begin{aligned} \pi_{j_t}^{*} \quad &= \quad p_{jt}^{*} x_{jt}^{*} - x_{jt}^{*} - F \\ &\Rightarrow \quad \pi_{j_t}^{*} = (\frac{1}{\alpha} - 1)\alpha^{\frac{2}{1-\alpha}}.L_t - F \end{aligned} \tag{9}$$

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

$$\left.\begin{aligned} x_{jt}^{*} = x_{it}^{*} = x_{t}^{*} = \alpha^{\frac{2}{1-\alpha}}.L_t; \\ p_{jt}^{*} = p_{it}^{*} = p^{*} = \tfrac{1}{\alpha}. \\ \pi_{j_t}^{*} = \pi_{i_t}^{*} = \pi_{t}^{*} = (\tfrac{1}{\alpha} - 1)\alpha^{\frac{2}{1-\alpha}}.L_t - F \end{aligned}\right\} \text{for all specialized inputs } i \text{ and } j. \tag{10}$$

Thus, the gross output produced in the manufacturing sector at time t(using the symmetric equilibrium condition) is:

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

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:

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

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 producers of specialised inputs earn non-negative profits if and only if (from equation (6)):

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

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 $\dfrac{V_t}{n_t}$ ratio, should be sufficiently high. 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.

4.2 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.

4.2.1 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)):

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

4.2.2 Dynamics of n_t:

Recall that the producers of specialized 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 specialized 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.[11] 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)):

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

4.2.3 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 $n_t < \bar{n}$, $\dot{L} < 0$.

Again, from (15),

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

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

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

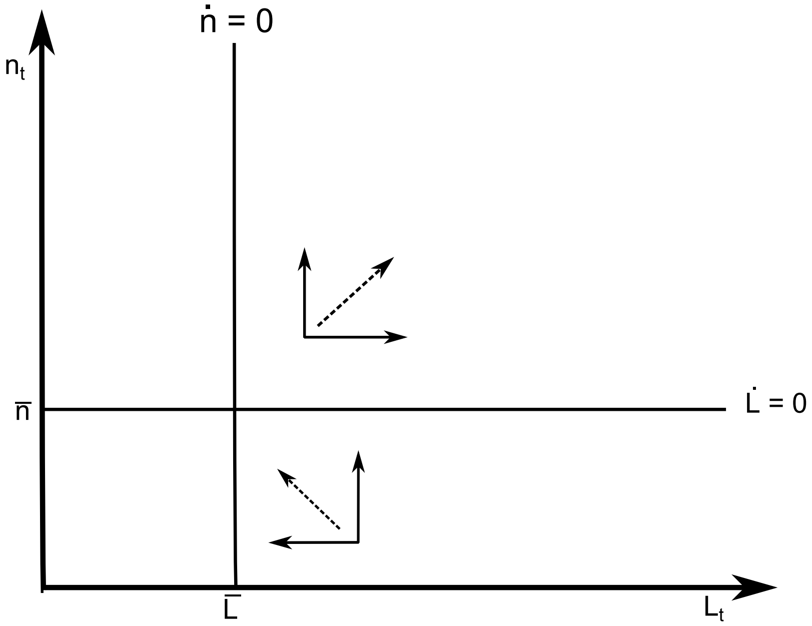

Figure 2: Dynamics of the Economy

We summarise all these information in the following phase diagram:

Notice that in the region where $n_t > \bar{n}$ and $L_t > \bar{L}$ both n_t and L_t are perpetually growing. It can also be easily shown that 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.

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[11] 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.

It therefore follows that in the region where both n_t and L_t are increasing, they are increasing at an increasing rate. Therefore, $\frac{d\left(\frac{\dot{V}}{V}\right)}{dt} = \frac{d\gamma_n}{dL}.\frac{dL}{dt} + \frac{d\gamma_L}{dn}.\frac{dn}{dt} > 0$, i.e. manufacturing output increases at an increasing rate.

4.2.4 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 alternative sector. In the long run, as more and more labour move to manufacturing, the wage rate in the alternative 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 [12]. Private investment had responded as the market expanded.

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[12] See Chakravarty (1987).

5 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. The results have been presented visually 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 co-integration analysis.

Cointegration among a set of variables suggests the presence of a long run 'equilibrium' relationship among 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 crosses a threshold, a positive feedback mechanism between 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.

The data used is from the 'National Accounts Statistics' of India's Central Statistical Organisation. 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 a Water Supply, and Construction. Core Producer Services (CPS) comprises Electricity, Gas and Water Supply, Trade, Transport by other means, Storage, Railways, Communication, Banking and 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 three series, namely, primary sector (p), manufacturing (m) and producer services (ps). We use four different tests for a unit root, namely the ADF, Philips-Perron, KPSS and 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 the Appendix Section A. The results of the unit root tests show that time series for producer services (ps) and manufacturing are $I(1)$ and for primary production is $I(0)$.[13] Hence, we can

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[13] Note that in the case of primary, the ADF and KPSS tests showed the presence of a unit root, the Zivot and Andrews test, which allows for a trend break in the series, showed the series to be stationary.

expect cointegration between producer services production and manufacturing alone. We use the Engle-Granger two-step procedure. 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 (Gregory, Nasonb, and Watta, 1996; 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[14]. First, we consider the test of cointegration with a structural break. Here we use the test developed by Carrion-i-Silvestre and Sansó (2006). This LM-type test tests the null of cointegration allowing for the possibility of 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 to be estimated by minimising the sum of residual squares over all possible break points as given in Bai and Perron (1998). In order to implement this test, first we estimated the break points in the cointegration regression by minimising the sum of residual squares. The results of the cointegration test incorporating a structural break is reported in 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.

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[14] 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).

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. The details of the methodology and its advantage compared to an alternative procedure is given in the Appendix Section B. Table 4 presents the result. It shows that in all the cases cointegration exits during 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[15]. 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. Table 5 presents the results of the cointegration breakdown test. It shows that the null hypothesis of no breakdown in cointegration during the first 15 years of the data period is rejected by both the tests.

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

Table 4: Identification of segmented cointegration

Model	Period of Cointegration	Minimum BIC2
$m_t = \alpha + \beta ps_t + u_t$	1965-66 to 2009-10	-404.54
$ps_t = \lambda + \delta m_t + e_t$	1965-66 to 2009-10	-404.15
$m_t = \gamma + \theta cps_t + \epsilon_t$	1965-66 to 2009-10	-414.47
$cps_t = \mu + \phi m_t + \nu_t$	1965-66 to 2009-10	-410.89

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

Notes: p-values are computed using subsampling 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.

Table 6 presents the cointegration test 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 (not the distribution) of the test statistic will differ depending on which series is used as the regressand. Therefore, it is advised to repeat the procedure with different regressand and compute the test statistic in each case, 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 shows the existence of cointegration during this period[16].

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.

We next estimate the dynamic specification relating manufacturing to producer services incorporating the rate of change of primary production as a control variable. In our theoretical model manufacturing production and that of producer services are expected to affect one another contemporaneously because the latter are inputs into the former. As contemporaneous values are used as regressors the estimation uses instrumental variables (GMM-IV). The instruments used are lagged values of the current explanatory variables up to the second lag and the absolute deviation from the average annual rainfall. 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

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

and Model Selection Criterion-BIC proposed by Andrews and Lu (2001) was used to choose the lag length and validate the break in coefficients[17]. The model thus arrived at is reported in Table 7. Note that the model includes an intercept dummy. The generalized R-squared (GR^2) appropriate to IV estimation proposed by Pesaran and Smith (1994) is also reported.

Table 7: Dynamic Specification: GMM-IV Estimates

Explanatory Variables	Dependent Variable			
	Δm_t	Δps_t	Δm_t	Δcps_t
Δm_t		0.203		0.571
		(3.75)*		(4.50)*
Δps_t	0.986			
	(8.89)*			
Δcps_t			0.935	
			(11.72)*	
Δp_t	0.014	-0.002	-0.023	0.012
	(0.59)	(-0.16)	(-0.73)	(0.38)
Δm_{t-1}	0.404		0.312	
	(8.25)*		(5.29)*	
Δps_{t-1}		0.239		
		(3.69)*		
Δcps_{t-1}				-0.216
				(-1.78)
ECM	-0.805	-0.133	-0.697	-0.303
	(-20.59)*	(-3.43)*	(-24.62)*	(-3.86)*
D	-0.027	0.022	-0.021	0.033
	(-4.96*)	(10.17)*	(-8.39)*	(8.27)*
Constant	-0.021	0.022	-0.008	0.026
	(-3.62)*	(10.43)*	(-2.46)*	(5.46)*
GR^2	0.49	0.59	0.53	0.59
Hansen's J (χ^2)	1.05 (0.78)	1.48 (0.69)	0.99 (0.80)	1.58 (0.66)

Notes: (1) z values robust to heteroskedasticity and autocorrelation are in parenthesis, except for Hansen's J where p-values are reported. * indicates significance at 5% level. (2) Instruments used are lagged values of the current explanatory variables and the absolute deviation from the average annual rainfall. *ECM* denotes the error-correction mechanism. (3) D is a dummy variable to capture intercept shift.

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[17] Given the length of the sample period, i.e., forty five years, one break was considered. Breakpoints were estimated by minimising the sum of squared residuals. See Perron and Yamamoto (2013) for a discussion of the properties of the estimates in the context of instrumental variables estimation.

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

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. We provide two explanations of this. First supply of producer services can be less responsive to market signals as they are provided by the public sector. In India this maybe particularly so as a large part of producer services are 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. When restricted definition of producer services is used - 'core producer services' which excludes public administration and defence - it is found that response of this variable is be more than twice that of the 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.

6 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 cognizance of the importance of 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 recognized in the literature, however, no satisfactory explanation has been provided thus far[18]. We have here provided such an explanation. This draws upon the literature on economic development that highlights the existence of positive feedback and the consequent cumulative causation that is set off once an economy has crossed a threshold size.

We have written down a model with interacting manufacturing and services 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 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, with existence of 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 capacity to provide a wide 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

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[18] See DeLong (2003).

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 explanation. 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 mechanism of long-term growth which continues 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 smaller. Internal dynamics matter here in that the pre-existing growth would have provided the incentive for private provision. This is yet another mechanism whereby "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 has 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 on the importance of the process of cumulative causation via positive feedback as a generic mechanism of growth. The results presented here attest that.

Appendix

This Appendix contains the following sections. Section A gives the details of the unit root testing procedure and test results. Section B explains the estimation of segmented cointegration and section C presents a note on the data used.

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.

ADF Test: As plots of all the series against time show an increasing trend, unit root tests were conducted with the alternative hypothesis of trend stationarity and the null of unit root (see Elder and Kennedy (2001, p.141)). 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 (see Ng and Perron (1995)). 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 Phillips and Perron (1988), 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 total length of the time series[19]. We use Z_t statistics and critical values were computed using the response surface regressions given in MacKinnon (2010).

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

Kwiatkowski-Phillips - Schmidt - Shin Test (KPSS test): This test, proposed by Kwiatkowski, Phillips, Schmidt, and Shin (1992), 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). This test allows for one break either in trend or in intercept or in both while testing for 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.

The results of the unit root tests are presented in Table 8 and Table 9.

Table 8: 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

Table 9: 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

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 information criteria 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 method 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.

C The Data

The data is taken from the ‘National Accounts Statistics of India’ of the Central Statistical Organisation, Government of India. The income categories, in 2004-05 prices, used in the investigation were arrived according to the following grouping:

1. Primary: Agriculture, Forestry and Logging, Fishing, Mining and Quarrying.
2. Manufacturing: as in the National Accounts.
3. Services:
   (a) Producer Services: Electricity, Gas and Water Supply, Construction; Trade, Hotels and Restaurants; Transport, Storage and Communication; FIRE; Community and Personal Services.
   (b) Core Producer Services: Electricity, Gas & Water supply; Trade; Transport, Storage and Communication; and Finance, Insurance and Real Estate (FIRE).

Rainfall Data: The data on annual rainfall is obtained from *Indian Institute of Tropical Meteorology* (IITM), Pune, India. The series was downloaded from the URL `ftp://www.tropmet.res.in/pub/data/rain/iitm-regionrf.txt`. The URL was accessed on October 21, 2014 and again checked on November 26, 2014.

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