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Adjustment of Indian Manufacturing Firms to
Pro-Market Economic Liberalizing Reforms,
1988-2006: A Time-Varying Panel Smooth
Transition Regression (TV-PSTR) Approach

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Abstract

This paper for the first time employs the Time Varying Panel Smooth Transition Regression (TV-PSTR) approach to model the dynamic adjustments of firms and the evolution of India's industrial structure in the bigger setting of decades against the backdrop of India's unexpected dramatic liberalizing reform starting from 1991, using Indian manufacturing firm data. It finds that the transition of market structure and productivity after liberalization do follow a smooth transition process. Instead of the previously assumed instantaneous 'big-bang' shift just after reforms, it actually took years for the Indian manufacturing industries start to react to the reforms, and the transitional impact of reforms took approximately four to eight years to complete. There is strong evidence of increased competition, which reduces the markup and make welfare gains possible from the reduction of dead weight losses. Except for the Leather and Chemical industries, RTS in most industries shrink after the transition. The effects of reforms on total factor productivity (TFP) are mixed: most import-competing industries, which suffer most from the shrinking of market size experienced no change or decreasing TFP growth; whereas the export-oriented industry, as the industry which benefit most from economy of scale, enjoyed a huge TFP growth following the reforms.

Keywords: Panel Smooth Transition Regression Model, Market Efficiency, Productivity Growth

JEL classification: C52, D24, F12, F13, L60

1 Introduction

During the past several decades, lots of developing countries launched dramatic pro-market economic liberalization in an effort to attain higher growth. These liberalization efforts, broadly defined to include trade and entry liberalization, regulatory reform, ER regime reform and privatization, are believed to transform economies via more competition (domestic and foreign) and the removal of distortions in relative prices. Therefore it may bring the country welfare gains through several possible channels, which have been questions receiving the extensive interests of country policy makers. First, it has been argued that, in imperfectly competitive markets, pro-market liberalization will bring welfare gains by reducing the dead weight losses created by domestic monopolies and oligopolies by increasing competition, and by reducing price-marginal cost markups.¹ Secondly, there may be scale efficiency gain of trade by moving the firms down their average cost curves, thereby effectively raising firm size and scale efficiency. In addition, trade liberalization, as the major component of Indian pro-market liberalizing efforts, has been argued to have dynamic effects on firms' productivity growth through innovation.

In contrast to the theoretical predictions on the effect of liberalization on competition and markups, theoretical predictions about firm activity (dynamic effects) from macro models of entry liberalization and deregulation are ambiguous. (See endogenous growth theories by Grossman and Helpman (1990 and 1994); Melitz and Constantini (2008)) Trade can potentially be growth generating as well as growth decelerating. Trade can enhance growth permanently by facilitating the international exchange of knowledge and technology. Trade can have growth decelerating effects if it, via market size effects, reduces domestic firms' incentives to innovate or diverts resources away from R&D.² As outlined by Melitz and Constantini

¹This argument was first made in context of domestic monopolies in the classic paper by Bhagwati (1965), and was subsequently extended to oligopolies by the more recent work of Helpman and Krugman (1989), inter alia. See Helpman and Krugman (1989) for a detailed discussion.

²Theoretically, Krugman (1986) and Lucas (1988) argue that trade encourages learning by doing and innovation, leading to productivity growth. However, Rodrik (1992a and 1992b) has questioned the importance of these supposed productivity gains, and claims that there are no theoretical reasons to believe that the protection of domestic markets discourages productivity growth. This skepticism stems from the view that trade liberalization might retard productivity growth by shrinking domestic firms' sales, which would in turn reduce the incentive for these firms to invest in technological efforts.

(2008), these dynamic effects are characterized by a heterogeneous firm-level adjustment process following the reforms. Firm-level productivity evolves stochastically, and innovation involves a trade-off between its cost and a return in terms of a better distribution of future productivity draws. Moreover, their model shows there will be an industrial evolution over its entire transition path to a new steady state. In particular, how the relative timing and magnitude of firm-level productivity improvements and export market entry decisions are also determined by non-technological factors such as the timing of trade liberalization announcements and the speed of liberalization. Although theory has provided us some implications on liberalization-growth nexus, few studies have systematically examined the growth performance of firms, or more specifically model the dynamic adjustments process of micro-economic industrial structure following the liberalizing reforms.³

In the context of developing countries, several studies have explored the relationship between firm productivity and trade reforms using firm level data. Tybout et al. (1991) find no evidence of increased productivity following liberalization in Chile. Harrison (1994), Tybout and Westbrook (1995), Pavcnik (2002), Fernandes (2007) and Muendler (2004), on the other hand, do observe productivity increases following liberalization in, respectively, Cote d'Ivoire, Mexico, Chile, Colombia and Brazil. Krishna & Mitra (1998) find mixed results of change in productivity growth in four manufacturing industries with weak significance. However, they, as with almost all previous studies, assumed an instantaneous discrete shift in market efficiency parameters and productivity growth following the reforms, either by imposing a post-reform dummy or using one period lag output tariffs as a measure of trade reforms. However, linear estimation can not account for non-linear dynamics by imposing the unrealistic and restricting assumption of coefficient stability. Instead, it is more reasonable to model the transition after liberal-

³The widespread liberalizing reforms of the 1980s and 1990s around the world have provided researchers with good opportunities for estimating productivity gains from enhanced competition, and hence generated large empirical literature. However, before the availability of sufficiently detailed firm level data, most studies that examined this question either employed calibrated industry (Examples of simulated industry studies include the works of Dixit (1988), Rodrik (1988) and Baldwin and Krugman (1988)) or provided econometric estimates using industry-level aggregate data (Oczkowski and Sharma (2001)). One obvious weakness of these studies is that industry level data mask the extensive firm level variations. For better studying the dynamics of changes after regulatory reforms, especially with short time series, one needs to delve into micro panel data, which provides us repeated observations of enough cross-sections.

ization as a sequenced smooth process by a flexible functional form.⁴ There are two main reasons behind this argument: first, reforms taking time to gain credibility and market reactions; secondly, micro level restructure after unexpected macro level reforms usually take time due to various rigidities and adjustment cost of investment at micro level. It usually take years before the dynamic effects of trade on productivity growth start to happen, and continue for years.

This study takes a new approach to the question, Time Varying Panel Smooth Transition Regression (TV-PSTR) model. The starting point of this study is to recognize that the core mechanism that drives economic growth following liberalization is massive microeconomic restructuring and factor reallocation, which must be a slow process. Hence, it starts from the presumption that any changes in economic performance following reforms and liberalization may be more appropriately modeled as a steady transition rather than a discrete change. A standard explicit or implicit assumption underlying linear models is that there is a single structural break in the sample. In this study that assumption is replaced by a more general one stating that the parameters of the model may change continuously and smoothly as a function of time, which is more consistent with the firms' adjustment behaviors and economic evolution process. Moreover, this TV-PSTR model not only allows for discrete changes in parameters, but also allow for any form of nonlinear transition path. With discrete change ('big bang' shift) in parameters as a special case within this more general framework, the model doesn't lose its generality. Instead of using a priori information to fix the date of a transition, the speed and the timing of the transition are endogenously determined by the data. With the above merits, the TV-PSTR model has great advantage over conventional approach and doesn't put any prior estimation restrictions on the process of transition.

Utilizing this TV-PSTR approach and the natural liberalizing experiment of India, I document some stylized facts about the evolution of India's industrial structure against the backdrop of India's unexpected dramatic liberalizing reform starting from 1991. More precisely, I estimate the transition of average industry level price-marginal cost markups, RTS and productivity growth in nine two-digit level manufacturing industries in India using firm level panel data. A full production function with substantial flexi-

⁴Greenaway, Leybourne and Sapsford (1997) and McGillivray (1999) suggest that the effects of liberalization on GDP growth rates follow a smooth transition S curve process.

bility is employed, which allows for both non-perfect competitive market and non-constant return to scales. By relaxing the perfect competition and CRS assumptions⁵, this study intends to capture the gains from market and scale efficiency. After we identify speed parameter and hence the dynamic production function, we will be able evaluate the average industrial Total Factor Productivity (TFP) changes as the residuals in output growth after singling out estimated changes due to factor growth. Note that this study do not formally test whether liberalization results in growth. The results are, however, informative in two respects. Firstly, they post a clear picture of the adjustment and evolution process of Indian industries after pro-market liberalizing reforms. Secondly, they also point the way to improved econometric modeling of these processes.

India is a suitable case study because of its long history of protecting its domestic manufacturing sector. Moreover, the extensive changes in the economic regime of India coming unexpectedly after several decades of restrictive external policies, provided a good controlled experiment. This unanticipated, together with the gradual nature of the reforms and the time reform policy takes to gain credibility, lead to slow adjustments of firms, which justify the use of the new approach. Last but not least, the Indian data set used in this paper contains detailed firm level data on a large sample of firms in a variety of industries, thereby facilitating analysis at a higher level of disaggregation than previous studies.

The main findings of this paper are that the transition of market structure and productivity after liberalization do follow a smooth transition process. Instead of the previously assumed instantaneous ‘big-bang’ shift just after reforms, it actually took years for the Indian manufacturing industries start to react to the reforms, and the transitional impact of reforms took approximately four to eight years to complete. There is strong evidence of

⁵Traditionally, the methodology employed for estimating productivity growth is based on the Solow (1957) growth accounting approach, which assumes perfect competition and constant returns to scale (CRS). However, changes in the trade environment under liberalizing reforms appears to alter the nature of competition and returns to scale. (Melitz (2003)) If policy reforms affect the nature of competition, then the productivity changes associated with trade reform estimated by the Solow growth accounting model may be mismeasured and biased. Also, it will fail to capture the additional welfare gains from the reduction of dead weight losses by increasing competition and lowering markups. Harrison (1994) on Cote d’Ivoire and Krishna & Mitra (1998) on India, being aware of policy reforms affecting the nature of competition and Returns To Scale (RTS), respectively, are important exceptions.

increased competition, which reduces the markup and make welfare gains possible from the reduction of dead weight losses. Except for the Leather and Chemical industries, RTS in most industries shrink after the transition. The effects of reforms on total factor productivity (TFP) are mixed: most import-competing industries, which suffer most from the shrinking of market size experienced no change or decreasing TFP growth; whereas the export-oriented industry, as the industry which benefit most from economy of scale, enjoyed a huge TFP growth in response to reforms.

The main contribution of this paper is that for the first time it applies the Time Varying Panel Smooth Transition Regression (TV-PSTR) model to study the dynamics of market structure and productivity growth after liberalization in an emerging market. There is a growing body of empirical economic literature on the effects of reforms right after the reform year assuming there is a single structural break in the sample, but none of them characterize and model the adjustments and transition of the economy in the bigger setting of decades following the initial reforms. This study makes an attempt to fill this gap in the literature. This study proposes an innovative way of modeling slow structural changes as a smooth transition between states before and after any unexpected regime switching. In particular, instead of using a priori information to fix the date of transition, the speed and the timing of the transition are endogenously determined by the data.

The remainder of this paper is organized as follows. Section 2 briefly discusses the complex economic liberalizing reforms in India. Section 3 outlines the Time Varying Panel Smooth Transition Regression Model (TV-PSTR) and estimation methodology, discusses some econometric issues and describes the data. Section 4 presents and discusses the estimation results. Section 5 concludes.

2 Liberalizing Reforms in India

Before 1991, India's industrial structure was highly inefficient under the regime supported by a highly protective trade policy, and tailor-made protection to each sector of industry India characterized by "license raj" and heavy controls over private investment. Before reforms, India had one of the world's most complex trade regimes, characterized by severe quantitative restrictions on imports and exports, and extraordinarily high tariffs on

imports based on a strong belief in export pessimism, and in the effectiveness of import substitution. Imports of manufactured consumer goods were completely banned. For capital goods, raw materials and intermediates, certain lists of goods were freely importable, but for most items where domestic substitutes were produced, imports were only possible with import licenses.⁶

In July, 1991, forced by a severe balance of payments crisis, the newly elected Indian government approached the IMF, and launched a series of complex and dramatic economic reforms required by the strong conditionality attached with its loan. Given several earlier attempts to avoid IMF loans and the associated conditionalities, the large number of members of the new cabinet who had been cabinet members in past governments with inward-looking trade policies, and the heavy reliance on tariffs as a source of revenues, these reforms came as a surprise. Many of the resulting economic reforms directly or indirectly led to a substantial liberalization of the corporate sector, and have brought significant changes to the environment in which Indian companies previously operated. A great deal has been achieved in terms of greater liberalization and openness after ten years of gradualist reforms.

The principal aim of these reforms was to strengthen market discipline and promote greater competition. These pro-market liberalization efforts, broadly defined to include trade and entry liberalization, regulatory reform, ER regime reform and privatization, are very complex in nature. These were done by putting an end to the “license raj”, namely through the abolition of the Industries Development and Regulation Act (1951) and amendments to the Companies Act and several other major laws.⁷ In addition, the gov-

⁶For a classic and highly readable account of India's economic policies in this earlier period, see Bhagwati and Desai (1970). The costs imposed by these policies had been extensively studied (for example, Bhagwati and Desai, 1965; Bhagwati and Srinivasan, 1971; Ahluwalia, 1985)

⁷These had imposed a heavy legal and regulatory burden on the corporate sector. The 1951 Industries Development and Regulation (IDR) Act put in place a system of mandatory licenses, which acted to limit a firm's ability to expand capacity, change product mix, introduce new processes, and import machinery and equipment without obtaining various licenses from the central government. The list of industries reserved solely for the public sector—which used to cover 18 industries, including iron and steel, heavy plant and machinery, telecommunications and telecom equipment, minerals, oil, mining, air transport services and electricity generation and distribution—has been drastically reduced to three: defense aircrafts and warships, atomic energy generation and railway transport. Except for a few hazardous and environmentally sensitive industries, industrial licensing by the central government has been almost abolished. The requirement that investments by large

ernment announced its primary trade reforms which included the removal of most import licensing and other non-tariff barriers on all imports of intermediate and capital goods, and significant reductions in tariffs on imports.⁸ Indian companies were allowed to enter into joint ventures with multinational enterprises more freely, import new technologies and capital goods, expand productive capacity, and introduce new products without obtaining industrial licenses.⁹

The reforms were not only complex, but also were gradual when implemented. Import licensing was abolished relatively early for capital goods and intermediates. These became freely importable in 1993, simultaneously with the switch to a flexible exchange rate regime. Removing quantitative restrictions on imports of capital goods and intermediates was relatively easy, because the number of domestic producers was small, and the industry welcomed the move as making it more competitive. It was much more difficult in the case of final consumer goods because the number of domestic producers affected was very large. Quantitative restrictions on imports of manufactured consumer goods and agricultural products were finally removed on April 1, 2001, ten years after the reforms began, in part because of a ruling by a World Trade Organization dispute panel on a complaint brought by the United States. Progress in reducing tariff protection, the second element in the trade strategy, has been even slower and not always steady. Tariffs across a wide range of industries fell from a simple average of about 85 percent in 1990 to a value of approximately 28 percent in 2005 (Figure 1). Table 1 shows the reduction in average tariffs in several industrial sectors before and after the primary trade liberalization.¹⁰ We can see after huge tariff reductions in the primary trade reforms, there are further liberalizing efforts afterwards for each industry.¹¹

industrial houses needed a separate clearance under the Monopolies and Restrictive Trade Practices Act to discourage the concentration of economic power was abolished. The act itself was replaced by a more modern competition law in the Ninth Plan period when steps had been taken to dereserve a number of small-scale industries, particularly those industries with the greatest export potential. This new competition law focuses more on anti-competitive practices, by giving greater consideration to abuse of market dominance, rather than through firm size per se.

⁸Prior to the reform, a policy of import substitution was implemented with high tariffs and a requirement of multiple import licenses, shielding domestic firms from foreign competition.

⁹See Chopra et. al. (1995) for a complete description of the macroeconomic and structural reforms in the aftermath of the 1991 crisis.

¹⁰Average industry level tariff data are from the World Bank.

¹¹Although India's tariff levels are significantly lower than in 1991, they remain among

As predicted by Melitz and Constantini (2008), the unanticipated, gradual and complex nature of the reforms, together with the time reform policy takes to gain credibility, lead to slow adjustments of firms, which justify the use of the new approach. With the help of this approach, this study will be able to estimate the whole evolution of India's industrial structure against the backdrop of India's unexpected dramatic liberalizing reforms starting from 1991. In particular, instead of using a priori information to fix the date of transition as what linear estimation did, the speed and the timing of the transition are endogenously determined by the data.

3 The Time Varying Panel Smooth Transition Regression (TV-PSTR) Model and Estimation Issues

3.1 The TV-PSTR Model

The Smooth Transition Regression Model (STR), initiated by Bacon and Watts (1971), may be seen as a generalized switching regression model in such a way that the transition from one extreme regime to the other is not discrete, but smooth, as a function of the continuous transition variable. The TV-PSTR model, as a young member of the STR family, is a newly developed type of STR model by Gonzalez et al (2005), which extends its application on panel data and uses time t as the transition variable.

Consider the nonlinear regression model,

$$y_{it} = x'_{it}\varphi + (x'_{it}\theta)S(\gamma, c; z_t) + u_{it}, \quad t = 1, \dots, T, \quad (1)$$

where $x_t = (1, x_{1t}, \dots, x_{qt})'$ is the vector of explanatory variables, $\varphi = (\varphi_0, \varphi_1, \dots, \varphi_m)'$, and $\theta = (\theta_0, \theta_1, \dots, \theta_m)'$ with $m = 1 + q$ are parameter vectors, and $\{u_t\}$ is a sequence of iid errors. S is the transition function, a bounded continuous transition function between zero and unity. Granger and Terasverta(1993, Chap. 7) define S of the form,

$$S(r, c; z_t) = (1 + \exp\{-\gamma(z_t - c)\})^{-1}, \quad \gamma > 0. \quad (2)$$

the highest in the developing world, as tariffs in most other developing countries has also decreased over the period.

Assuming $\gamma > 0$,¹² the transition function (2) is a monotonically increasing function of z_t .¹³ The slope parameter, γ , indicates how rapid the transition, and the location parameter, c , determines in which year the transition midpoint occurs. If γ takes a large value then the transition is completed in a short period of time, and as $\gamma \rightarrow \infty$, the model collapses to one with an instantaneous structural break at time $t = \tau$; the smaller the γ , the smoother (slower) the transition process. Thus, our model is a more general framework, which embeds the standard structural break model (the most popular alternative to parameter constancy in econometric work) as a special case, and may often provide a more realistic assumption than that of a single structural break. With the transition variable, $z_t=t$, the TV-PSTR model is testing the constancy of regression parameters against continuous structural change.

By writing (1) as $y_t = x_t'(\varphi + \theta S) + u_t$, it is seen that the model is locally linear in x_t , and that the combined parameter vector $\varphi + \theta S$. If S is bounded between 0 and 1, the combined parameters fluctuate between φ and $\varphi + \theta$, and the model transition occurs smoothly between the initial and final state.

A standard explicit or implicit assumption underlying linear models is that there is a single structural break in the sample. In this study that assumption is replaced by a more general one stating that the parameters of the model may change continuously over time. Moreover, in sharp contrast to conventional approaches to modeling structural change, no a priori information is used to fix the date of a transition, that is, the midpoint of the transition is determined endogenously by the location parameter c , together with the transition speed parameter γ effectively determining the start and end points.

¹²If $\gamma < 0$, the initial and final model states are reversed but the interpretation of the parameters remains the same.

¹³The logistic function S_t as specified here does impose certain restrictions, in that the transition path is monotonic. More flexible specifications could also be considered, which allow for non-monotonic transition paths, by including a higher order polynomial in t in the exponential term of S_t . However, this more complex specifications will lose economic sense and the advantage of straightforward interpretation of our specification. Moreover, since the number of observations available in this study is relatively small, degrees of freedom problems would also quickly arise. Therefore, we will use equation (2) as the definition of S_t for the estimation, and solve this problem by testing the flexibility of model specification later based on a short sequence of nested tests as in Terasvirta (1994) and Granger and Terasvirta (1993, ch.7). Our specification survives the tests, and results are available upon requests.

In developing the analytical framework we follow the methodology initially advocated by Hall (1988) and extended by Harrison (1994) and Krishna & Mitra (1998). Consider a homogenous production function of degree θ , for firms in an industry:

$$Y = A \cdot f \cdot G(L, M, K), \quad (3)$$

where output Y is produced by a firm with inputs, labor L , material M and capital K . A is the technology shock, $G()$ is a general functional form, f is a firm specific parameter which allows for firm specific differences in technology. Taking the logs and differentiating both sides of (3) w.r.t time gives:

$$\begin{aligned} \frac{1}{Y} \cdot \frac{dY}{dt} &= \frac{\partial G}{\partial L} \cdot \frac{L}{G} \left(\frac{1}{L} \cdot \frac{dL}{dt} \right) + \frac{\partial G}{\partial M} \cdot \frac{M}{G} \left(\frac{1}{M} \cdot \frac{dM}{dt} \right) \\ &+ \frac{\partial G}{\partial K} \cdot \frac{K}{G} \left(\frac{1}{K} \cdot \frac{dK}{dt} \right) + \frac{1}{A} \cdot \frac{dA}{dt}. \end{aligned} \quad (4)$$

Assuming that firms have market power in the goods market but are competitive in the factor market, the resulting first-order optimality conditions imply:

$$\frac{\partial G}{\partial L} \cdot \frac{L}{G} = \left(\frac{P}{MC} \right) \frac{wL}{PY} = \mu\alpha, \quad (5)$$

$$\frac{\partial G}{\partial M} \cdot \frac{M}{G} = \left(\frac{P}{MC} \right) \frac{rM}{PY} = \mu\delta, \quad (6)$$

$$\frac{\partial G}{\partial K} \cdot \frac{K}{G} = \left(\frac{P}{MC} \right) \frac{rK}{PY} = \mu\beta, \quad (7)$$

where P , w , r are the prices of output, labor, material and capital respectively; MC is marginal cost; $\mu = P/MC$ is the price-marginal cost markup; and α , δ and β are labor, material and capital revenue shares. Combining equations (4) and (5)–(7) and expressing the result in discrete time, we get:

$$\Delta y = \mu(\alpha\Delta l + \delta\Delta m + \beta\Delta k) + \Delta a, \quad (8)$$

where lower case letters are log terms. To incorporate the returns-to-scale parameter (θ) into the framework, we apply Euler's theorem to equation (3) which gives:

$$\theta = \frac{\partial G}{\partial L} \cdot \frac{L}{G} + \frac{\partial G}{\partial M} \cdot \frac{M}{G} + \frac{\partial G}{\partial K} \cdot \frac{K}{G} = \mu(\alpha + \delta + \beta). \quad (9)$$

Combining (8) and (9) we can write:

$$\Delta y^* = \mu \Delta x^* + (\theta - 1) \Delta k + \Delta a, \quad (10)$$

where $y^* = \ln(Y/K)$, $\Delta x^* = \alpha \Delta l^* + \delta \Delta m^*$ with $l^* = \ln(L/K)$ and $m^* = \ln(M/K)$. Equation (10) is the basic estimating equation which permits both non-competitive pricing behavior through a mark-up, μ , and non-constant returns to scale through a scale parameter, θ .

The TV-PSTR model for equation (10) can be written as:

$$\Delta y_{it}^* = \mu \Delta x_{it}^* + \mu_x S_t \Delta x_{it}^* + (\theta - 1) \Delta k_{it} + \theta_k S_t \Delta k_{it} + \eta S_t + u_{it}, \quad (11)$$

where u_{it} is disturbance term, and $S_t = 1/\{1 + \exp[-\gamma(t - c)]\}$ is the smooth transition function (monotonically increasing in t and lies between 0 and 1). The subscripts i and t are for firm and time (year); η measures the change in productivity growth over the transition process; γ is the velocity or speed of transition; and c is the location of transition, which measures the number of years before the transition midpoint, a number between 0 and the total number of years, T , in the sample. μ_x and θ_k are the total change of markup and RTS over the transition.

3.2 Estimation methodology and data

Equation (11) is our final estimation equation. Since the model is highly non-linear, to get the consistent estimates of the TV-PSTR model for equation (11), we apply Nonlinear Least Squares (NLS) to determine the values of the parameters that minimize the concentrated sum of squared errors, conditional on γ and c .¹⁴ A practical issue that deserves special attention in the estimation of the PSTR model is the selection of starting parameter values in the transition function. In this paper, I apply simulated annealing instead of the often used means of grid search to get the starting value of (γ, c) .¹⁵ The (γ, c) space is then sampled more densely than in the case of

¹⁴Parameters are obtained by ordinary least squares at each iteration in the non-linear optimization. In case the errors are normally distributed, this estimation procedure is equivalent to maximum likelihood, (where the likelihood function is first concentrated with respect to the fixed effects μ .) The appendix in Gonzalez et al (2005) paper considers the properties of the ML estimator in full detail, including a formal proof of its consistency and asymptotic normality.

¹⁵For practical implementation, see Goffe, Ferrier, and Rogers (1994) and Brooks and Morgan (1995)

a grid search, which improves the quality of the starting values. As pointed out in Granger and Terasvirta (1993, Chap. 7), while the other parameter estimates can converge quickly, that for γ may converge very slowly, particularly if the true parameter value is large (such that the transition occurs quickly). This is because a large set of estimated values of γ result in very similar values of S_t , which deviate noticeably from each other only in a local neighborhood of the location parameter, τ . The practical consequence of this is that standard errors of the NLS estimate of γ may appear artificially large, and therefore should not be taken necessarily to indicate insignificance of the estimate.

The data used in the estimation are Indian PROWESS firm level data, obtained from the Centre for Monitoring the Indian Economy (CMIE). The dataset contains annual financial report data from 1988-2006 for firms which are listed on various stock exchanges in the country. In addition, if an entity is not listed, it qualifies for inclusion in the database if the average sum of sales and total assets is at least Rs.200 million ($\approx US\$4.6$ million) as per the latest audited financial results.¹⁶ The database covers all industries in the manufacturing sector. To the extent that a particular industry is dominated by the unorganised/small-scale firms, it is under-represented in the database. In this study, due to the limited number of firms with available data for several industries, we will present results for nine two-digit level manufacturing industries as listed in Table 3. These nine industries cover most of the manufacturing sector, and are a much more broader coverage than previous studies on similar topic. (For example, for unknown reason, Krishna & Mitra (1998) only report results for four industries.)

Deflated real output, labor, raw materials and energy, capital stock, and their shares in real output, are used in the estimation of our panel of firms. Real output was obtained by deflating nominal output by sectoral price level deflators. Real labor was obtained by deflating the wage bill by the public sector employee wage rates.¹⁷ Material inputs were deflated by the producer

¹⁶Thus, the unorganised/small-scale firms who form about 30 per cent of the manufacturing sector as a whole in India are not covered in this database.

¹⁷The sectoral price deflators and the public sector employee wage rates were obtained from the 'Economic Survey' which is published annually by the Indian Ministry of Finance. The public sector employee wage rate is a particularly good indicator of the overall manufacturing wage rate, itself not available for recent years due to reporting lags, since the ratio of the public sector wage rate to the overall manufacturing wage rate was almost constant in the last 20 years.

price index (PPI) each year.¹⁸ Real capital stock was computed by deflating net fixed assets by sector level investment deflators.¹⁹ The sample period for analysis considered here is from 1988 to 2006, a total of 19 years ($T=19$).

4 Empirical Results

4.1 Comparison of estimation results of TV-PSTR Model with that based on the restricted assumption of instantaneous ‘big bang’ shift

To model the impact of trade liberalization on the production relationship, previous studies have incorporated intercept and slope liberalization dummy variables into equation (10).²⁰ As mentioned in the introduction, a weakness of this approach is that it assumes the impact of reforms are best represented as a discrete ‘big bang’ effect on the markup and scale parameters. However, recent evidence suggests that the effects of reforms maybe better modeled as having undergone a smooth non-linear transition through time, with reforms taking time to gain credibility and market reactions. Especially for India, since the reforms are gradual, it is reasonable to expect a sequenced transition process. Moreover, the TV-PSTR model, as a more realistic assumption than that of a single structural break, includes the discrete change in parameters as a special case within this more general framework. Thus, the model doesn’t lose its generality. In particular, instead of using a priori information to fix the date of a transition, the speed and the timing of the transition are endogenously determined by the data.

Before we see the estimation results from our superior TV-PSTR model, it is interesting to look at the estimation results if we use the restricted assumption of instantaneous ‘big bang’ shift, and whether they make sense. These results can also be used as a comparison basis with those of the TV-PSTR model. Table 2 show both the estimation results of TV-PSTR Model and that based on the restricted assumption of an instantaneous ‘big bang’ shift. Estimation results on left hand is from Krishna & Mitra (1998). They used the same dataset, but covered the period of 1986-1993 with more years of data available before the reform. For unknown reason, only 4 industries in India were covered in their paper, and transport equipment industry is

¹⁸PPI was obtained from the RBI.

¹⁹The sector level investment deflators were obtained from the World Bank.

²⁰See Harrison (1994) Krishna and Mitra (1998) and other previous studies.

the only one we have in common. The liberalization time dummy is 0/1, with value of 0 before 1991 liberalization reform and 1 after. With very low R^2 statistics, the overall fit of the model is poor. More importantly, the estimates of μ and μ_x don't make any sense. The initial price-marginal cost ratio are values of one, which is contradictory with the reality of non-perfect competitive market under protection in India. Moreover, the estimates for changes of P/MC and productivity growth parameters after the liberalization are not significant. This weak results are largely caused by the dubious assumption of instantaneous 'big bang' shift in parameters right after the reform since the micro restructuring did not happen overnight right after the reform. Now let us use the TV-PSTR approach, in comparison.

4.2 Estimation results on the TV-PSTR Model

The estimation results on the TV-PSTR Model from equation (11) are presented in Table 3. Relaxing the assumption of transition time and speed (an instantaneous 'big bang' shift) significantly improves our regression estimates. LM_F test values for all industries are significant at the 5 per cent level, implying an overall good fit for the model. Moreover, all estimates survive the diagnostic checks, which means no remaining heterogeneity in the error term.²¹ The estimates of markup before liberalization are all values exceeding unity, which make sense and reflect the imperfect competitive market reality in India before the liberalization reforms. In comparison, the estimates for transport equipment industry are listed on the right hand side column in Table 2. All the estimates are significant at 5 percent level. More importantly, the estimated transition speed parameter γ is a small number of 9.144, which means the transition is a slow process instead of of a big bang shift. Moreover, the estimated location parameter c tells us the transition did not happen until eight years after the main reform. Therefore the estimates based on conventional assumption of instantaneous big bang shift from Krishna & Mitra (1998) are biased, and even outside the confidence bands of the estimates based on the more general and flexible TV-PSTR approach.

²¹The results of which are available upon request.

4.2.1 Estimation of price-marginal cost ratio

Based on the price marginal cost ratio, scale, and transition parameter estimates from Table 3, the time-series smooth transition behavior of the price-MC ratio and scale parameters is plotted in Figures 3 and 4. As shown in Figure 3, price-MC ratio vary substantially from sector to sector, and in general appear to be linked with the level of protection. The change of mark-up parameter, μ_x , for all industries are negative and significant, which provide strong evidences of increases in competition, which pushes down the markup and makes it possible for India to get welfare gains from reduction of dead weight losses.

4.2.2 Estimation of speed and timing of transition

In particular, instead of using a priori information to fix the date of a transition, the speed and the timing of the transition are endogenously determined by the data. Except for paper industry, transition speed parameter, γ , for all industries are very small numbers, which implies the effects of liberalization on market structure and productivity do follow a smooth transition process, instead of the previously assumed instantaneous ‘big-bang’ shift just after reforms.

Moreover Figures 3 and 4 also show that for most industries, transition takes approximately four to eight years to move completely from a pre-reform to a post-reform era. It took years for the Indian firms start to react to the reforms, and the starting point for a transition in the Metal industry was as late as approximately 2000. The timing of the transition differs across sectors. The transition mid-points for five out of the nine industries happen around 2000, which coincide with the major policy change, the removal of quantitative restrictions on imports of manufactured consumer goods and agricultural products.

The delayed transition is not surprising if we recognize that the core mechanism that drives economic growth following liberalization is massive microeconomic restructuring and factor reallocation. This must be a slow process since reforms take time to gain credibility and market reactions from the firms, and restructuring involves adjustment cost of investment. Besides, the delays of actions by state governments may also play a role.²² Kambham-

²²Industrial liberalization by the central government needs to be accompanied by sup-

pati (1996) provides a possible explanations for relatively fast transition in paper industry. In 1990, the market concentration index CR4, which equals the sum of the market shares of the four largest firms in a narrowly defined industry, ranged from highest of 100 for matches industry to lowest of 10.4 in paper industry, while the average CR4 for all manufacturing industries was as high as around 70. The low market concentration in paper industry before liberalization means firms don't have much market power, and the industry is not dominated by a few large firms. So that the firms cannot use pricing strategy or colluding strategy to drive out the new competitors, they have no other choice but to restructuring as quickly as possible.

4.2.3 Estimation of scale efficiency and TFP growth

The policy changes under the liberalizing reforms were expected to generate faster industrial growth and greater penetration of world markets in industrial products, but performance in this respect has been disappointing. As shown in Figure 4, except for the Leather industry, returns to scale in most industries shrank significantly after the transition. The effects of reforms on TFP are mixed (shown in Table 3): for most industries TFP either has no change or fell slightly after the transition; while the leather industry enjoyed a TFP growth rate of 24 per cent over the transition.

One possible explanation for the poor performance of most manufacturing industries may lie in their modestly improved export performance. India's share in world exports, which had declined steadily since 1960, increased slightly from around 0.5 percent in 1990-1991 to 0.6 percent in 1999-2000, with much of the increase due to agricultural exports. India's manufactured exports had a 0.5 percent share in world markets in 1990, and this rose to only 0.55 percent by 1999.²³ Unlike the case in China and South-East Asia, foreign direct investment in India did not play an important role

porting action by state governments. Private investors require many permissions from state governments to start operations, like connections to electricity and water supply and environmental clearances. They must also interact with the state bureaucracy in the course of day-to-day operations because of laws governing pollution, sanitation, workers welfare and safety and such. Complaints of delays, corruption and harassment arising from these interactions are common.

²³One reason why export performance has been modest is the slow progress in lowering import duties that make India a high-cost producer and therefore less attractive as a base for export production. Exporters have long been able to import inputs needed for exports at zero duty, but the complex procedure for obtaining the necessary duty-free import licenses typically involves high transactions cost and delays. High levels of protection

in export penetration, and was instead, oriented mainly toward the domestic market. These investments inflows added great competitive pressure to domestic firms, and at the same time further squeezed their market shares. The leather industry, on the other hand, benefited most from the liberalization and expanded its scale significantly by exporting. India is now among the top ten exporters of leather and leather products in the world.

In an effort to test our guess, following Ghose (2000), I classify industries into two groups based on their value of net exports (exports - imports) as percentage of output, import-competing and export-oriented industries (as shown in Table 4). Industries with a significantly decreasing TFP growth rate, are import-competing industries which suffer the most from shrinking market size; whereas the leather and metal industry, as the export-oriented industry which benefited most from economy of scale, enjoyed a huge TFP growth in response to reforms. To further confirm this, we estimate the average change of TFP growth rate in the two groups, import-competing v.s. export-oriented Industries, and the results are shown in Table 5. This evidence is consistent with the endogenous growth model prediction, which says TFP growth after liberalization depends on whether trade is encouraging or discouraging R&D and innovation. Trade liberalization can stimulate TFP growth, but only when it spurs firms' incentives to innovate. If the market size shrinks, trade can reduce the incentives faced by domestic producers to innovate, which therefore slow down their TFP growth rate.

One possible reason why export performance has been modest is the slow progress in lowering import duties that make India a high-cost producer and therefore less attractive as a base for export production. Exporters have long been able to import inputs needed for exports at zero duty, but the complex procedure for obtaining the necessary duty-free import licenses typically involves high transactions cost and delays. High levels of protection compared with other countries also explains why foreign direct investment in India has been much more oriented to the protected domestic market, rather than using India as a base for exports. However, high tariffs are only part of the

compared with other countries also explains why foreign direct investment in India has been much more oriented to the protected domestic market, rather than using India as a base for exports. However, high tariffs are only part of the explanation for poor export performance. The reservation of many potentially exportable items for production in the small-scale sector (which has only recently been relaxed) was also a relevant factor. The poor quality of India's infrastructure compared with infrastructure in East and South-East Asia is yet another.

explanation for poor export performance. The reservation of many potentially exportable items for production in the small-scale sector (which has only recently been relaxed) was also a relevant factor. The poor quality of Indias infrastructure compared with infrastructure in East and South-East Asia is yet another.

In addition, inflexibility of the labor market is a major factor reducing India's competitiveness in exports, and also in reducing industrial productivity generally (Planning Commission, 2001). Any firm wishing to close down a plant or to retrench labor in any unit employing more than 100 workers can only do so with the permission of the state government, and this permission is rarely granted. These provisions discourage employment and are especially onerous for labor-intensive sectors. The increased competition in the goods market has made labor more willing to take reasonable positions, because lack of flexibility only leads to firms losing market share.

With exogenously determined levels of firm-productivity, Melitz (2003) provides a framework of monopolistic competition with heterogeneous firms, and predicts that opening up trade leads to changes in firm-composition within industries along with improvements in aggregate industry productivity: that low productivity firms exit; that intermediate productivity firms survive contract; and that new and high productivity firms enter the markets and expand. Although the market environment was more like oligopoly than monopolistic competition, it would also be interesting to see what actually happened empirically in India following the liberalization reforms. Consistent with the observation in Topalova (2004), there seems to be very little exit at the firm level in India's industry. Different explanations may account for this such as lingering restrictions and regulation constraining firm flexibility to adjust, inefficiency in the financial sector, and more importantly the important remaining role of incumbent considering the oligopolistic real sector before reforms.²⁴ One addition explanation is embedded in the limited sample size of firm level data in India. As mentioned earlier, the dataset the paper uses contains only annual financial report data from firms which are listed on various stock exchanges in the country, or with the average sum of sales and total assets is at least Rs.200 million (\approx US\$4.6 million). Thus, the unorganised/small-scale firms who form about 30 per cent of the

²⁴Goldberg et al. (2009) argue that remnants of industrial regulation still affect the operation of Indian firms and may constrain their flexibility to adjust to new economic conditions.

manufacturing sector as a whole in India, and are more vulnerable and more likely to exit, are not covered in this database. Therefore, we further divide the firms into two groups: existing firms before 1991 reforms and new-entry firms after that. Their average TFP growth performance both before and after the transition (transition mid-point) are shown in Table 6. Consistent with the theory prediction, new-entry firms do tend to have relatively high overall productivity growth estimates than do existing firms which were under protection. On average, there is only a slight improvement in the overall average manufacturing TFP growth estimates over the transition process.

It can be argued that the liberalization and initial relaxation of controls has created a more competitive environment, and given restructuring pressure to domestic firms. However, this could have led to industrial growth only if industrial investment had been oriented to tapping export markets, as was the case in East Asia. As it happened, India's industrial and trade reforms were not strong enough, nor adequately supported by infrastructure and labor market reforms, to generate such a thrust.²⁵

5 Conclusion

In this paper, I employ the TV-PSTR model to investigate the transition dynamics of price-marginal cost markups, returns to scales (RTS) and productivity growth in Indian manufacturing industries associated with India's unexpected dramatic pro-market economic liberalizing reforms. Using Indian manufacturing firm level data for the period from 1988 to 2006. I find that the transition after liberalization does follow a smooth process, instead of the previously assumed instantaneous 'big-bang' shift just after reforms. The dynamic adjustments of industrial structure do not occur immediately after the primary reforms, and do not occur over the same time period for all industries. Also the length of the transition process varies across industries. It actually took years for Indian firms in manufacturing industries to react to the reforms, and the transitional impact of reforms takes approximately

²⁵The one area that has shown robust growth through the 1990s, with a strong export orientation, is software development and various new types of services enabled by information technology, like medical transcription, backup accounting and customer related services. India's success in this area is one of the most visible achievements of trade policy reforms, which allow access to imports and technology at exceptionally low rates of duty, and also because of the fact that exports in this area depend primarily on telecommunications infrastructure, which has improved considerably in the post-reform period.

four to eight years to complete. There is strong evidence of increases in competition, which pushes down the markup and makes it possible to obtain welfare gains from reduction of dead weight losses by increasing competition and lower markups. Except for the leather industries, RTS in most industries shrink after the transition. As predicted by the endogenous growth theory, the effects of reforms on TFP are mixed, depending on whether trade is increasing its market size or not, and hence possibly encouraging or discouraging R&D and innovation. After the liberalization reforms, generally, import-competing industries which suffer heavily from the shrinking market size, experienced no significant increase in TFP growth; whereas the export-oriented industry, which benefit most from economy of scale, enjoyed a huge TFP growth in response to reforms. In terms of policy implication, It is important to facilitate exports and exploit returns to scale, and innovation spurring policy environment to stimulate productivity growth and counteract the possible disincentive to innovate caused by shrinking market size.

As pointed out by Panagariya (2004), a lack of acceleration of growth in the industrial sector is the most disappointing aspect of the 1990s experience, and also the key to explaining why India nevertheless continues to lag behind China. In 1980, the proportion of GDP originating in the industry was already 48.5 per cent in China, in India it was only 24.2 (Table 7). Services, on the other hand, contributed only 21.4 per cent to GDP in China but as much as 37.2 per cent in India. In the following 20 years, despite considerable growth, the share of industry did not rise in India. Instead, the entire decline in the share of agriculture was absorbed by services. Though a similar process was observed in China, the share of industry in GDP was already quite high there. To catch up, India are suggested to free the industry of continuing restraints: bring all tariffs down to 10 per cent or less; abolish the small-scale labor-intensive industries reservation (draconian labor laws); institute an exit policy and bankruptcy laws; and privatize all public sector undertakings. In some ways, given the advantage India enjoys in the information technology sector over China, its overall prospects for growth are even better than those of China but only if the conventional industry is given a fair chance, but only when if it has a more strong formal sector.

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Table 1: Reduction in Average Tariff Rate in Indian Manufacturing Sector

Industry	1990	1992	1997	1999	2001
Food	85.3	47.5	27.7	30.6	40.6
Beverage	190.7	181.9	130.9	121.8	114.6
Textiles	93.9	62.1	38.0	38.3	29.7
Textile Products	99.8	65.0	39.9	39.9	35.0
Leather	82.1	55.3	19.4	29.8	27.7
Leather Products	100.0	65.0	40.0	40.0	35.0
Paper	90.5	58.5	23.1	31.7	30.4
Chemicals	77.1	63.4	29.1	34.1	33.4
Chemical Products	82.8	58.9	31.5	35.3	34.2
Rubber	95.0	63.4	39.4	40.0	33.4
Plastic Products	100.7	64.9	31.7	35.2	34.6
Metal	84.6	64.8	28.5	33.9	33.7
Metal Products	75.0	59.9	29.7	32.4	33.8
Machinery	82.0	57.7	31.1	31.5	27.8
Transport Equipment	62.8	52.7	31.1	35.6	38.9

Table 2: Comparison of Estimation Results of STR Model with that of Conventional Approach on Transport Equipment Industry in India

	“Big Bang” Shift right after reform		Smooth Transition Regression
Sample Period	1986-1993		1988-2005
$\mu = \frac{P}{MC}$	1.00* (0.09)	$\mu = \frac{P}{MC}$	1.199* (0.115)
$\Delta\mu \cdot Tdum$	-0.71 (0.40)	μ_x	-0.367* (0.177)
$\theta - 1$ ($\theta = 1$ CRS)	0.08 (0.08)	$\theta - 1$ ($\theta = 1$ CRS)	-0.128* (0.008)
$\Delta\theta \cdot Tdum$	-0.96* (0.13)	θ_k	-0.319* (0.132)
$Tdum$	-0.00 (0.02)	η	-0.039* (0.006)
		γ	9.144
		c	12.565
R^2	0.38	LM_F	3.673

Estimation results on left hand is from Krishna & Mitra (1998).

Table 3: Estimation Results on the TV-PSTR Model

Industry Estimate	Food and Beverage	Textiles and Products	Leather and Products	Paper and Products	Chemical and Products	Rubber and Plastics	Metal and Products	Machinery and Equipment	Transport Equipment
μ	1.112* (0.058)	1.340* (0.046)	2.053* (0.161)	1.878* (0.667)	1.336* (0.066)	1.200* (0.062)	1.510* (0.106)	1.261* (0.050)	1.199* (0.115)
μ_x	-0.499* (0.101)	-0.456* (0.101)	-0.915* (0.257)	-0.677* (0.074)	-0.149* (0.107)	-0.489* (0.104)	-0.841* (0.185)	-0.487* (0.091)	-0.367* (0.177)
$\theta - 1$	-0.210* (0.057)	-0.007 (0.047)	-0.075 (0.152)	0.835* (0.071)	-0.333* (0.065)	-0.190 (0.123)	0.044 (0.092)	-0.021 (0.045)	-0.128* (0.008)
θ_k	-0.017 (0.181)	-0.128 (0.101)	1.252* (0.399)	-0.886* (0.079)	0.233 (0.138)	-0.201 (0.150)	-0.272 (0.150)	-0.314* (0.083)	-0.319* (0.132)
η	0.001 (0.681)	-0.008* (0.002)	0.241* (0.047)	-0.020 ^a (0.010)	-0.149 (0.006)	-0.008 (0.009)	0.116* (0.005)	-0.026* (0.004)	-0.039* (0.006)
γ	2.605	2.615	1.419	112.487	1.945	4.968	1.844	2.594	9.144
c	13.091	13.039	11.412	7.566	8.936	13.924	15.960	13.039	12.565
LM_F	33.656	22.089	19.647	11.506	18.276	10.388	17.420	32.233	3.673
N	475	462	222	101	430	247	226	637	137

^aSignificant at 5 percent significance level. Heteroscedasticity-consistent standard error in parenthesis

Table 4: Estimation Results Classified by Import-competing v.s. Export-oriented Industries

		Import-competing	Export-oriented	RTS	TFP
Textiles & Products		√		–	↓
Leather & Products			√	↑	↑
Paper & Products		√		↓	↓
Chemical & Products	basic industrial chemical	√		–	–
	chemical products		√		
Metal & Products			√	–	↑
Machinery & Equipment		√		↓	↓
Transport Equipment		√		↓	↓

Industries classified following Ghose (2000).

Table 5: Average Change of TFP Growth by Import-competing v.s. Export-oriented Industries

*

	Pre-transition Productivity Performance	Post-transition Productivity Performance	Change of TFP Growth
Firms in Import-competing Industries	0.002	-0.009	-1.1%
Firms in Export-oriented Industries	-0.006	0.114	12.0%

^aHere TFP growth is calculated using the relevant Tornquist index number formula with markup μ and θ incorporated in the definition:

$$TFP = [\ln Y_t - \ln Y_{t-1}] - \mu[\alpha(\ln L_t - \ln L_{t-1}) + \delta(\ln M_t - \ln M_{t-1}) + (\theta/\mu - \alpha - \delta)(\ln K_t - \ln K_{t-1})].$$

where $\alpha = (1/2)(\alpha_t + \alpha_{t-1})$ and $\delta = (1/2)(\delta_t + \delta_{t-1})$. To identify the periods of pre- and post-transition we rely on the transition location mid-point estimate from table 3. Even though the changes in parameters follow a smooth transition, the mid-point of this transition provides a useful reference point for the timing of major reforms.

Table 6: Total Factor Productivity Growth Estimates of Existing and New-Entry firms

*

	Pre-transition Productivity Performance	Post-transition Productivity Performance	Change of TFP Growth
Existing firms before 1991 reform	-0.004	0.003	0.7%
New-Entry firms after 1991 reform	0.021	0.024	0.3%

Table 7: Composition of GDP (per cent)

	1980	1990	2000
China			
Agriculture	30.1	27	15.9
Industry	48.5	41.6	50.9
Services	21.4	31.3	33.2
India			
Agriculture	38.6	31.3	24.9
Industry	24.2	27.6	26.9
Services	37.2	41.1	48.2

Source: World Bank, Basic indicators.

*Here TFP growth is calculated using the relevant Tornquist index number formula with markup μ and θ incorporated in the definition:

$$TFP = [\ln Y_t - \ln Y_{t-1}] - \mu[\alpha(\ln L_t - \ln L_{t-1}) + \delta(\ln M_t - \ln M_{t-1}) + (\theta/\mu - \alpha - \delta)(\ln K_t - \ln K_{t-1})].$$

where $\alpha = (1/2)(\alpha_t + \alpha_{t-1})$ and $\delta = (1/2)(\delta_t + \delta_{t-1})$. To identify the periods of pre- and post-transition we rely on the transition location mid-point estimate from table 3. Even though the changes in parameters follow a smooth transition, the mid-point of this transition provides a useful reference point for the timing of major reforms.

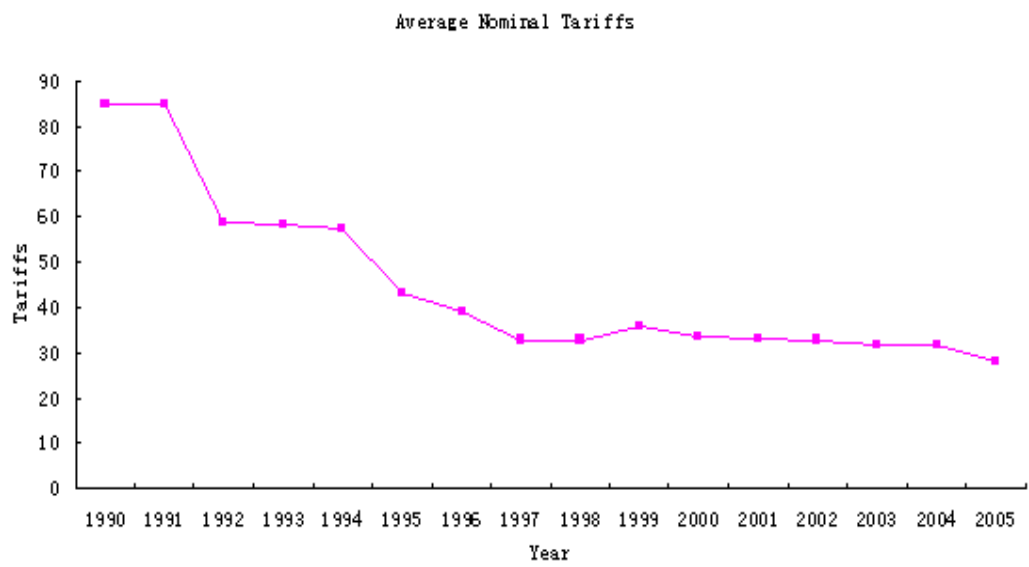


Figure 1: Evolution of Tariffs in India

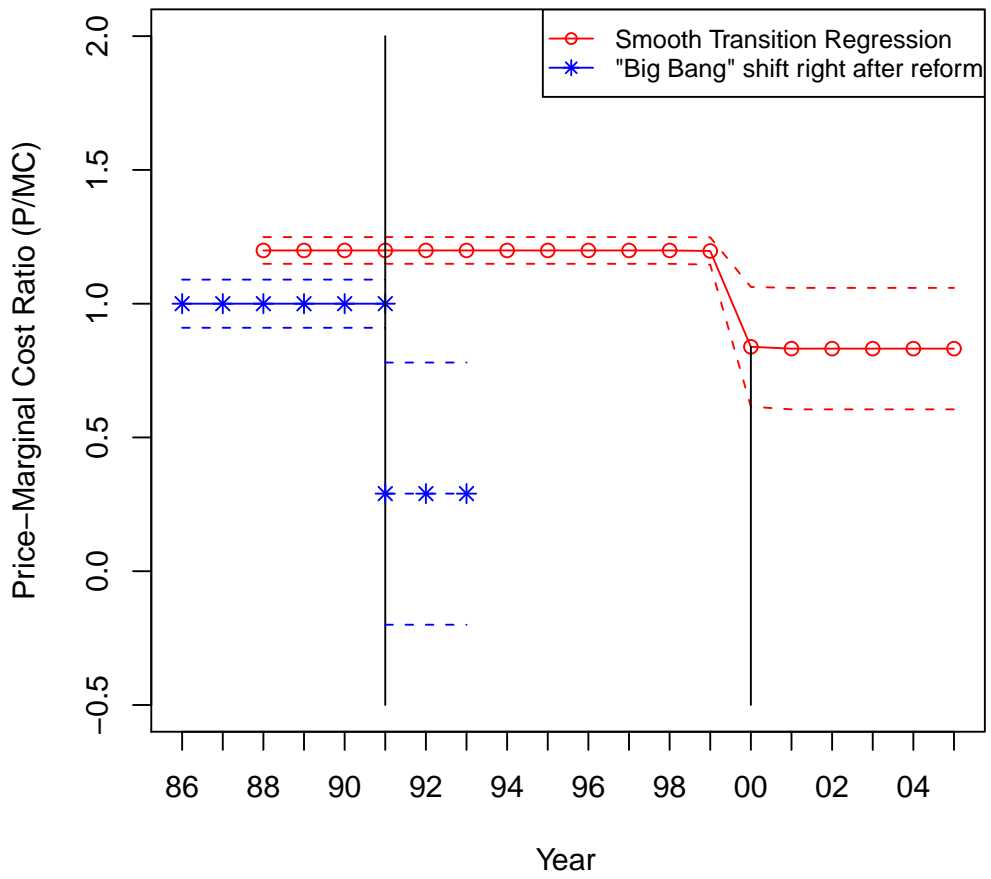


Figure 2: Comparison of Estimated Transition Dynamics of P/MC in Indian Transport Equipment Industry

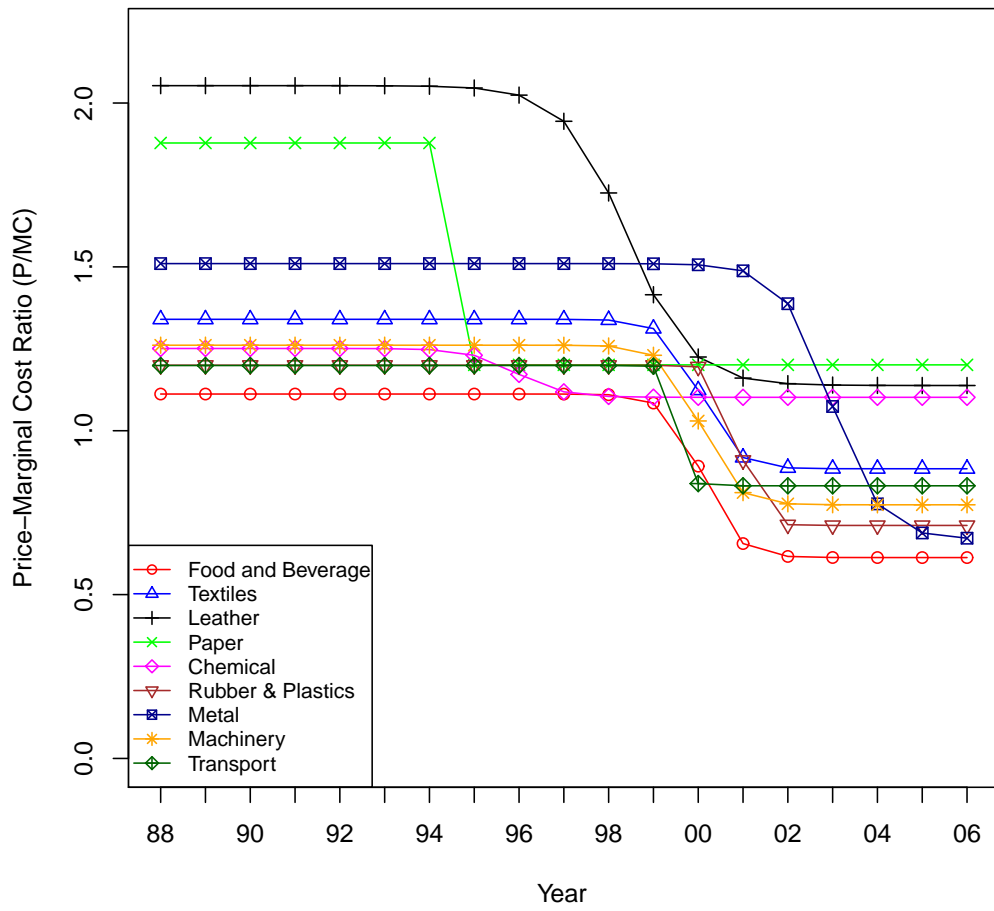


Figure 3: Estimated Price-Marginal Cost (P/MC) Ratio

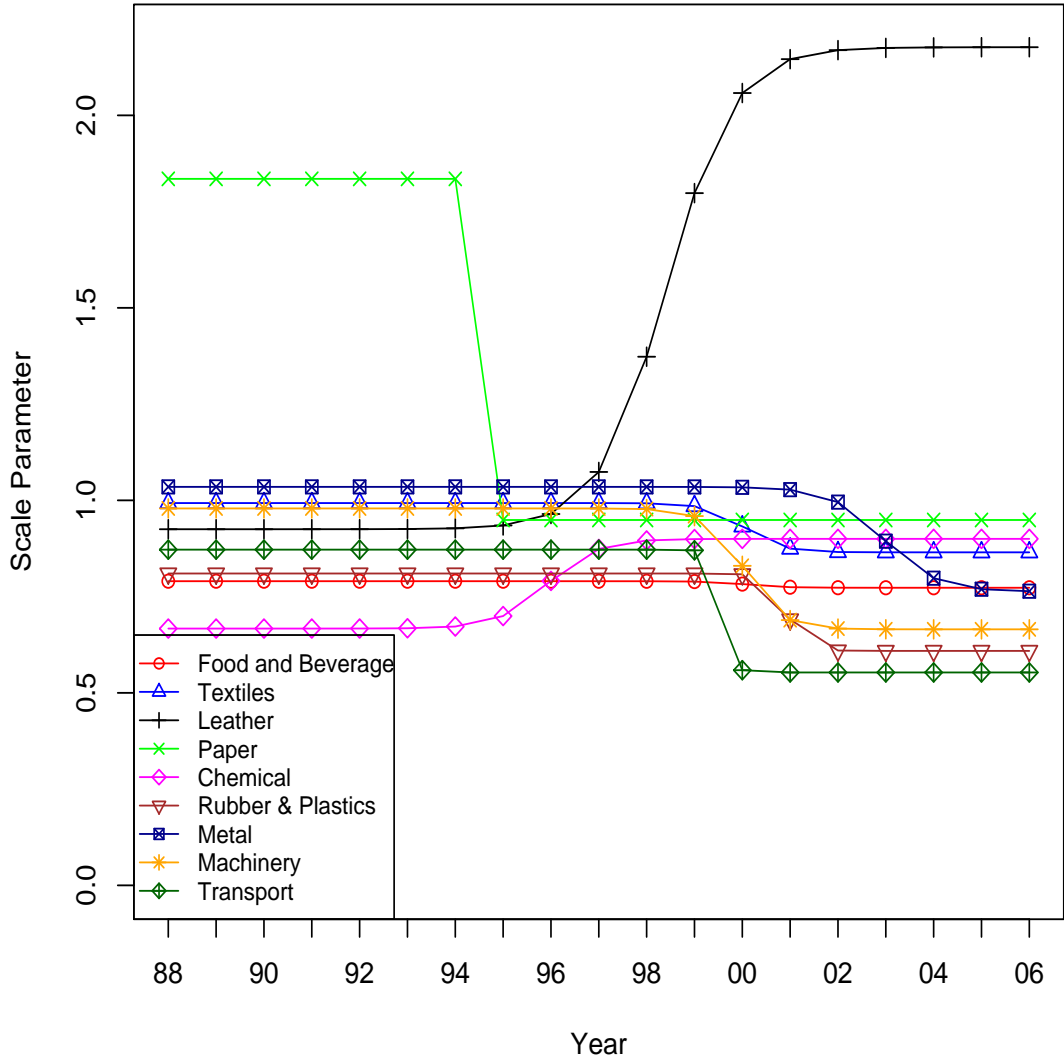


Figure 4: Estimated Scale Parameters