License Reform in India: Theory and Evidence*

A. V. Chari

Yale University

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Abstract

How do barriers to entry and expansion affect productivity? I answer this question by examining the impact of India's industrial policy reforms during the 1980s. In 1985, the "License Raj", which controlled entry and capacity expansion in Indian manufacturing industries, was partially dismantled by removing a subset of industries from its jurisdiction. To assess the impact of this deregulation on TFP, I embed entry and expansion constraints in a heterogeneous firm model of industry equilibrium. The model predicts that relaxing these constraints improves average industry productivity via changes in the composition of firms in the industry. Moreover, the model yields structural equations that can be used to recover estimates of the TFP gains as well as estimates of the relative contributions of the changes in entry and expansion costs. Using establishment-level data, I find that over a ten year period the reform resulted in a relative TFP improvement of nearly 32% in the industries that were deregulated. The decomposition of these gains suggests that changes in entry and expansion costs contributed almost equally to the productivity improvement.

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1 Introduction

Inefficient controls and regulations have stifled the growth of many under-developed economies; relaxing these controls appears to have resulted in significant productivity and output gains.[1] This paper adopts a structural approach to examine reforms that relaxed entry and expansion constraints in Indian industry and provides an alternative methodology for estimating productivity gains. Because changes in entry and expansion costs impact productivity in different ways, the structural exercise also allows for measurement of their relative contributions to the overall productivity improvement. I find that the reforms resulted in a relative TFP gain of 32% in the industries that were deregulated and that changes in entry and expansion costs contributed almost equally to this improvement.

Industrial performance in India during the first two decades after independence was modest, and was followed by a long period of decline from the 1970s to the early 1980s, during which manufacturing TFP grew at a rate of -0.3% (Bosworth, Collins and Virmani 2007). Following the slowdown in the 1970s, TFP growth in manufacturing rebounded to about 2% in the 1980s, although the exact timing of the turnaround is disputed (Wallack 2004, Panagariya 2004). Rodrik and Subramanian (2004) attribute the recovery to a pro-business shift in policy that occurred around this time. This shift in policy manifested itself in a first wave of reforms aimed at easing controls on private sector investment, partially reflecting the concern that these controls had been responsible for the poor industrial growth in the preceding years. As I show in this paper, this wave of reforms appears to have been almost completely responsible for the observed TFP recovery.

The centerpiece of the new policies was the reform of the License-Raj - a system of controls that regulated entry and capacity expansion in industry by requiring firms to obtain licenses for these activities. The licensing regime has been plausibly associated with low industrial productivity: by restricting expansion, it may have kept firms inefficiently small, and by restricting entry (and hence competition) it may have allowed inefficient producers to survive. In 1985, a subset of manufacturing industries was removed from the jurisdiction of the license regime. Although the resurgence in TFP coinciding with the timing of these reforms is significant, there are surprisingly few studies of the effects of this license reform. The literature has predominantly focused on the major liberalization episode of 1991, which abolished licensing for another large set of industries

[1] See for example Bruhn (2007) and Kaplan, Piedra and Seira (2006) on the effects of easing entry regulations in Mexico; Tybout, de Melo and Corbo (1990) and Pavcnic (2002) on the intra-industry effects on productivity following trade liberalization in Chile; Besley and Burgess (2004) and Aghion et al (2007)on the effects of labor regulations in India.

and slashed tariff rates across the board.[2] A notable exception is Aghion et al (2007), although their focus is not on how de-licensing improved productivity, but on how the reform has interacted with regional institutions to produce heterogeneous responses in employment and output across the different states of India.

This paper therefore contributes to the literature by providing a detailed examination of TFP growth due to the license reforms of 1985. I infer the productivity effects using a model in which productivity gains from the reform arise from changes in the composition of firms in the industry. While this particular approach to thinking about productivity gains has gained popularity in the trade literature due to recent theoretical contributions by Melitz (2003), Bernard, Redding and Schott (2007) et al, it has not been empirically implemented. I show how such a model of industry equilibrium with heterogeneous firms can be used to not only quantify the productivity gains due to the reform, but also to identify the sources of these gains. This methodology for obtaining productivity effects is also particularly useful in this context because the Annual Survey of Industries (ASI), although the principal source of data on industrial production in India, does not allow establishments to be linked over time and this has proved to be a challenge for the consistent estimation of production functions.[3] The methodology outlined in this paper avoids this problem by obtaining productivity effects indirectly by relating them to changes in quantities such as the number of firms and establishment size.

I construct a multi-sector model of industry equilibrium with heterogeneous firms (that differ in their productivities) à la Hopenhayn (1992), which incorporates the two essential features of the license regime, namely, the cost of entry and the cost of expanding capacity. Specifically, I model the entry cost as a cost that is paid up-front before an entrant learns its productivity. The cost of expanding capacity is modeled as quadratic and increasing in output. The model predicts that reducing these costs unambiguously increases average productivity by changing the composition of firms in the industry: the intuition is that high costs of entry shield inefficient incumbents from competition and allow them to survive, while high costs of expansion allow unproductive firms to survive by restricting the more productive firms from expanding.

However the model also predicts that the responses to the reform along the intensive and extensive margins of adjustment should be different across the short- and long-run. In the short-run, which is defined to be a time-frame in which no entry or exit is possible, the only impact of the

[2] For example, see Krishna and Mitra (1998), Sivadasan (2004) and Topalova (2005).
[3] However, see Sivadasan (2004), for an alternative approach.

reform is via the reduction in expansion costs. This reduction allows incumbent firms to expand, but the resulting fall in prices must force the least productive of these firms to temporarily shut down. The short-run response is therefore characterized by an increase in firm sizes (the intensive margin of adjustment) and a decline in the number of operating firms (the extensive margin of adjustment). In the long-run, however, the reduction in the entry costs makes the market more competitive, and thereby prevents individual firms from becoming too large. The transition from the short-run to the long-run must therefore involve an increase in the number of firms and a decline in firm sizes.

The predictions of this model are testable. Using plant-level data from the ASI, I verify that these predictions match closely with the observed responses in the industries that were deregulated – firm sizes increase and the number of operating firms declines in the short-run, and this pattern is reversed in moving to the long-run equilibrium. Empirically, the importance of this variation in short- and long-run responses is that it allows me to separately identify the changes in entry and expansion costs. This follows from the fact that the short-run response derives purely from the change in the latter, and once this change has been identified, the change in entry costs can be deduced from the long-run response (which is due to changes in both costs). I derive structural equations from the model that directly relate the short- and long-run responses in establishment size and number of firms to the changes in entry and expansion costs and estimate these equations using the data. Using this methodology, I find that entry costs fell by about 60% (on average, across deregulated industries), while expansion costs were reduced by about 50%.

In turn, knowing how these two costs changed allows me to identify the sources of the productivity gains induced by the reform. Estimates from the model indicate that relative TFP improvement in the deregulated industries was of the order of 32% over a period of 10 years, corresponding roughly to a 3% annual improvement. This finding is remarkable insofar as it suggests that the turnaround in TFP during the 1980s was entirely due to the de-licensing reform. Moreover, I find that 45% of this reform-induced TFP gain can be attributed to the relaxation of capacity constraints and the remainder to the reduction in entry costs - the license regime appears to have created equal inefficiencies along the two margins of adjustment.

These results have broad implications for industrial policy in developing countries. Entry regulation is by no means peculiar to India; almost all countries require entrepreneurs to go through some minimum procedures before they can obtain permission to start production. The model outlined in this paper provides a useful framework for thinking about the effects of these entry regulations. In addition to proposing a particular estimation methodology, it also underlines the distinction between short- and long-run responses that should be borne in mind when looking at the data. In a recent study, Djankov et al (2002) find that the restrictiveness of entry procedures varies considerably across countries, but is typically greater in poorer countries.[4]The strong intra-industry effects of deregulating entry in India suggest that this policy reform should be accorded high priority in these countries.

The remainder of this paper is organized as follows: Section 2 details the reforms, Section 3 describes the data and the descriptive evidence, Section 4 lays out the theoretical model, Section 5 discusses the estimation methodology and the results, and Section 6 concludes.

2 Background

India is an interesting example of an economy in which government regulations also appear to have shaped the pattern of specialization. Several authors (notably Kochhar et al 2006) have remarked on the peculiar pattern of India's development; although industrialization has been a strong policy emphasis from the time of independence, the particular strategy of industrialization that India adopted emphasized investment in the capital goods sector as a pre-requisite to successful long-term industrialization. In practice, this was achieved by import-substitution and a rigid set of controls that regulated the flow of private investment into industries. This strategy, coupled with the subsidization of tertiary education and the boom in the demand for services in the 1990s, has created the paradox of a poor economy specializing in capital-intensive and skill-intensive sectors.

As Kochhar et al point out, the restrictions on entry and capacity creation in the private sector also resulted in relatively small establishments - in 1990, the average manufacturing firm in India was more than 10 times smaller than its counterpart in the US. By 2004, the industrial sector contributed only 28% of total value added in the economy and only accounted for 18% of total employment (Bosworth and Collins 2007). This contrasts with the industrial sector in China, which contributed nearly 60% of total value added while employing about 20% of the workforce and was therefore twice as productive.

In the early decades the results of these policies were unspectacular, but not sufficiently alarming to engender doubt in the system of controls. The productivity slowdown of the 1970s caused

[4]Interestingly, in 1999, India ranks in the middle in terms of number of procedures, with an average of 10 procedures, compared to Canada with 2 and the Dominican Republic with 21. In terms of the actual costs of entry, though, India is still a major offender, outdone only by a few countries like Bolivia, Tanzania and Nigeria.

policy-makers to rethink the soundness of the regulatory regime. By this time, it was also clear that restrictive regulations in practice had become an anti-competitive tool and an expedient for bureaucratic corruption. In 1985, following the assassination of Indira Gandhi and the accession to power of her son Rajiv Gandhi, the infamous "license-raj" was partially reformed by removing a significant subset of industries from its jurisdiction. Under this system, entry into and expansion of capacity in industry required official sanction in the form of licenses. The actual granting of the licenses was subject to the vagaries of the bureaucracy, and since every project required at least a few licenses, with the likelihood of being held up at any stage, the incentive to pursue any investment was severely limited.

Although the exact timing of these reforms was somewhat unexpected, it is nonetheless plausible that the industries that were de-licensed in this first wave of reform were different from the ones for which licensing was retained. As I show in Section 3.2, on average, the de-licensed industries were larger in terms of employment, output and number of establishments. However, I also show that this difference in initial levels does not appear to translate into a violation of the identification assumption used in this paper.

By 1991, a host of factors, including a rising external debt and a subsequent downgrading of India's credit rating along with large withdrawals of deposits by Non-Resident Indians and reduced remittances of Indians working in the Middle East (due to the Gulf War), had brought the country to the brink of a balance of payments crisis. 1991 also saw the assassination of Rajiv Gandhi. The new government, led by Narasimha Rao, sought for and obtained a bailout from the IMF, which, as part of the conditions of the loan, insisted on major economic reforms. Thus, in 1991, the New Industrial Policy was born. The New Industrial Policy virtually abolished the system of licensing (retaining it in only a few industries), expanded the limit on foreign equity participation and relaxed the rules with respect to technology transfer. For reasons that I elaborate in the next section, in this paper I study only the effects of the de-licensing reforms of 1985.

3 Data and Descriptive Evidence

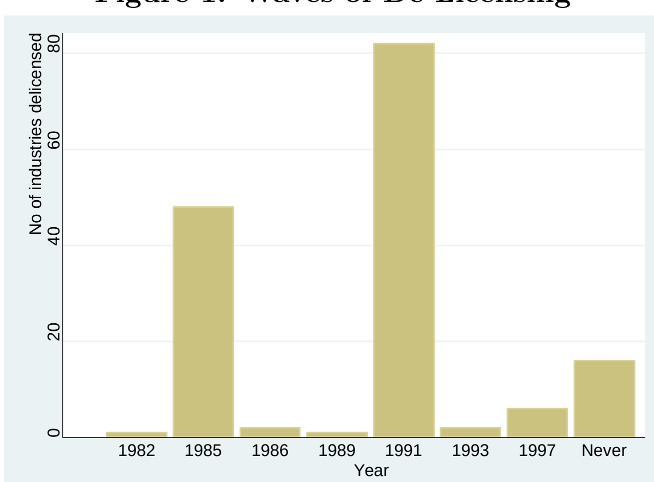
3.1 Data

The principal dataset used in this paper is from the Annual Survey of Industries (ASI) in India which covers the organized manufacturing sector. This data is maintained and disseminated by the Central Statistical Organization (CSO). I have three years of data, corresponding to the years 1982-83, 1987-88 and 1993-94. The data are at the factory-level and include reported input usage (including labor, capital and raw materials) as well as value added, revenues, ownership (public or private) and some regional identifiers (district and state of location). Each establishment is identified as belonging to a 3-digit industry (as per the National Industrial Classification of 1987). Importantly, establishment-level identifiers are not available to link establishments over time. Factories that are closed or not operating are also identified in the data: this is important for identifying the short-run effects of the reform on the number of operating establishments.

Since data on physical output is not available (only revenues are reported), I use price deflators at the 3-digit industry level constructed from the Wholesale Price Indices published by the Reserve Bank of India. There does not exist an exact mapping from the commodities in the WPI data to the industries in the ASI data, because the classification of commodities in the WPI is on the basis of use (e.g. beverages) whereas the classification of industries is by processes (e.g. spinning of cotton). In all such cases, I have calculated the price-deflators as averages of the relevant 2-digit industry deflators. This introduces a significant limitation in the data: as I argue in the next section, the coarseness of the price data creates a downward bias in the estimates of output gains in the de-licensed industries.

The data on de-licensing are taken from Aghion, Burgess, Redding and Zilibotti (2007). As per their classification, as many as 44 3-digit manufacturing industries were de-licensed in 1985, while another 82 industries were de-licensed in 1991. Figure 1 shows the waves of de-licensing over the years covered by the data.

Figure 1: Waves of De-Licensing



Note: Industries that were not de-licensed as of 1997 are labeled "Never". (Source: Aghion et al 2007)

In terms of size, the industries that were de-licensed in 1985 accounted for nearly 55% and 51% of total formal sector manufacturing output and employment respectively in 1982. In the empirical and theoretical analysis, I concentrate on the reform of 1985, treating the year 1982-83 as pre-reform, and 1987-88 and 1993-94 as short-run and long-run post-reform equilibria respectively. A point worth keeping in mind when examining the results is that the coding of de-licensing is fairly coarse - a 3-digit industry is coded as having been de-licensed if any part of it was de-licensed. This feature of the data works against us, making it harder to identify the effects of the reform.

3.2 Descriptive results

Table 1 below (reproduced from Bosworth, Collins and Virmani 2007) shows historical rates of growth of output per worker and TFP in manufacturing. Both output per worker and TFP slowed down in the period 1973-83, and then recovered strongly in the period 1983-93. Note also that in the latter period the growth in output per worker was driven by the growth in TFP, whereas in the former period it was not. The TFP growth rate declined again in the mid-1990s, following the economic liberalization of 1991.

Table 1: Annual growth rates in manufacturing

Period	*Output per worker*	*TFP*
1960-73	3.4	1.1
1973-83	1	-0.3
1983-93	3.9	2.1
1993-99	5.5	0.3

(Source: Bosworth, Collins and Virmani 2007)

Are the de-licensing reform of 1985 and the upturn in TFP growth connected? Why did TFP growth decline in the post-1991 period? In this paper, I attempt an answer to the first of these questions.

In thinking about the reforms of 1985, a natural question is: How were the industries deregulated in 1985 different from the ones that were not? Table A1 (in Appendix A, p. 24) compares the de-licensed and un-delicensed industries for each of the three years in terms of real output, employment and number of establishments. The industries that were de-licensed in 1985 appear to have been larger along all three dimensions in the pre-reform year 1982.

I now ask how establishment size and the number of establishments were affected by the reform, since the license regime was presumably constraining both entry and expansion. Table 2 below shows how establishment size (measured by within-industry average establishment output) and the number of establishments changed on average for the industries de-licensed in 1985, relative to the industries that were not de-licensed, for the two time-periods under consideration. To account for the possibility that industries that were de-licensed in 1991 may not constitute an appropriate comparison group over the second period, I consider two comparison groups: Control Group 1 includes all industries that were not de-licensed in 1985, while Control Group 2 includes only those industries that were not de-licensed in 1991.

Table 2: Changes in number and size of establishments

	1982-87			1987-93		
	De-Licensed	Control 1	Control 2	De-Licensed	Control 1	Control 2
	[1]	[2]	[3]	[4]	[5]	[6]
% Change in Size	55.8	17.3	7.1	8.3	27.8	31.7
% Change in Number	-7.2	11.6	12	30.2	7.9	-5.4
Observations	46	112	36	46	112	36

Source: Annual Survey of Industries

The pattern is striking. Relative to control group industries, establishments in industries de-licensed in 1985 appear to first expand in size and the number of operating establishments falls. Over the second period (1987-93) this pattern reverses; establishments in the deregulated industries become smaller and there are many more of them. Over the entire period 1982-93, total output in these industries increased by 22%, in relative terms. The implied changes in total output are likely to be underestimates, due to the limitation of the price data mentioned in the previous section: even though prices plausibly declined in the de-regulated industries, the available price data does not reveal any such change.

A potential concern is that similar trends existed prior to the reform, since we already know that the industries that were deregulated in 1985 were larger. To check whether these trends in the number and size of establishments existed prior to the reform, I look at aggregate industry level figures published by the CSO for the years 1981-1985. I regress changes in the log number of establishments and establishment size on an indicator for de-licensing and include year fixed effects. As Table A2 (Appendix A, p. 24) shows, no such trends existed prior to 1985. This provides some reassurance that the observed pattern of changes shown in Table 2 did in fact derive from the reform.

Another concern with the changes reported in Table 2 is that the standard errors (not shown) are fairly high and it is not possible to reject the hypothesis that there is no significant difference between de-licensed and un-delicensed industries in terms of changes in these quantities. As Aghion et al (2007) show, there is considerable heterogeneity at the regional level, since each state decides its own labor laws and these laws have been changing over time. To allow for state-level factors such as state-specific labor regulations that might have affected the growth rates of these variables, I construct a balanced panel of state-industries and regress growth rates in establishment size and number of establishments on an indicator for whether the industry was de-licensed in 1985, and include state-level fixed effects. The specifications are:

$$\Delta \log(\bar{y}_{is}) = \alpha + \beta d_i^{1985} + \chi_s + \epsilon_i \tag{1}$$

and

$$\Delta \log(N_{is}) = \mu + \gamma d_i^{1985} + \lambda_s + \eta_i \tag{2}$$

where $\bar{y}_{is}$ and N_{is} are the average output (the measure of establishment size) and number of establishments in industry i in state s, $d_i^{1985} = 1$ if industry i was de-licensed in 1985 and χ_s and λ_s capture state-level factors that affect the growth rates of $\bar{y}_{is}$ and N_{is}, but do not interact with the de-licensing reform. That is, the coefficients on the de-licensing dummy obtained from these regressions indicate how much differential growth in number of establishments and average output would have obtained for the de-licensed industries had all states been identical.

Table A3 (p. 25) shows how de-licensing in 1985 differentially affected the number of establishments and average output in each state-industry cell, relative to undelicensed state-industry cells. Table A4 (p. 25) repeats these regressions for the industries that were de-licensed in 1991, using industries that had not been de-licensed as of 1991 as a comparison group. Finally, Table A5 (p. 26) returns to the industries de-licensed in 1985, using industries that were not de-licensed in 1991 as a comparison group.

Once again, the pattern of responses in number of establishments and average output for the first set of de-licensed industries is exactly the same that we found at the aggregate level, although the magnitudes are somewhat different and the estimates are much more precise. Interestingly, it appears (see Table A4) that the second wave of de-licensing did have a short-run effect after all, resulting in net entry and a decline in average output. On the basis of this evidence it appears that the first set of de-licensed industries were in fact different from those de-licensed in 1991. While it would be interesting to examine the long-run impact of this second wave of reforms to confirm this hypothesis, the lack of data precludes such an analysis. For the remainder of this paper, therefore, I concentrate on the effects of the licensing reforms of 1985.

These preliminary results are purely descriptive and cannot be interpreted without a model. I construct, therefore, in the next section, a model that takes into account the changes in both entry and expansion costs implied by the removal of licensing. The short- and long-run predictions of this model exactly match the observed short- and long-run responses of the de-licensed industries observed in the data. By matching the observed responses with the predictions from the model, I can then obtain estimates of the changes in entry and expansion costs following the reform, and quantify their relative contributions to productivity gains from the reform.

For comparison with the results to be presented later, I derive some initial measures of TFP change due to the reform. The methodology of estimating production functions, controlling for input endogeneity as in Olley and Pakes (1996) or Levinsohn and Petrin (2003), is unavailable in this setting since the data does not constitute a panel of establishments. I show in the next two sections how a structural model may be used to derive indirect measures of the relative productivity effects for the de-licensed industries. For now, Table A6 (p. 26) reports how TFP has changed for these industries, using a naive estimation strategy: I obtain average TFP for each state-industry cell in each year, by a regression of log real output per worker on the log of the capital-labor ratio. I then regress changes in TFP at the state-industry level on a dummy for de-licensing and state fixed effects. The results are variable, depending on whether the comparison group includes industries de-licensed in 1991. Both regressions, however, suggest an overall relative TFP gain of about 20% over the entire period 1982-1993.

Using the results of the naive production function regression, I obtain the elasticity of output with respect to capital for each state-industry as the coefficient on the log (K/L) ratio. I regress these elasticities on a de-licensing dummy and state fixed effects and find that on average the industries that were de-licensed in 1985 did not differ significantly from the remaining industries in terms of their production technology. Table A7 (p. 27) shows the results of this regression.

We can also use the production function regression to compare productivity distributions in the two sets of industries. Establishment-level productivities are obtained as residuals from the production function regressions. For each industry, I fit a Pareto distribution to these productivities. The Pareto distribution is characterized by its location and shape. For each industry, I allow the location parameter to vary by state but restrict the shape parameter to be the same across states.

Adapting the methodology outlined in Norman, Kotz and Balakrishnan (1994), these parameters are estimated from a regression of log(1-F) on the log of productivity (where F is the empirical cdf of the productivities) while allowing for state-specific intercepts. Table A8 (p. 27) shows that the average values of the shape parameter thus obtained are not significantly different across the two sets of industries. I use these results in the estimation in Section 5.

I turn now to the theoretical model of the license regime and the policy reform.

4 Theoretical Model

4.1 Setup

The theoretical model combines the notion of competitive equilibrium in Hopenhayn (1992) with the demand structure in Melitz and Ottaviano (2005). The original feature of this model is the introduction of a cost of capacity expansion; as we will see, this generates a set of interesting predictions.

I first describe the demand side of the model. There are C identical consumers, each with 1 unit of income. There are M manufacturing sector goods and an outside good. Following Melitz and Ottaviano (2005), the representative consumer's utility function is quasi-linear in the outside good (the numeraire) and quadratic in the other M goods:

$$U = q_o + \sum_{i=1}^{M}(a_i q_i - \frac{b_i}{2} q_i^2) \tag{3}$$

where q_0 denotes her consumption of the outside good and q_i is her consumption of the i-th manufacturing sector good. Given this specification, there are no income effects operating on the manufacturing sector.

The consumer's inverse demand function for good i is therefore given by:

$$p_i = a_i - b_i q_i \tag{4}$$

where p_i is the price of the i-th good relative to the numeraire, and since there are C consumers, the aggregate demand for the i-th good is given by $Q_i = Cq_i$.

The outside good is produced using only labor, under constant returns to scale, and is sold in a competitive market. This pins the wage rate to 1. The manufacturing sector uses both labor and capital in production. Input markets are assumed to be perfectly competitive. Since all industries are treated alike in the utility function, I describe below the production side and the equilibrium conditions that obtain for a representative industry. This simplifies the notation by allowing me to drop industry subscripts.

The setup of the production side is in the spirit of Hopenhayn (1992). Firms in the representative industry produce a homogeneous good and are price-takers. There is an unbounded pool of potential entrants. These potential entrants are ex-ante identical; however, they learn their respective (constant) marginal costs of production once they have paid a (sunk) cost of entry, denoted by f, which corresponds to the cost of obtaining a license to enter an industry. These marginal costs are assumed to be random drawings from a distribution with cdf $G(.)$ and a finite mean.

After paying the cost of entry and learning its marginal cost, x, an entrant can decide whether to stay and produce or to exit. If it chooses to produce, it must also obtain a capacity license to produce its desired level of output. I model the cost of obtaining a capacity license as being quadratic in output: this is consistent with the fact that one of the goals of the licensing policy was to control the degree of concentration in each industry.[5]

The total marginal cost for a firm that has drawn a technological marginal cost of production x is therefore given by:

$$c = x + \theta y \tag{5}$$

where θy represents the cost of obtaining a license to produce an additional unit of output, given the current level of output, y.[6]Each firm maximizes its profit given the price, p, and this determines its output, revenue and profit:

$$\text{Output:}\ y(x) = \frac{p-x}{\theta} \tag{6}$$

$$\text{Revenue:}\quad r(x) = p(\frac{p-x}{\theta}) \tag{7}$$

$$\text{Profit:}\quad \pi(x) = \frac{(p-x)^2}{2\theta} \tag{8}$$

For any given price, p, there exists a cutoff (technological) marginal cost, x^*, such that an entrant who has drawn x^* will be indifferent between entering and staying out. Since the cost of obtaining a capacity license is a continuous function of output, it follows that $x^* = p$ and that this

[5]This assumption is also necessary from a modeling viewpoint: since the marginal (technological) cost of production is assumed to be constant, if the capacity license cost were also independent of the level of output, the most productive firm would simply take over the entire market.

[6]For generality, I allow the cost of expansion as well as the cost of entry to be different across industries.

marginal firm produces zero output, i.e. $y(x^*) = 0$. We can therefore rewrite Eqns (6), (7) and (8) in terms of this cutoff cost:

$$y(x) = \frac{x^* - x}{\theta} \tag{9}$$

$$r(x) = x^*(\frac{x^* - x}{\theta}) \tag{10}$$

$$\pi(x) = \frac{(x^* - x)^2}{2\theta} \tag{11}$$

4.2 Solving for the equilibrium

There is entry into the industry until the cost of entry equals the ex-ante expected profit. The cutoff cost, x^*, and hence the equilibrium price, are determined by the free entry condition:

$$\int_0^{x^*} \pi(x) dG(x) = f \tag{12}$$

This also pins down average output, revenue and profit in the industry. Finally, the mass of firms is determined by the equality of supply and demand:

$$p = x^* = a - \frac{b}{C} N \int_0^{x^*} y(x) d\tilde{G}(x) \tag{13}$$

where $\tilde{G}(x)$ is the conditional distribution of surviving firms. Notice that, as in Melitz (2003), the number of firms and total industry output are affected by the level of demand, whereas all average quantities are determined independently of it. To solve explicitly for these equilibrium quantities, I assume, as in Melitz and Ottaviano (2005), that the distribution $G(.)$ of cost draws has the following cdf:

$$G(x) = (\frac{x}{x_m})^k \tag{14}$$

where the support of the distribution is $[0, x_m]$. This is equivalent to assuming that x is the inverse of a Pareto-distributed random variable. The Pareto distribution is not only analytically convenient, but is also generally considered to be a good approximation to the actual distribution of productivities. A useful property of this distribution is that it preserves its form after a right-truncation. That is, if the distribution were truncated above at a, the truncated cdf $\bar{G}(.)$ would be given by:

$$G(x) = (\frac{x}{a})^k \tag{15}$$

I now solve for x^* from Eqn (12):

$$x^* = [(k+1)(k+2)x_m^k \theta f]^{\frac{1}{k+2}} \tag{16}$$

The equilibrium number of firms and total output are given by:

$$N = \frac{C\theta(k+1)}{b}\frac{a-x^*}{x^*} \tag{17}$$

$$Q = \frac{C(a-x^*)}{b} \tag{18}$$

Finally, industry-level averages of output, revenue and profit are obtained as:

$$\bar{y} = \frac{x^*}{\theta(k+1)} \tag{19}$$

$$\bar{r} = \frac{(x^*)^2}{\theta(k+1)} \tag{20}$$

$$\bar{\pi} = \frac{(x^*)^2}{\theta(k+1)(k+2)} \tag{21}$$

It is easily seen that the cutoff (and hence the average) marginal cost increases in θ and f. Intuitively, larger entry barriers insulate incumbent firms from competition and allow unproductive firms to survive, while limits to expansion prevent the more productive firms from expanding and driving out the inefficient ones. We expect therefore that a reform that reduces θ and f should improve productivity and raise total output.

How do the number of firms and average industry output respond to changes in θ and f? Propositions 1 and 2 below state the relevant effects:

Proposition 1: Average output, revenue and profit per firm ($\bar{y}, \bar{r}$ and $\bar{\pi}$ respectively) are increasing in f and decreasing in θ.

Proposition 2: The number of firms N is decreasing in f and increasing in θ.

These results are in line with the intuition we began with: a reduction in entry costs encourages entry and thereby results in a larger number of firms and smaller firm sizes, whereas a reduction in the cost of expansion allows more productive firms to expand and thereby increases firm size while reducing the number of firms required to serve the market. The long-run effect of de-licensing can therefore be summarized as follows: (a) total output and average productivity rise, (b) the effect on average output, revenue, profit and the number of firms is ambiguous, since the changes in entry cost and expansion cost have opposite effects on these quantities.

4.3 Deriving the short-run response

I follow Melitz and Ottaviano (2005) in introducing the concept of a short-run equilibrium in this framework. The short-run is defined to be a time-frame in which there is no entry or exit. There is a fixed set of incumbent firms which react to the policy shock by expanding, contracting or temporarily shutting down.

To derive the short-run response to the policy shock, we reason as follows. Suppose the industry is initially in the pre-reform steady-state: the cutoff marginal cost is x^* and the number of firms operating is N^*. Denote the distribution of productivities of these firms by $\bar{G}(.)$. Note that the support of this distribution is $[0, x^*]$. Suppose now that there is a policy shock that reduces θ from θ_0 to θ_1 and f from f_0 to f_1. Since there is no entry in the short run, the change in the entry cost can have no short-run impact. However, the change in θ changes the optimal quantities for the incumbent firms. The fall in θ allows everyone to produce more, but the resulting fall in prices must cause some of the less-productive firms to suspend operation.

A new short-run cutoff cost obtains due to the exit of some relatively unproductive firms: we denote this by x^S. The new number of firms, denoted by N^S, is the set of incumbents whose cost is less than x_s:

$$N^S = N^* \bar{G}(x^S) \tag{22}$$

$$= N^* (\frac{x^S}{x^*})^k \tag{23}$$

This relation, together with the market-clearing condition, determines x^S and hence N^S in terms of x^* and N^*. Proposition 3 verifies that in the short-run, average output increases in response to the policy shock.

Proposition 3: If $\theta_1 < \theta_0$, then $\bar{y}^S > \bar{y}^*$

Note that we can still write the average output in this short-run equilibrium in terms of the new cutoff cost:

$$\bar{y}^S = \frac{x^S}{\theta_1(k+1)} \tag{24}$$

Hence,

$$\frac{\bar{y}^S}{\bar{y}^*} = \frac{x^S}{x^*}\frac{\theta_0}{\theta_1} = (\frac{N^S}{N^*})^{1/k}\frac{\theta_0}{\theta_1} \tag{25}$$

This equation will prove useful in estimating the change in θ using the observations on short-run responses in the number of firms and average output.

4.4 Moving to the long-run equilibrium

We now derive the change in average output when we move from the short-run to the long-run equilibrium. Super-scripting all new long-run equilibrium values by L, we can write:

$$\bar{y}^L = \frac{x^L}{\theta_1(k+1)} \tag{26}$$

Thus:

$$\frac{\bar{y}^L}{\bar{y}^S} = (\frac{\bar{y}^L}{\bar{y}^*})/(\frac{\bar{y}^S}{\bar{y}^*}) \tag{27}$$

$$= [\frac{x^L}{x^*}\frac{\theta_0}{\theta_1}]/[\frac{x^S}{x^*}\frac{\theta_0}{\theta_1}] \tag{28}$$

$$= \frac{x^L}{x^S} = \frac{x^L}{x^*}(\frac{N^S}{N^*})^{1/k} \tag{29}$$

where the last equality follows from Eqn (23). Recalling that $x_L = [(k+1)(k+2)x_m^k\theta_1 f_1]^{\frac{1}{k+2}}$, we have:

$$\frac{\bar{y}^L}{\bar{y}^S} = [\frac{\theta_1}{\theta_0}\frac{f_1}{f_0}]^{\frac{1}{k+2}}(\frac{N^*}{N^S})^{1/k} \tag{30}$$

Proposition 4 verifies that average output declines and the number of firms increases in going from the short-run to the long-run equilibrium.

Proposition 4: If $\theta_1 < \theta_0$ and $f_1 < f_0$, then $\bar{y}^L < \bar{y}^S$ and $N^L > N^S$.

The model therefore qualitatively reproduces the pattern in the data: in the short-run, average output increases and the number of firms declines, but over time the direction of these changes is reversed. In the next section, I explain how I use the relations implied by the model to obtain estimates of the changes in the entry cost and the cost of capacity expansion, and thereby, a decomposition of the productivity effects of the reform.

5 Estimation

The previous section established the main structural equations that will be used in the estimation. The fact that the short-run effects of de-licensing derive purely from the change in expansion cost provides a neat way to separately identify the change in this cost from the change in entry cost. Recall that the change in average output in the short-run is given by the relation:

$$\frac{\bar{y}^S}{\bar{y}^*} = \frac{x^S}{x^*}\frac{\theta_0}{\theta_1} = (\frac{N^S}{N^*})^{1/k}\frac{\theta_0}{\theta_1} \tag{31}$$

Writing this in logs, we have:

$$[log(\bar{y}^S) - log(\bar{y}^*)] - (1/k)[log(N^S) - log(N^*)] = -[log(\theta_1) - log(\theta_0)] \tag{32}$$

Since we have data on changes in average output and in the number of firms, we can obtain an estimate of the average change in capacity costs across de-licensed industries by regressing the left-hand side on an indicator of whether the industry was de-licensed. To make this operational, of course, we need to know the value of k, the shape parameter of the productivity distribution for each industry. For convenience, I set k to be equal to 1.5 for all industries: as I showed in Section 3, the average value of k is about 1.3 for both de-licensed as well as un-delicensed industries.

The results of this regression are shown in the first column of Table 3. The coefficient on the de-license dummy is 51.2%, implying that, on average, capacity expansion costs changed by about 51% following de-licensing.

We can now determine how entry costs changed using the relation between short-run and long-run equilibria. Writing Eqn (30) in logs, we have:

$$[log(\bar{y}_s) - log(\bar{y}^*)] - \frac{1}{k}[log(N^*) - log(N_s)] = \frac{1}{k+2}[log(f_0) - log(f_1)] - \frac{1}{k+2}[log(\theta_0) - log(\theta_1)] \tag{33}$$

Again, regressing the left hand side on an indicator for de-licensing produces an estimate of the difference of average changes in entry costs and expansion costs across the de-licensed industries. The results of this regression are shown in Column 2 of Table 3. The coefficient on the de-licensing dummy is -0.32. Using the fact that the average change in expansion costs was 51%, we find that the average implied change in entry costs was of the order of 61%. Finally, note that the change in cutoff marginal cost for the de-licensed industries is given by:

$$\frac{x^L}{x^*} = (\frac{f_1}{f_0}\frac{\theta_1}{\theta_0})^{\frac{1}{k+2}} \tag{34}$$

It follows that the average change in the cutoff marginal cost for de-licensed industries was about 32%.

Table 3: Estimating changes in entry and expansion costs

	[1]	[2]
De-Licensed in 1985	0.512**	-0.321
	(0.23)	(0.21)
Constant	0.09	0.356**
	(0.15)	(0.14)
Observations	158.00	158.00

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

This method is therefore essentially an application of difference-in-difference estimation, where the estimating equation and the interpretation of the coefficients is derived from the structural model.

With a knowledge of the changes in entry and expansion costs, we now turn to estimating the relative effects of these changes on the change in TFP for the deregulated industries. As I show below, we can estimate these TFP effects indirectly using the estimates of how entry and expansion costs have changed. This methodology represents an alternative to the production function estimation method of obtaining TFP effects.

To relate a firm's TFP to its marginal cost x, I assume that that the production function of a firm in industry i is Cobb-Douglas in capital and labor:

$$Y = \phi K^{\alpha} L^{1-\alpha} \tag{35}$$

It can be shown that the firm's TFP, ϕ, is related to its marginal cost x as follows:

$$x = \frac{1}{\phi}\frac{1}{1-\alpha}(\frac{r}{w}\frac{1-\alpha}{\alpha})^{\alpha} \tag{36}$$

Eqn (36) also relates the cutoff marginal cost x^* to the cutoff productivity, ϕ^*:

$$x^* = \frac{1}{\phi^*}\frac{1}{1-\alpha}(\frac{r}{w}\frac{1-\alpha}{\alpha})^{\alpha} \tag{37}$$

We can now write:

$$\frac{x^L}{x^*} = \frac{\phi^*}{\phi^L}\frac{(r^L/w^L)^{\alpha}}{(r^*/w^*)^{\alpha}} \tag{38}$$

or, in logs,

$$log(\phi^L) - log(\phi^*) = \alpha[log(r^L/w^L) - log(r^*/w^*)] - [log(x^L) - log(x^*)] \tag{39}$$

where, as before, starred values refer to pre-reform equilibrium quantities and L superscripts long-run equilibrium values.

Recall that for industries that were not de-licensed, $x^L = x^*$. Next, assuming perfect input markets, the bracketed part of the first term in Eqn (39) is the same for all industries. Further, as Table A7 (p. 28) showed, the average values of α (the elasticity of output with respect to capital) are not significantly different across the two groups of industries. It follows that the change in cutoff (and hence average) productivity in deregulated industries, relative to the un-delicensed ones, equals the change in the cutoff marginal cost due to de-licensing. Since the relation between cutoff and average productivity is linear (assuming that productivities follow a Pareto distribution), we can therefore say that average productivity growth over the period 1982-1993 due to de-licensing was nearly 32% in the de-licensed industries, implying a roughly 3% increase per year. Finally, the decomposition of the change in cutoff marginal cost implies that 45% of this growth in productivity can be attributed to the change in entry cost and the remainder to the change in expansion cost.

These results have interesting implications in terms of thinking about the policy regime and the pattern of TFP growth in the manufacturing sector. For one thing, it appears that the licensing policy created equal amounts of inefficiency along the two margins of adjustment - entry and expansion. Secondly, the implied relative TFP gain of 3% per year is striking, given that overall TFP growth for the manufacturing sector over this period, as calculated by Bosworth, Collins and Virmani (2007), was 2% per year. This implies that the TFP growth in the non-deregulated industries must have been negative and therefore that the entire TFP gain over this period is due to the effects of reform on the de-licensed industries.

6 Conclusion

What are the effects of relaxing constraints on entry and expansion? This paper answers this question by examining the reform of the License Raj: a policy regime that had constrained entry and capacity expansion in Indian industry. This policy regime is frequently implicated in explanations for poor productivity growth in Indian industry - by restricting expansion, it may have kept firms inefficiently small, and by restricting entry (and hence competition) it may have allowed inefficient producers to survive.

For the most part, these accounts have remained informal and there exist very few studies that attempt to quantitatively assess the impact of the policy reform. I offer a substantive as well as a methodological contribution to this literature. I construct a structural model of industry equilibrium, incorporating the essential features of the policy regime, in which firms differ in their productivities. In this model, productivity gains from the reform obtain via changes in the composition of firms in the industry. I show how this model can be used to not only quantify the productivity gains due to the reform, but also to decompose this gain into the relative contributions of the changes in entry and expansion costs. Estimating this model using establishment-level data, I find that the reform resulted in a significant improvement in total factor productivity, and moreover that changes in entry and expansion costs (implied by the reform) contributed almost equally to this gain.

The results confirm that the License Raj did indeed have a negative effect on industry productivity. Furthermore, it appears that the TFP recovery in the 1980s was driven by the de-licensing reform of 1985. A puzzle remains: following the recovery in the 1980s, why did TFP decline in the post-1991 period? There was a significant de-licensing episode in 1991, and this should presumably have generated TFP gains by the same mechanism outlined in this paper. A more detailed examination of the data and policy changes for the post-1991 period is called for.

A second question concerns the idea of looking at TFP gains deriving from intra-industry compositional changes. How do these gains compare with intra-plant TFP gains? Sivadasan (2004) finds that the FDI and tariff reforms of 1991 resulted in significant intra-plant productivity improvements, so there is some reason to believe that there were similar gains associated with the reform of 1985. Unfortunately, the lack of panel identifiers for establishments has precluded such an analysis.

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A Tables

Table A1: Descriptive Statistics									
	Delicensed in 1985			Delicensed in 1991			Never delicensed		
	1982	1987	1993	1982	1987	1993	1982	1987	1993
Mean log real output	21.37	21.86	22.24	20.37	20.7	21.1	21.12	21.3	21.57
	(1.96)	(1.50)	(1.63)	(1.99)	(1.86)	(2.02)	(2.24)	(2.16)	(2.53)
Mean log employment	10	10	10.14	9.07	9.23	9.25	9.65	9.62	9.5
	(1.59)	(1.35)	(1.33)	(1.80)	(1.66)	(1.71)	(1.83)	(1.85)	(1.84)
Mean log no of factories	11.55	11.39	12	9.55	9.77	10.06	10.06	10.24	10.17
	(2.97)	(2.84)	(2.72)	(3.02)	(2.85)	(3.07)	(3.42)	(3.32)	(3.05)
Observations	44	44	44	76	76	76	35	35	35

Note: Standard deviations in parentheses
Source: Annual Survey of Industries

Table A2: Changes in number and size of establishments, 1981-1985		
	Change in log(Plant Size) [1]	Change in log(No of Plants) [2]
De-Licensed in 1985	-0.006	0.015
	(0.03)	(0.02)
Year Effects	Yes	Yes
Constant	0.176***	-0.021
	(0.03)	(0.02)
Observations	632	632
R^2	0.05	0.13

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Changes in log number of plants and log of average output (the measure of establishment size) at the state-industry level regressed on a dummy that takes the value 1 if the industry was de-licensed in 1985. The control group consists of all other industries.

Table A3: Changes in number and size of establishments, 1982-1987 & 1987-1993

	1982-87		1987-93	
	No of plants	Establishment Size	No of plants	Establishment Size
	[1]	[2]	[3]	[4]
De-Licensed in 1985	-0.158***	0.225***	0.194***	-0.0616
	(0.05)	(0.07)	(0.05)	(0.07)
State fixed effects	Yes	Yes	Yes	Yes
Observations	1580	1580	1580	1580

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Changes in log number of plants and log of average output (the measure of establishment size) at the state-industry level regressed on a dummy that takes the value 1 if the industry was de-licensed in 1985. The control group consists of all other industries.

Table A4: Changes in number and size of establishments, 2nd wave of de-licensing

	1982-87		1987-93	
	No of plants	Establishment Size	No of plants	Establishment Size
	[1]	[2]	[3]	[4]
De-Licensed in 1991	-0.022	0.103	0.177**	-0.287***
	(0.09)	(0.11)	(0.09)	(0.11)
State fixed effects	Yes	Yes	Yes	Yes
Observations	1042	1042	1042	1042

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Changes in log number of plants and log of average output (the measure of establishment size) at the state-industry level regressed on a dummy that takes the value 1 if the industry was de-licensed in 1991. The control group consists of all industries that had not been de-licensed as of 1991.

Table A5: Changes in number and size of establishments using a different control group

	1982-87		1987-93	
	No of plants	Establishment Size	No of plants	Establishment Size
	[1]	[2]	[3]	[4]
De-Licensed in 1985	-0.176**	0.292***	0.318***	-0.259**
	(0.09)	(0.11)	(0.08)	(0.10)
State fixed effects	Yes	Yes	Yes	Yes
Observations	860	860	860	860

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Changes in log number of plants and log of average output (the measure of establishment size) at the state-industry level regressed on a dummy that takes the value 1 if the industry was de-licensed in 1985. The control group consists of all industries that were not de-licensed in 1991.

Table A6: Relative TFP Growth

	Group 1		Group 2	
	Change in log(TFP)		Change in log(TFP)	
	1982-87	1987-93	1982-87	1987-93
Delicensed in 1985	0.104**	0.106**	0.0215	0.227***
	(0.05)	(0.05)	(0.07)	(0.07)
State fixed effects	Yes	Yes	Yes	Yes
Observations	1577	1577	860	858
R^2	0.01	0.01	0.01	0.03

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Regressions in Group 1 include all industries that were not de-licensed in 1985 as a comparison group. Group 2 regressions only include industries that were not de-licensed in 1991 as a comparison group

Table A7: Elasticity of output	
	Alpha
De-licensed in 1985	-0.017
	(0.17)
State fixed effects	Yes
R^2	0.004
Observations	4280

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Regression of industry-state-specific on state fixed effects and a dummy that takes the value 1 if the industry was de-licensed in 1985. All three years of data have been pooled in this regression.

Table A8: Comparing shapes of productivity distributions		
	k	Obs
Delicensed in 1985	1.35	43
	(0.56)	
Others	1.32	113
	(0.98)	

Notes: Standard deviations in parentheses; k denotes the shape parameter of the productivity distribution