ABSTRACT

Title of dissertation: COMPETING OR COLLABORATING SIBLINGS? AN INVESTIGATION OF THE RELATIONSHIP BETWEEN INDUSTRIAL AND TRADE POLICIES

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This dissertation investigates the relationship between industrial and trade policies and their impact on firm-level incentives to become more productive. In Chapter two we use a two-sector growth model and show that the impact of a rise in competition in the intermediate goods sector (that invests in quality-enhancing technology) is sensitive to market structure in the final goods sector. We find that more competition in the intermediate goods sector (due to industrial policy reform) can lead to rising investment in technology and hence rising productivity. Further we find that industries that face more competition domestically can perform better in the face of foreign competition. That is, there may be strategic complementarities between industrial deregulation and trade reform. We also find that a rise in competition in the final goods sector can affect investment incentives in the intermediate goods sector and hence affect productivity. This study highlights the importance of market structure assumptions in growth models. The third chapter tests predictions from chapter two using two unique data sets. We use the industrial licensing

regime in India (operating from the 1950s onwards) and its gradual relaxation during the 1980s and 1990s to test whether industrial de-regulation that leads to more competition domestically, affects firm-level productivity. To our knowledge, ours is the only detailed data set on Indian industrial policy. Our firm-level data for the period 1980-94 is a census of firms in India and has been rarely used in literature. We also use the interesting chronology of reforms in India (industrial de-regulation in the 1980s and trade reforms in 1991) to test whether industries that faced more competition domestically tend to perform better when facing foreign competition. Our identification strategy uses an important institutional feature of Indian policy. Firms with assets below a certain defined rupee threshold were exempt from licensing requirements. This institutional feature provides us within-industry variation that allows us to identify the interaction between de-licensing and exemption status. We find that industrial de-regulation during the 1980s led to a significant rise in firm productivity. Further preliminary results suggest that there exists a strategic complementarity relationship between industrial and trade policies–industries and firms that were de-licensed tend to perform better vis productivity after trade liberalization. Our results are robust to the inclusion of a wide variety of firm and industry fixed effects and controls for policies other than de-licensing that may affect productivity. This chapter contributes to the literature by being the only detailed empirical analysis of the industrial licensing regime in India, especially the de-licensing that took place during the 1980s and by providing evidence of the crucial link between trade and industrial de-regulation.

COMPETING OR COLLABORATING SIBLINGS? AN INVESTIGATION OF THE RELATIONSHIP BETWEEN INDUSTRIAL AND TRADE POLICIES

by

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DEDICATION

For Nani and Daddy, Mom and Papa, and Gaurang. Your faith, love and support have made this possible.

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Chapter 1

Introduction

The interaction between trade liberalization and domestic industrial policy reform is of great importance in both trade and development literature. Recent evidence about the positive impact of trade liberalization (Tybout (2000), Epifani (2003)) on productivity, investment and welfare as well as the fact that several large and developing economies have joined the mainstream of the world economy have demonstrated that the economic and welfare implications of international trade are large and can not be ignored. However, these very high stakes have led to a debate in literature. On the one hand, some believe that competition from imports enhances the incentives of the firm to upgrade their technology (see, for example, Dollar and Kraay (2001), Frankel and Romer (1999), Sachs and Warner (1995)). On the other hand, others believe that these incentives are affected by domestic institutions and policies and trade reform will not be beneficial unless domestic polices are reformed as well (Rodrik and Rodriguez (2001)). That is, domestic institutions and policies can be used to achieve a superior economic outcome after trade liberalization. This issue is particularly important with regard to countries like India and China that had, or still have, very controlled industrial and trade policies. These policies created many distortions in these economies and it is of great interest to analyze– both theoretically as well as empirically– the implications of these distortions for the benefits from trade reforms.

The second chapter of this dissertation discusses market structure assumptions in standard models of economic growth and demonstrates that these assumptions are important in determining firm-level incentives to invest in quality-enhancing technology. We are particularly interested in the cases like that of India with regard to the kinds of industrial and trade policies that were in place. Since gaining independence in the 1940s, India followed a policy of close control of private enterprize in the manufacturing sector. The implementation of this control was via a licensing regime, which meant that each and every firm in each manufacturing industry needed to take permission from the government to enter or continue production. That is, entry into manufacturing industry was not free (i.e. not determined by market forces) and the threat of potential entry was low as well (since not every application submitted for entry into an industry would be accepted by the authorities). This led to the creation of artificial monopolies and oligopolies in almost all industries in the manufacturing sector.

This aspect of the licensing regime implies that the assumption of perfect competition is not valid for any sector of the Indian economy. Thus theoretical models that are used to generate predictions for India (for example, Aghion et al. (2003b), Aghion et al. (2004)) must take into account the distortions created by industrial licensing. The second chapter of this dissertation tries to capture significant features of industrial licensing in India in a theoretical model and in this way provides a richer, more realistic analysis of the effects of reforms- both domestic and external- on the incentive of firms to invest in quality enhancing technology.

The theory outlined in Chapter 2 demonstrates that a rise in competition in the sector that invests in quality-enhancing technological progress will, under certain conditions, lead to a rise in technological investment in that sector. This result is different from the standard Schumpeterian hypothesis that a rise in competition should, unambiguously, reduce firm-level incentives to invest in technology since the ability of the firm to appropriate surplus from investment falls as competition rises. Further, a rise in competition in downstream sectors (that do not invest in technology) also leads to a rise in the investment incentives of the sectors that invest. That is, a firm's incentives to invest are affected not only by the degree of competition in its own industry but also in other industries. Finally, we find that under certain conditions, trade liberalization and domestic competition are strategic complements. That is, a rise in domestic competition raises the marginal investment response of the intermediate goods firm to a rise in the threat of foreign entry.

The third chapter of this dissertation empirically tests important implications from Chapter 2. Our case study-India-is particularly interesting and relevant for two reasons. Firstly, as mentioned earlier a very rigid and stern industrial licensing regime was in operation for 40 years. Entry to into manufacturing industry was not free (i.e. not based on market forces) and the threat of potential entry was low as well. This in turn lead to monopolistic distortions in almost all sectors. The second feature that makes India a good case study for the relationship between trade and industrial reforms is the interesting chronology of reforms- industrial de-regulation in the 1980s and trade reforms in the 1990s. This chronology of reforms allows us to distinguish between the two types of reforms and to assess the relationship between them. The results of our empirical exercise provide several important insights into previously unexplored aspects of industrial licensing in India.

Licensing impacted a firm along two important dimensions. The workings of the regime affected both the ability as well as the incentives of a firm to invest in productivity. There were controls on the amount of output, the location of the plant, the technology used etc that were conditions printed on the license document and these directly controlled the ability of a firm to become productive. On the other hand, the regime implicitly controlled entry into an industry and hence, affected firm incentives to become productive. When an industry was de-licensed, both these controls were removed simultaneously. In this context, our identification strategy allows us to capture the impact of the relaxation of both direct and indirect controls on firms. That is, we can measure the impact of de-licensing on a firm's productivity because of relaxation of microeconomic constraints on the firm as well as the impact on productivity due to greater competition and a higher threat of potential entry faced by a firm.

Our identification strategy uses the distinction between two types of firms within an industry– small firms that were exempt from licensing provisions and large firms that were not exempt from licensing provisions. The main difference between these two types of firms was that Exempt firms did not need a license to operate and hence were not obliged to fulfill microeconomic conditions on output, location, technology etc. On the other hand, not exempt firms were required to obtain a license to enter as well as fulfill onerous conditions. Technically this distinction meant that there was free entry into the ranks of exempt firms in an industry and that all entrants would like to enter as exempt firms. But this was unlikely to be true. This is because the other accoutrements of the "License-Quota-Permit Raj" that operated in India meant that a manufacturing license was just a part of a whole bundle of permissions and licenses that a firm needed to operate. Thus there were implicit entry barriers into the ranks of exempt firms and explicit entry barriers into the ranks of not exempt firms. This means that de-licensing of an industry reduced entry barriers for both of exempt as well as not exempt firms and that our empirical strategy catches these effects.

Our empirical study demonstrates that de-licensing of Indian industry (that took place is a piece-meal manner during the 1980s followed by a big push in 1991) lead to a rise in productivity of the firms that were affected by it. Thus the intuition provided to us by the theory in Chapter 2 is borne out by data. In the presence of market structure distortions in all sectors, firms that face a more competitive environment domestically will respond by improving their productivity. It is to be noted that de-licensing could impact the productivity of a firm by several mechanisms other than that of a rise in competition. Our empirical application of results from Chapter 2 does not address the issue of mechanism but provides highly suggestive evidence.

Further, firms in industries that were deregulated prior to the trade reform episode in 1991 performed much better after the trade reforms. Again, the strategic complementarity result postulated in Chapter 2 is borne out by the Indian experience. This finding has an important policy implications for developed as well as developing countries– it might be economically more efficient to target domestic distortions in order to make domestic firms more competitive in the world market. In our case study, the domestic distortion was due to a policy of licensing. However, a wide variety of other policies like production subsidies, entry barriers into industry, financial aid to ailing domestic firms etc can be analyzed in the framework proposed by this thesis.

This dissertation contributes to the theoretical and empirical literature in three ways. Firstly, it investigates the importance of market structure in the sector that does investment on investment incentives of the firm. It highlights the importance of competitive pressure from another source- the buying industry. So it is not just the competitive environment immediately around the firm that affects investment incentives. A broader definition of competitiveness is required to fully assess the response of firms to domestic and foreign competition. Secondly, the strategic complementarity of foreign and domestic competition is an important theoretical result that points towards the importance of realistic modeling of the institutional environment in which firms operate.

Thirdly, this dissertation is one of the first empirical investigations into the microeconomic impact of industrial licensing (and hence de-licensing) on productivity of Indian firms. Given the scope of the licensing regime in India in terms of the number of firms it impacted in a number of ways as well as in terms of the time span of the "License Raj", it is, a priori, an interesting unexplored question. Further, we use two unique data sets to provide conclusive evidence of the link between industrial deregulation and higher productivity in Indian manufacturing and the strategic complementarity relationship between industrial and trade policies.

There are several questions that remain unanswered about the Indian policy experiments. However, this dissertation is an initial attempt to analyze and quantify some important facts about India.

Chapter 2

Strategic Complementarities between Trade and Industrial Policies: A Theoretical Investigation

This chapter investigates theoretically the link between industrial policies that affect the degree of competition in an industry and trade reforms with respect to their impact on firm-level incentives to invest in quality-enhancing technology. We try to capture significant features of an economy where industrial regulation takes the form of restrictions on the entry of new firms.

Following Aghion et al. (2003b), we set up a two sector growth model. The intermediate goods sector invests in quality-enhancing technological progress and is assumed to be monopolistically competitive. The monopoly power of each producer in the intermediate goods sector provides this producer with incentive to invest in quality-enhancing technology. In the benchmark case, the final goods sector (that buys intermediate goods varieties for production) is modeled as perfectly competitive. However in the presence of industrial policy that regulates entry into manufacturing industry (for example, the industrial licensing regime in India) this assumption is not likely to be valid in most cases. So we model the final goods sector as a monopoly.

We find that our model gives substantially different results than the benchmark case. A rise in competition in the intermediate goods sector (that invests in quality-enhancing technological progress) will, under certain conditions, lead to a rise in investment. This result is different from the standard Schumpeterian hypothesis that a rise in competition should, unambiguously, reduce firm-level incentives to invest in technology since the ability of the firm to appropriate surplus from investment falls as competition rises. Given that the final goods sector has market power and can control its output level, the intermediate goods firm faces two contradictory forces. On the one hand, increased competition reduces the mark-up over costs that it can charge and hence, reduces the returns from investment. However, as the price-cost margin in the intermediate goods sector gets squeezed, derived demand for its product from the final goods sector rises. This in turn raises the incentive to invest in technology.

The second important result is that a rise in competition in the final goods sector also leads to a rise in the investment incentives of the intermediate goods firm. Since the output of the final goods sector now plays an important role in determining the returns to investment, a rise in output in the final goods sector (due to a rise in domestic competition) encourages the intermediate goods firm to invest in technology.

Finally, we find that under certain conditions, trade liberalization and domestic competition are strategic complements. That is, a rise in domestic competition raises the marginal investment response of the intermediate goods firm to a rise in the threat of foreign entry. The intuition behind this result is that more domestic competition forces the firm to make productivity or quality decisions that in turn help it respond to high quality foreign competitors.

An important point to note is that the framework presented in this paper is applicable to a wide variety of distortionary domestic policies. In Chapter 1 we mentioned the specific case of India and its policy of industrial licensing that affected market structure and incentives as a motivation for this dissertation. However policies like regulation of industry, subsidies to domestic producers, research and development support to incumbent producers etc, which distort market structure and affect firm incentives to invest and innovate, can all be analyzed within our framework.

2.1 Literature

There has been a recent stream of literature in industrial organization and endogenous growth examining the relationship between product market competition and innovation. Aghion et al. (2001) analyze the interplay between innovation and product market competition and finds that product market competition (that is, how substitutable two goods are in the consumers demand function) enhances innovation in sectors where firms were already close to the technological frontier and discourages innovation in sectors where firms are below the frontier. Aghion et al. (2003a) use a model of step-by-step innovation to finds an inverted-U shaped relationship between product market competition and innovation. This is supported by data on firms in the UK.

While these papers provide an interesting framework in which to analyze the issue of competition and innovation, they do not address the question of whether their results are eroded or enhanced as a result of competition from high technology foreign firms. That is, what is the interaction between domestic competition and foreign competition? To our knowledge ours is one of the few papers that investigates the issue of the interaction between foreign and domestic competition via their impact on innovation incentives. Further, these papers do not investigate the issue of interactions between the market structures in upstream and downstream industries.

Aghion et al. (2003b) and Aghion et al. (2004) are of particular relevance to our results. Using the theoretical framework of Acemoglu et al. (2003), they assess the impact of the institution of minimum wage laws on firm-level investment and use the 1991 trade liberalization in India to illustrate how reform may have unequal effects on industries and regions. Their main theoretical results are that liberalization enhances investment in industries that were initially close to the technological frontier and that pro-worker legislation lowers investment and this negative effect is magnified by liberalization. Their empirical results confirm the main predictions of the model. However, as mentioned earlier their theoretical model does not try to model industrial policy in India and how this affected market structure and hence innovation incentives. The policy of close control of private sector initiative was in place for nearly 40 years and affected all aspects of production, distribution and even consumption. Our model tries to capture the effect of policy on market structure and thus attempts to provide a richer characterization of innovation incentives.

Melitz (2003) shows how a trade liberalization leads to reallocation of resources across heterogenous firms. High productivity firms invest more as a result of liberalization and try to enter foreign markets while low productivity firms exit. Thus similar to our model, high productivity firms have a better chance to survive in a more competitive environment. Our model however, investigates whether the initial state of "high" productivity was a result of domestic industrial policy rather than an exogenous event. This is particularly relevant for the case of India where monopolies and oligopolies were created by industrial policy.

2.2 Model

The model builds on Acemoglu et al. (2003), Aghion et al. (2003b) and Aghion et al. (2004). It is a discrete time growth model where foreign firms are allowed to enter each period and sell their goods. Briefly, there are two sectors in the economy. The intermediate goods sector (henceforth, IG) produces varieties of the intermediate good (that differ in quality) and these are used by the final goods sector (henceforth, FG) in production. Note that the FG producer cares about the quantity and quality of the intermediate goods.

In the IG sector there is a monopolist in each variety of the intermediate good and this monopolist chooses inputs (capital and labor) to maximize profits at the beginning of each period, keeping in mind the derived demand of its product from the final goods sector.

Within the same period, this monopolist also chooses the amount of investment in quality-enhancing technology to maximize expected profits. The expectation is over the probability of entry of foreign varieties that could replace the domestic monopolist. The foreign firm decides whether or not to enter *after* observing the investment in quality by the domestic intermediate producer *but within the same time period.*

It is important to note that there is no profit maximization across time periods in this model. That is, the entire maximization problem described above is repeated each period. However, past investment decisions do affect IG firms since last period's quality determines the level of quality that the firm can achieve in this period. This is because technology evolves in a discrete manner. The details of the model are described in sections below.

2.2.1 Finals Goods Sector

All agents live for one period. There are two sectors in the economy. Following Acemoglu et al. (2003), there is a unique final good in the economy and the final goods (henceforth, FG) sector uses labor and a continuum of intermediate goods to produce output according to the aggregate production function:

$$y_t = {L_{0t}}^{1-\alpha}\left[\int_0^1 A_t(v)^\delta x_t(v)^\alpha dv\right] \tag{2.1}$$

Here L_{0t} is the number of production workers in the final goods sector at time t. We assume that there is a fixed supply of labor in the economy $\bar{L}$ that must be split between the FG and IG sectors. $x_t(v)$ is the quantity of intermediate input produced in sector v and date t. $A_t(v)$ is the quality of the intermediate input v in producing the final good and α and δ belong to (0,1). The final good can be used either for consumption or as an input in the production of intermediate goods or for investments in innovations.

An important feature of the production function is that it allows for the possibility of increasing, decreasing or constant returns to scale to the composite intermediate good. That is, $\alpha + \delta$ can be greater than, equal to or less than unity.

The next three sections describe the intermediate goods sector, the process of technological innovation and the process of entry by foreign competitors. These are derived from Aghion et al. (2003a).

2.2.2 Intermediate Goods Sector

Following Acemoglu et al. (2003) and Aghion et al. (2003b), in each intermediate good sector v there exists a monopolist firm. There are many different varieties v of the intermediate good and each variety differs from the other in terms of its quality $A(v)$. That is, the intermediate goods sector is monopolistically competitive. This is because the FG sector demands an IG variety based on its price and quality. So the variable v refers both to an intermediate sector industry and to the intermediate firm that is active in that sector. For simplicity, each variety v can have one of two qualities–advanced or backward. We explain this more in the next section.

As mentioned earlier, intermediate producers live for one period only and there is no profit maximization across periods. The production technology uses labor and capital to produce $x_t(v)$ units of the good v:

$$x_t(v) = k_t(v)^{\beta} l_t(v)^{1-\beta} \tag{2.2}$$

In each period, the intermediate goods producer in each variety observes the derived demand for its product from the final goods sector and chooses its optimal inputs of capital and labor. Then within the same period, it observes the threat of potential entry from foreign firms and maximizes its expected profits to chose the optimal level of investment in technology. The section below describes the process of investment in greater detail.

An important point to note with regard to the assumption of monopolistic competition in the IG sector is that this is a feature of Schumpeterian models. The basic point is that some market power is required for any firm to have incentive to invest in technology and this in turn, generates the standard result that a decline in market power reduces the incentives of firms to invest.

2.2.3 Investment by Intermediate Goods Sector: Production of Quality

As mentioned earlier, the numerous producers of intermediate goods compete in quality. To simplify the model, IG firms differ in quality by discrete amounts. That is, in each period domestic IG firms differ in their current distance from the "technological frontier"–defined as the highest quality under which the variety is produced anywhere in the world. Note that foreign firms are assumed to be on the frontier and thus, have the highest quality goods. The productivity of the frontier technology in period t is given by $\bar{A}_t$. We assume that this frontier grows at the exogenous rate g. That is

$$\bar{A}_t = (1 + g)\bar{A}_{t-1} \tag{2.3}$$

Here g is the rate of growth of rate of global technological advance. Further we assume that a producer of any variety v of the IG can be on the frontier or just one step below it. That is, at the beginning of period t, the IG firm v can be in any of two states:

- "Advanced" with productivity $A_{t-1}(v) = \bar{A}_{t-1}$. These are the firms on the current technological frontier.
- "Backward" with productivity $A_{t-1}(v) = \bar{A}_{t-2}$. These are firms that are one step behind the frontier.

Before they decide production levels for period t, the firms must decide whether or not to undertake innovative investments to enhance their productivity. The investments have stochastic returns where the probability of success equals the investment intensity z_t. The cost function for investment is quadratic in the investment intensity and is a function of the current level of technology.

$$c_t(v) = \frac{1}{2} {z_t}^2 \bar{A}_{t-1}(v)^{\frac{\delta}{1-\alpha}} \tag{2.4}$$

If research is successful then the incumbent firm can adopt the next most productive technology. Thus a firm that was on the frontier in period t-1 continues to be a frontier firm while a firm that was backward in t-1 advances to the level of the advanced firm in t-1. If investment is not successful then the firm continues to produce at the initial productivity.

Following Aghion et al. (2003b), we make the following simplifying assumptions about firm dynamics.

- If an advanced firm is successful at time t-1 then it starts as an advanced firm at time t. All other firms start as backward firms.
- Note the implicit assumption of spillovers because firms that were backward at time t produce at productivity $\bar{A}_{t-2}$ in time t+1 rather than at $\bar{A}_{t-3}$.

The following matrix represents the four possibilities that a particular IG variety firm can be in period t, conditional on its productivity at the end of period $t-1$.

Initial Productivity	Advanced in $t-1$	Backward in $t-1$
Invest successfully in t	Initial=$\bar{A}_{t-1}$	Initial=$\bar{A}_{t-2}$
	Final=$(1+g)\bar{A}_{t-1} = \bar{A}_t$	Final=$(1+g)\bar{A}_{t-2} = \bar{A}_{t-1}$
Invest unsuccessfully in t	Initial=$\bar{A}_{t-1}$	Initial=$\bar{A}_{t-2}$
	Final=$\bar{A}_t$	Final=$\bar{A}_{t-1}$ (spill-overs)

Table 2.1: Productivity of IG Firm

2.2.4 Foreign Entry into the Intermediate Goods Sector

We assume that entry by a foreign firm is such that the foreign firm does not permanently replace local producers. It enters to sell its product (produced elsewhere) and leaves. This means that the foreign firm will not directly affect the distribution of productivity in the next period. One interpretation of this product entry assumption is that entry threat is primarily due to lower barriers to trade in the economy. Another possibility is that product differentiation and knowledge of local market conditions allows domestic producers to remain in the market after foreign entry.

Foreign firms in each variety of the intermediate good observe the outcome of investment by domestic firms in period t before deciding whether to stay out or to pay an entry fee ζ and enter and be allowed to sell with probability μ in the same period. This μ can be thought of as ease of entry into the domestic market. A higher μ denotes lower tariffs, higher import quotas and any other regulations which facilitate foreign entry and is consistent with our application to the case of India which followed highly restrictive trade policies up to very recently. For the purpose of this preliminary investigation, μ is exogenous and equal across sectors. In particular it is assumed to be the same for sectors with a backward domestic producer and sectors with an advanced domestic producer.

Further, the foreign firm is assumed to have the highest quality product. That is, he operates on the technology frontier with productivity or quality $\bar{A}_t$[1]. The setup of the model then implies that if the foreign firm decides to enter the market, he can displace the domestic producer of that variety, depending on the quality of the domestic producer and the entry cost ζ. If the foreign firm (FF) enters and competes with a backward firm (that has quality lower than the technological frontier) then FF gains the entire market. If FF enters and competes with an Advanced firm (that is on the technological frontier and hence has the same quality as the foreign firm) then Bertrand competition implies that the profits of both firms are zero.

Following Aghion et al. (2003b), we assume that the value of parameters is such that the FF will always enter if the domestic firm (DF) is backward (that is, ζ is sufficiently small) and FF will never enter if DF is advanced and on the frontier.

[1] Note that the frontier itself advances at a rate of g (Equation 2.3).

Thus, the end of the period probability of entry into the market for v is

$$\text{Prob(Entry in period } t) = \begin{cases} 0 & \text{if DF is advanced in } t-1 \text{ and invests successfully in } t \\ \mu & \text{otherwise} \end{cases}$$

These probabilities will be used by the IG firm in order to maximize its expected profits.

2.3 Market Structure

Our central goal is to analyze whether the incentives of IG firms to invest are invariant to the particular market structure that is assumed for their industry and for the FG industry. The price of the intermediate goods variety v, i.e., $p(v)$ will be a measure of the threat of potential entry from domestic competitors into the IG sector while the parameter μ will measure the threat of potential entry from foreign competitors. Intuitively, each firm in the IG industry will decide how much to invest depending on how much of the gains from investment it can appropriate. These gain depend on $p(v)$– the price that the firm can charge. This price, in turn, depends on the market structure in that industry. Further, investment will also depend on the market structure in the FG industry because market structure may determine implicit bargaining power in the negotiations betweens the two sectors regarding the split of surplus from investment. In this model, we use the equilibrium output of the FG sector, $y(.)$ as an indicator of market structure in the FG industry.

In the sections below we first solve the intermediate goods monopolist's problem assuming that the final goods sector is perfectly competitive and then we solve the model for the case where the final goods sector is monopolist.

2.3.1 The Benchmark Case: Competitive FG, Monopolist IG

Following Aghion et al. (2003b), we first derive equilibrium investment in technology for the case where the FG sector is perfectly competitive. In all the analysis below we assume that wages are the same for both sectors-intermediate and final. That is, there is perfect mobility of labor between the two sectors. Further, in this case we assume that the final good is the numeraire so $p_y = 1$. Perfect competition in the FG sector implies that payment to inputs must equal the marginal product of inputs. Using the production function of the FG sector (Equation 2.1), the price of the intermediate good v is

$$p_t(v) = \alpha {L_{Ot}}^{1-\alpha} \frac{A_t(v)^{\delta}}{x_t(v)^{1-\alpha}} \tag{2.5}$$

Similarly for labor,

$$w_t = (1-\alpha){L_{Ot}}^{-\alpha}\left[\int_0^1 A_t(v)^{\delta} x_t(v)^{\alpha} dv\right] \tag{2.6}$$

We can use Equation 2.5 to get the derived demand by the FG sector for intermediate good v

$$x_t(v) = L_{Ot}\left[\frac{\alpha A_t(v)^{\delta}}{p_t(v)}\right]^{\frac{1}{1-\alpha}} \tag{2.7}$$

An important point is that the elasticity of demand for variety v with respect to its price is constant. That is, $\epsilon = \frac{1}{1-\alpha}$.

We assume that the IG firm is a price taker in the market for labor and capital and that he chooses his inputs $l_t(v)$ and $k_t(v)$ to maximize profits. The profit function of IG firm v can then be written as

$$\pi_t(v) = Max_{k_t(v),l_t(v)}\{p_t(v)k_t(v)^{\beta}l_t(v)^{1-\beta} - k_t(v) - w_t l_t(v)\} \tag{2.8}$$
$$\text{s.t. } k_t(v)^{\beta}l_t(v)^{1-\beta} \geq L_{Ot}\left[\frac{\alpha A_t(v)^{\delta}}{p_t(v)}\right]^{\frac{1}{1-\alpha}}$$

From the first order conditions for profit maximization, we find that the derived demands for labor and capital by the IG monopolist are given by $l_t(v) = \left[\frac{1-\beta}{w_t\beta}\right]^{\beta} x_t(v)$ and $k_t(v) = \left[\frac{1-\beta}{w_t\beta}\right]^{\beta-1} x_t(v)$ where $x_t(v)$ is the demand for the variety v by the final goods sector. Putting these into the profit function we get

$$\pi_t(v) = \left[p_t(v) - \left(\frac{w\beta}{1-\beta}\right)^{-\beta} - \left(\frac{w\beta}{1-\beta}\right)^{1-\beta}\right] x_t(v) \tag{2.9}$$

Thus the intermediate goods monopolist has constant marginal cost of production $\Omega \equiv \left(\frac{w\beta}{1-\beta}\right)^{-\beta} + \left(\frac{w\beta}{1-\beta}\right)^{1-\beta}$. Further, the each monopolist faces a derived demand curve that has constant price elasticity. Thus profit maximization will lead the monopolist to choose a constant mark-up over marginal costs. That is, $\frac{p_t(v)-\Omega}{p_t(v)} \equiv \epsilon = \frac{1}{1-\alpha}$. This leads us to an important result that the price of each and every variety of intermediate good is equal.

$$p_t(v) = \frac{1}{\alpha}\Omega \equiv \chi \text{ for all varieties } v \tag{2.10}$$

This parameter χ is a measure of the extent of domestic competition that an intermediate goods producer faces. A decline in χ can be thought of as a decline in the price-cost margin that the intermediate firm can charge. Another possibility is that χ is the highest price that the domestic monopolist can charge without inducing entry by other domestic firms[2]. From Equation 2.1 we note that α is a measure of the

[2]For example, if there is a competitive fringe in the intermediate goods sector that is less efficient

degree of substitutability between varieties of the IG in the final goods production function. Thus, a rise in substitutability reduces the price that each producer v can charge.

Before going further, we can solve for the derived demand for labor in the FG goods sector (L_0) by using the full employment condition for labor. From the profit maximization exercise of the IG producer, the demand for labor by the producer of variety v is $l_t(v) = \left[\frac{1-\beta}{\beta w_t}\right]^\beta x_t(v)^d$. So the total labor demand in the IG sector is

$$\begin{aligned} L_{IG} &= \int_0^1 (l_t(v))dv = \left[\frac{1-\beta}{\beta w_t}\right]^\beta \int_0^1 L_{Ot}\left[\frac{\alpha A_t(v)^\delta}{p_t(v)}\right]^{\frac{1}{1-\alpha}} \\ &= \alpha^{\frac{1}{1-\alpha}}\left[\frac{1-\beta}{\beta w_t}\right]^\beta \chi^{\frac{-1}{1-\alpha}} A_t{}^* L_{ot} \end{aligned}$$

The labor demand for the FG sector can be found using the full employment condition

$$L_0 + L_{IG} = \bar{L} \tag{2.11}$$

Thus the demand for labor in the FG sector is given by the expression below.

$$L_O = \left(1 + \alpha^{\frac{1}{1-\alpha}}\left[\frac{1-\beta}{\beta w_t}\right]^\beta \chi^{\frac{-1}{1-\alpha}} A_t\right)^{-1} \bar{L} \tag{2.12}$$

The equilibrium production of the final good is given by

$$y_t = \frac{\alpha^{\frac{1}{1-\alpha}}}{\alpha}\chi^{\frac{-\alpha}{1-\alpha}} L_{ot} A_t^* \tag{2.13}$$

where

$$A_t^* \equiv \int_0^1 A_t(v)^{\frac{\delta}{1-\alpha}} dv \tag{2.14}$$

in production and hence makes negative profits at the current price. Then χ will be the maximum price the incumbent producer can charge while still keeping out the competitive fringe.

is the average productivity in the IG industry.

Now, after substituting for $p_t(v) = \chi$ into the profit function and the derived demand function for variety v, we can write profits of the IG firm as

$$\pi_t(v) = \alpha^{\frac{1}{1-\alpha}} (\chi - \Omega) \chi^{\frac{-1}{1-\alpha}} L_{Ot} A_t(v)^{\frac{\delta}{1-\alpha}} \tag{2.15}$$

Equilibrium Investment

In Section 2.2.4, we described the rules that govern the entry of foreign firms into the market. If the foreign firm is competing with an advanced, high quality domestic firm who invested in technology and succeeded in maintaining its position at the global technological frontier, then we assume that there is Bertrand competition between the foreign and domestic firms and that the foreign firm will not enter at all in those cases (given an entry cost ζ). However when faced with a backward domestic adversary, the foreign firm will enter and take over the entire market in that particular variety. Further note that the probability that a domestic firm v will innovate successfully, is equal to the intensity of investment, z. This means that the only cases when a backward firm earns non-zero profits in period t are

- If it invests successfully in period t (and achieves quality $A_t = \bar{A}_{t-1}$)–this happens with probability z– and foreign firms stay out–probability $(1 - \mu)$. Thus the probability that a backward firm invests successfully and the foreign firm does not enter is $z(1 - \mu)$. In this case the domestic monopolist earns payoffs $\pi_t(v) = \alpha^{\frac{1}{1-\alpha}} (\chi - \Omega) \chi^{\frac{-1}{1-\alpha}} L_{Ot} \bar{A}_{t-1}^{\frac{\delta}{1-\alpha}}$.

- If it invests unsuccessfully in period t (with quality $A_t = \bar{A}_{t-2}$) and foreign firms stay out. This happens with probability $(1-z)(1-\mu)$ and the payoffs are $\pi_t(v) = \alpha^{\frac{1}{1-\alpha}}(\chi - \Omega)\chi^{\frac{-1}{1-\alpha}} L_{Ot} \bar{A}_{t-2}^{\frac{\delta}{1-\alpha}}$.

In the other two cases where foreign firms do enter, the incumbent backward firm earns zero profits.

Similarly, the cases when an advanced firm earns non-zero profits are

- If it invests successfully in period t and foreign firms stay out. This happens with probability $z(1-\mu)$. However we assume that the values of parameters are such that the foreign firms will never enter if domestic firm is on the frontier. That is, $\mu = 0$. The domestic firm earns payoffs $\pi_t(v) = \alpha^{\frac{1}{1-\alpha}}(\chi - \Omega)\chi^{\frac{-1}{1-\alpha}} L_{Ot} \bar{A}_t^{\frac{\delta}{1-\alpha}}$.

- If it invests unsuccessfully in period t and foreign firms stay out. This happens with probability $(1-z)(1-\mu)$ and the payoffs are
$\pi_t(v) = \alpha^{\frac{1}{1-\alpha}}(\chi - \Omega)\chi^{\frac{-1}{1-\alpha}} L_{Ot} \bar{A}_{t-1}^{\frac{\delta}{1-\alpha}}$.

A firm chooses investment z_t to maximize its expected profits. The last term in the equation below represents the costs of investing z_t (Equation 2.4).

$$\begin{aligned} E\pi_t(v, Backward) &= \alpha^{\frac{1}{1-\alpha}}(\chi - \Omega)\chi^{\frac{-1}{1-\alpha}} L_{Ot}\left[z(1-\mu)\bar{A}_{t-1}^{\frac{\delta}{1-\alpha}} + (1-z)(1-\mu)\bar{A}_{t-2}^{\frac{\delta}{1-\alpha}}\right] \\ &\quad -\frac{1}{2}z^2 \bar{A}_{t-2}^{\frac{\delta}{1-\alpha}} \end{aligned} \tag{2.16}$$

This gives equilibrium intensity as

$$z_B = \alpha^{\frac{1}{1-\alpha}}(\chi - \Omega)\chi^{\frac{-1}{1-\alpha}} L_{Ot}(1-\mu)(1+g)^{\frac{\delta}{1-\alpha}} \tag{2.17}$$

Note we use the fact that $\bar{A}_{t-1} = (1+g)\bar{A}_{t-2}$.

Similarly the expected profit for an advanced firm in period t is

$$E\pi_t(v, Advanced) = \alpha^{\frac{1}{1-\alpha}} (\chi - \Omega) \chi^{\frac{-1}{1-\alpha}} L_{Ot} \left[z\bar{A}_{t-1}^{\frac{\delta}{1-\alpha}} + (1-z)(1-\mu)\bar{A}_{t-2}^{\frac{\delta}{1-\alpha}} \right] - \frac{1}{2} z^2 \bar{A}_{t-2}^{\frac{\delta}{1-\alpha}} \tag{2.18}$$

This gives equilibrium intensity as

$$z_A = \alpha^{\frac{1}{1-\alpha}} (\chi - \Omega) \chi^{\frac{-1}{1-\alpha}} L_{Ot} \left[(1+g)^{\frac{\delta}{1-\alpha}} - (1-\mu) \right] \tag{2.19}$$

Equations 2.19 and 2.17 can be used to analyze the effects of competition on investment in productivity-enhancing technology [3].

Comparative Statics

Analyzing the expressions for equilibrium investment in quality-enhancing technology we find that similar to Aghion et al. (2003b), there is differential response to a trade liberalization episode across firms based on the initial level of quality that they start from. That is, $\frac{\partial z_A}{\partial \mu} > 0$ and $\frac{\partial z_B}{\partial \mu} < 0$. Under increased threat of entry, advanced firms raise their investment since they know that there exists a chance that their investment will be successful and the foreign firm will not enter. On the other hand, backwards firm reduce investment when they perceive higher threat of entry. This is because their expected gains from the investment are lower because there is a higher chance that the FF will enter and they will earn zero profits.

[3] Note that the market clearing wage rate can be calculated using Equation 2.6 as $w_t = \frac{1-\alpha}{\alpha} \chi^{\frac{-\alpha}{1-\alpha}} A^*{}_t$ where $A_t^* \equiv \int_0^1 A_t(v)^{\frac{\delta}{1-\alpha}} dv$ is the average quality in the intermediate goods industry at time t.

Thus post-liberalization, productivity should be higher in industries with higher pre-liberalization productivity.

Further, the standard Schumpeterian motive for investment holds- the higher the price that the intermediate goods producer can charge for his product, the larger the share of surplus that he can appropriate and hence, the higher the returns to investment in quality. That is,

$$\frac{dz_A}{dw} > 0 \Leftrightarrow \frac{dz_A}{d\chi} > 0 \text{ if } \Omega > (1-(1-\alpha)^2)\chi \Rightarrow \Omega \geq \alpha\chi \tag{2.20}$$

The details of this derivation are presented in Appendix A.1.

Moreover, given the previous result it is easily seen that domestic competition as measured by χ and foreign competition as measured by μ are strategic substitutes. That is,

$$\frac{d^2 z_i}{d\mu d\chi} \begin{cases} > 0 & \text{for i=Advanced} \\ < 0 & \text{for i=Backward} \end{cases} \tag{2.21}$$

The more monopoly power in the IG sector or the higher the threat of potential entry into the IG sector (as measured by a higher χ), the more aggressive will be its response to the increased threat of foreign entry (measured by a higher μ).

2.3.2 Monopoly in the FG Sector

We investigate the implication of assuming that the FG sector, that buys intermediate goods, has some market power. For this preliminary theoretical exercise, we assume that the FG sector is monopolist in the market for the final good. That is, the FG producer faces a downward sloping demand for his good. The demand function is linear [4]. We discuss the choice of FG output by the monopolist below. The output of the final goods sector–$y(.)$–is an important variable in our analysis.

In order to minimize costs, the FG producer chooses $x_t(v)$ (taking the price of inputs w and $p(v)$ as given[5] to solve

$$C(p(v), w, y) = Min_{L_{ot}, x(v), v\epsilon(0,1)} w_t L_{ot} + \int_0^1 p(v)x(v)dv \tag{2.22}$$

subject to producing enough so that the FG monopolist can produce his monopoly quantity y. That is,

$$y_t \leq {L_{0t}}^{1-\alpha} \left[\int_0^1 A_t(v)^{\delta} x_t(v)^{\alpha} dv \right] \tag{2.23}$$

The details of the cost minimization are in Appendix A.2. Using the first order conditions and the constraints, we are able to derive the expression for the derived demand for variety v as

$$x_t(v) = \frac{\alpha w L_{ot}}{1-\alpha} \left[\frac{A_t(v)^{\frac{\delta}{1-\alpha}}}{p_t(v)^{\frac{1}{1-\alpha}}} \right] \left[\int_0^1 \frac{A_t(v)^{\frac{\delta}{1-\alpha}}}{p_t(v)^{\frac{\alpha}{1-\alpha}}} \right]^{-1}$$

The first thing to note about the derived demand function is that given the property that a monopolistically competitive IG producer does not take account of the effect of his actions on the average price (Tirole (1988)), the elasticity of demand with respect to price is constant and equal to $\frac{1}{1-\alpha}$. Thus, a profit maximizing IG producer who faces constant marginal cost of production and a constant elasticity of demand

[4]The demand curve takes the form $P_y = a - by$.

[5]We assume that the monopolist in the FG sector takes $p(v)$ as given. That is, the FG firm does not use its monopsony power over the IG sector. Though this is an interesting case to think about, it may be algebraically untractable as is the case with models with many layers of competition.

will charge a constant mark-up over costs. Thus exactly similar to the perfectly competitive FG case,

$$p_t(v) = \chi = \frac{1}{\alpha}\Omega \text{ for all varieties v} \tag{2.24}$$

Substituting this into the derived demand equation and using the FG production function gives us

$$x_t(v) = \frac{\alpha w L_{ot}}{1-\alpha}\left[\frac{A_t(v)^{\frac{\delta}{1-\alpha}}}{\chi A^*}\right] = \left[\frac{w\alpha}{1-\alpha}\right]^{1-\alpha}\left[\frac{A(v)^{\frac{\delta}{1-\alpha}} y_m}{\chi^{1-\alpha} A^{*2-\alpha}}\right] \tag{2.25}$$

where y_m is the equilibrium monopoly output for the final goods sector. The cost function of the final goods producer can then be written as

$$C(p(v), y) = \left[w\left(\frac{1-\alpha}{w\alpha}\right)^{\alpha} + \left(\frac{1-\alpha}{w\alpha}\right)^{\alpha-1}\right]\chi^{\alpha} A^{*\alpha-1} y_m \tag{2.26}$$

Here χ is given by Equation 2.24. Thus the final goods monopolist has a constant marginal cost of production. Note that the total cost rises in χ- the price of the inputs and falls in A^*- the average quality or productivity of the inputs.

Now profit maximization for the final goods monopolist implies that he will choose y_m to equate marginal revenue to marginal cost [6]. That is,

$$a - 2by_m = \left[w\left(\frac{1-\alpha}{w\alpha}\right)^{\alpha} + \left(\frac{1-\alpha}{w\alpha}\right)^{\alpha-1}\right]\chi^{\alpha} A^{*\alpha-1}$$

Thus, equilibrium final goods output is given by

$$y_m = \frac{1}{2b}\left[a - \frac{M\chi^{\alpha}}{A^{*1-\alpha}}\right] \tag{2.27}$$

[6] The demand curve facing the final goods monopolist is $P_y = a - by$. So marginal revenue is $a - 2by$.

where $M \equiv w\left(\frac{1-\alpha}{w\alpha}\right)^{\alpha}+\left(\frac{1-\alpha}{w\alpha}\right)^{\alpha-1}$. Equations 2.25 and 2.27 give us a full description of the final goods sectors demand for intermediate goods.

Given that the derived demand for each intermediate goods variety depends on the output of the final goods sector which in turn depends on the price and the quality of the variety, *the level of output y_m can be used as a measure of the market power of the final goods monopolist in its relationship with the intermediate goods sector.* The intuition for this result is that higher price or lower quality of a variety will reduce the optimal output of the FG sector and will in turn exert pressure on the IG sector to either reduce price or increase quality by investing more. Thus, its scale of operation is the bargaining chip that the FG sector uses against the IG sector producers.

Equilibrium Investment

The intermediate goods producers profit maximizing exercise is similar to the case where the final goods producer is perfectly competitive. His profit function after optimal choice of labor and capital has been made is

$$\pi_t(v) = [\chi - \Omega]\, x_t(v)$$

where $\Omega \equiv \left(\frac{w\beta}{1-\beta}\right)^{-\beta}+\left(\frac{w\beta}{1-\beta}\right)^{1-\beta}$ is the constant marginal cost of production. Other than the derived demand for the intermediate good, nothing has changed for the intermediate goods producer. Following the same procedure as in Section 2.3.1, the equilibrium investment in productivity-enhancing technology by the intermediate goods producer is given by

$$z_B = (\chi - \Omega)\, \chi^{\alpha-1} \left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha} \frac{(1-\mu)(1+g)^{\frac{\delta}{1-\alpha}}}{A^{*2-\alpha}} y_m \tag{2.28}$$

$$z_A = (\chi - \Omega)\, \chi^{\alpha-1} \left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha} \frac{\left[(1+g)^{\frac{\delta}{1-\alpha}} - (1-\mu)\right]}{A^{*2-\alpha}} y_m \tag{2.29}$$

2.3.3 Results

In this section we analyze the impact of market structure in the final goods sector on equilibrium investment in the intermediate goods sector.

Foreign Entry

In the model, the probability that a foreign firm enters the domestic market to sell its product is given by μ. As mentioned earlier, μ is an exogenous parameter and can be thought of as a measure of trade openness. Thus, an increase in μ could be due to a trade liberalization episode. From Equations 2.28 and 2.29, we see that the basic effect of the threat of foreign entry is the same as in the original model (Aghion et al. (2003b)). Advanced firms are spurred by the threat of entry to invest more in order to deter foreign entry while backward firms invest less because there is a lower chance of them being able to deter entry and hence lower expected payoffs to investment.

Effect of Domestic Competition

An important parameter in our model is χ, the price that the IG producer charges for the variety that he produces. As we show in Section 2.3.2 (Equation 2.25) and Appendix A.2, the derived demand for each variety is such that the IG monopolists in all varieties charge a common price χ. Now we conduct an interesting thought experiment and allow χ to change.

As mentioned earlier, χ can be interpreted as a measure of the degree of domestic competition in the IG sector. Suppose that the IG monopolist is charging a constant mark-up over marginal cost. If entry occurs into the IG sector, it is plausible that this mark-up falls (either due to rise in costs or decline in prices)[7].

Another way that increased competition may affect χ is in the long term. As entry in to the intermediate goods sector continues, the elasticity of demand for each intermediate good variety may rise. That is, the market for intermediate goods starts saturating. This in turn will lower the price-cost margin that each intermediate goods producer can charge.

As shown by Equation 2.24, the price χ is a function of w. So in order to

[7]Note that there can not be entry in the model since the IG sector requires market power in order to invest in quality-enhancing technology. However, a fall in χ mimics the impact of actual entry on IG firms. Further, Aghion et al. (2003b) assume that the IG sector is monopolistically competitive but is surrounded by a higher-cost, lower-quality "competitive fringe". In this set up, χ can be interpreted as the highest price that the monopolist in variety v can charge without inducing entry by producers in the competitive fringe. That is, at any price higher than χ even the not-so-productive firms in the fringe can sell profitably and hence have incentive to enter.

totally differentiate equilibrium investment (Equations 2.28 and 2.29) with respect to χ and to maintain algebraic tractability, we analyze a special case where a change in χ occurs due to a changes in w and $\bar{L}$ (the endowment of labor in the economy) that leave the allocation of labor between the IG and FG sectors unchanged. We arrive at the following proposition[8].

Proposition 1: *Under the assumption that the FG sector is monopolistic and the IG sector is monopolistically competitive, we find that*

$$\begin{aligned}\frac{dz_i}{d\chi} &= C\left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha}\chi^{\alpha-1}\left[\frac{(1-\alpha)\Omega y_m}{\chi}+\frac{(1-\alpha)(\chi-\Omega)y_m}{w}\frac{dw}{d\chi}+(\chi-\Omega)\frac{dy_m}{d\chi}\right]\\ &< 0 \text{ for } \ \chi>\bar{\chi}, i = Advanced, Backward\end{aligned}$$

i.e., more competition in the IG sector (lower χ) leads to higher investment in technology if the initial entry barriers are above a threshold.

The first term in the square brackets is the standard Schumpeterian effect-lower price means that the IG monopolist is appropriating a smaller share of the surplus and hence will invest less. This effect was present in the benchmark case when the FG sector was assumed to be perfectly competitive. The second term shows the direct impact of a change in wages (due to a change in labor endowment) on investment in the IG sector. A rise in wages causes the final goods sector to substitute out of labor into the intermediate good. This means a rise in the derived demand for intermediates. This allows the IG producer to raise the price of intermediates χ. Thus the direct effect of a change in wages that changes χ bolsters the standard Schumpeterian result by providing greater incentive to the IG monopolist

[8]Details are presented in Appendix A.3

to invest in technology.

The third term is unique to the case where FG sector is monopolistic. This is the Bi-lateral monopoly effect–a lower price of intermediates will raise the output of the FG goods sector and raise the profits/investment of the IG producer. The main intuition for this result is that while the perfectly competitive FG sector takes account of the price and average quality of the intermediate goods ex post (Equation 2.13 shows that total FG output decreases in the price and rises in average quality), monopoly power in the FG sector allows the producer to take *ex ante* account of the price and average quality and chose its output accordingly. Thus, the FG monopolist chooses its output level (Equation 2.27) and hence, its derived demand for each variety of intermediates, taking into account the price of the variety χ, the quality of the variety $A(v)$ *and* the average quality in the intermediate goods sector A^* and forces the IG producer to respond via investment in quality [9].

The bi-lateral monopoly effect outweighs the Schumpeterian effect when the initial price distortion in the IG sector is very high ($\chi > \bar{\chi}$). If the initial price is very high and if it falls even a little, there will be a large response of FG output $y(.)$ to this and the larger sale volume will compensate the IG producer for the decline in price. This is borne out by the fact that the elasticity of y with respect to χ is

[9]Note that while we allow the FG producer to take advantage of his monopoly position in the market for final goods, he does not use his monopsony power as the only buyer of intermediate goods. While that would be an interesting case to examine, there is likely to be indeterminacy in models with many layers of competition and we will not be able to get a simple, closed form solution to the model.

strictly rising in χ[10].

An interesting feature of this result is that it holds at the profit maximizing price $\chi = \frac{1}{\alpha}\Omega$. That is, when the intermediate goods firm is charging its monopoly price there is a positive level of final goods output $\bar{y}$ such that if final goods output is below $\bar{y}$ then a fall in the price of the intermediate good will force the intermediate goods firm to invest more in technology. This is because equilibrium output y_m (Equation 2.27) is strictly decreasing in χ. When we analyze the conditions when $y_m \leq \bar{y}$, we find that the average quality of intermediates A^* must be lower than some level. That is, $\chi \leq \bar{\chi} \Rightarrow y_m \leq \bar{y} \Leftrightarrow A^* \leq \bar{A}^*$. So a rise in domestic competition forces the IG sector producer to increase his investment in productivity when $A^* \leq \bar{A}^*$. Intuitively, the price of the intermediate goods matters to the final goods firm. But, holding the price constant, the average quality of intermediate goods also matters. Given that the intermediate producer is charging his monopoly price, the average quality of his product needs to be higher than a threshold level in order to induce adequate demand from the final goods buyer.

An important observation about the impact of competition can be made from Equation 2.25. If we look at Equation 2.25 (that shows the derived demand for variety v of the intermediates good) we notice that demand for variety v is directly proportional to the quality of variety v $(A(v))$, and inversely proportional to the index of average quality in the intermediate sector (A^*). That is, the final goods monopolist weighs the quality of each input against the average quality of inputs that is available to him in the market. Holding χ constant, the demand for v will rise

[10]From Equation 2.27, the elasticity of y with respect to χ is given by $\epsilon_y = \frac{\alpha M \chi^{\alpha}}{2bA^{*1-\alpha} y_m}$.

only if $A(v)$ rises relative to A^*. That is, the average quality in the intermediates goods sector can be used as an index of competitive pressure in the intermediate goods sector.

It is interesting to contrast this result with the one obtained when the final goods sector was modeled as perfectly competitive. In Section 2.3.1 we found that $\frac{dz_i}{d\chi} > 0$ for all values of χ. That is, when the buying industry (final goods sector) does not have any market power, only the standard Schumpeterian motive operates and more monopoly power to the intermediates sector (measured by a higher χ) will lead to higher productivity/quality in that sector. However when the buying industry has some market power, it takes ex ante account of the price and quality of each variety while determining its output level (y_m) and hence, the derived demand for the variety. This, in turn, allows the FG sector to get higher quality or lower price products from the intermediate goods sector. Thus there exists a range where even a fall in χ will spur investment in the intermediates sector[11].

[11]In Appendix A.5 we investigate the case of a regulated monopolist in the final goods sector. We assume that the government applies licensing to the final goods sector by constraining the FG monopolist to produce on or below a certain level. We find that the supply curve of the monopolist is perfectly inelastic (at the level of the government-given output) for cost (and hence χ, the price of IG varieties) less than a certain level. For cost (and χ) above this level, the supply curve is the same as the function derived in Section 2.3.2. Thus, for $\chi < \chi^C$, a decline in market power in the IG sector will lead to lower investment in technology in the IG sector. But for $\chi \geq \chi^C$, a fall in χ (maybe due to removal of entry restrictions in the IG sector) might have a positive impact on investment in productivity. That is, with a more distorted IG sector (measured by a higher χ), there is a higher chance of more competition fueling a rise in investment and productivity in the

If we analyze the equations for the derived demand for intermediate variety v in the two market structures (Equations 2.7 and 2.25) we find an important difference. The perfectly competitive firm does not take ex ante account of the average quality of intermediate goods when it decides to buy variety v even though ex post, its output depends on average quality (Equation 2.13). On the other hand, a monopolist firm takes the average quality into account ex ante. More generally, we can think of A^* as price weighted average quality.

Interaction of Domestic Competition and Foreign Entry

We can analyze how a unit rise in domestic competition in the IG industry will impact the responsiveness of IG firms to threat of foreign entry. We find that

Proposition 2*: Under the assumption that the FG sector is monopolistic and the IG sector is monopolistically competitive, we find that*

$$\frac{d^2 z_i}{d\chi d\mu} \begin{cases} < 0 & \text{for } \chi > \bar{\chi}, i = Advanced \\ > 0 & \text{for } \chi > \bar{\chi}, i = Backward \end{cases} \tag{2.30}$$

That is, the firm is more responsive to foreign entry when the domestic environment is more competitive.

The derivation of this result is given in Appendix A.2. This is our main theoretical result and this points towards a strategic complementarity relationship between industrial and trade policy. That is, industrial deregulation (i.e., higher threat of potential entry as measured by a decline in χ) raises the marginal investment response of a firm to trade reform. The condition $\chi > \bar{\chi}$ means more distortion in the

IG sector.

IG sector. Another way to think about it is that domestic and foreign competition are strategic substitutes in the range $\chi < \bar{\chi}$ and strategic complements in the range $\chi > \bar{\chi}$.

The intuition behind this result is the balance between the standard Schumpeterian hypothesis that a rise in price of the product raises incentives to invest and the bilateral monopoly feature of the model that underlies the result in Proposition 1. A decline in price of the IG good reduces the incentives of the IG producer to invest in quality. However, a lower price also raises derived demand for the product and hence encourages investment.

Note that when the final goods sector was modeled as perfectly competitive, we got the result that μ and χ are always strategic substitutes.

Effect of Market Structure in the Buying Industry

Another important variable in our model is $y_m(.)$–the output of the final goods sector producer. This provides an indirect measure of the market structure and competition in the FG sector. Using Equations 2.28 and 2.29, we see that given average quality in the intermediates good industry, a rise in the output of the upstream monopolist y leads to a rise in investment intensity of both types of firms. Details are in Appendix A.4.

Proposition 3: *Under the assumption that the FG sector is monopolistic and the IG sector is monopolistically competitive, we find that*

$$\frac{\partial z_i}{\partial y_m(.)} > 0, \quad i = Advanced, Backward \tag{2.31}$$

That is, the intermediate goods firm is affected not only by a change in competition in its own industry, but also by a change in competition in its buying industry.

Thus, as the final goods industry moves from a monopoly to perfectly competitive and final goods output rises, the investment incentives of the intermediate goods sector rise, since derived demand for each variety rises with final goods sector output.

Another Complementarity

In our model, we consider two possible measures of domestic competition. The first one, χ, measures the level of competition in the intermediate goods sector. The second one, y_m, represents the degree of competition in the final goods sector. The more the market power the final goods producer has, the lower will be his output and hence the higher the price of his product p_y. As we have seen, a rise in output of the final goods sector directly affects the derived demand for intermediates by this sector and hence raises the pay-offs to investment in technology. Further we find that,

Proposition 4: *Under the assumption that the FG sector is monopolistic and the IG sector is monopolistically competitive, we find that*

$$\frac{\partial^2 z_i}{\partial \chi \partial y_m} \begin{cases} > 0 & \textit{for } i = \textit{Advanced} \\ < 0 & \textit{for } i = \textit{Backward} \end{cases} \tag{2.32}$$

That is, an intermediate goods firm is more responsive to foreign entry when he sells to a more competitive final goods sector at home.

Thus, what matters to the intermediate goods producer is not only competition in the intermediate sector but also in the final goods sector. More market power in the final goods sector (measured by lower y_m) reduces the gains from investment in technology (since some gains will now be appropriated by the final goods monopolist). As output in the final goods sector rises, the derived demand for each variety of intermediates rises, raising incentives for investment. Now, when faced with threat of foreign entry, the intermediate goods producer, who already has a higher level of investment, will be spurred to invest more in technology in order to deter entry by the foreign seller.

2.4 Robustness Checks

In this section we test how robust our theoretical results are to various assumptions that we have made.

A particular feature of our model is that the generation of quality needs investment–z–but no resources. That is, investment is similar to advertising expenditure for the IG firm. We test the robustness of our results to a more general specification of the quality-generation process and let production of quality use labor so that we can check whether our results in previous sections are due to the fact that investment is a manna from heaven. In that case, labor will need to be diverted from the production of physical units of the intermediate good into research and development in order to produce better quality/productivity. So we can think of investment intensity z as the number of workers that were removed from production and into research and development (or we can think of the production function for quality as Probability of Successful innovation= $z = l_{rd}$). The profit function (after maximization with respect to capital and labor used in production of quantity) is given by

$$\pi_t(v) = \left(\frac{\chi - \omega}{\chi^{1-\alpha} {A^*}_t^{2-\alpha}}\right) \left(\frac{w\alpha}{1-\alpha}^{1-\alpha}\right) y_m - wz - \frac{1}{2} z^2 \bar{A}_{t-1}^{\frac{\delta}{1-\alpha}} \tag{2.33}$$

Then maximization of expected utility with respect to z gives us equilibrium investment as

$$z_A = (\chi - \Omega)\, \chi^{\alpha-1} \left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha} \frac{\left[(1+g)^{\frac{\delta}{1-\alpha}} - (1-\mu)\right]}{{A^*}_t^{2-\alpha}} y_m - \frac{w}{\bar{A}_{t-1}^{\frac{\delta}{1-\alpha}}} \tag{2.34}$$

Thus we see that equilibrium investment in the case where production of quality requires labor is lower than investment in the case with no labor . The second term on the right hand side reflects the marginal cost of each unit of z in terms of the cost of workers that need to be hired[12]. All the results regarding domestic competition, foreign competition and the relationship between the two remain essentially the same as the ones described in Section 2.3.3. So the incentives to invest in quality in response to domestic and foreign competition change magnitude but not signs.

[12]We can impose the full employment condition here to get the expression for L_0 and hence for y(.). The condition is that $L_0 + \int_0^1 (l_i + z_i)di = \bar{L}$ where l_i is the equilibrium labor requirement for production of quantity and z_i is the labor required for R and D. Solving this equation for L_0 we find that output of the FG sector is lower than in the case where quality does not require labor. This is because the IG sector now demands more labor (since it needs labor to produce quality and quantity) and this cuts into the amount of labor that can be employed in the FG sector.

2.5 Conclusions

The main conclusion of this chapter is that assumptions about market structure in all sectors of the economy matter. Under the assumption that the FG sector has market power in the final goods market, we find that the investment incentives of the intermediate goods producers are substantively different then the benchmark case. The basic intuition underlying this is that control over output level matters. Derived demand for intermediate goods depend on final good output. A monopolist final goods firm uses the level of its output as a mechanism to induce the intermediate goods firm to provide it better quality or lower price of inputs ex ante. When the final goods sector is modeled as perfectly competitive, it takes only ex post account of the price and quality of the goods that it buys and hence cannot use the bi-lateral monopoly factor to get better quality from the intermediate goods sector.

Our study has several important implications. Firstly, seemingly innocuous assumptions about market structure can matter. Secondly, competitive environment needs to be defined more broadly to be able to have a richer characterization of investment incentives. For example, our model shows that entry de-regulation in the final goods sector can affect investment in the intermediate goods sector.

Further, we provide a richer characterization of the effects of entry de-regulation in the intermediate goods sector. In the case where the final goods sector is perfectly competitive, any de-regulation in the intermediate goods sector that raises competition (modeled as a fall in the price of intermediates) has the effect of unambiguously lowering technological investment in the intermediate sector. However when we model the final goods sector to have ex ante control over its output level by giving it some market power we find that under certain conditions, entry de-regulation in the intermediate goods sector can raise the level of technological investment. That is, under certain conditions it is possible to spur technological development in the economy by reducing the market power of firms that invest in technological development.

The last point to note is that the framework presented in this paper is applicable to a wide variety of distortionary domestic policies. We mention the specific case of India and its policy industrial licensing that affected market structure as a motivation for this paper. However policies like regulation of industry, subsidies to domestic producers, research and development support to incumbent producers etc, which distort market structure and affect firm incentives to invest and innovate, can all be analyzed within our framework.

Chapter 3

Competing or Collaborating Siblings? Industrial and Trade Policies in India

3.1 Introduction

There has been intense debate over the past few decades about the impact of trade liberalization on welfare, growth and productivity. This question is of immense importance and relevance to developing countries, in particular large and populous economies like China, India and Brazil that have recently entered the mainstream of the world economy. Some argue that the contribution of trade towards raising competition faced by firms is a way to promote growth in developing countries (for example, Dollar and Kraay (2001), Frankel and Romer (1999), Sachs and Warner (1995)). Others (Rodrik and Rodriguez (2001)) stress the importance of domestic institutions and conditions in the success of trade liberalization.

This debate is further confounded by the debate about whether competition itself enhances or erodes firm-level incentives to innovate and grow. The standard argument that market power reduces firm-level incentive to innovate is pitted against the Schumpeterian argument that the more the surplus a firm can appropriate (via more market power) the greater the incentive to invest in technology. This is a question of policy relevance not only for developing countries but also for developed countries.

In this chapter, we are interested in the impact of domestic economic conditions and of trade reforms on firm-level productivity for the case of India. The specific economic condition that we investigate is the level of competition that a particular firm or industry faces in the domestic market. Then we assess the impact of competition from abroad (due to trade reforms). So the basic empirical questions that this chapter tries to test are what is the first, most proximate impact of a rise in competition as a result of industrial de-regulation that a firm faces on a commonly used measure of productivity-output per worker and further, what is the relationship between domestic and foreign competition? Can the benefits from trade reform be enhanced by encouraging more competition within domestic industry?

As mentioned earlier, several large developing countries have recently undertaken trade liberalization and deregulation. Our case study-India-is particularly interesting and relevant for two reasons. As already mentioned, a very rigid and stern industrial licensing regime was in operation for 40 years. Entry to into manufacturing industry was not free (i.e. not based on market forces) and this in turn lead to monopolistic distortions in almost all sectors. The second feature that makes India a good case study for the relationship between trade and industrial reforms is the interesting chronology of reforms- industrial de-regulation in the 1980s and trade reforms in the 1990s. This chronology of reforms allows us to distinguish between the two types of reforms and to assess the relationship between them.

It is important to note that though there have been several studies of the impact of trade liberalization in India on firm-level productivity (e.g., Krishna and

Mitra (1996), P. Balakrishan and Babu (2000), Sivadasan (2003)), this is the first attempt to assess the impact of the reforms of the 1980s. None of the previous studies control for the changes in the 1980s and hence provide biased estimates of the impact of trade reform. This issue is even more important in the light of a puzzling empirical result. As Panagariya (2002), Panagariya (2004) and Delong (2001) point out, reliable productivity measures show a sharp rise in productivity levels and rates of growth prior to the trade reforms of the 1990s.

We use two unique data sets on India to test our predictions. The first data set on industrial policy in India from 1970 onwards is to our knowledge, the only comprehensive data set on industrial policy and one that allows econometric estimation of the impact of deregulation. We are able to identify which industry was deregulated in which year of the 1970s, 1980s and 1990s. Further we use a new plant-level data set for the period 1980-1994. This is a census of firms in India and has only recently been made available to researchers. The span of our data allows us to capture the impact of the reforms of the 1980s and the 1990s.

The specific predictions we test are derived from theory. In Chapter 2 we use a two sector Schumpeterian growth model based on Aghion et al. (2003b) and Acemoglu et al. (2003) and analyze firm-level incentives to invest in quality-enhancing technology. The intermediate goods sector invests in technology and the final goods sector production function includes both the quantity and the quality of these intermediates. Proposition 1 states that given monopolistic distortion in the final goods sector, more competition in the intermediate goods sector (modeled as a fall in the price that the firm is able to charge for its product) can lead to a rise in technological investment by the firm and hence to a rise in the productivity of the firm. In the Indian case, firms in industries that were deregulated faced a more competitive, market-based environment and these firms can be used to test our prediction.

Further, Proposition 2 gives us an indication of the impact of a rise in competition from foreign producers on the firm. Our second prediction is that under certain conditions, industries that face more competition domestically (that is, industries that were deregulated) tend to perform better in the face of foreign competition. That is, there may be strategic complementarity between industrial de-regulation and trade reform. The intuition behind this result is that competition at home forces the firm to make investment in productivity-enhancing technology and that these investments prepare the firm to compete with foreign entrants. The policy implication of this prediction is that it may be possible to raise the benefits from a trade liberalization episode by first facilitating greater competition domestically.

Our identification strategy to assess the impact of domestic deregulation on firm-level productivity uses an important institutional feature of Indian policy. Firms with assets below a certain defined rupee threshold were exempt from licensing requirements. Thus in any industry, some firms are "non-licensed" or "exempt" (since they are below the licensing threshold). So in industries that were "de-licensed" by the government, a firm is treated by de-licensing reform only if it was large enough to be under licensing at the time of the reform. This institutional feature provides within-industry variation that allows us to identify the interaction between de-licensing and size. Given the nature of the licensing regime in India, the coefficient on this interaction gives the joint impact of two mechanisms through which de-licensing in India affected firm-level productivity. The first mechanism is the removal of direct, microeconomic constraints on the firm (for example, output limits) which impacted the ability of a firm to become more productive while the second mechanism is the removal of entry restrictions on the industry as a whole which impacted the incentives of firms to become productive.

Our main result is that piece-meal industrial de-regulation that took place in the 1980s has a positive and significant impact on labor productivity. Further, preliminary results suggest that there exists strategic complementarity between trade liberalization in 1991 and industrial de-regulation. That is, industries that were de-regulated tended to fare better after the trade liberalization episode.

We conduct a variety of robustness tests. Firstly, we test an implication of our identification assumption that for the group of industries where exemption from licensing was not granted, there should be no size-based response to de-licensing. Secondly, we analyze the distribution of assets and the rates of growth of assets of exempt firms over licensed and de-licensed industries and show that there was no difference between the response of exempt firms in the two types of industries. This means that the argument that firms choose their assets and hence, choose their exemption status, based on anticipations of reform may not hold. We also provide evidence that there was no bunching of a large number of firms under the threshold and hence firms were not deliberately trying to stay exempt from licensing requirements. Another test of our identification assumption is that there should be no variation in the response of firms to de-licensing around arbitrary thresholds and we find that to be the case in our data. Our results are robust to the inclusion of a wide variety of firm-level controls (ownership, organization, location (urban/rural and state) and wage to rental ratio) as well as industry-level controls (industry fixed effects, entry for firms belonging to large houses etc) that may affect firm-level productivity and/or be correlated with size. We also control for industry-level time-varying factors (by including industry-year fixed effects). Since our data does not allow us to follow a firm over time, we use certain firm-level identifiers to create a pseudo-panel. We are able to identify several cross-sections of very similar firms in our sample. Using the pseudo-panel we find that both our important results are robust to the inclusion of firm-level fixed effects.

De-regulation can change investment decisions and productivity by many different mechanisms. The one implied by our theoretical model is an increase in the threat of potential entry and higher competition from new firms as measured by a reduction in the price-cost margin of the firm. Other mechanisms can include a rise in capacity utilization if the firm had excess capacity prior to de-regulation, a change in the capital to labor ratio in case regulation involved restrictions on the level of capital a firm could use in production, a decline in corruption that releases resources to be used for productive purposes etc. Though any full story about the impact of a de-regulation episode should include details of the mechanism through which de-regulation affects the firm, in this chapter we focus on the impact of de-regulation on investment and productivity choices rather than on the mechanisms through which this impact might occur.

3.2 Literature Survey

Our paper contributes to two main strands of literature. The first strand focuses on the impact of competition -domestic or foreign- on firm-level productivity and incentives. The second strand focuses on the impact of trade reforms on firm productivity.

There has been a stream of recent papers that examine the relationship between competition and productivity. Heterogeneous firm models highlight how competition could lead to higher aggregate productivity levels by forcing the exit of unproductive firms and leading to reallocation of resources from less productive to more productive firms (e.g., Hopenhayn (1992), Melitz (2003)). Representative firm models highlight broadly two channels through which competition could affect firm productivity: by providing better (worse) incentives for managers and workers to reduce slack and cut costs e.g, Schmidt (1997) or by providing better (worse) incentives for innovation or for adopting new technologies e.g., Aghion et al. (1999) and Aghion and Howitt (1992). This strand of literature has examined the relationship between product market competition and innovation. Aghion et al. (2001) analyze the interplay between innovation and product market competition and finds that product market competition (that is, how substitutable two goods are in the consumers demand function) enhances innovation in sectors where firms were already close to the technological frontier and discourages innovation in sectors where firms are below the frontier. Aghion et al. (2003a) use a model of step-by-step innovation to find an inverted-U shaped relationship between product market competition and innovation. This is supported by data on firms in the UK. Nickell (1996) reviews the studies that directly relate competition to productivity and finds a generally positive effect of competition on productivity. Djankov and Murrell (2002) review studies on the impact of product market competition on productivity in transition economies and find that in general more competition improves firm performance. Aghion et al. (2003b) use a Schumpeterian endogenous growth model to derive their main theoretical predictions. This model consists of a perfectly competitive final goods sector and a monopolistically competitive intermediate goods sector. They find that industries that were closer to the technological frontier pre-reforms tend to do better than other industries. Further, industries located in states that have pro-business policies (for example, a lower minimum wage) tend to perform better. Aghion et al. (2004) assess the impact of domestic deregulation on industry productivity for the case of India and find that industries that were deregulated tend to have higher productivity.

Aghion et al. (2003b) and Aghion et al. (2004) are of particular relevance to our results. They assess the impact of the institution of minimum wage laws on firm-level investment and use the 1991 trade liberalization in India to illustrate how reform may have unequal effects on industries and regions. Their main theoretical results are that liberalization enhances investment in industries that were initially close to the technological frontier and that pro-worker legislation lowers investment and this negative effect is magnified by liberalization. Their empirical results confirm the main predictions of the model.

This dissertation contributes to this strand of literature in two ways. Firstly, most theoretical models do not try to model industrial policy in India and how this affected market structure and hence innovation incentives. The policy of close control of private sector initiative was in place for nearly 40 years and affected all aspects of production, distribution and even consumption. Our model tries instead, to capture the effect of policy on market structure and the predictions of our theoretical model provide a richer characterization of innovation incentives.

In addition to this, we address the question of whether our results regarding domestic de-regulation are eroded or enhanced as a result of competition from high technology foreign firms. That is, what is the interaction between domestic competition and foreign competition?

Secondly, contrary to both Aghion et al. (2003b) and Aghion et al. (2004) who assess the impact of deregulation on industry productivity we use detailed and reliable firm-level data for the 15 year period. Most other studies on India use industry-level data. Further we have a detailed (and to our knowledge, the only) data set on Indian industrial policy from 1970 to 1994. Instead of analyzing the impact of isolated reforms (for example Aghion et al. (2004) use deregulation in 1985) we are able to analyze the impact of all changes in industrial policy in the 1980s and 1990s. We provide more details about our data in Section 3.4.

As in the case of increasing competition, theoretically trade liberalization could have both a positive as well as a negative impact on productivity. Different theoretical models give startlingly different results about impact of trade reforms. Thus the effect of trade liberalization on productivity is an empirical question. While the early evidence was somewhat mixed (Tybout (1992)), recent surveys by Tybout

(2000) and Epifani (2003) conclude that the empirical literature generally support a positive effect of trade liberalization on productivity. For the case of India, several studies have used micro data to study the impact of trade reform on productivity ((e.g., Krishna and Mitra (1996), P. Balakrishan and Babu (2000)) and have come to very different conclusions. Krishna and Mitra (1996) who use firm-level data for the period 1986-1993 from several industries and find strong evidence of an increase in competition (as reflected in the reductions in price-marginal cost markups) and some evidence of an increase in the growth rate of productivity. P. Balakrishan and Babu (2000) use a sample of 2300 firms over the period 1988-89 to 1997-98 to find no evidence of acceleration in productivity growth as a result of the 1991 reforms. Das (2003) uses standard growth accounting on manufacturing industries during 1980-2000 and finds no evidence of change in TFP growth following the 1990s reforms. More recently, Topalova (2003) has used a more sophisticated methodology for calculating productivity and concludes that reductions in trade protection lead to higher levels of productivity in Indian manufacturing over the period 1989-2001. In a recent study Sivadasan (2003) uses a comprehensive and highly detailed firm-level data set and finds an 30 to 35% increase in mean intra-plant productivity level in tariff liberalized industries. There is also a 25% increase in aggregate output growth and a 20% increase in aggregate productivity growth following tariff liberalization.

We contribute to this literature by providing reliable estimates of the impact of trade reforms on firm-level productivity *after controlling for the effect of domestic de-regulation*. Other than Aghion et al. (2004) who use limited deregulation data for one year of the 1980s, none of the papers mentioned above control for the industrial de-regulation that took place in India during the 1980s. Hence their estimates of the impact of the trade liberalization of 1991 may be biased since some of the rise in productivity may have been due to de-regulation during the 1980s. Interest in the reforms of the 1980s has recently been revived due to a puzzling empirical result. As Panagariya (2002), Panagariya (2004) and Delong (2001) point out, reliable productivity measures show a sharp rise in productivity levels and rates of growth prior to the 1991 sweeping reforms. In a recent paper Rodrik and Subramanian (2004) argue that the structural break in Indian growth came in the early eighties because there was an attitudinal shift on the part of the government towards a pro-business approach rather than due to actual policy changes like de-licensing. However, unlike us they do not use data on policy reform to prove this hypothesis.

3.3 Background on Indian Industrial Policy

The licensing of industries was one of the major methods to control private enterprize in India. The mixed economy framework mandated a role for the private sector . However, it was felt that the private sector would need encouragement to invest in the desirable areas. Hence industrial licensing evolved as a method to direct investment in desirable directions. Details about the evolution of the system are presented in Appendix B.1. Here we present a brief description of the system and important changes.

A license was a document that permitted a firm to continue/begin production in an industry. It was issued by the Ministry of Industry in New Delhi. Under the Industries (Development and Regulation) Act 1951 (henceforth referred to as IDRA), all factories (defined as *enterprises that did not use power but employed more than 100 workers or enterprises that used power and employed more than 50 workers*) that were already operating or wished to operate in a specified list of industries were required by the government to obtain a license.

The scope of a license was fairly broad especially from the late 1960s onwards. Almost by definition, the licensing regime controlled entry into the industry and hence the amount of competition faced by a firm. Section 1 of Appendix B.1 goes into details about the considerations of the licensing committee while debating a license. These were mainly macro-economic in nature and had little to do with the merits of the project. A license also specified the amount of output that a firm could produce. It was conditional on the proposed location of the project. Permission would be required to change location. The exact nature of the item to be produced was also specified and the firm needed to take permission or another license to change his product mix. Even the kind of technology and inputs that the firm could use in production (though not specified on the license) was determined because the most crucial raw materials (steel, cement, fuel etc) were controlled by the government and the firm needed to get annual allotments of these for production.

However, the effect of a permanent license to produce (combined with a low threat of potential entry) on firm-level incentives to reduce costs, modernize technology, improve quality and engage in monopolistic practices was raised by one committee after another starting from 1965, a mere 15 years after licensing was implemented. One of the earliest observations were made by the *The Monopolies*

Inquiry Commission 1965 chaired by K. C. Dasgupta.

"*.....the requirement of law that new industries with capital over a specified amount could not be started without a license is a formidable obstacle in the way of new entrepreneurs freely entering the lists.*" [1].

Further,

"*The system of controls on the shape of Industrial licensing however necessary from other points of views, has restricted the freedom of entry into industry and so helped to produce concentration*"[2].

Thus, the licensing regime in India affected firm-level productivity and costs through its control on both the firm's *ability and incentives* to innovate, reduce costs, adopt new technology etc. The direct controls on outputs and inputs affected ability and the indirect control of entry affected incentives. Even if the direct controls were not implemented fully due to corruption etc, the effect of the indirect controls on incentives was very large. Licensing restricted entry into most sectors and created artificial monopolies and oligopolies. The average four-firm concentration ratio in Indian manufacturing in 1981 was 54.2% compared to 32% for the US in 1977. Even among developing countries, India seems to be closer to Poland (64.8% in 1988) than Brazil (32% in 1988).

[1] Dasgupta (1965), page 7

[2] Dasgupta (1965), page 8

3.4 Data

The data used in this paper comes primarily from two sources. In order to measure changes in the competitive environment faced by a firm (the right hand side explanatory variable), we have collected a detailed data set of industrial policy in India (to our knowledge, the only one existing) from the 1970s onwards. Using this data, we can identify which four-digit industry underwent reform (freedom from licensing requirements) in each year of the 1970s, 1980s and 1990s. The main source of data was internal government publications and notifications . Some commonly available publications like the Economic Survey were also used. Common publications, however, do not reveal the level of detail about the conditions under which firms were eligible to avail of certain policies. Study of government notifications, memos etc provided insight into the ideology of policy-makers and provided rich detail that we exploit in our identification strategy.

It is important to note that this is the first attempt to collect and compile data on Indian industrial policy for the period 1970-1995 in a manner that allows econometric estimation of the impact of policy changes. One reason for this is that detailed data on industrial policy pre-1991 are available only in obscure government notifications which are not easily available. Secondly, in the literature on India, the reforms of the 1980s are usually dismissed as too small and scattered to have had a significant effect on anything. There has not been a single detailed empirical study of these early reforms. As mentioned earlier, the reforms of the 1980s have been of great interest lately. Reliable productivity measures for India show a sharp rise in productivity levels and rates of growth prior to the 1991 sweeping reforms.

In the 1980s, the government started relaxing the licensing regime by "de-licensing" certain industries. From the late 1960s onwards it was starting to get clear that the strangle hold of regulation on Indian industry was fatal for it and many assessments of the system in the 1960s and 1970s advocated relaxation of regulations. Certain attempts were made in the 1970s [3]. But it was in the 1980s that any significant change in the working of the system occurred. Table 3.1 shows the percentage of manufacturing output and value added that was de-licensed in each year of the 1980s and 1990s. We also show the percentage of factory output and value added that was de-licensed (factories are defined as firms not using power and 100 or more employees and firms using power employing 50 or more employees) since under the IDRA 1951, only these factories were under the ambit of licensing.

This piece-meal approach to reforming industrial policy continued through the 1980s. In 1991, the Indian economy faced a balance of payment crisis and was forced to take loans from international organizations. Under pressure from these organizations, the biggest de-licensing episode occurred. Almost all industrial licensing was removed (other than for 16% of manufacturing output). Along with this, there was across the board reductions in tariffs and rationalization of non-tariff trade barriers. The rupee was de-valued by 22% (from Rs. 21.2 against the dollar

[3] The first "de-licensing" of firms was done in 1966 and by 1969, 41 items were de-licensed. However in 1973, these industries were licensed again and it was only in 1975 that the second phase of de-licensing began when 21 industries accounting for 3% of manufacturing output were de-licensed.

to Rs. 25.8). The sheer scale and scope of the reforms were so large that this reform episode has been the one that has caught the imagination of policy-makers and researchers alike.

Table 3.1 brings forward two important points that challenge the predictions of other studies on India. The first is that with respect to the percentage of manufacturing output that they affected, the reforms of the 1980s were quite significant. Cumulatively, 23% of output and 23.6% of value added in 1990 had been de-licensed. Hence, studies that ignore pre-1991 changes in the licensing regime provide misleading estimates of the impact of the 1991 crisis. Secondly, de-licensing in 1991 was not "across the board" as is the common assumption in most studies. 16% of manufacturing output and value added were still under compulsory licensing post-1991. Some of these industries were gradually de-licensed in 1993 and 1994. But studies that ignore the actual chronology of de-licensing post-1991 also overstate the impact of the 1991 crisis.

To measure the left-hand side variable-productivity of the firm- we use a rich and rarely used unit-level database. The source for unit-level data for this study is the Annual Survey of Industries conducted by the Central Statistical Organization (CSO), a department of the Ministry of Programme Planning and Implementation, Government of India. The survey covers all factories registered under the Factories Act 1948 (defined as units employing 20 or more workers). Note that the survey covers only the formal sector in Indian manufacturing. The ASI frame can be classified into 2 sectors-the census sector and the sample sector. Units in the census sector (all factories with more than 100 workers) are covered with a sampling probability of one while units in the sample sector are covered with probabilities one-half or one-third.

This rich unit-level database has been rarely used in literature since it has only recently been made available to researchers in electronic format. A recent paper that has utilized this database is Sivadasan (2003) who calculates the impact of the trade and foreign investment reforms that were done in 1991 on total factor productivity in Indian manufacturing. Most other papers (for example, Aghion et al. (2004)) use ASI data at the industry-state level.

We obtained this data for the 14 year period 1980-81 to 1994-95. The length of our data allows us to cover all the reforms of the 1980s as well as the major reform episode of 1991. The data is reported on a financial year basis. That is, 1980-81 refers to the period between 1 April 1980 and 31 March 1981.

For our analysis, we use all unit-level data on all factories as defined by the Industries (Development and Regulation) Act 1951 since these units were the ones that came under the ambit of industrial licensing. These are units that employ 50 or more workers and use power in the production process or units that employ 100 or more workers without the aid of power. The non-factory units that we exclude are large in number (an average of 30% over our time period) but account for only 14% of total output and 18% of employment in registered manufacturing.

Since we use log of output per worker, observations for which the output or worker figures are less than or equal to zero are excluded from the analysis. Further, 42000 firms are listed as being closed in the year of the survey and these are also excluded from the analysis.

The basic characteristics of the data that we use for our analysis are summarized in Table 3.2. As mentioned earlier the census sector of the ASI comprises of units employing 100 or more workers while our subset consists of units employing 100 or more workers without power and 50 or more workers with power. Thus, nearly 80% of our data has a sampling probability of one. On average there are around 15000 units a year corresponding to a population of 20000 units. Note that the sampling scheme changed in 1987. In all our analysis, we weight observations using the multiplier or the inverse sampling probability to adjust for sampling frequency. Summary statistics of our key variables are presented in Table 3.3.

Real output is measured as value of total output measured in 1993-94 prices. The deflator used is the sector specific wholesale price index [4]. Labor is measured as the number of employees.

3.5 Identification Strategy and Estimation Equation

3.5.1 Estimation Equation

The prediction from our theoretical model that we want to test is that a more competitive domestic environment forces firms to raise their investment in productivity-enhancing technology and hence leads to higher productivity. As explained in Section 3.3 the industrial licensing regime in India affected market structure and market power of firms operating in the manufacturing sector, mainly through restriction of entry. It also affected investment incentives of firms via its control of firm output,

[4]Source: various issues of the Reserve Bank of India Bulletin

location, raw material usage etc. Thus, a removal of licensing requirements from an industry led to a more competitive, market-driven environment. The main equation that this translates into is given by

$$y_{ijts} = \alpha + \beta_1 De_{jt} + \eta X_{ijts} + \epsilon_{ijts} \tag{3.1}$$

Here y_{ijts} is the log of output per worker for a factory i producing in industry j, located in state s at time t. De_{jt} is an indicator that takes in a value of one in all years greater than equal to year t if industry j was de-licensed in year t.

However we need to control for macroeconomic changes that may affect firms for example rates of interest, exchange rate etc. We control for these by putting in year fixed effects into our regression equation. The second area of concern is industry-specific factors that may affect firm-level productivity and we control for these using industry-fixed effects. Thus our estimation equation is

$$y_{ijts} = \beta_0 + \alpha_j + \delta_t + \beta_1 De_{jt} + \eta X_{ijts} + \epsilon_{ijts} \tag{3.2}$$

Here α_j, δ_t are industry and year effects. The vector X_{ijts} contains other firm, industry and state level controls. We explain these controls in detail in Section 3.5.5.

3.5.2 Identification Problem and Strategy

The estimation of Equation 3.2 may not give unbiased, consistent estimates. Note that main explanatory variable De_{jt} varies at the industry level. Political economy factors like political affiliation, lobbying power etc are also at the industry-level and these might affect whether industry j gets de-licensed. Since these political economy factors are not observed, they become part of the error term. But this then means that the error term is correlated with a key right hand side variable- the de-licensing dummy- leading to omitted variable bias. Under these circumstances we will not be able to identify the co-efficient on De_{jt}. Industry-fixed effects may capture some of these political economy un-observables. However, in order to get reliable estimates of the impact of industrial de-regulation we need within-industry variation.

One important reason for our concern is that the reforms of the 1980s have been characterized by some as "reforms by stealth". There was no consensus for economic reforms in the 1980s. It is clear from policy documents that the government was at pains to portray the changes of the 1980s as a continuation of the existing system (even though these were dramatic changes that veered away from the high-regulation, socialist paradigm in operation). Under these circumstances it is possible that the government was choosing industries for de-regulation based on certain characteristics that either raised the chances of the success of the reforms (for example, picking high productivity industries) or that minimized social costs in case of failure (for example, picking high technology industries to minimize employment effects).

Our identification strategy uses important institutional features of industrial policy in India. Firms that had assets in plant and machinery, land and building less than a certain amount were free ("exempt" in official parlance) from industrial licensing requirements. This was an important component of the governments strategy to promote the growth of smaller firms that would be main engine of employment generation in the manufacturing sector. These firms would also satisfy consumption needs of the economy and would be a mechanism to spread economic growth to far-flung regions of the country. Further, this was also a pragmatic decision so that the administrative burden of the licensing regime did not grow too large. By the late-1960s, as the manufacturing sector took off, there were reports of long delays in the grant of licenses. By giving exemption to some firms, the intent was to lessen the sheer volume of applications that the licensing authority had to process. Note that these exempt firms could enter and operate in any industry and without restrictions on output or investment as long as they stayed below the threshold [5]. This meant that in each licensed industry there is a group of firms that is not under licensing. We call these the "exempt" firms.

Further, in the 1980s certain industries were "de-licensed". That is, all firms (irrespective of whether they were exempt or not) were freed from licensing requirements in these industries. In terms of our identification strategy, this means that from 1984 onwards all firms in certain "de-licensed" industries were not under licensing requirements.

Keeping in mind the institutional features of industrial policy in India, in each de-licensed industry there is a group of firms that are not affected by the reform since they were not under licensing to begin with (the exempt firms). So the industry in which a firm produces as well the firm's exemption status jointly determine the

[5] In some cases, certain additional conditions like upper limits on foreign exchange requirements for the project needed to be fulfilled in order for the firm to be "exempt". Despite this, according to officials, a large number of firms were able to take advantage of this scheme. However note that this means that entry into exempt firms was not entirely free.

firm's exposure to de-licensing.

To sum up, a firm is treated by de-licensing reform in industry A in year t if

- Industry A was de-licensed in year t.
- The firm was under licensing to begin with. That is, it was not granted an exemption from licensing.

The criterion for exemption was in terms of the original rupee value of plant and machinery, land and building owned (or proposed to be owned) by the firm. This definition was constant for all industries. That is, an exempt firm in industry A would face the same threshold as an exempt firm in industry B. Over our sample period 1980-1994, the rupee value of this definition was changed twice-in 1983-84 and 1990-91[6]. From the period 1980-81 to 1982-83, a firm whose assets in plant and machinery were worth less than of equal to Rs. 30 million was defined as small. In 1983-84[7], the threshold was increased to Rs. 50 million and in 1990[8], to Rs. 150 million. Note that inflation in the price of land or machinery would not change the exempt/not-exempt status of the firm since this was based on the original or book value of assets (not current value).

However, this "exemption" from licensing was not available to firms in a group

[6]In May 1990, in an Industrial Policy statement the government raised the exemption limit to Rs. 500 million. However, in November 1990 a new government came to power and by April-May 1991, the foreign exchange crisis was taking hold. Given these two factors, the implementation of the May 1990 statement in actual practice is in doubt.

[7]Source: Ministry of Industry Notification S.O. 328(E) dated 23 April 1983.

[8]Source: Economic Survey 1990-91.

of industries referred to as Schedule IV and Schedule V industries [9]. Schedule IV included industries like textiles produced on power looms that were items of mass consumption over whose production, pricing and distribution the government wanted close control. Schedule V industries were the industries that were deemed to be using "scarce" raw materials (imported or domestic). So in these industries, all firms were under licensing. We do not include these industries in our main estimation equation but we use them to provide a test of our identification assumption.

Thus the actual equation that we estimate is

$$y_{ijts} = \beta_0 + \alpha_j + \delta_t + \beta_1 De_{jt} + \beta_2 NotExempt_{it} + \beta_3 De_{jt} NotExempt_{it} + \eta X_{ijts} + \epsilon_{ijts} \tag{3.3}$$

Here $NotExempt_{it}$ takes on a value of one when the firm is not exempt from licensing requirements. Our identification strategy allows us to deal with the problem that industry-level un-observables may make De_{jt} correlated with the error term. If we suppose that there were unobservable factors that determined whether industry A was de-licensed in year t, as long as these factors were industry-specific they should be same for *all* firms within industry A. That is, a exempt firm ($NotExempt_{it}$=0) in industry A has the same un-observables as does a non-exempt firm ($NotExempt_{it}$=1) in industry A. Thus, any variation in productivity around

[9] Source: Government of India, Ministry of Industry Notification 16 Feb, 1973. S.O. 98(E)/IDRA/29B/73/1 specifies these industries and the subsequent changes to these lists were gathered from amendments to this notification as well as other notifications and press notes issued by the government.

the threshold for licensing should come from de-licensing. Thus, co-efficient β_3 on the interaction of size and de-licensing -$De_{jt}NotExempt_{it}$- is identified.

As mentioned in Section 3.3, the licensing regime affected both the ability as well as the incentives of a firm to invest in productivity. The controls on the amount of output, the location of the plant, the technology used etc directly controlled the ability of a firm while controls on entry into an industry affected incentives. When an industry was de-licensed, both these controls were removed simultaneously. In this context, the coefficient β_3 captures the impact of the relaxation of both direct and indirect controls on firms. That is, β_3 measures the impact of de-licensing on a non-exempt firm's productivity because of relaxation of output, locational and other constraints as well as the impact on productivity due to more competition and a higher threat of potential entry.

The first mechanism–relaxation of direct controls on the ability of a firm–makes sense since only the not exempt firms were under the burden of fulfilling onerous conditions on output, location etc while exempt firms were not (as long as they maintained assets below the government definition). Thus, there is differential impact on these two types of firms within an industry of de-licensing.

The argument with regard to the second mechanism–higher threat of potential entry–is more nuanced. One might argue that if there were no barriers to entry as a small, exempt firm while there were huge barriers to entry as a large, not exempt firm (in the form of the cost of procuring a license) then no firm would want to enter as a not exempt, large firm in the pre-reform period. All firms would enter small and would grow until they reach the threshold amount of assets. This means that de-licensing will not increase entry into the ranks of not exempt firms while exempt firms have free entry both pre- and post-reforms. If this were the case then our identification strategy does not capture the impact of entry de-regulation on the productivity of firms.

However, the argument above assumes that there are no costs to entering as a small, exempt firm. This assumption is not likely to be true because a license to produce was only one in a whole package of permissions and permits that a firm needed to get in order to commence production. For example, in order to get exemption firms needed to agree to an upper limit on foreign exchange requirements. Further, on the basis of the recommendations made by the licensing committee, the firm had to get allotments of essential raw materials from another committee that was in charge of allocations. Similarly, the firm needed to go through a separate procedure to get permission to procure foreign exchange and to import any raw materials or machines. Further, the firm needed to get financing for its project but applied to financial institutions *after* getting all the required permits and licenses. All these procedures and permissions were more likely to be more difficult and costly for a small firm. So if a firm decided to enter the industry as small, the firm not only suffered the loss of economies of scale but also faced additional costs of being small. Thus, while there were no explicit entry barriers into the exempt category of firms, the other accoutrements of the licensing and trade regime created entry barriers and it is by no means obvious that a firm would always want to enter small in size, pre-reforms. This means that de-licensing of an industry reduced entry barriers for both of exempt as well as not exempt firms and that our empirical strategy catches these effects.

Our identification strategy has been used extensively in the evaluation of social programs in developing countries. Similar strategies have been used in the public finance literature to evaluate the effect of public policies. Rosenzweig and Wolpin (1988) first proposed the use of fixed effects methods for evaluating the impact of public programs in developing countries. Gertler and Molyneaux (1994) applied these methods to the problem of estimating the returns to family planning programs by controlling for unobservable region-specific cultural and religious norms. Duflo (2000) uses this strategy to evaluate returns to a school-building program in Indonesia. She uses variations in program intensity over regions as well as the date of birth to identify individuals who would be most affected by this program. Children who were at or below the school-going age at the time the program was implemented will benefit more than children who were older. Further, this difference is higher in regions that received more schools. Angrist and Evans (1996) use a similar strategy to identify the effects of state abortion reforms on labor market outcomes. The causal relationship they want to identify is between teen-child bearing and labor market outcomes. However, it is possible that women who bear children as teenagers would have bad labor market outcomes due to unobservable variables leading to biased OLS estimates. So Angrist and Evans (1996) create an instrument for teen child-bearing that is an interaction of the state of birth and the year of birth. The latter captures the exposure that a woman had (in her teen years) to liberal abortion environment. So women with more years of exposure to a liberal environment are less likely to be teen-mothers than women with less years of exposure. However this difference is likely to be more in states that reformed their abortion laws. More recently, Visaria (2004) uses this strategy to identify the effect of judicial quality on economic outcomes. The sources of variation in her application are the monetary threshold for claims to be eligible for these tribunals, and the staggered introduction of debt-recovery tribunals across Indian states.

The Indian reforms of the 1980s are well-suited to the use of fixed-effects methods because the variations in the regulatory environment come from a well-defined series of reforms. This makes it possible to test an implication of the identification assumption that any variation in performance of firms due to de-licensing should come around the actual exemption status. We use a group of industries where all firms were under licensing i.e. no firm was granted an exemption. For this group of industries, since the threshold for exemption did not apply, the co-efficient on the interaction of De_{jt} and $NotExempt_{it}$ should be insignificant. That is, there should be no variation in the response to de-licensing around the exemption threshold. The results of this specification test are reported in Appendix B.3.

3.5.3 Exogeneity of Exemption Status

In order to get unbiased and consistent estimates from Equation 3.3, we need to make sure that the sources of variation in our data are exogenous. The first issue was that of omitted variable bias that may make the de-licensing dummy endogenous. To solve that we use an institutional feature of Indian policy making, as explained in the previous section.

However, a second source of bias arises from the possibility that firms may be endogenously choosing their exemption status (i.e. the size of their assets in plant, machinery, land and building) based on anticipations of de-licensing. Suppose that the main benefit to a firm for choosing a low level of capital comes from the fact that the firm is free from licensing requirements. Then if the firm is truly constrained by the threshold and is anticipating de-licensing of its industry (when it will loose its privileged status) it will increase its capital even if that means that it is above the threshold.

There are several reasons why an exempt firm will want to increase its capital if it anticipates de-licensing. The first is that if the main reason why the firm is keeping a low capital stock is to escape from licensing then as soon as this privilege is removed, the firm will no longer benefit from constraining its capital and hence will want to expand. Another reason is that de-licensing means that the firm will be competing in an environment of free entry for larger firms (remember that exemption was only for "smaller" proposals). In order to compete it might be necessary to take advantage of economies of scale and that might entail increasing its assets. In the sections below we investigate the possibility that firms chose their assets in anticipation of de-licensing of their industry. If this is the case, there should be a difference in the distribution of firms over industries. Industries that were de-licensed should have a lower proportion of exempt firms (as these firms raise their assets in plant, machinery, land and building because they no longer stand to gain from having low assets). Further, the rates of growth and levels of assets of exempt firms should be higher in de-licensed industries post-reform.

The first important point to note about de-regulation reforms in India is that there was an exogenous break in the pattern of de-regulation in 1991. Up to 1991, de-licensing was done in a piece-meal manner-a few industries each year. The extent of the balance of payment crisis in 1991 and the conditions attached with foreign loans were completely exogenous. By far the largest de-licensing episode occurred in 1991. Thus, it seems unlikely that firms would be choosing their assets endogenously with respect to the de-licensing in 1991. Thus, in our discussion of endogeneity of exemption status we focus on de-licensing episodes in the 1980s.

With regard to the reforms in the 1980s, we conduct a number of tests of the exogeneity of exemption status, in terms of size of assets. An analysis of the data reveals little evidence of firms choosing their assets (and hence their exemption status) in anticipation of de-licensing.

(a) In the industries that were de-licensed during the 1980s, the proportion of exempt firms was 0.95 pre-reform (1980-83) and it fell to an average of 0.93 during the reforms (1984-89). This pattern was identical to that in industries that were not de-licensed in the 1980s (here the proportion of exempt firms fell from 0.97 to 0.95). That is, there was no sudden inexplicable decline in the proportion of exempt firms post-reform. Similarly, the average annual rate of growth of the number of exempt firms also maintained its pattern across industries (It rose from 1.6% to 2.4% in the de-licensed industries and from -1.5% to 0.5% in the still-licensed industries.).

(b) In Table 3.4 we investigate the pattern of the average annual rates of growth of assets in plant, machinery, land and building across exempt firms. We see that while the rate of growth of the mean is higher in de-licensed industries as compared to licensed industries, the top 25% of firms grew faster in licensed industries than in de-licensed industries during 1984-89 (12.97% as compared to 10.53%). This is contrary to what we would find if firms were choosing their assets based on reforms. Similarly in the top 50% of firms, the rate of growth of assets is slightly higher for exempt firms in licensed industries. Thus, in firms that were closer to the threshold-and hence more likely to be endogenously choosing size- there is little or no difference in the behavior of growth of assets.

(c) In Figure 3.1 we investigate the distribution of exempt firms over assets in industries in two year-1983 (the year preceding the first deregulation episode) and 1988 (the year immediately after the reforms of the 1980s). Within each graph the solid line represents the year 1988 while the dashed line represents the year 1983. We see that the distributions are very similar in de-licensed industries as compared to licensed industries. This is especially true towards the end of the distribution i.e. nearer to the threshold.

    Note that there is a large mass of firms with very little assets in plant, machinery, land and building. To get a clearer idea of the effect of reforms on the distribution of assets, in Figure 3.3 we present the distribution assets of firms with assets below Rs. 4.5 million (ie. the really small firms) and in Figure 3.2 the distribution of assets of firms with assets greater than Rs. 4.5 million but less than the threshold amount of Rs. 50 million[10] . We see that the distribution of really small firms (Figure 3.3) in de-licensed industries is quite different from the distribution in licensed industries especially in the lower range. But this difference is constant over time i.e. it holds for both years. Towards the end of the distribution, in both types of industries, the density is higher in 1988 as compared to 1983.

In Figure 3.2 again we see that the distribution of assets is very similar in licensed and de-licensed industries especially as assets rise. Towards the beginning of the distribution (i.e., for firms with assets close to Rs. 4.5 million), licensed industries tend to have a higher density in 1988 while de-licensed industries tend to have lower density. But the important point to note is that this difference crops up very far from the threshold of Rs. 50 million. For firms closer to the threshold and hence more important for us with regard to the potential problem of endogeneity, the distributions are very similar.

Thus we see that the behavior of exempt firms with respect to assets in plant and machinery, land and buildings is not different over de-licensed and licensed industries[11]. Hence the argument that firms may choose size in anticipation of de-

[10]We choose the threshold of Rs. 4.5 million since this categorization was used by the government to define "small" firms. These firms were given special assistance and encouragement from the government. In this respect it is interesting to analyze the behavior of these firms. We also analyzed the behavior of exempt firms around randomly chosen thresholds and our findings are similar. There is little difference in the behavior of exempt firms (no matter how far from the actual threshold) across licensed and de-licensed industries.

[11]We also analyzed the distribution of other firm characteristics like assets in plant and machinery

licensing does not seem to hold in our data.

(d) Other evidence against this argument arises from an analysis of whether the threshold (on assets in plant, machinery, land and building) implemented by the government was binding for exempt firms. If there was a large mass of exempt firms that were on or slightly below the threshold and were maintaining low levels of assets deliberately then the magnitude of the endogeneity problem is bound to be quite large. However as we demonstrate in Appendix B.2, we do not find any evidence of bunching below the threshold for licensing. We do not find a large mass of firms directly below the threshold[12]. The threshold is binding only for the top 1% of firms (that too with a utilization rate of only 80%) and utilization rates drop of sharply for the other percentiles. Further, there is no evidence to suggest that firms directly above the threshold (and hence, licensed) were racing to raise their assets in plant and machinery-another indication that the asset limits might not be constraining[13].

and employment over exemption status and industries. Here too we find that the patterns are very similar in de-licensed industries as compared to licensed industries.

[12]In Appendix B.2 we also conduct this analysis for the capital to labor ratio and find that there is no bunching of firms around the average capital-labor ratio (as implied by the threshold) within an industry and year.

[13]This point should not be taken to imply that the licensing regime itself was not binding since firms were not trying to escape it. As pointed out in Section 3.3, the licensing system controlled two things at the firm-level-a firms ability (via control of the amounts of capital, output etc) and a firms incentives (via control of entry into the industry).

3.5.4 Comparability of non-equivalent groups

Our empirical strategy depends on the difference in performance between exempt and not exempt firms in response to de-licensing. However exempt and not exempt firms are different in a crucial dimension– size. Hence we are concerned that there may be other variables, other than de-licensing that may lead to this differential response between exempt and not exempt firms. In order to check the equivalence of these two types of firms, we conduct a series of simple tests in Appendix B.5. We find that in terms of trends of major variables as well as the evolution of the distribution of major variables, not exempt and exempt firms behave in a similar manner particularly in the pre-reform period. That is, there are differences in exempt and not exempt firms but that these differences do not change over time or due to any other variables prior to the reforms.

3.5.5 Controls

In this section we talk about the controls that are included in the X_{ijt} variable in Equation 3.3. We use our industrial policy database to control for policies that may affect the ability and/or incentives of the firm to raise its productivity.

- Policies regarding **dominant firms and firms belonging to large and/or foreign owned industrial houses**. Control of large private industry was an important objective of policy in India. The main objective was to prevent the concentration of economic power in a few private hands. Since the inception of the licensing system, certain large industrial houses were considered dangerous and hence all licensing proposals from these houses were treated with suspicion. In 1973, the government streamlined its policies regarding large industrial houses and announced a list of industries in which large and/or foreign owned houses were allowed to operate[14]. We control for this list of industries in which large and/or foreign owned houses were allowed to operate. We define

$$Large_{jt} = \begin{cases} 1 & \text{if industry } j \text{ was open for large houses in year } t \\ 0 & \text{otherwise} \end{cases}$$

- Controls for the **ownership and organization structure** of the firm. Controls for these are included since the ability to take productivity enhancing decisions and the flexibility that a firm has in adapting to a changed policy environment may depend on whether the firm is owned by the government or by the private sector. Similarly, joint family owned firms might behave differently compared to private limited firms or co-operative societies. Further, ownership and management structure of the firm might affect financial constraints faced by the firm and hence the assets of the existing or proposed factory. We define dummy variables for each type of ownership and organization structure[15].

[14]Even in these industries, the stated policy was one of preference for non-large firms. If a large house wanted to set up a firm in an industry not on this list then it would have to undertake an export obligation of 60-75% of output.

[15]For ownership, there are 6 categories-owned by central government, owned by state government, jointly owned by state and central government, wholly privately owned, joint sector firm with majority private ownership and joint sector firm with majority public ownership. Organization includes individual proprietorship, joint family run, other partnership, public limited firm,

- The **location of a firm** is another important variable that maybe correlated with its productivity or its size. In addition to controlling for the state in which a firm is located, we also control for whether it was located in an urban, rural or metropolitan area. It is possible that the level of infrastructure that are available to a firm is different if it is located in an urban area as compared with a rural area and this in turn maybe correlated with the productivity of the firm. We define $urban_i = 1$ if firm i is located in urban area, 0 else and $metro_i = 1$ if firm i is located in metropolitan area, 0 else.

- One issue that we are concerned with is the **relationship between the size of the firm and the productivity of the firm**. In particular, productivity of the firm as measured by output per worker may be determined by its size. If we were to measure size by output then this would be true by definition. Our definition of size however, is based on the assets of the firm in plant and machinery. But it is still possible that output per worker (our measure of productivity) is affected by capital per worker (for example, in any linear homogenous production function) and so size (and hence exemption status) and productivity are directly related. We cannot directly put the capital-labor ratio in our estimation equation (since the variable Ne_{it} is a function of capital). So we need a proxy for the capital to labor ratio in our estimation equation.

  We use the average price of capital relative to price of labor in a state s in year

private limited firm, public corporation, co-operative society and other.

t. We use the deflator for net fixed capital formation (with base 1993-94)[16] as a proxy for the price of capital. In our unit-level data we have the wage bill as well as the number of workers employed by each unit. So we are able to impute the annual wage rate that a firm has to pay. Since this wage rate is in nominal terms we deflate it so that it has base 1993-94 (similar to our measure for price of capital). The reason why we use state-year averages of this cost ratio is because firm level cost ratios might be endogenous with technology and productivity choices of the firm. Further, labor laws (for example, minimum wage) and their implementation is at the state level. So the average cost ratio captures the major institutional features of the labor market in India.

3.6 Results

3.6.1 Main Results

In Table 3.5 we present our baseline results for the estimation of Equation 3.3. In each specification we have included all the controls mentioned in the previous section. These regressions are within-industry. That is we are estimating a firms performance relative to the average performance of the 4-digit industry to which the firm belongs. We have also included year and state fixed effects. Standard errors are clustered around four-digit industry. Column 1 of Table 3.5 shows the results of our main specification on the sample of factories, excluding Schedule IV and Schedule V industries. Thus we see that on average firms that were not exempt from licensing

[16]Source: National Account Statistics

and were in de-licensed industries had 16.1% higher labor productivity. Our estimate is significant at the 5% level. That is, industrial de-regulation leads to a significant rise in the firm productivity. As mentioned earlier, licensing affected both the ability and the incentives of a firm to become productive. Hence, the 16.1% increase in productivity is due to removal of direct restrictions on firms (an impact on the ability of the firm) as well as due to higher competition and lower entry barriers into the industry (an impact on the incentives of a firm).

In Column 2 of the table we present regression results for the period 1980-90. Note that an important point of our analysis is that the reforms of the 1980s have been unfairly ignored by the literature. So it would be interesting to see the impact of those piece-meal reforms on productivity, not the path-breaking reforms of 1991. We find that the average firm that was treated with de-licensing during the 1980s did better than a non-treated firm. However this effect is significant only at the 17% level. Thus, the reforms of the 1980s did have some impact on firm productivity but this effect was small. Note that the total impact of de-licensing ($\beta_1 + \beta_3$) is very small for the period 1980-90. One possible rationalization for this small impact on productivity during the 1980s could be the lack of an enabling environment. That is, a rise in domestic competition can change the incentives of the firm to raise its productivity but this effect is reinforced by other factors. One such important factor that we will investigate is competition from abroad i.e. trade reform.

However, different industries may have very different productivity paths and that our coefficient may be capturing some of this time-varying heterogeneity. In Column 3 we check the robustness of our results to the inclusion of 3-digit industry specific time trends in addition to year effects. In Column 4 we report the results for the year 1980-90 after including industry-specific trends. We see that the interaction term is considerably lower in magnitude and is significant at the 10% level. Thus, even after controlling for time-varying growth paths in different industries, we find that firms that were affected by de-licensing had higher labor productivity than firms that were not affected. For the 1980s, the coefficient on the interaction is positive and insignificant.

Thus our baseline results support our intuition and the first prediction from our theory-firms in more competitive, deregulated industries tend to have higher productivity. An important point to note from Table 3.5 is that in all the specifications, the average impact of de-licensing on all firms in the industry (the coefficient on De_{jt}) is negative. That is, industries that were deregulated have lower productivity on average compared with industries that were not deregulated. It is the not exempt firms (that were under licensing) that see a rise in their productivity after de-licensing. But in almost all cases, the total effect ($\beta_1 + \beta_3$) is positive[17].

From Table 3.5, the role of exemption status also becomes clearer. In all the specifications the coefficient on $NotExempt_{it}$ is large and positive. That is, not exempt firms had higher productivity than exempt firms. This could be a reflection

[17] The fact that β_2 is negative in all the specifications might point towards the fact that the government was choosing low productivity industries for de-licensing. This means that our coefficients may still be biased due to industry-specific un-observables. However industry-year fixed effects can capture these omitted industry-level factors and our results are robust to these effects for the 1980s as well as for the full time span 1980-94 (Columns 1 and 2 of Table 3.6).

of the economies of scale enjoyed by larger firms.

In Appendix B.3 we show the results of the basic regression for Special industries. These were industries in which there was no distinction between exempt and not exempt firms. This allows us to test an implication of our identification strategy that there should be no variation in the performance of exempt and not exempt firms due to de-licensing of special industries. We find that this is the case in our data.

In Appendix B.4 we provide details of another specification test. One implication of our identification assumption is that if we choose arbitrary thresholds for exemption from licensing, then we should not find any variation in the response of firms to de-licensing around these arbitrary thresholds. That is, if the true threshold matters then randomly chosen thresholds should not. We find that this is true in our data. The significance level of the interaction coefficients when plotted against distance from the actual threshold takes a bell-shape. That is, the interaction between de-licensing and the random threshold (both above and below the actual threshold) is insignificant far from the actual threshold and rises in significance as we approach the true threshold.

Our baseline results are robust to a variety of checks which are presented in Table 3.6. One of the first things that we may be worried about is the possibility of sample selection. In our main regressions we are excluding firms in Schedule IV and V industries. It is possible that the Schedule IV and Schedule V industries (which did not have exemptions from licensing for any firms) may have special characteristics that may be correlated with size or with productivity. As we see in Appendix B.3 (Column 2, Table B.4), the coefficient on the interaction of delicensing with exemption status for non-schedule IV and V industries is significant and positive even when we include Schedule IV and V industries separately[18].

In Table 3.6, Columns 1 and 2 we subject our results to a strict check. We are not satisfied that industry-specific time trends capture all the industry-specific heterogeneity that we may falsely attribute to reforms. Hence we include 2-digit industry-year effects into our main regression as well as in the regression for the years 1980-90. We find that magnitude of the interaction coefficient is lower than the baseline specification but it is still quite large and significant at the 10% level. For the period 1980-90, the coefficient on the interaction is positive and significant at the 19% level. We also test our results using 4-digit industry effects interacted with year effects. Note that this means that the coefficient on De_{jt} is not identified since De_{jt} varies at the 4-digit industry level. However the interaction term $De_{jt} * Ne_{it}$ is identified and the coefficient on it is 0.15 and is significant at the 1% level. There is also a possibility that our results may be driven by some outliers. Column 3 of the table shows the results of our main regression when we winsorize the dependent variable by 1%.

When we control for industry-year effects (Table 3.6), we are worried that the time paths of growth might be highly dissimilar across industries and we wish to control for that. In Column 4 of Table 3.6 we subject our result to a stricter check. We include industry-state-year effects. Our concern is that industries in different

[18] We also tried regressions including non-factories in the sample. Our results are robust to the inclusion of these firms.

states may have different time paths of growth. This could be due to different growth paths of infrastructure, financial markets, labor laws, wage to rental ratios etc in different states. These factors may affect the incentives and the ability of firms located in different states differently. If de-regulated industries are disproportionately located in states that have higher growth rates of these variables then we maybe falsely attributing this to the reforms (rather than to the growth of these variables). We find that after controlling for three-way 3-digit industry, state, year effects the average affected firm (with $Ne_{it}De_{jt} = 1$) still has higher productivity than others. Further note that in this specification the average impact of de-licensing (β_1) is positive. That is, after controlling for industry-state-year interactions all firms in de-licensed industries performed better than firms in licensed industries. This means that the total impact of de-licensing ($\beta_1 + \beta_3$) is quite large.

3.6.2 Controlling for firm-level un-observables

A very important source of bias in our co-efficient estimates may be due to reverse causality. The main causal story that we want to tell is that the productivity of a firm that was under licensing requirements ($NotExempt_{it} = 1$) and was in an industry that was de-licensed by the government will be affected by de-licensing. However, it may be that a firm of a particular productivity may chose to be exempt from licensing. That is, firms that have low productivity may have a systematic tendency to stay exempt from licensing requirements since that keeps them protected from the larger, licensed firms. Then, since low productivity firms are choosing to be "non-treated" firms, we will see a large effect of de-licensing even if it did not have a large impact. That is, our estimates of the impact of de-licensing are biased upwards.

On the other hand, it is also possible that low productivity firms chose to be under licensing even though there are constraints. This is because a license to produce was permanent and entry into an industry was not governed by market conditions. Thus there would be a high chance of a low productivity firm surviving and even making super-normal profits without inducing entry from competitors. In this case, treated firms in our sample are systematically low productivity and this will bias our estimates downwards.

Another story we can think of is that firms with low managerial ability chose to be under licensing since they know they will not be able to compete in a more competitive environment. Again, if we are not able to control for these firm-level effects then our estimates may suffer from omitted variable bias.

Ideally, we would like to verify that the results reported above are robust to the inclusion of firm-level fixed effects. That is, we would require information on firm identity and the ability to follow a firm over time. In our data we can theoretically identify 200,000 observations over time (those belonging to the census sector). However, we have not been provided with firm identity numbers by the ASI. But we do have rich data on a variety of firm identifiers and we try to use those data to construct a firm identity number.

We use information on 6 firm-level identifiers:

1. Four-digit industry of production;

2. State where firm is located;
3. Whether located in rural, urban or metropolitan area;
4. The year that the firm started production;
5. The ownership structure of the firm (government owned, wholly privately owned or joint sector)
6. The area in which a firm is located.

There are other firm-level identifiers that could be used like the organization structure of the firm (proprietorship, co-operative society, private corporation etc) and a finer division of the ownership structure (whether owned by the state or central government). However we do not use these since they might change over time for a given firm. Thus, it is possible that a firms organization changes over time from a joint family proprietorship to a private limited company or that a wholly central government owned firm becomes a joint partnership with the state government. However, it is unlikely that a government owned firm (either state or central government) will change to a wholly private firm over time.

The six variables that we have chosen are available for 198,942 observations. Note that our sample of 200,000 observations also includes firms that were closed during the accounting year. We cannot use these firms in our estimation since output and employment figures are not available however we include closed firms while creating the firm-level identifier. This means that the same identifying number is assigned to a firm that is in the data and producing in year t, is closed for production in year $t+1$ but enters production again in year $t+2$.

Using these identifiers, we are able to uniquely identify approximately 33,207 firms. For the other firms, there are multiple identity numbers within each year and we drop those firms. Further note that each of these firms does not exist every year. That is, we have only surviving firms in our sample. Our total sample size is 140,562 including closed firms and 100,000 excluding closed firms.

We are still concerned whether we are capturing the same firm over time. It may be that another firm with very similar characteristics existed in the same region and in later years we are capturing that firm. To check for this we use two pieces of information from our data set- the opening and closing stock of fixed capital owned by the firm. Suppose that firm 1 ended year 1980 with Rs. 1 million of capital stock. Then we check whether the firm identified as 1 in 1981 started with capital stock close to Rs. 1 million. This cross-check supports our firm identifier.

Our main concern is that this may not be a random sample. So we provide some descriptive statistics of our panel of firms as compared to all factories. Figure 3.4 shows the distribution of productivity in exempt and not exempt firms for the pseudo-panel and the full sample firms. The black solid line represents unique firms while the red dashed line represents the all firms. As we can see that the distribution of productivity is very similar for both types of firms over exemption status. Any difference between unique firms and all factories are constant over exemption status and hence will get canceled out. For example, the sample of unique firms has higher productivity for both types of firms-exempt and not exempt from licensing requirements. In Figure 3.5 we investigate the distribution of assets (in plant, machinery, land, building) for exempt firm over de-licensing reform in the full sample and in the pseudo-panel. Within each graph the solid line represents the year 1988 while the dashed line represents the year 1983. Comparing this graph to Figure 3.1 (that was drawn for the full sample) we can see that the behavior of exempt firms over licensing reform and over time is the same for the full sample as for the pseudo-panel.

The results of the estimation of Equation 3.3 on uniquely identified firms are presented in Column 1 of Table 3.7. We estimate a within-firm regression with year dummies and standard errors clustered around 4 digit industry. The coefficient on the interaction of exemption status with de-licensing is positive and significant at the 5% level. That is, firms that were treated with de-licensing reform (they were not exempt from licensing and were in industries that were de-licensed) performed 5.7% better on average than non-treated firms, conditional on firm-level factors (the total impact of deregulation on not exempt firms is $\beta_1 + \beta_3$). In Column 2 of Table 3.7 we include 2-digit industry-year fixed effects to capture different growth paths of different industries and we find that similar to our baseline results, the coefficient on the interaction term is lower in magnitude. The average treated firm did 7.7% better than a non-treated firm, even after controlling for firm-specific factors and for industry-year interactions. In Column 3 of the table we present the results for the year 1980-90. The coefficient on the interaction is 0.079 and is significant at the 10% level. That is, after controlling for firm-specific factors, we find that the reforms of the 1980s had a positive and significant impact on the firms that were affected by these reforms.

3.7 The Relationship between Trade and Industrial Reforms

3.7.1 Does Deregulation Matter?

As mentioned earlier, one important feature of the Indian case is the interesting chronology of reforms. In the 1980s, policy was geared towards de-regulating industry to reduce administrative burden as well as unnecessary checks on firm-level decision making. There was little interest in trade reforms and the changes in trade policy that occurred were primarily of the nature of streamlining of the system, rationalization of administrative procedures etc. It was only in 1991, under pressure from international organizations, that the first steps were taken towards trade reforms. Following the industrial policy statement of August 1991, there were across-the-board tariff cuts bring down the average un-weighted tariff to 60%[19].

Given this chronology of events an important question that arises is what happened to the industries that were deregulated in the 1980s post-trade reform? In this section we will try to assess the impact of the 1991 changes in industrial and trade policies on firm-level productivity.

In Column 1 of Table 3.8 we present a simple estimate of the post-1991 performance of firms in industries that were de-licensed in the 1980s . We define $D80_{jt} = 1$ if industry j was de-regulated in year $s \leq t$ of the 1980s, 0 otherwise. That is, the $D80_{jt}$ variable is the same as the De_{jt} variable. We simply don't include the

[19]The strength of pre-reform trade barriers and hence the scope of the reforms can be gauged from the fact that according to Panagariya (2004), in 1990-91 the highest tariff rate stood at 355%, the simple average of all tariffs at 113% and the import-weighted average of tariff rates at 87%.

industries that were deregulated in 1991 and 1993. Our estimation equation is

$$\begin{aligned} y_{ijts} &= \delta_0 + \delta_t + \gamma_j + \beta_0 D80_{jt} + \beta_1 NotExempt_{it} + \beta_2 Post91_t \\ &+\beta_3 D80_j NotExempt_{it} + \beta_4 D80_j NotExempt_{it} Post91_t \\ &+\beta_5 D80_j Post91_t + \eta X_{jts} + \epsilon_{jts} \end{aligned} \quad (3.4)$$

The coefficients β_0, β_1 and β_3 have the same interpretations as in Equation 3.3. The coefficient on $NotExempt_{it}D80_{jt}$ is the impact of de-licensing on the firms that were affected by it . The coefficient β_4 then measures impact of deregulation (conducted in the 1980s) on the affected population of firms in the post-trade reform period (Post-1991). Column 1 of Table 3.8 shows that this estimate is positive and significant. That is, the average productivity of affected firms (not exempt from licensing and in de-licensed industries) in the post-trade reform period was 8.4% higher than that of firms that were not deregulated during the 1980s. To get a sense of the impact of deregulation and trade relative to general macroeconomic trends we also present the coefficients on the year dummies below Table 3.8. In the second column of the table, we include the variable $D80_j * Post91_t$. We are worried that without this term, the coefficient on $Notexempt_{it}D80_jPost91_t$ might be capturing differential trends in productivity in de-licensed industries, post 1991. As Column 2 shows, the coefficient β_4 declines in magnitude after we control for this and significant at the 16% level. We do not include an interaction of $NotExempt_{it}$ and $Post91_t$ since size-based exemption of firms from licensing provisions was no longer a government policy after the reforms of 1991.

In Column 3 of Table 3.8, we check the robustness of our results by running within-firm regressions using our pseudo-panel. Note that even after controlling for $D80_j Post91_t$, there is 13% higher productivity for firms that were deregulated in the 1980s, in the post-1991 period. This confirms our main result that firms that were affected by de-licensing during the 1980s performed better than other firms in the post-1991 period. This points towards a complementarity relationship between trade and industrial policy. That is, a rise in domestic competition raises the marginal response to a trade reform episode.

To assess the immediate and medium-term impact of trade reforms, in Column 4 of Table 3.8 we split the post 1991 period into two subperiods. We define $Trade1 = 1$ if year is 1991 or 1992, 0 otherwise, and $Trade2 = 1$ if year is 1993 or 1994, 0 otherwise, and interact $NotExempt_{it} D80_{jt}$ with both of these variables. As we can see from Table 3.8, the immediate short-term impact of the trade reforms was higher productivity for firms that were affected by de-licensing during the 1980s while the medium term impact is insignificant. As we get more firm-level data for the post-1991 period, we might be able to draw firmer conclusion about the short-, medium- and long-term impact of these reforms.

3.7.2 Testing Predictions from Theory

The theoretical model in Chapter 2 postulates a two-step relationship between trade and industrial policies and the innovation incentives of the firm. The first is the link between trade policy and innovation incentives. The second is the link between industrial policy (deregulation) and the response of innovation to trade reform.

The link between trade policy and innovation incentives is mediated by the technological status of the industry. Specifically, trade liberalization encourages innovation in industries that are more advanced technologically and discourages innovation in other industries. The intuition for this result is that not-so-advanced industries know that they will not be able to compete with foreign firms (assumed to be very advanced) and would prefer to cut their losses by not investing in technology. On the other hand, advanced industries realize that they have a good chance of deterring entry by foreign competitors if they invest in technology and manage to become productive enough to deter entry by foreign firms.

The second link is that between industrial policy and innovation. Our theory postulates that there is a relationship between trade and industrial policies vis their effect on a firm's incentives to invest in innovation. That is, under certain conditions[20] an industry that faces more domestic competition will have a higher marginal response to the higher threat of entry following a trade liberalization episode. A technologically advanced industry will raise its investment in productivity in response to a more competition from abroad, but this response will be higher when he faces more competition at home.

This strategic complementarity relationship means that productivity will be higher in industries that are initially more competitive (in the case of India, due to

[20]The condition is that there is a high degree of monopolistic distortion prior to industrial deregulation. That is, the price-cost margin of the industry is above a certain level. This condition will be true for industries that were subject to industrial licensing since by default, entry into the industry was determined exogenously and was not a result of market forces.

industrial deregulation that removed barriers to entry into industry) and now face a higher threat of entry from foreign competitors. Further given the relationship between the technological nature of the industry (advanced or backward) and trade reform, this positive relationship between industrial deregulation and trade reform rises as the industry becomes more advanced i.e. improves in technology. This translates into a prediction of higher productivity in industries that were deregulated in the 1980s and had higher productivity (i.e. were more advanced), in the post-1991 period.

There are two points to note about our result. The first is that we do not explicitly model trade. That is, the trade reform is modeled as a rise in the threat of entry from foreign competitors and advanced industries react by competing while backward industries by retreating. That is, the only impact of trade that we are interested in comes through the resultant increase in competition. The second point to notice is that in our case, industrial deregulation was followed by a rise in competition *due to a trade reform episode*.

Thus, an interesting test of our predictions from the theory is the following. Do industries that were affected by the first rise in competition during the 1980s and were technologically advanced as a result of that, become more productive after the second rise in competition during the 1990s?

We try a direct test of our theoretical prediction by analyzing the performance of firms in industries that were deregulated in the 1980s, in the period after 1991. Note that de-licensing in the 1980s occurred in the years 1984, 1985, 1986 and 1987. So the period 1988-1990 can be used to measure the medium-term impact of de-licensing in the absence of trade reform. The period 1991-94 can be used to measure the immediate impact of the trade reform episode.

Now we include a variable to indicate the technological status of an industry. We define the technological status of an industry based on its performance in the years 1983 and 1988. We define

$$Initial_j = \begin{cases} 1 & \text{industry j has higher productivity in 1988 compared to 1983} \\ 0 & \text{otherwise} \end{cases}$$

Our regression equation, which we estimate for the period 1988-94, is given below

$$y_{ijts} = \beta_0 + \delta_t + \zeta_j + \gamma_0 Initial_j Post91_t + \gamma_1 D80_j + \gamma_2 D80_j Post91_t + \gamma_3 D80_j Intial_j Post91_t + \eta X_{ijts} + \epsilon_{ijts} \tag{3.5}$$

Here y_{ijts} is the productivity of firm i industry j at time t, located in state s. The coefficient on $Initial_j Post91_t$ is a test of our prediction that technologically advanced industries perform better after a trade reform episode. The coefficient on $D80_j Intial_j Post91_t$ is a test of our prediction that the marginal response to trade reform rises as the industry faces more competition domestically. Thus $\gamma_3 > 0$ will confirm our prediction that industries respond more aggressively to trade reform if they face more competition domestically[21]. We include $D80_j$ to control for any special features that these industries may have. We include $D80_j Post91_t$ to control

[21] In our definition of the initial productivity status of the industry there is an implicit assumption of spill-overs from deregulation. As mentioned earlier, only Not Exempt firms were under the ambit of licensing and hence were affected by de-licensing. Since we define *Initial* using the average productivity of an industry, both exempt and non-exempt firms are included in the calculation of

to allow for heterogenous response to the macroeconomic shock in the deregulated industries.

In Table 3.10 we present the estimates of this equation for the period 1988-94. In Column 1 we control for 2-digit industry-year effects (to control for time-varying heterogeneity in industry growth paths), state effects and firm-level controls like ownership, organization, location etc. These are within-industry regressions. We use 4-digit industry effects and since $D80_j$ varies at 4-digit industry, γ_1 is not identified. However the coefficient of interest is identified. As Column 2 shows γ_3 is positive and significant. Thus, industries that were de-regulated in the 1980s and were technologically advanced did better in the period of high competition following trade reform[22].

An important point to note from Column 1 is that the coefficient on γ_2 is negative and insignificant. That is, industries that were deregulated during the 1980s on average performed the same or worse in the post-1991 period. However the impact of $D80_j$ in the post-1991 period is $\gamma_2 + \gamma_3 \times Initial_j$. Thus an advanced

Initial. Thus, the implicit assumption is that there were spill-overs from the de-licensing of Not Exempt firms on the productivity of Exempt firms. This could be because Exempt firms were forced to deal with freer entry post-reforms, in all types of firms. This means that industries where the Exempt firms also became more productive after de-licensing are more likely to have done well between 1983 and 1988.

[22]In the context of our discussion of the definition of Initial, this result implies that industries where even the Exempt firms became more productive after de-licensing, raising average industry productivity, did really well after trade reforms. Thus, the impact of trade reforms is enhanced when there are productivity spill-overs to firms that were not affected by de-licensing.

industry that was deregulated in the 1980s had 17.8% higher productivity on average in the post-1991 period (since γ_2 is not significant).

Note that γ_0 is negative. That is, industries that were doing well during the 1980s performed worse after trade reforms. However, the total impact of trade reforms is $\gamma_0 + \gamma_3$ for advanced industries that were deregulated during the 1980s and this is positive. One possible reason for the negative impact of trade reform on advanced industries could be that there is no notion of comparative advantage in our model and estimation. It is possible that some industries may be technologically advanced prior to trade reform but they collapse after trade reforms since they do not have a comparative advantage in that product. As a caveat, in a differentiated product model such as ours, some goods in all industries could be exported after trade reform unless firm productivity falls too low and it can not overcome a trading cost.

In Column 2 we present results for when we control for 3-digit industry rather than 4-digit. The purpose of this is to be able to identify the coefficient on $D80_j$. This analysis bears out our basic results. The coefficient γ_3 is positive confirming the strategic complementarity relationship between trade and industrial policy. The total impact of deregulation during the 1980s was to raise the post-1991 productivity of those industries ($\gamma_1 + \gamma_2$) by 6.6%.

It is interesting to note that our results are very similar to the ones presented here when we try a very different measure of whether the firm is advanced or not. Rather than comparing inter-temporal advance in the technical status of the industry, we compare average productivity of each industry with the maximum productivity in that industry in the year 1988. That is, we take into account not only the highest productivity in an industry but also the dispersion of firms according to productivity, within the industry. And our main result, that industries that are more productive and were deregulated during the 1980s performed better after the reforms of 1991 holds. That is, this very different measure of distance from the technological frontier also provides evidence of the strategic complementarity relationship between trade and industrial policy. However here too we get the puzzling result that industries that are closer to the frontier, perform worse after 1991[23].

Our preliminary and simple tests show that firms in industries that were delicensed in the 1980s and hence faced a more competitive, market-oriented environment as well as lesser restrictions on their abilities during the 1980s, performed better after a trade reform episode as compared to firms in industries that were

[23] A possible explanation for this result is a composition effect. Our measure of the technological status of the industry takes in to account average industry productivity and compares it with the maximum industry productivity. Suppose that firms are heterogenous in productivity within an industry and there are fixed and variable costs to exporting (a Melitz (2003) set-up). After trade reforms, firms with the lowest productivity exit (or supply only the domestic market) while the highest productivity firms expand and their labor productivity rises. Keeping in mind our definition of the frontier, in an industry where there are many productive firms, trade reform could lead to a decline in recorded productivity since these firms lose sales to foreign varieties. In an industry with a large dispersion of productivity, the least productive firms exit while the most productive firms expand and record even higher output per worker. Thus industries that are "advanced" see a decline in productivity while the "backward" ones see a rise in productivity. This point again reveals that integrating an explicit trade model into our model might yield interesting and important predictions

not de-regulated in the 1980s. Thus the strategic complementarity relationship postulated by our theory seems to hold for the case of India. Future work that ties together our theory with a trade model may shed more light on the our model and predictions.

3.8 Conclusions and Future Work

In this chapter we use two unique data sets, the institutional features of Indian policy and the interesting chronology of reforms in India to address two issues. The first is whether industrial de-regulation that increases the level of competition that a firm has to face leads affects firm-level productivity. We find the answer to this is affirmative. Confirming our intuition as well as predictions from our theoretical model we find that firms that were affected by de-licensing had higher labor productivity than non-affected firms. Thus, lesser controls on ability as well as more competition and a higher threat of potential entry spur firms to perform better. We solve the problem of industry-level omitted variables that may bias our estimates by using the fact that some firms were exempt from licensing. By differencing over these two types of firms we are able to get consistent, unbiased estimates of the impact of reforms.

The second issue that we address is whether there is a relationship between industrial deregulation and trade reform. Given the chronology of reforms in India, what happened to the productivity of the firms that were in industries deregulated during the 1980s *after the trade reforms of 1991*? We find that firms in industries that were de-licensed in the 1980s and had higher productivity as a result of that tended to have higher productivity post-1991.

Our results are robust to the inclusion of a wide variety of firm- and industry-level controls and fixed effects. One implication of using fixed-effect methods to assess the impact of reforms is that we can test an implication of our identification assumption-for the set of industries were exemption from licensing was not available there should be no variation in the performance of firms due to de-licensing around the threshold for licensing-and we find that this assumption holds. In another specification test, we check for the significance of randomly chosen thresholds for licensing and find that only the official threshold matters with respect to differential performance in exempt and not exempt firms. Further we find no evidence of bunching of firms around the threshold for licensing and no evidence of firms choosing their exemption status based on anticipations of de-licensing reform. We also construct a panel of firms to test the robustness of our estimates to the inclusion of firm fixed effects.

Our results have interesting policy implications. An important one is that domestic competitive environment can be used to prepare firms in the economy for trade reforms. Under competition from high-productivity foreign firms, domestic firms that are not productive may want to cut their losses and not invest in productivity-enhancing technology. However, a rise in the level of domestic competition and lesser controls on microeconomic decisions can spur these firms to make investments in technology prior to facing competition from abroad and hence prepare them for an even more competitive environment.

There are several important issues that remain to be answered about the Indian reforms. The first is the debate about the unexplained rise in the total factor productivity of Indian manufacturing prior to the reforms of 1991 (Delong (2001), Panagariya (2001), Panagariya (2002), Panagariya (2004)). Our estimates of labor productivity reveal that there was rise in productivity during the 1980s and that this was the result of de-licensing. We can extend this study to other measures of productivity and assess whether total factor productivity rose as a result of de-licensing.

Another issue is that of the mechanism through which de-licensing affected firm productivity. Our current estimates measure both the impact of removal of controls on ability as well as incentives. It may be possible to delineate the role of firm-level incentives to invest in technology as a result of more competition from the role of firm-level ability to invest in technology as a result of de-regulation. Licensing curbed the ability of the firm because many firm-level decisions (location, amount produced etc) were decided by licensing authorities. We have detailed information on these policies and analysis may shed more light on the issue of ability vs. incentives as well as on the role of locational or output constraints.

We can test another prediction from our theoretical model that the productivity is affected by the level of competition in your own sector as well as the level of competition in your upstream sector(Propositions 3 and 4, Section 2.3.3). The intuition for this result is that a reduction in the monopolistic distortion in the upstream sector raises the bargaining power of the downstream sector, allowing it to recoup more of the surplus from its investment in technology. Thus, even if the downstream industry is not deregulated there should be a rise in its productivity if its principal upstream buyer is deregulated. Using input-output matrices for the 1980s and 1990s we can identify the principle buying sector for each industry and test this prediction.

We also plan to assess the impact of a firm's technological status (as opposed to an industry's technological status) on its response to more competition from abroad. For this, we can use our pseudo-panel of firms to identify those firms that saw an increase in their productivity between 1980 and 1990 and showing that they experience an increase in productivity after 1991 greater than the ones that did not see a rise in productivity between 1980 and 1990.

Finally, as mentioned earlier it might be very informative and interesting to try to incorporate a trade model into our simple theoretical framework in order to gain more insight in to the mechanisms through which trade can affect firm-level productivity.

Tables

	All Output	Factory Output	All Value Added	Factory Value Added
1984	7.00	7.10	10.00	10.10
1985	18.30	20.30	27.70	29.00
1986	3.80	3.60	3.70	3.70
1987	26.50	27.90	32.70	32.50
1991	59.10	58.30	56.90	56.30
1992	0.00	0.00	0.00	0.00
1993	2.60	2.80	3.20	3.20

Table 3.1: Percentage of Output and Value Added De-licensed in each year. Source: Annual Survey of Industries; "Guidelines for Industry", Ministry of Industry (various issues) and own calculations. Note: Factories are defined as enterprizes using power in the production process and 50 or more workers or enterprisers not using power in the production process and 100 or more workers. According to the act under which licensing was promulgated in India, these factories were the ones under licensing.

Year	Inverse of Sampling Probability		
	1	2	3
1980	13,345	2,880	0
1981	13,746	2,910	0
1982	14,771	2,913	0
1983	13,883	2,319	0
1984	13,398	2,240	0
1985	13,785	2,439	0
1986	13,747	2,236	0
1987	11,080	2	2,786
1988	11,183	1	2,804
1989	11,195	186	2,880
1990	10,894	321	2,801
1991	11,202	353	2,752
1992	11,739	289	3,183
1993	11,915	312	3,413
1994	12,607	349	3,380

Table 3.2: Characteristics of the data

Variable	Mean	Std. Dev.
Not Exempt Firms (Observations=12825)		
Ln (Output per Worker)	8.6	1.113734
Real Output (1993-94 Rs.)	1.25E+07	2.95E+07
Book value of Assets in Plant, machinery, land and building (Rs.)	4.45E+08	1.98E+09
Employees	1814.088	3369.832
Exempt Firms (Observations=286567)		
Ln (Output per worker)	7.22921	1.452706
Real Output (1993-94 Rs.)	591649.6	1333756
Book value of Assets in Plant, machinery, land and building (Rs.)	6612464	1.53E+07
Employees	219.8095	683.028

Table 3.3: Summary Statistics for All Factories. Factories are defined as enterprizes using power in the production process and 50 or more workers or enterprizes not using power in the production process and 100 or more workers. According to the act under which licensing was promulgated in India, these factories were the ones under licensing. Not exempt firms are those that were under licensing, exempt firms are those that were granted an exemption from licensing based on the size of their assets.

	Exempt Firms in Licensed Industries		
	Mean	Median	75th Percentile
1980s	16.99	17.13	17.77
1980-83	26.26	29.73	23.81
1984-89	6.70	11.52	12.97
	Exempt Firms in De-licensed Industries		
	Mean	Median	75th Percentile
1980s	15.45	14.09	15.96
1980-83	20.04	16.96	19.39
1984-89	7.05	10.88	10.53

Table 3.4: Average Annual Rates of Growth of Assets(%). Schedule IV and V industries are not included here. Assets refers to the book value of assets in plant, machinery, land and building.

Note: For Tables 3.5 to 3.10, *** refers to significance at the 1% level, ** to 5% and * to 10% level. Controls are ownership, organization, location of the firm, whether large firms were allowed to enter the industry, wage to rental ratio. The dependant variable is log(Output per worker). Each observation is weighted by its sampling probability. $NotExempt_{it} = 1$ if firm was under licensing requirements, $De_{jt} = 1$ if industry was de-licensed in year t. For all regressions standard errors are clustered around 4-digit industry.

	Baseline	Baseline 1980-90	Industry-trend	Industry-trend 1980-90
NotExempt	0.593***	0.587***	0.607***	0.598***
	[0.100]	[0.096]	[0.096]	[0.096]
De	-0.055***	-0.093**	-0.064***	-0.067**
	[0.021]	[0.042]	[0.020]	[0.033]
De*NotExempt	0.161**	0.148	0.132*	0.102
	[0.078]	[0.112]	[0.073]	[0.114]
Constant	6.252***	6.428***	6.187***	6.412***
	[0.150]	[0.209]	[0.134]	[0.170]
Observations	172297	125898	172297	125898
R-squared	0.51	0.52	0.51	0.53
Industry-Trend (3-digit)	No	No	Yes	Yes
Industry FE (4-digit)	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Table 3.5: Baseline Results. These regressions do not include Schedule IV and Schedule V industries.

	Ind-Year Effects	Ind-Year 1980-90	Winsorised	Ind-State -Year Effects
NotExempt	0.612***	0.595***	0.590***	0.673***
	[0.097]	[0.098]	[0.093]	[0.022]
De	-0.008	-0.015	-0.01	0.338***
	[0.024]	[0.029]	[0.023]	[0.037]
De*NotExempt	0.128*	0.128	0.113*	0.094***
	[0.070]	[0.109]	[0.067]	[0.032]
Constant	6.260***	6.608***	6.270***	6.415***
	[0.148]	[0.220]	[0.153]	[0.037]
Observations	172297	115357	172297	172297
R-squared	0.51	0.53	0.52	0.62
Industry-Year (2-digit)	Yes	Yes	Yes	No
Ind-State-Year Effects	No	No	No	Yes
Industry FE (4-digit)	Industry FE (4-digit)	Yes	Yes	Yes
State FE	State FE	Yes	Yes	Yes
Year FE	Year FE	Yes	Yes	Yes

Table 3.6: Robustness Checks. These regressions do not include Schedule IV and V industries.

	Base	Industry-Year Effects	1980-90
	1	2	3
NotExempt=1	0.126***	0.141***	0.109***
	[0.032]	[0.033]	[0.036]
De=1	-0.048**	-0.03	-0.0405
	[0.024]	[0.026]	[0.034]
De*NotExempt	0.105**	0.077*	0.079*
	[0.044]	[0.040]	[0.048]
Constant	7.323***	7.370***	6.81***
	[0.053]	[0.072]	[0.071]
Observations	94714	94714	68348
R-squared	0.05	0.07	0.06
Number of group(id23)	33207	33207	26065
Industry Effects	Yes	Yes	Yes
State Effects	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes
Industry-Year Effects	No	Yes	Yes

Table 3.7: Results for Pseudo-Panel of firms. These are within-firm regressions. In columns 2 and 3 we include 2-digit industry effects interacted with year effects.

	Baseline	Baseline Robust	Pseudo-Panel	Medium & Short run
NotExempt	0.644***	0.644***	0.150***	0.644***
	[0.094]	[0.094]	[0.027]	[0.094]
D80	0.027	0.013	-0.082***	0.027
	[0.032]	[0.030]	[0.031]	[0.032]
NE*D80	0.058	0.066	0.054	0.058
	[0.112]	[0.112]	[0.035]	[0.112]
NE*D80*Post91	0.084*	0.067†	0.137***	
	[0.046]	[0.048]	[0.045]	
D80*Post91		0.038	-0.002	
		[0.035]	[0.041]	
NE*D80*Trade1				0.141***
				[0.046]
NE*D80*Trade2				0.042
				[0.058]
Post91	0.788***	0.784***	0.426***	
	[0.126]	[0.128]	[0.035]	
Trade1				0.856***
				[0.118]
Trade2				1.053***
				[0.141]
Constant	6.259***	6.258***	7.210***	6.258***
	[0.148]	[0.148]	[0.020]	[0.148]
Observations	172297	172297	95639	172297
	0.51	0.51	0.04	0.51
2-digit Industry-Year effects	Yes	Yes	Yes	Yes
Industry Effects	4-digit	4-digit	4-digit	4-digit
State Effects	Yes	Yes	Yes	Yes

Table 3.8: Impact of Trade Reforms. These regressions do not include Special industries. † represents significance at the 16% level.

	Baseline	Baseline Robust	Pseudo-Panel	Medium & Short run
1981	0.126***	0.126***	0.050***	0.126***
	[0.035]	[0.035]	[0.016]	[0.035]
1982	0.096**	0.096**	0.050***	0.096**
	[0.042]	[0.042]	[0.015]	[0.042]
1983	0.194***	0.194***	0.076***	0.194***
	[0.050]	[0.050]	[0.023]	[0.050]
1984	0.442***	0.443***	0.135***	0.442***
	[0.093]	[0.092]	[0.024]	[0.093]
1985	0.562***	0.564***	0.233***	0.562***
	[0.098]	[0.097]	[0.034]	[0.098]
1986	0.595***	0.597***	0.254***	0.595***
	[0.113]	[0.111]	[0.031]	[0.113]
1987	0.582***	0.585***	0.250***	0.582***
	[0.106]	[0.104]	[0.029]	[0.106]
1988	0.737***	0.740***	0.315***	0.737***
	[0.132]	[0.131]	[0.031]	[0.132]
1989	0.784***	0.787***	0.405***	0.784***
	[0.116]	[0.114]	[0.032]	[0.116]
1990	0.710***	0.712***	0.455***	0.710***
	[0.078]	[0.077]	[0.029]	[0.078]
1991	0.068**	0.068**	0.029	0.068**
	[0.032]	[0.032]	[0.026]	[0.033]
1992	0.070**	0.054**	-0.022	-0.068**
	[0.031]	[0.030]	[0.020]	[0.032]
1993	0.074**	0.074**	-0.027	-0.190***
	[0.030]	[0.029]	[0.017]	[0.032]
1994	0.265***	0.264***	0.029	0.068**
	[0.052]	[0.052]	[0.026]	[0.034]

Table 3.9: Year Effects in Trade Regression

	Within 4-digit industry	Within 3-digit industry
Initial*Post91*D80	0.178**	0.511***
	[0.074]	[0.121]
Initial*Post91	-0.084**	-0.161**
	[0.042]	[0.063]
D80		0.477***
		[0.156]
D80*Post91	-0.113	-0.411***
	[0.071]	[0.110]
Constant	6.567***	6.546***
	[0.202]	[0.199]
Observations	75476	75476
R-squared	0.46	0.44
2-digit Industry Year effects	Yes	Yes
Industry Effects	4-digit	3-digit
State Effects	Yes	Yes
Year Effects	Yes	Yes

Table 3.10: Impact of Trade Reforms on Advanced Industries. These regressions do not include Special industries.

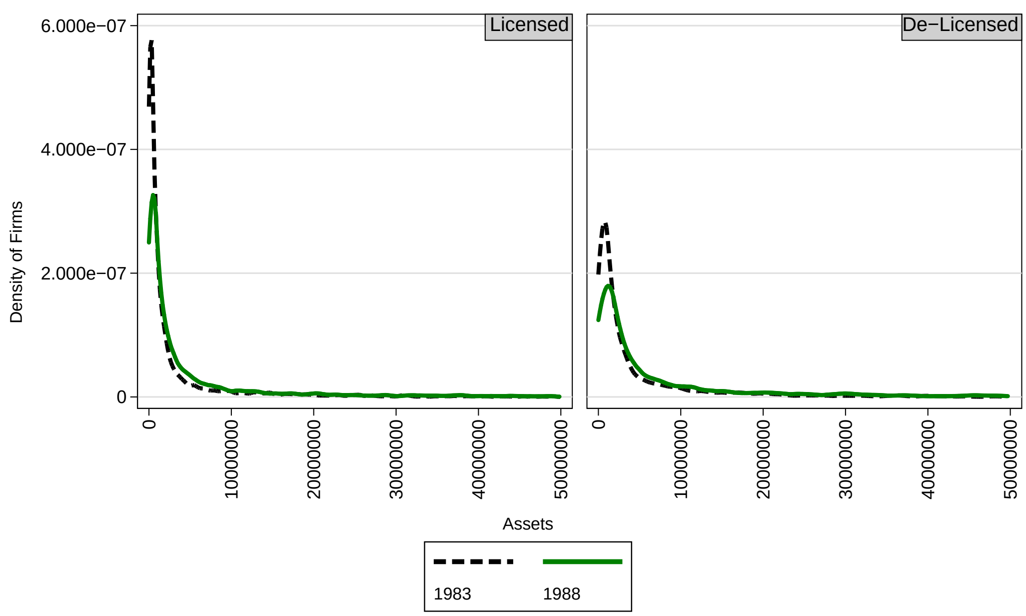

Figure 3.1: Distribution of Assets of Exempt firms: Assets≤Rs.50 million.

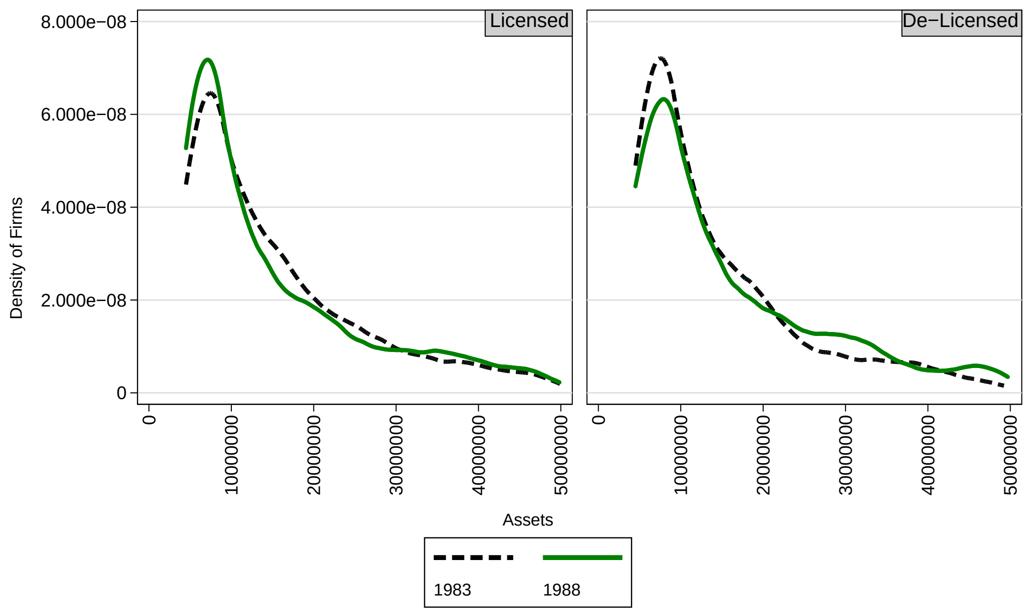

Figure 3.2: Distribution of Assets of Exempt firms: Rs.50 million≥Assets>Rs.4.5 million.

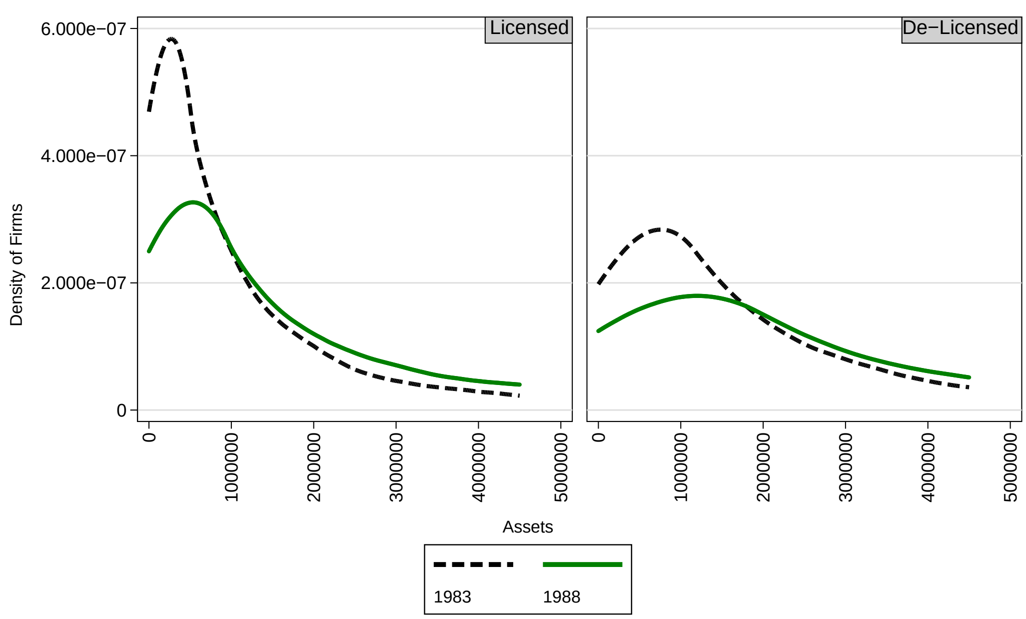

Figure 3.3: Distribution of Assets of Exempt firms: Assets≤Rs.4.5 million.

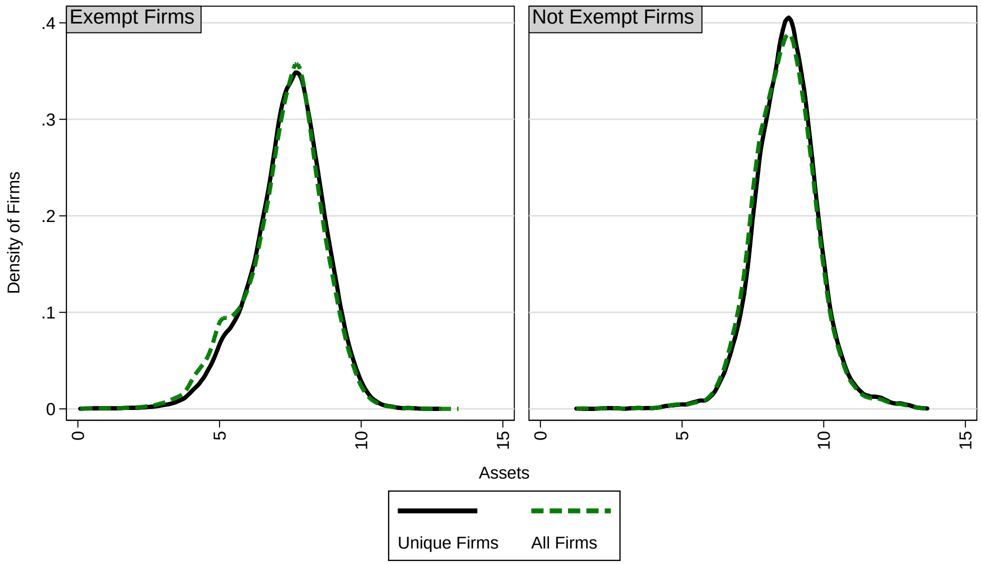

Figure 3.4: Distribution of Productivity in the Pseudo-panel. The solid line represents the distribution of unique firms-those that were assigned a firm id number. The dashed line represents all firms.

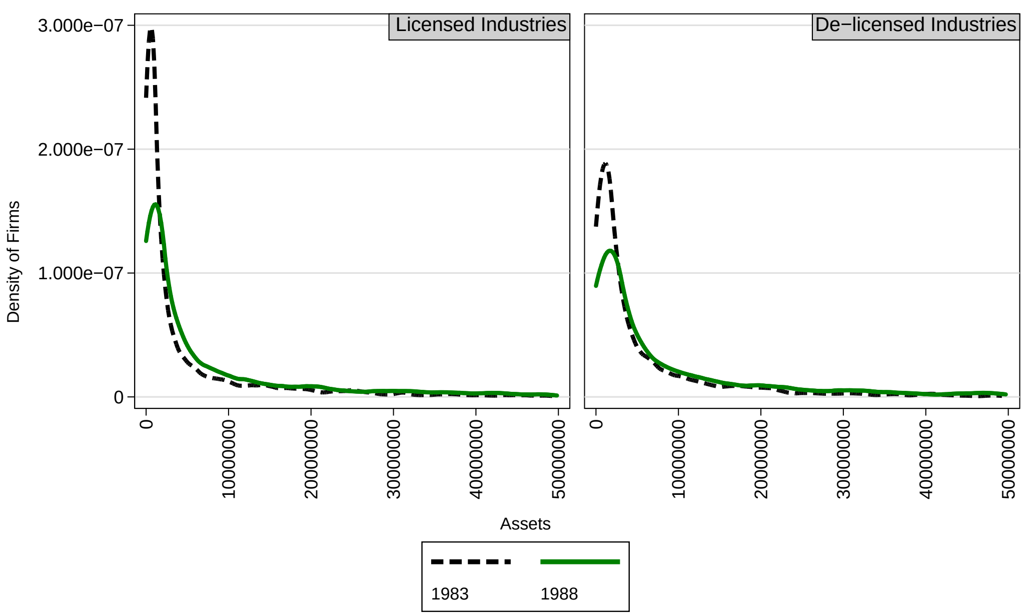

Figure 3.5: Distribution of Assets of Exempt Firms in the Pseudo-panel. The dashed line represents the distribution of unique firms in 1983, the solid line in 1988.

Appendix A

Appendices to Chapter 2

A.1 Proof of Equations 2.20 and 2.21

The equation for equilibrium investment by an advanced IG producer when the FG sector is assumed to be perfectly competitive is given by Equation 2.19.

$$\begin{aligned} z_A &= \alpha^{\frac{1}{1-\alpha}} (\chi - \Omega) \chi^{\frac{-1}{1-\alpha}} L_{Ot} \left[(1+g)^{\frac{\delta}{1-\alpha}} - (1-\mu) \right] \\ &= K (\chi - \Omega) \chi^{\frac{-1}{1-\alpha}} L_{Ot} \end{aligned} \tag{A.1}$$

Here $K \equiv \alpha^{\frac{1}{1-\alpha}} \left[(1+g)^{\frac{\delta}{1-\alpha}} - (1-\mu) \right]$. In the above equation, L_0 refers to the demand for labor by the FG sector that is given by the following equation.

$$L_O = \left(1 + \alpha^{\frac{1}{1-\alpha}} \left(\frac{1-\beta}{\beta w} \right)^{\beta} \chi^{\frac{-1}{1-\alpha}} A^* \right)^{-1} \bar{L} \tag{A.2}$$

We want to analyze the effect of a rise in χ, the price that the IG monopolist can charge on his incentives to invest in productivity. That is, we wish to obtain the total derivative of z_A with respect to χ keeping in mind that χ is a function of the parameter w, the wage rate in the economy. The relationship between χ and w is given by the equation

$$\chi = \frac{1}{\alpha} \left[\left(\frac{w\beta}{1-\beta} \right)^{-\beta} + \left(\frac{w\beta}{1-\beta} \right)^{1-\beta} \right] \tag{A.3}$$

Thus, any change in the wage rate will affect χ and hence z_A.

For algebraic tractability as well as to get a meaningful expression for $\frac{dz_a}{d\chi}$, we make the simplifying assumption that both w and $\bar{L}$ change such that the allocation of labor between the intermediate and final goods sector is unchanged. That is, we allow w and $\bar{L}$ to change such that $dL_0 = 0$. Thus, a change in the total endowment of labor $\bar{L}$ occurs (holding L_0 constant) and this leads to a change in the equilibrium wage rate w (we explore the direction of this change below). In turn, a wage in w results in a change in χ which affects the incentives of an firm to invest.

First we investigate the impact of a change in the labor endowment on the wage rate. From Equation A.2, we see that

$$dL_0 = \frac{-\bar{L}}{D^2}dD + \frac{1}{D}d\bar{L} \tag{A.4}$$

where $D \equiv \left(1 + \alpha^{\frac{1}{1-\alpha}} \left(\frac{1-\beta}{\beta w}\right)^{\beta} \chi^{\frac{-1}{1-\alpha}} A^*\right)$. Setting $DL_0 = 0$, we get

$$d\bar{L} = L_0 dD = (-1)L_0\alpha^{\frac{1}{1-\alpha}} A^* \chi^{\frac{-1}{1-\alpha}} \left(\frac{1-\beta}{w\beta}\right)^{\beta} \left[\frac{1}{(1-\alpha)\chi}d\chi + \frac{\beta}{w}\chi^{\frac{-1}{1-\alpha}}dw\right] \tag{A.5}$$

Hence the total derivative of $\bar{L}$ with respect to w is given by

$$\frac{d\bar{L}}{dw} = (-1)L_0\alpha^{\frac{1}{1-\alpha}} A^* \chi^{\frac{-1}{1-\alpha}} \left(\frac{1-\beta}{w\beta}\right)^{\beta} \left[\frac{1}{(1-\alpha)\chi}\frac{d\chi}{dw} + \frac{\beta}{w}\chi^{\frac{-1}{1-\alpha}}\right] \tag{A.6}$$

Using the relationship between χ and w given by Equation A.3, we get the following equation for the total derivative of χ with respect to the wage rate w.

$$\frac{d\chi}{dw} = \frac{1}{\alpha}\frac{\beta}{w}\left(\frac{1-\beta}{w\beta}\right)^{\beta}(w-1) > 0 \tag{A.7}$$

Plugging this into Equation A.6, we get

$$\frac{d\bar{L}}{dw} = (-1)L_0\alpha^{\frac{1}{1-\alpha}}A^*\chi^{\frac{-1}{1-\alpha}}\left(\frac{1-\beta}{w\beta}\right)^{\beta}\left[\frac{1}{(1-\alpha)\chi}\frac{\beta}{w}\left(\frac{1-\beta}{w\beta}\right)+\frac{\beta}{w}\chi^{\frac{-1}{1-\alpha}}\right] < 0 \quad \text{(A.8)}$$

This means that when the total endowment of labor $\bar{L}$ rises such that there is no impact on the distribution of labor between the intermediate and final goods sector then wages in the economy will fall. Intuitively this makes sense– a rise in the supply of labor reduces wages in the economy.

Also note that from Equation A.7, a rise in the wage rate in the economy leads to a rise in the price of the other input as well. That is, χ rises when w rises (as a result of the change in the labor endowment). Intuitively, labor and the intermediate goods varieties are imperfect substitutes in the final goods production function. Thus when labor becomes more costly, the final goods producer tends to reduce his demand for labor and raise his demand for the intermediate goods varieties. This leads to an excess demand for intermediate varieties, leading to a rise in their price. Another way to think about the positive relationship between w and χ is that a rise in w contributes to rising marginal costs Ω in the IG sector. Given that each IG producer faces a constant elasticity of demand and constant marginal costs, he will charge a constant mark-up over costs $\frac{\chi-\Omega}{\chi} = \frac{1}{1-\alpha}$. This in turn means that when marginal costs rise as a result of a rise in w, in order to maintain a constant mark-up the IG monopolist will raise his price χ.

The basic equation for investment in technology (Equation A.1) tell us that the total derivative of z_A with respect to w is

$$\begin{aligned}\frac{dz_A}{dw} &= K\left[(\chi-\Omega)\,\chi^{\frac{-1}{1-\alpha}}\frac{dL_{Ot}}{dw}+L_{0t}\frac{d\,(\chi-\Omega)\,\chi^{\frac{-1}{1-\alpha}}}{dw}\right] \\ &= KL_{Ot}\left[\chi^{\frac{-1}{1-\alpha}}(\frac{d\chi}{dw}-\frac{d\Omega}{dw})-\frac{(\chi-\Omega)}{1-\alpha}\chi^{(\frac{-1}{1-\alpha})-1}\frac{d\chi}{dw}\right] \end{aligned} \tag{A.9}$$

In step one, the first expression inside the square brackets is zero because of our assumption that the distribution of labor between the two sectors remains unchanged as a result of a change in w and $\bar{L}$. That is, $dL_0 = 0$. Now we use the relationship between χ and Ω given by $\chi = \alpha^{-1}\Omega$ to get $d\Omega = \alpha d\chi$. Substituting into the above expression we get

$$\begin{aligned}\frac{dz_A}{dw} &= KL_{Ot}\chi^{\frac{-1}{1-\alpha}}\left[(1-\alpha)\frac{d\chi}{dw}-\frac{(\chi-\Omega)}{(1-\alpha)\chi}\frac{d\chi}{dw}\right] \\ &= KL_{Ot}\chi^{\frac{-1}{1-\alpha}}\left[\frac{((1-\alpha)^2-1)\chi+\Omega}{(1-\alpha)\chi}\right]\frac{d\chi}{dw}\end{aligned} \tag{A.10}$$

In order to decide the sign of this expression, we use the fact that $\frac{d\chi}{dw} > 0$ (from Equation A.7) and that $0 < \alpha < 1$. This means that $((1-\alpha)^2 - 1) < 1$ and hence,

$$\frac{dz_A}{dw} > 0 \Leftrightarrow \frac{dz_A}{d\chi} > 0 \text{ if } \Omega > (1-(1-\alpha)^2)\chi \Rightarrow \Omega \geq \alpha\chi \tag{A.11}$$

And the condition specified above holds when $\Omega \geq \alpha\chi$[1]. That is, at the profit maximizing price of $\chi = \frac{1}{\alpha}\Omega$, the investment response of an intermediate goods firm

[1]To see this, assume that $\Omega = \alpha\chi$. Then the condition $\Omega > (1-(1-\alpha)^2)\chi$ becomes $\alpha\chi > (1-(1-\alpha)^2)\chi \Rightarrow 1-(1-\alpha)^2 > \alpha \Rightarrow 1-(1-\alpha)^2-\alpha > 0$. The last condition is true for $\alpha > 0$. Thus, our initial assumption holds.

to a change in the price that it can charge (χ) is positive. That is, a fall in market power of the intermediate goods firm (as a result of a change in w and $\bar{L}$) will lead to a decline in the incentives of the firm to invest in productivity enhancing technology. Note that to get the result in Equation A.11, we use the result in Equation A.7 that a rise in wages (as a result of a change in $\bar{L}$) will lead to a rise in χ.

In order to see the result in Equation 2.21, note that from Equation A.1, $sign(\frac{d^2 z_A}{d\mu d\chi}) = sign(\frac{dK}{d\mu}) \times sign(\frac{dz_A}{d\chi})$. The definition of K for an advanced IG firm is $K \equiv \alpha^{\frac{1}{1-\alpha}} \left[(1+g)^{\frac{\delta}{1-\alpha}} - (1-\mu)\right]$. Hence, $sign(\frac{dK}{d\mu}) > 0$ and $sign(\frac{d^2 z_A}{d\mu d\chi}) > 0$ for an advanced firm. For a backward firm $K \equiv \alpha^{\frac{1}{1-\alpha}} \left[(1-\mu)(1+g)^{\frac{\delta}{1-\alpha}}\right]$. Hence, $sign(\frac{dK}{d\mu}) < 0$ and $sign(\frac{d^2 z_A}{d\mu d\chi}) < 0$

A.2 Cost Minimization Exercise of FG Monopolist

The final goods producer solves the cost maximization problem given below.

$$C(p(v), y) = Min_{L_{ot}, x(v), v\epsilon(0,1)} w_t L_{ot} + \int_0^1 p(v)x(v)dv \tag{A.12}$$

subject to $y_t \leq \frac{1}{\alpha} {L_{0t}}^{1-\alpha} \left[\int_0^1 A_t(v)^\delta x_t(v)^\alpha dv\right]$.

This yields first order conditions

$$\frac{w}{p(v)} = \left(\frac{1-\alpha}{\alpha}\right) \frac{(\int_0^1 A_t(v)^\delta x_t(v)^\alpha dv)}{L_o A(v)^\delta} x(v)^{1-\alpha} \tag{A.13}$$

$$\frac{p(v)}{p(v')} = \left(\frac{A(v)}{A(v')}\right)^\delta \left(\frac{x(v')}{x(v)}\right)^{1-\alpha} \tag{A.14}$$

Using the second set of first order conditions, we can get x(v') as a function of x(v)

$$x(v') = \left(\frac{A(v')}{A(v)}\right)^{\frac{\delta}{1-\alpha}} \left(\frac{p(v)}{p(v')}\right)^{\frac{1}{1-\alpha}} x(v) \text{ for all v'} \tag{A.15}$$

Using the above expression we can solve for $(\int_0^1 A_t(v)^\delta x_t(v)^\alpha dv)$ in terms of x(v),

$$\int_0^1 A_t(v)^\delta x_t(v)^\alpha dv = \frac{x(v)^\alpha p(v)^{\frac{\alpha}{1-\alpha}}}{A(v)^{\frac{\alpha\delta}{1-\alpha}}} \left[\int_0^1 A(v)^{\frac{\delta}{1-\alpha}} p(v)^{\frac{-\alpha}{1-\alpha}} dv\right] \tag{A.16}$$

Using this expression in Equation A.13 we get the derived demand for variety v as

$$x(v) = \frac{\alpha w L_{ot}}{1-\alpha} \left[\frac{A(v)^{\frac{\delta}{1-\alpha}}}{p(v)^{\frac{1}{1-\alpha}}}\right] \bar{A}^{-1} \tag{A.17}$$

where $\bar{A} \equiv \int_0^1 A(v)^{\frac{\delta}{1-\alpha}} p(v)^{\frac{-\alpha}{1-\alpha}} dv$ is the price-weighted average productivity in the IG sector. Note that the elasticity of demand is constant and hence a profit maximizing monopolist producer in the intermediate goods sector will charge a constant mark-up over costs. That is, $p(v) = \chi$ for all varieties v. Plugging this into the derived demand function, we get

$$x(v) = \frac{\alpha w L_{ot}}{1-\alpha} \left[\frac{A(v)^{\frac{\delta}{1-\alpha}}}{\chi A^*}\right] \tag{A.18}$$

where $A^* \equiv \int_0^1 A(v)^{\frac{\delta}{1-\alpha}} dv$ is the average quality in the intermediate goods sector.

Now we can use the above expression in the production function to get the derived demand for labor by the final goods sector as a function of the output of the final goods sector. Final goods sector output is given by $y = {L_o}^{1-\alpha} \int_0^1 A_t(v)^\delta x_t(v)^\alpha dv = \left[\frac{w\alpha}{(1-\alpha)\chi}\right]^\alpha {A^*}^{1-\alpha} L_o$. And so labor demand is $L_o = \left[\frac{(1-\alpha)\chi}{w\alpha}\right]^\alpha \frac{y}{{A^*}^{1-\alpha}}$. Now we can substitute for L_o in Equation A.18 to get an expression for derived demand for the intermediate good as a function of output y.

$$x(v) = \left[\frac{w\alpha}{1-\alpha}\right]^{1-\alpha}\left[\frac{A(v)^{\frac{\delta}{1-\alpha}}y}{\chi^{1-\alpha}A^{*2-\alpha}}\right] \tag{A.19}$$

So the cost function for the final goods monopolist is

$$\begin{aligned} C(p(v), y) &= Min_{L_{ot}, x(v), v\epsilon(0,1)} w_t L_{ot} + \int_0^1 p(v)x(v)dv \\ &= \left[w\left(\frac{1-\alpha}{w\alpha}\right)^{\alpha} + \left(\frac{1-\alpha}{w\alpha}\right)^{\alpha-1}\right]\chi^{\alpha}A^{*\alpha-1}y \end{aligned} \tag{A.20}$$

Note that the monopolist has constant marginal cost of production. His cost rises as χ, the price of intermediates, rises and falls as the average quality of the intermediates A^* rises.

A.3 Proof of Propositions 1 and 2

Now we come to the case where the final goods sector is a monopoly. Now

$$\begin{aligned} z_A &= \frac{\left[(1+g)^{\frac{\delta}{1-\alpha}} - (1-\mu)\right]}{A^{*2-\alpha}}(\chi - \Omega)\chi^{\alpha-1}\left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha} y_m \\ &= C(\chi - \Omega)\chi^{\alpha-1}\left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha} y_m \end{aligned} \tag{A.21}$$

Here $C \equiv \frac{[(1+g)^{\frac{\delta}{1-\alpha}} - (1-\mu)]}{A^{*2-\alpha}}$ and y_m refers to the monopoly output of the final goods sector firm and is given by the equation below.

$$y_m = \frac{1}{2b}\left[a - \frac{M\chi^{\alpha}}{A^{*1-\alpha}}\right] \tag{A.22}$$

Here M is the marginal cost of production faced by the FG sector firm. This is given by the expression

$$M \equiv w\left(\frac{1-\alpha}{w\alpha}\right)^{\alpha} + \left(\frac{1-\alpha}{w\alpha}\right)^{\alpha-1}$$

The total derivative of z_A (Equation A.21) is given by

$$dz_A = \left[\frac{\partial z_A}{\partial w}dw + \frac{\partial z_A}{\partial \chi}d\chi + \frac{\partial z_A}{\partial \Omega}d\Omega + \frac{\partial z_A}{\partial y_m}dy_m\right] \tag{A.23}$$

The first term in Equation A.23 represents the direct impact of a rise in w on the investment incentives of an IG firm and is given by

$$\frac{\partial z_A}{\partial w}dw = C\left(\frac{w\alpha}{1-\alpha}\right)^{-\alpha}\alpha(\chi-\Omega)\chi^{\alpha-1}dw > 0 \tag{A.24}$$

That is, the direct impact of a rise in the wage rate on investment in the IG sector is positive. This is because a rise in the wage rate reduces the demand for labor in the FG sector and props up the demand for intermediate goods.

The next two terms in Equation A.23 represent the indirect impact of a rise in w on z via its impact on the price χ and cost Ω in the IG sector.

$$\begin{aligned}
\frac{\partial z_A}{\partial \chi}d\chi + \frac{\partial z_A}{\partial \Omega}d\Omega &= C\left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha} y_m\left\{\chi^{\alpha-1}(d\chi-d\Omega)-(1-\alpha)\chi^{\alpha-2}(\chi-\Omega)d\chi\right\} \\
&= C\left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha} y_m(1-\alpha)\chi^{\alpha-1}\left\{d\chi - \frac{(\chi-\Omega)}{\chi}\right\}d\chi \\
&\quad (\text{ using } d\Omega = \alpha d\chi) \\
&= C\left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha} y_m(1-\alpha)\chi^{\alpha-2}\Omega d\chi > 0 \qquad \text{(A.25)}
\end{aligned}$$

The above expression tells us that the indirect response of investment z_A to a change in w via changes in χ and Ω is positive. A rise in Ω means a rise in costs for the intermediate goods sector firm and this has a negative impact on investment in productivity. However, an increase in χ ameliorates this negative impact since a rise in χ implies that the IG firm can appropriate more surplus from the FG sector by charging a higher price.

Thus, when we substitute these expressions into Equation A.23 we get

$$
\begin{aligned}
dz_A &= C\left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha} y_m(1-\alpha)\chi^{\alpha-2}\Omega d\chi + C\left(\frac{w\alpha}{1-\alpha}\right)^{-\alpha}\alpha(\chi-\Omega)\chi^{\alpha-1}dw \\
&+ C\left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha}(\chi-\Omega)\chi^{\alpha-1}dy_m \qquad \text{(A.26)}
\end{aligned}
$$

Hence,

$$
\begin{aligned}
C^{-1}\left(\frac{w\alpha}{1-\alpha}\right)^{\alpha-1}\chi^{1-\alpha}dz_A &= \frac{(1-\alpha)\Omega y_m}{\chi}d\chi + \frac{(1-\alpha)(\chi-\Omega)y_m}{w}dw \\
&+ (\chi-\Omega)dy_m \\
C^{-1}\left(\frac{w\alpha}{1-\alpha}\right)^{\alpha-1}\chi^{1-\alpha}\frac{dz_A}{dw} &= \frac{(1-\alpha)\Omega y_m}{\chi}\frac{d\chi}{dw} + \frac{(1-\alpha)(\chi-\Omega)y_m}{w} \\
&+ (\chi-\Omega)\frac{dy_m}{dw}
\end{aligned}
\qquad \text{(A.27)}
$$

Now we use Equation A.22 to solve for dy_m in Equation A.27.

$$
\begin{aligned}
dy_m &= \frac{-\alpha M\chi^{\alpha-1}}{A^{*1-\alpha}}d\chi + \frac{-\chi^{\alpha}}{A^{*1-\alpha}}dM \\
&= \frac{-\alpha M\chi^{\alpha-1}}{A^{*1-\alpha}}d\chi + \frac{-\chi^{\alpha}}{A^{*1-\alpha}}\left(\frac{1-\alpha}{w\alpha}\right)^{\alpha}dw \\
&= \frac{-\alpha(a-2by_m)}{\chi}d\chi + \frac{-(a-2by_m)}{M}\left(\frac{1-\alpha}{w\alpha}\right)^{\alpha}dw < 0 \\
&= \frac{a\alpha}{\chi}d\chi + \left(\frac{1-\alpha}{w\alpha}\right)^{\alpha}\frac{a}{M}dw - 2by_m\left[\frac{\alpha}{\chi}d\chi + \frac{a}{M}\left(\frac{1-\alpha}{w\alpha}\right)^{\alpha}dw\right] \qquad \text{(A.28)} \\
&< 0
\end{aligned}
$$

In order to go from step one to two of the derivation above we use the definition of M to get that $dM = \left(\frac{1-\alpha}{w\alpha}\right)^{\alpha} dw$. From the second to the third step we use the expression $y_m = \frac{1}{2b}\left[a - \frac{M\chi^{\alpha}}{A^{*1-\alpha}}\right]$ (Equation A.22) to get that $\frac{M\chi^{\alpha}}{A^{*1-\alpha}} = a - 2by_m$. Thus, the indirect impact of a rise in w on investment z_A via output of the FG monopolist y_m is negative. This is because an increase in the wage rate increases costs for the

FG firm and it reacts by lowering output. Costs increase because the FG sector employs labor (direct impact given by $dM > 0$) and also because $\frac{d\chi}{dw} > 0$. That is, a rise in wages leads to a rise in the prices of the intermediate goods as well.

Now we substitute this expression in for dy_m into Equation A.27. Thus, we infer that the total impact of a rise in wages on invest in productivity in the IG sector is negative when right hand side of Equation A.27 is negative. That condition is given by

$$(\chi - \Omega)|\frac{dy_m}{dw}| > \frac{(1-\alpha)\Omega y_m}{\chi}\frac{d\chi}{dw} + \frac{(1-\alpha)(\chi-\Omega)y_m}{w} \tag{A.29}$$

Using Equation A.29, we can simplify this inequality in terms of y_m and we get the result that

$$\frac{dz_A}{d\chi}\begin{cases} < 0 & \text{if } y < \bar{y} \\ > 0 & \text{else} \end{cases} \tag{A.30}$$

Here the threshold level $\bar{y}$ is given by

$$\bar{y} \equiv \frac{\left[\frac{a\alpha}{\chi}\frac{d\chi}{dw} + \frac{a}{M}\left(\frac{1-\alpha}{w\alpha}\right)^{\alpha}\right]}{\left[\frac{2b\alpha}{\chi}\frac{d\chi}{dw} + \frac{2b}{M}\left(\frac{1-\alpha}{w\alpha}\right)^{\alpha} + \frac{1-\alpha}{\chi-\Omega}\left(\frac{\Omega}{\chi}\frac{d\chi}{dw} + \frac{\chi-\Omega}{w}\right)\right]^{-1}} \tag{A.31}$$

Here $\frac{d\chi}{dw}$ is given by Equation A.7 as $\frac{1}{\alpha}\frac{\beta}{w}\left(\frac{1-\beta}{w\beta}\right)^{\beta}(w-1) > 0$.

Note that from Equation A.22, the condition $y_m < \bar{y}$ translates into a condition $\chi > \bar{\chi}$ since equilibrium FG output is negatively related to the price of intermediate goods.

For the proof of Proposition 2, note from Equation A.21 that $sign(\frac{d^2 z_A}{d\mu d\chi}) = sign(\frac{dC}{d\mu}) \times sign(\frac{dz_A}{d\chi})$. As shown above, $sign(\frac{dz_A}{d\chi}) < 0$ for $\chi > \bar{\chi}$. The definition of C for an advanced IG firm is $C \equiv \frac{[(1+g)^{\frac{\delta}{1-\alpha}} - (1-\mu)]}{A^{*2-\alpha}}$. Hence, $sign(\frac{dC}{d\mu}) > 0$ and thus, $sign(\frac{d^2 z_A}{d\mu d\chi}) < 0$ for $\chi > \bar{\chi}$.The definition of C for a backward IG firm is $C \equiv \frac{[(1-\mu)(1+g)^{\frac{\delta}{1-\alpha}}]}{A^{*2-\alpha}}$. Hence, $sign(\frac{dC}{d\mu}) < 0$ and thus, $sign(\frac{d^2 z_A}{d\mu d\chi}) > 0$ for $\chi > \bar{\chi}$.

A.4 Proofs of Propositions 3 and 4

Equations 2.28 and 2.29 give the expression for investment in technology done by an IG firm. Suppose there is an increase in the equilibrium output of the FG sectro y_m (due to an change in parameters a or b). Then

$$\begin{aligned} z_B &= (\chi - \Omega)\, \chi^{\alpha-1} \left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha} \frac{(1-\mu)(1+g)^{\frac{\delta}{1-\alpha}}}{A^{*2-\alpha}} y_m \\ &\Downarrow \\ \frac{\partial z_B}{\partial y_m} &= (\chi - \Omega)\, \chi^{\alpha-1} \left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha} \frac{(1-\mu)(1+g)^{\frac{\delta}{1-\alpha}}}{A^{*2-\alpha}} \qquad \text{(A.32)} \\ &> 0 \end{aligned}$$

And hence,

$$\begin{aligned} \frac{\partial^2 z_B}{\partial \mu \partial y_m} &= (\chi - \Omega)\, \chi^{\alpha-1} \left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha} \frac{(-1)(1+g)^{\frac{\delta}{1-\alpha}}}{A^{*2-\alpha}} \qquad \text{(A.33)} \\ &< 0 \end{aligned}$$

Similarly

$$\begin{aligned} z_A &= (\chi - \Omega)\, \chi^{\alpha-1} \left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha} \frac{[(1+g)^{\frac{\delta}{1-\alpha}} - (1-\mu)]}{A^{*2-\alpha}} y_m \\ &\Downarrow \\ \frac{\partial z_A}{\partial y_m} &= (\chi - \Omega)\, \chi^{\alpha-1} \left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha} \frac{[(1+g)^{\frac{\delta}{1-\alpha}} - (1-\mu)]}{A^{*2-\alpha}} \qquad \text{(A.34)} \\ &> 0 \end{aligned}$$

And hence,

$$\frac{\partial^2 z_A}{\partial\mu\partial y_m} = (\chi - \Omega)\,\chi^{\alpha-1}\left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha}\frac{1}{A^{*2-\alpha}} \tag{A.35}$$
$$> 0$$

A.5 Regulated Monopolist in the Final Goods Sector

In this section we analyze the implications of modeling the final goods sector's market structure as that of a regulated monopolist. The form of the regulation is that the monopolist needs to produce on or below a defined level y^C. This is consistent with the provisions of the license regime in India whereby every license had an output limit printed on it and it was illegal to produce above this specified limit.

From Appendix A.2 we know that the cost function for the unconstrained monopolist is given by

$$C(p(v), y) = Min_{L_{ot},x(v),v\epsilon(0,1)} w_t L_{ot} + \int_0^1 p(v)x(v)dv \tag{A.36}$$
$$= \left[w\left(\frac{1-\alpha}{w\alpha}\right)^{\alpha} + \left(\frac{1-\alpha}{w\alpha}\right)^{\alpha-1}\right]\chi^{\alpha}A^{*\alpha-1}y$$

That is, total cost is a linear function of the output of the firm $y(.)$. In other words, marginal cost is constant in output but is strictly increasing in χ and w, the price of the inputs as shown in the equation below.

$$MC(w,\chi,A^*) = \frac{\partial C(p(v),y)}{\partial y} = \left[w\left(\frac{1-\alpha}{w\alpha}\right)^{\alpha} + \left(\frac{1-\alpha}{w\alpha}\right)^{\alpha-1}\right]\chi^{\alpha}A^{*\alpha-1} \tag{A.37}$$
$$= W(w)\chi^{\alpha}A^{*\alpha-1}$$

The marginal revenue for this monopolist is given by

$$MR(y(.)) = a - 2by(.) \tag{A.38}$$

The optimal supply function for the constrained monopolist is a function of marginal cost. A constrained monopolist will produce the threshold level y^C up till the point that $MC(\chi, w, A^*) <= MR(y^C)$. That is, at the given level of input prices (χ and w), the monopolist earns a positive profit. Now suppose that the level of χ is such that $MC(\chi, w, A^*) > MR(y^C)$ then the monopolist will produce according to the schedule given by equation 2.22

$$y_m = \frac{1}{2b}\left[a - \frac{M\chi^{\alpha}}{A^{*1-\alpha}}\right] \tag{A.39}$$

where $M \equiv w\left(\frac{1-\alpha}{w\alpha}\right)^{\alpha} + \left(\frac{1-\alpha}{w\alpha}\right)^{\alpha-1}$.

That is, for lower levels of marginal cost (and hence, χ) the monopolist can get as close as possible to his optimal profit maximizing output y^m by producing the constrained output level y^C. Once marginal costs cross a threshold level, the optimal profit maximizing output level shifts. Since the constraint is an upper bound on output the monopolist can always produce a lesser amount if it maximizes his profits. In Figure A.1 we show the profit maximization exercise of the constrained monopolist.

The output level y^M is the optimal output for an unconstrained monopolist when the unconstrained firm faces a marginal cost curve $MC(\chi_1)$ and y^C is the maximum output decided by the government. Given the constraint, the firm produces y^C since it is making a profit on each additional unit at that point. But suppose that the marginal cost firm facing the firm is $MC(\chi_2)$ which is above $MC(\chi^C)$ (the level of marginal cost that makes y^C the optimal output) then the constrained monopolist maximizes profits by producing at $y^{M'}$ which is on the supply curve of the unconstrained monopolist. That is, the supply schedule of the constrained final goods monopolist is given by

$$y^{M\prime} = \begin{cases} y^C & \text{if } MC(\chi) \leq MR(y^C) \text{ or } \chi \leq \chi^C \\ y^M & \text{if } MC(\chi) > MR(y^C) \text{ or } \chi > \chi^C \end{cases} \tag{A.40}$$

Here we use the fact that marginal cost is strictly increasing in χ. This means that the response of the FG sector output (and hence the IG sector investment in technology) to liberalization of entry restrictions will be different depending on the initial level of monopolistic distortion in the IG sector.

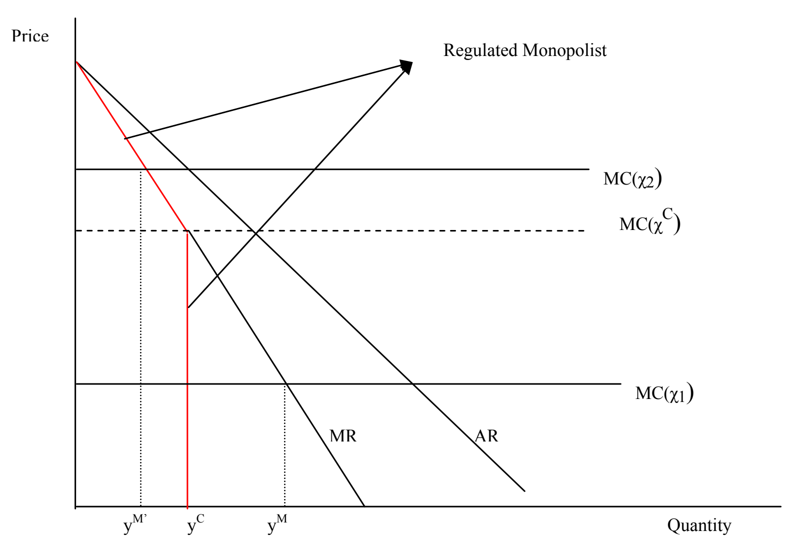

Figure A.1: Supply curve of Constrained Monopolist.

Now using Equations 2.28, 2.29 and 2.30,

$$\frac{\partial z_{Ad}}{\partial \chi} = \begin{cases} \left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha} \frac{[(1+g)^{\frac{\delta}{1-\alpha}}-(1-\mu)]}{A^{*2-\alpha}} \left[\frac{y^M(\alpha\chi+(1-\alpha)\Omega)}{\chi^{2-\alpha}} + \frac{\chi-\Omega}{\chi^{1-\alpha}}\frac{\partial y_m}{\partial \chi}\right] & \text{if } \chi > \chi^C \\ \left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha} \frac{[(1+g)^{\frac{\delta}{1-\alpha}}-(1-\mu)]}{A^{*2-\alpha}} \left[\frac{y^C(\alpha\chi+(1-\alpha)\Omega)}{\chi^{2-\alpha}}\right] < 0 & \text{if } \chi \leq \chi^C \end{cases} \tag{A.41}$$

Here χ^C is the level of χ that makes y^C (the government defined output level) the optimal choice for the monopolist. Suppose that the initial level of monopolistic distortion in the IG sector is not very high (i.e., a low value for χ). Then the FG monopolist is on the inelastic portion of his supply curve. In that case, $\frac{\partial y^M}{\partial \chi}$ is zero and only the Schumpeterian force operates on the IG firms. A rise in domestic competition (modeled as a fall in χ) will lead each producer of intermediate goods varieties to reduce their investment in quality-enhancing technology. However, if the initial level of monopolistic distortion in the IG sector is very high (i.e., a high level of χ) then it is possible (from Equation 2.30) to have a case when a fall in entry barriers in to the IG sector will force the IG firms to invest more in technology.

This result holds for Proposition 2 as well. That is, for high initial levels of χ, industrial and trade policies are strategic complements. That is, more competition in the domestic market may raise the marginal response of domestic firms to a trade liberalization episode even in the case when the FG sector is constrained with respect to output[2].

[2] A point to note here is that the condition for the bi-lateral monopoly effect to outweigh the Schumpeterian effect in Equation 2.30, the condition is $\chi > \bar{\chi}$ where the threshold level is given by the implicit equation derived when we plug in Equation A.31 into Equation A.22. We would like to compare $\bar{\chi}$ and χ^C in order to get more insight. However, the solution to this implicit equation is hard to obtain.

Appendix B

Appendices to Chapter 3

B.1 Background on Industrial Licensing in India

B.1.1 The Procedures

After independence from the British in 1948, India adopted a mixed economy framework. The main pillars of this framework were a major role of the public sector in economic development and control of private industry. These principles were codified in the Industries (Development and Regulation) Act of 1951 (referred to as IDRA from now on). Under this act, the central government was given the right to issue licenses to firms for entering or for continuing production in manufacturing and certain basic industries were reserved for the public sector. That is, no private firm could produce in those industries.

The main aim of licensing was to direct investment of "precious" capital into the desired industries. Policy-makers at that time felt that private industry could not be trusted to invest in strategic and/or important industries like machine tools, steel, cement, chemicals etc and would probably invest in quick-return industries like consumer goods. Over time the licensing regime was used to fulfill a variety of policy purposes like encouragement to small-scale firms, control of large firms to prevent concentration of economic power in a few hands and to promote even growth in all regions of the country.

A license was a document that permitted a firm to continue/begin production in an industry. It was issued by the Ministry of Industry in New Delhi. Under the IDRA, 1951 all *factories (defined as enterprizes that did not use power but employed more than 100 workers or enterprizes that used power and employed more than 50 workers)* that were already operating or wished to operate in a specified list of industries were required by the government to obtain a license. The point of licensing was to direct investment into desirable directions and hence the Act specified a list of important industries in which licensing would exist. These industries are referred to as "First Schedule" industries.

All applications for license were debated upon by the Licensing Committee consisting of officers from the administrative ministry (Industry), the Planning Commission and representatives of other government departments and the Director General of Technical Development. This was the nodal body for technical recommendations. It gave recommendations to the licensing committee on crucial aspects of the project. These recommendations included the optimal size of the project, the technology to be used in the project, the amount of raw materials-domestic and imported-required etc. The DGTD also granted annual allotments of raw materials once the license was granted. The licensing committee hearing was at the end a long chain of clearances that a firm had to obtain.

If the project was approved by the Committee then the firm was granted a "Letter of Intent" valid for one year. If the firm was able to show sufficient progress in the implementation of the project then it was issued a license. If production commenced within two years of the issue of the license then the license was permanent. Otherwise the license was revoked.

Conversations with officials who were on the licensing committee during the 1980s revealed that the most important concern for the licensing committee while debating a particular case was the *demand-supply situation of the good*. The government maintained highly detailed records of the exact production of the good that was already taking place (all registered/licensed units were required to submit detailed monthly production reports) and so had information on the supply of the good. Information about capacity utilization of existing plants and demand projections from the Planning Commission were used to compute the demand side of the equation. The applicant was also required to give demand projections for the product. If it was felt that there was enough existing capacity to satisfy demand then the application was rejected *irrespective of the quality of the proposed good and the nature and productivity of the technology* that was proposed to be used. That is, the new project was not assessed on the merit of its efficiency, productivity or quality.

Another important facet was the *type of the good*. There was a disdain for variety in policy-makers of the time. Competition was thought to be wasteful and Nehru once remarked "Why do we need nineteen brands of toothpaste?" as reported by Das (2000)[1]. This was especially true for "luxury goods"-those which were deemed to be unnecessary and could not be afforded by the masses-like air conditioners, cosmetics etc. Another important consideration was *import and foreign exchange*

[1]Page 153.

requirements. A large number of applications were rejected because they required "too" much foreign exchange.

B.1.2 Scope of Licensing

The scope of a license was fairly broad especially from the late 1960s onwards. The conditions that a license specified were many. It specified the amount of output that a firm could produce. It was conditional on the proposed location of the project. Permission would be required to change location. The exact nature of the item to be produced was also specified and the firm needed to take permission or another license to change its product mix. Even the kind of technology and inputs that the firm could use in production (though not specified on the license) was determined by the Licensing Committee and the DGTD. This was because the most crucial raw materials (steel, cement, fuel etc) were controlled by the government and the firm needed to get annual allotments of these for production. Further a whole separate license was required for any machine, equipment , components or raw materials that needed to be imported. Even for that, the DGTD and the licensing committee made recommendations to the Capital Goods Licensing Committee about the nature and quantity of imports to be permitted.

According to Marathe (1989)[2], the initial purpose of licensing was not to take over decision-making from the firm. It was basically meant to guide investment. However, the precarious foreign exchange position in the 1960s meant that imports and hence foreign exchange needed to be controlled stringently. In order to obtain a

[2]Pages 85-86.

license to import raw materials or components, it became necessary for the firm to specify in much more detail the quantity and the exact nature of the good it would produce (in an example from Marathe (1989), the firm would need to specify that it planned to produce multi-spindle lathes instead of simply machine tools). This was because import licenses would be granted only for the exact components needed for lathes. Capacity constraints also started to be important in the licensing process because of the need to restrict imports. These details were primarily administrative in nature and had no business on a legal document like a license but over time, administrative convenience prevailed.

As the licensing mechanism became a tool for dealing with problems of administrative allocation of foreign exchange, the interpretation of various clauses of the IDRA became more and more strict and rigid. Even though the act itself took a lenient view of "substantial expansion" of production (under this clause the firm needs to take permission to substantially expand production), gradually capacity limits started being specified on licenses and over time, maximum capacity became equated with maximum production permissible. Marathe (1989) attributes both foreign exchange constraints as well as the control system feeding off of itself for the fact that by the 1970s,

"*.....the judgement of the Government and Planners on questions such as the size, the nature of the equipment, the process and sometimes even the actual physical location of a unit often prevailed over the judgment of the entrepreneur concerned.*"[3].

[3]Marathe (1989), page 88

B.1.3 Implementation of the License Raj

An important point that arises given the strict nature of the conditions that a firm was obligated to follow is whether the firm had any incentives to follow those conditions. Conversations with government of India officials who had been members of the licensing committee in the 1970s and 1980s as well as officers of the DGTD reveal that surprisingly, there were very little direct checks on the factory to see whether the conditions were being satisfied or not. That is, at first glance a license was a toothless piece of paper and there was no mechanism to make the entrepreneur follow its conditions. As a reminder, a license restricted entry into an industry, the amount produced by the firm, the product mix of the firm and sometimes, the location of the factory.

The main way in which licensing requirements were implemented were by an even more potent force than physical inspections. This force was the fact that *all essential raw materials for production- steel, cement, coal, fuel, furnace oil, railway wagon movements, licenses to import equipment and raw materials etc- were not freely available in the market*. Each and every firm was allotted a certain amount of these inputs each year based on the output limits specified on their license. Thus, it was very difficult for the entrepreneur to produce over the limit on his license since basic raw materials were allotted to him based on the licensed amount. Further licensing officials also reveal that during the actual licensing process there was almost no verification of the details provided by the entrepreneur. If he stated that his plant was located in district A then this was taken as given. However once the license was granted and the entrepreneur was petitioning the DGTD to allot him his quota of raw materials for the year, each and every aspect of the project was thoroughly scrutinized to check whether conditions were satisfied. Further any direct assistance from the government (in the form of inputs, credit etc) legally obligated the firm to send detailed monthly production reports to the DGTD. These reports were also scrutinized for discrepancies.

Even though production without inputs allotted by the government would be difficult, it was not impossible since there was a black market for these inputs. This raises the possibility of entrepreneurs obtaining a license and then never going back to the DGTD for allotment of inputs. This way they could locate anywhere and produce whatever they wanted. Government officials were unwilling to put a number on the percentage of license-holders that were forced to come back to the DGTD for inputs and other permissions required for production. But when pressed, they revealed that 95% of license holders who wanted to commence production within two years of issue had to come to the DGTD for some allotment or the other and would have to pass a highly rigorous investigation of their project.

Officers gave an example of their power over the license-holder when questioned about the possibility that a lot of license-holders could have operated under the radar and flouted the license conditions. Suppose an entrepreneur was issued a license that specified that he was allowed to produce 10,000 units of a good per year. He would need cement to build the plant where production would take place and he would need equipment. The allotments of cement and equipment that were made by the government were based on 10,000 units. So the factory would be so small that it could not accommodate another machine even if the entrepreneur was able to obtain it from the black market.

A different perspective on this issue is available from several government of India reports. It was starting to become obvious in the 1960s itself that the licensing regime was not able to fulfill its primary objective-to direct investment in desired directions. Several committees and study groups were established during the 1960s and 1970s that studied the impact and performance of the licensing regime (Hazari (1967), Dutt (1969), Ramakrishna (1978) etc) also concluded that there was little follow-up of licenses to ensure that the projects were taking off. For example the Dutt Committee Report concluded that the licensing system had failed to prevent growth of capacity in less essential industries and could not be expected to ensure the creation of capacity in the more essential ones.

The Study Group on Industrial Regulation and Procedures under G.V. Ramakrishna (Ramakrishna (1978) in its report stated that "*installed capacity was in several cases more than targeted capacity and in many more cases significantly lower than the targeted capacity*" [4]. It also went on to observe that

"*....the penal provisions of the Act have also not been very effective in enabling the enforcement of the conditions of industrial licenses. In many cases where actual production exceeds the licensed capacity by several times, it has not been possible effectively to use these provisions to bring such production in conformity with industrial licenses issued.*"[5].

[4] Paragraph 1.20

[5] Paragraph 1.21

It must be noted however, that these reports were comparing capacity created under the licensing regime to targets specified in the five year plans. That is, "excess capacity" as compared to what the planners expected was needed. This is no way meant that the existing firms had a free hand in determining their production levels or that there was free entry into any industry. That is, *even if the firm was producing more than the amount specified on the license, it is by no means clear that it was producing its optimal quantity given the constraints on obtaining inputs.*

The constraints that the licensing regime imposed on producers were severe. It was under the pain of imprisonment that a firm could produce above the amount specified on its license. A firm producing plastic buckets needed permission if it wanted to produce plastic toys instead. Availability of crucial raw materials was at the mercy of the DGTD and was done on the basis of the capacity specified on the license. There is also anecdotal evidence of shortages of many commodities. For example there was a ten year waiting list for scooters and yet the owner of the largest scooter company was hauled up about why he was producing more than his licensed capacity [6]. One of India's largest industrialists remarked in 1969 that

"*I cannot decide how much to borrow, what shares to issue, at what price, what wages or bonus to pay and what dividend to give. I even need government permission for the salary I pay to a senior executive.*"[7].

The reports that were commissioned in the 1960s and the 1970s reveal a crucial point- *whether or not the licensing Raj was able to control capacity, it was most*

[6] Das (2000), page 175

[7] Das (2000), page 168

certainly able to control entry into an industry. In this respect licensing provided industrialists with a great deal of protection. Evidence of this started to emerge early in the licensing regime and the *The Monopolies Inquiry Commission 1965* was one the earliest committees established to look into this. Though the purpose of the commission was to look at the practices of certain "large industrial houses", it gave broad recommendation regarding concentration and monopoly power in Indian industry. Based on interviews with a wide spectrum of Indian industry as well as analysis of detailed questionnaires that were sent to firms, it stated that

"*.....the requirement of law that new industries with capital over a specified amount could not be started without a license is a formidable obstacle in the way of new entrepreneurs freely entering the lists.*" [8]

Further,

"*The system of controls on the shape of Industrial Licensing however necessary from other points of views, has restricted the freedom of entry into industry and so helped to produce concentration*"[9].

The Committee also mentioned the issue of high costs of production in Indian manufacturing and averred that *" The cost of production remains high due to the fact that top firms have not exerted themselves sufficiently......secure in the belief that in the absence of competition from abroad there was little risk of losing their market dominance".*[10].

The *Hazari Committee 1967* (Hazari (1967)) also found evidence of industri-

[8]Dasgupta (1965), page 7

[9]Dasgupta (1965), page 8

[10]Dasgupta (1965), page 142

alists pre-empting licenses. That is, a firm would send multiple applications for the same product. This ensured that it would be granted at least some of the planned capacity in that item, keeping out rivals. In no uncertain terms the committee remarked that

"*The obligation on all units have fixed assets more than Rs. 25 lakhs to take out a license for new articles-applications which can be rejected out of hand on the ground of sufficient **licensed** (not necessarily actual) capacity keeps at bay existing large undertakings which might have the capacity to offer competitive products by feasible diversification. Enterprize plus imaginative understanding of licensing formalities thus enables the [name of large industrialist] to foreclose the market.*"[11]

In conclusion, it seems that licensing was quite successful in providing firms protection from entry into the industry even if the stern conditions on capacity and output were not always implemented. *Once a firm obtained a license, it held at best a monopolistic and at worse, an oligopolistic position in the industry.* Even the threat of potential entry was low since there were reports of firms pre-empting capacity. That is, once a firm was granted a license in a particular item it would file multiple applications under different names so that all the "planned production capacity" in that item was under its control. This phenomenon has been mentioned by some of the government reports as well as anecdotal accounts. Government officials who scrutinized these applications report seeing as many as seven identical applications for the same item on the same day. Even the spelling mistakes in the applications were identical.

[11] Hazari (1967), paragraph 13.5

Thus, the licensing regime in India affected firm-level productivity and costs through its control on both the firm's *ability and incentives* to innovate, reduce costs, adopt new technology etc. The direct controls on outputs and inputs determined ability and the indirect control of entry determined incentives. Even if the direct controls where not implemented fully due to corruption etc, the effect of the indirect controls on incentives was very large as evident from the fact that each and every account of that time attributed the high costs, obsolete technology and low productivity of Indian industry to the lack of competition, among other factors.

B.2 Behavior of Non-licensed Firms

In this appendix we analyze our unit-level data in greater detail. In particular we investigate the behavior of non-licensed firms across de-licensed and licensed industries. Our main conclusion from this analysis is that there is little evidence of the claim that firms may choose their size (defined by assets in plant, machinery, land and building) in anticipation of de-licensing.

B.2.1 Nature of Asset Limits

In order to show that firms were not choosing size endogenous with policy during the 1980s, we first demonstrate some statistics. The first and important point is whether *the limit on assets in plant and machinery was binding* for a non-licensed firm. If the definition is not truly binding then the magnitude of the problem of endogeneity is bound to be low. Table B.1 shows the utilization rates of non-licensed firms in various percentiles below the threshold.

We see that for the entire period, the top 1% of non-licensed firms were using on average only 80% of the rupee amount that was allowed to them. This rate drops off sharply as the top 5% of firms use only 42.3% and the top 25% of firms use only 7.3% of the threshold.

That is, the threshold is binding only for the top 1% of firms which represent a very small number of firms compared to the total number of non-licensed firms. Further they represent a very small percentage of the total output of non-licensed firms (in 1985, the top 1% of firms accounted for 6.5% of output).

B.2.2 Distribution of Firms Around the Threshold

Another way in which we can check whether the asset limits were binding on non-licensed firms is by number of firms that were on or directly below the asset limit. If the limit was binding and firms were deliberately choosing to be under the threshold, we should see a large mass of firms on or just below the limit. In Table B.2 we present the frequency distribution of firms in bands around the threshold. In the first panel of the table, each column shows the number of firms that were x% below the specified asset limit and in the second panel, the number of firms that were x% above the asset limit.

Column 2 shows that the number of firms that were 1% below the rupee threshold was few in number in absolute terms as well as relative to the total number

Year	Mean Assets in Plant, Machinery, Land & Buildings (Rs.)	Utilization Rates of Permissible Limit within Percentiles of Threshold		
		99^{th}	95^{th}	90^{th}
1980	2.00E+06	74.70	36.00	18.70
1981	2.09E+06	78.70	38.30	19.40
1982	2.25E+06	79.30	41.30	21.90
1983	3.58E+06	77.00	37.80	20.80
1984	3.99E+06	78.80	41.40	24.40
1985	4.05E+06	79.20	42.20	24.00
1986	4.50E+06	82.20	45.80	27.20
1987	4.76E+06	84.40	48.60	28.00
1988	5.16E+06	86.80	51.80	31.60
1989	5.31E+06	86.40	52.80	32.40
1990	9.83E+06	72.70	34.30	18.60
1991	1.06E+07	76.00	36.90	20.30
1992	1.15E+07	78.00	39.40	22.30
1993	1.23E+07	80.70	42.30	24.10
1994	1.37E+07	81.30	45.60	27.80

Table B.1: Utilization Rates for Exempt firms of small firms. However one could argue that this might be because of indivisibility of investment in plant and machinery. Thus we present the number of firms that were within 5, 10, 20 and even 50% of the rupee threshold. Even when we take firms that were spending more than 80% of the threshold amount (the column marked 20%) we find that they accounted for only 2% of the total number of small firms during the 1980s. Thus there is not much evidence of bunching around the threshold for licensing.

In the second part of the table we present the frequency distribution of firms that were above the rupee threshold. Here we find that the frequency distribution of firms is very similar above and below the threshold. Suppose in general firms prefer to remain small and hence, under the licensing radar. But once a firm crosses the threshold it has incentive to invest a lot in plant and machinery. That is, once it is categorized as licensed by the government then it is in its interest to increase its assets in plant and machinery as much as it wants. This means that we should find that there aren't too many licensed firms that are really close to the threshold. But we see that there are as many firms in bands above the threshold as there are below. Further, licensed firms that are 1% above the cut-off constitute on average 0.9% of the total number of licensed firms (on average over the entire period). The corresponding figure for non-licensed firms that are 1% below the threshold is 0.04%. If it were true that firms were choosing to remain small then the figures should be reversed. That is, the percentage of firms directly below the threshold should be much larger than the number of firms directly above the threshold.

Another point to note is that the rate of growth of the number of firms that are 1% below the threshold (Column 2) is almost always higher than the rate of growth of the number of firms that are 20, 50, 80% below the threshold (Column 6) as well as the rate of growth of all non-licensed firms[12]. This again points to the fact that firms were not deliberately suppressing their investment in plant and machinery in order to remain below the threshold.

B.2.3 Capital-Labor Ratio

The main issue that we want to deal with is the possibility that firms that were Exempt from licensing (i.e. had capital below a certain defined level) might not be targeting the absolute levels of capital. Rather they might be targeting the capital to labor ratio which allows them to remain "exempt" from licensing requirements yet allow them to be competitive. Are Exempt firms choosing their capital-labor ratio in response to the anticipation of deregulation? Analysis of data reveals that this is not the case. In Figure B.1 below we show the distribution of capital to labor ratio of Exempt firms in de-licensed and still licensed industries[13]. The dotted line refers to the pre-reform year 1983 while the solid line refers to the post-reform year 1988. That is, we are comparing the behavior of Exempt firms across deregulated

[12] We also analyzed the rates of growth of assets in each band below the threshold and we find that the rate of growth declines as the amount of assets that a firm holds declines. That is, firms spending 80% of the threshold amount had higher rates of growth compared to firms spending 50 or 10% of the threshold amount. This means that larger non-licensed firms were growing faster. This would not have been true if firms were deliberately trying to keep assets low.

[13] We do not have figures for the actual capital that a firm owns so we proxy for that using assets in plant and machinery.

Year	Cumulative Distribution of Firms in Bands Below the Cut-off							
	1%	5%	10%	20%	50%	80%	90%	Total
1980	3	36	63	249	636	2298	3549	18,530
1981	5	38	74	292	727	2375	3680	18,947
1982	8	34	74	304	848	2714	4145	19,815
1983	5	33	61	281	694	2518	3833	17,960
1984	8	35	76	339	774	2692	4072	17,213
1985	3	35	73	346	793	2787	4256	17,895
1986	7	37	91	378	918	3015	4616	17,371
1987	9	46	114	413	1021	3367	5147	18,439
1988	10	66	138	457	1190	3501	5470	18,425
1989	9	84	147	509	1240	3887	5876	18,875
1990	5	20	56	252	622	2565	4060	19,389
1991	7	34	68	271	717	2739	4370	19,512
1992	8	44	86	337	884	3149	5025	21,024
1993	12	57	99	389	995	3445	5467	21,787
1994	9	54	109	429	1132	4023	6149	22,252
Year	Cumulative Distribution of Firms in Bands Above the Cut-off							
	1%	5%	10%	20%	50%	80%	90%	Total
1980	3	27	49	183	309	503	517	575
1981	3	20	46	218	350	569	590	619
1982	8	42	69	251	441	713	741	782
1983	3	31	76	225	366	522	542	581
1984	4	35	70	244	409	602	622	686
1985	10	39	88	264	452	685	711	785
1986	8	38	82	289	495	787	814	887
1987	12	52	88	346	598	931	962	1,031
1988	11	52	93	350	589	965	1005	1,192
1989	13	50	98	348	632	1021	1066	1,346
1990	7	33	54	185	316	462	473	565
1991	6	39	82	243	374	550	565	674
1992	8	45	93	258	452	679	699	867
1993	8	54	102	279	490	764	794	1,026
1994	10	65	123	351	585	914	958	1,232

Table B.2: Distribution of Firms near the Threshold for Licensing and regulated industries, pre and post reforms. In case firms are anticipating deregulation, they might want to change their capital to labor ratio. However the graphs below show that this is not true.

The distribution of capital-labor ratio is very similar across the two sets of industries (de-licensed and licensed) in both periods (pre and post reforms). That is, there is no systematic tendency towards using the capital to labor ratio as a means towards preparing for anticipated deregulation.

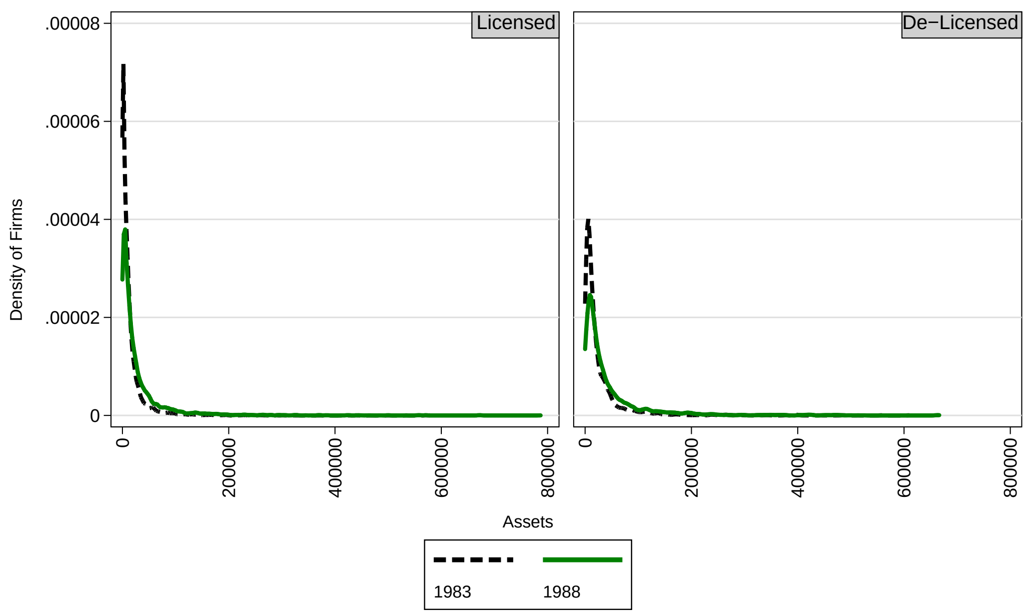

Figure B.1: Distribution of Capital-Labor Ratio over Exempt Firms.

We also check for whether firms are taking the average capital to labor ratio (implied by the nominal threshold set by the government) as the cut-off rather than the absolute value of capital. We define $\left(\frac{\bar{K}}{L}\right)_t = \text{Average}\left[\frac{K_{ijt}}{L_{ijt}}\right]$ for all firms i that are on or 10% around the threshold at the time t. Then we find the proportion of exempt firms (whose absolute capital lies below the threshold) in bands around

Year	1%	5%	10%	20%	50%	80%	90%
1980	0.49%	2.01%	2.56%	5.22%	15.29%	17.04%	6.56%
1981	0.63%	2.20%	2.59%	5.80%	17.44%	18.73%	7.91%
1982	0.60%	2.03%	2.33%	4.74%	14.58%	15.90%	6.39%
1983	0.60%	2.43%	3.01%	5.90%	18.55%	20.15%	7.57%
1984	0.44%	2.08%	2.78%	5.10%	18.18%	27.49%	11.23%
1985	0.56%	1.82%	2.47%	5.50%	15.53%	16.78%	6.28%
1986	0.37%	1.68%	2.15%	4.46%	16.91%	28.01%	13.36%
1987	0.44%	2.38%	2.74%	5.57%	17.53%	16.95%	6.37%
1988	0.57%	2.61%	2.91%	5.18%	16.49%	17.74%	6.53%
1989	0.65%	1.96%	2.94%	5.72%	17.88%	20.49%	7.67%
1990	0.37%	1.79%	2.42%	4.53%	15.95%	24.89%	13.36%
1991	0.57%	1.76%	2.88%	4.74%	16.60%	23.67%	12.52%
1992	0.52%	2.23%	2.28%	4.56%	16.73%	23.60%	12.36%
1993	0.51%	1.52%	2.49%	5.40%	16.05%	20.84%	9.20%
1994	0.40%	1.58%	1.92%	4.12%	14.52%	24.12%	13.90%

Proportion of Exempt firms in Bands Around the Average KL Ratio

Table B.3: Distribution of Firms near the Threshold for Licensing

the average capital-labor ratio. The Table B.3 shows these figures. For example, Column 1 shows the percentage of actually exempt firms that are either 1% below or 1% above the average capital-labor ratio. As we can see, the proportion is very small. Even when we allow for firms to be within 20% of the average capital to labor ratio at the threshold, only 5% of all exempt firms (nearly 200, 000 firms) are in that band.

B.3 Specification Test using Special Industries

In Table B.4 we report the results of our falsification regression using the group of special industries in which no firm had exemption from licensing. An assumption of our identification strategy is that the coefficient on the interaction of exemption status and de-licensing should be insignificant for this group of industries. In Column 1, the coefficients are from estimation of Equation 3.3 on the group of industries were exemption from licensing was not available (the Schedule IV and V industries). As we see the co-efficient on the interaction of de-licensing with exemptions status is not significant. That is, there is no exemption-based response to de-licensing in these industries. This shows that our identification assumption holds.

However we might be worried that this is not a powerful test since the number of observations is small as compared to the full sample. Note that the magnitude on the interaction coefficient is large in magnitude.

Another area of concern could be the schedule IV and Schedule V industries may not have enough variation in productivity as compared to other industries (where exemption from licensing was allowed) and this might affect the power of our specification test. However the coefficient of variation in log output per worker is 17% for Schedule IV and V industries as compared with 20% for other industries.

In Column 2 of Table B.4 we present another specification test. We estimate modified Equation 3.3 for all industries (including schedule IV and V industries). We define $Special_{jt} = 1$ if industry j was included in Schedule IV or V in year t, 0 otherwise and estimate

$$y_{ijts} = \beta_0 + \alpha_j + \delta_t + \beta_1 De_{jt} + \beta_2 NotExempt_{it} + \beta_3 De_{jt} NotExempt_{it} \quad \text{(B.1)}$$
$$+\beta_4 Special_{jt} + \beta_5 De_{jt} NotExempt_{it} Special_{jt} + \eta X_{ijts} + \epsilon_{ijts}$$

That is, we include the special industries (without exemption from licensing) into our main regression and allow them to have a different intercept and slope as compared to the other industries. By pooling all industries we increase the power of our test. The first thing to notice is that coefficient on the interaction of exemption status and de-licensing is very small in magnitude and insignificant for the special industries. Further we find that we accept the hypothesis that $\beta_3 + \beta_5 = 0$ i.e. we accept the hypothesis that there is no variation in the performance of firms in de-licensed industries around the threshold for licensing, for the set of industries where this threshold was not relevant.

	Only Special Industries	All industries
NotExempt	0.637***	0.613***
	[0.094]	[0.083]
De	-0.001	-0.042*
	[0.070]	[0.025]
De*NotExempt	0.107	0.146**
	[0.107]	[0.065]
Special		0.072
		[0.068]
Special*De*NotExempt		-0.011
		[0.079]
Rent-Wage Ratio	-1.601***	-1.324***
	[0.408]	[0.288]
Constant	6.252***	6.285***
	[0.150]	[0.151]
Observations	172297	206640
R-squared	0.51	0.51
Industry FE (4-digit)	Yes	Yes
State FE	Yes	Yes
Year FE	Yes	Yes
F-test on restriction $\beta_3 + \beta_5 = 0$		1.85

Table B.4: Falsification Test using Special Industries. Special refers to Schedule IV and V industries that did not have size-based exemption from licensing.

B.4 Specification Test using Various Thresholds for Exemption

In this appendix we check our specification using various thresholds for exemption. Our identification assumption implies that there should be variation in the response of firms to de-licensing around the actual threshold for licensing. For all other hypothetical thresholds, the interaction coefficient between de-licensing and exemption status should be insignificant.

In order to conduct this specification test we use the following methodology. The actual exemption threshold is in nominal rupees and this nominal value was changed twice over our time period. Given the span of the data and possibility of inflation, we can not use absolute deviations from the actual threshold to generate our hypothetical thresholds.

We generate our hypothetical thresholds in the following way. For each year and conditional on actual exemption status, we sort firms according to their assets in plant, machinery, land and building. Then we take the rupee amount below which there are 10% of the firms in that year and assume those firms are Exempt from licensing requirements. That is, we take the 10^{th} percentile as our first threshold. This means that 10% of actually Exempt firms are treated as Exempt and 90% of actually exempt firms are treated as Not Exempt. Similarly, the next threshold is defined as the rupee amount of the 20^{th} percentile and hence 20% of actually Exempt firms are treated as Exempt and the other 80% are shifted into the Not Exempt category. Thus at the 90^{th} percentile, we treat 90% of actually Exempt firms as exempt and 10% of actually exempt firms as Not Exempt.

Similarly we sort the firms above the actual threshold in each year according to their assets and take the various percentiles as our cut-off points. Thus the first cut-off above the actual threshold shifts 10% of the actually Not Exempt firms as Exempt, the second cut-off shifts 20% of actually Not Exempt firms into the Exempt category etc.

Thus we continually shift firms from the Not Exempt category into the Exempt category as we approach the actual threshold and then go beyond it.

We define $NE(x)_{it} = 0$ if firm i is in the xth percentile in year t, 1 else and estimate the equation below for different values of x

$$y_{ijts} = \beta_0 + \alpha_j + \delta_t + \beta_1 De_{jt} + \beta_2 NE(x)_{it} + \beta_3 De_{jt} NE(x)_{it} + \eta X_{ijts} + \epsilon_{ijts} \quad \text{(B.2)}$$

Note that in this specification test we include the year 1980-91. This is because size-based exemption from licensing was completely removed during the 1991 reforms. That is, all firms in licensed industries were licensed and all firms in de-licensed industries were de-licensed. This means that this robustness test is valid only for the period in which exemption from licensing is an issue for firms.

In Table B.5 we present the coefficients, standard errors, t-statistics and z-statistics for the interaction term $De_{jt}NE(x)_{it}$. If our identification strategy is correct then the interaction terms should be insignificant far from the actual threshold and should become more significant as we approach the threshold from either side. As can be seen the interaction coefficient is not significant at either extremes and rises in significance as we approach the threshold. Further as can be seen in

Figure B.2 (given below) where we plot the coefficient estimates and their confidence interval on distance from the actual threshold, the confidence interval of the coefficients is very large at the extremes and narrows as we approach the actual threshold. That is, the coefficients are much more precise near the actual threshold than away from it.

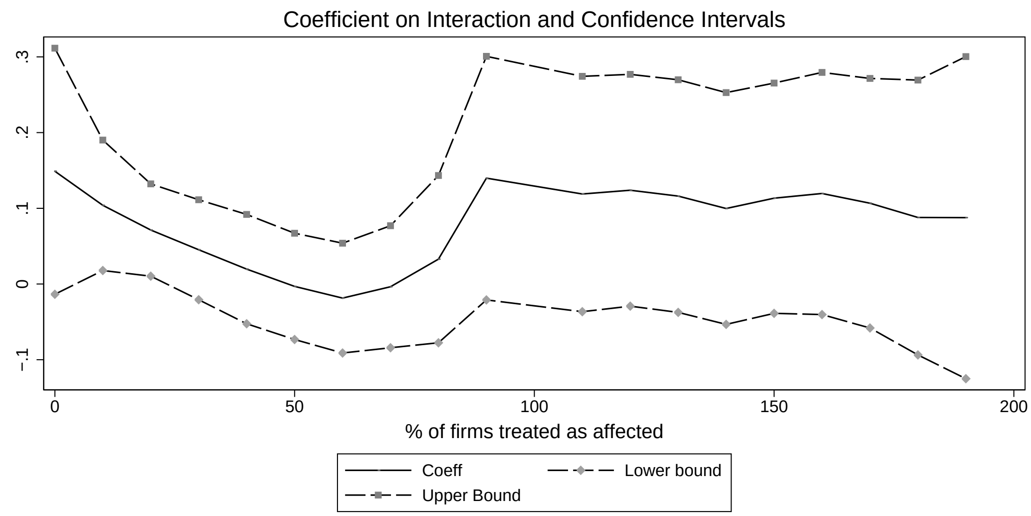

Figure B.2: Coefficient on Interaction and Confidence Intervals

% of actually Exempt firms treated as Not Exempt	Coefficient on Interaction	Standard Error	z-statistic	t-statistic
90	0.13987	0.08183	1.709286	1.71
80	0.0328603	0.056206	0.584645	0.58
70	-0.0035671	0.040994	-0.08702	-0.09
60	-0.01859	0.036891	-0.50392	-0.5
50	-0.0031225	0.035701	-0.08746	-0.09
40	0.0197247	0.036726	0.537079	0.54
30	0.0452736	0.033586	1.347974	1.35
20	0.0713353	0.031008	2.300567	2.3
10	0.1040062	0.043816	2.373698	2.37
Actual threshold	0.1489872	0.08268	1.801976	1.8
110	0.1189155	0.079071	1.503915	1.5
120	0.1238649	0.077874	1.590587	1.59
130	0.1161601	0.078147	1.486438	1.49
140	0.0997598	0.077873	1.281056	1.28
150	0.113357	0.077358	1.465358	1.47
160	0.1195946	0.081337	1.470359	1.47
170	0.1067452	0.083844	1.273135	1.27
180	0.0878918	0.092328	0.951953	0.95
190	0.0876862	0.108197	0.81043	0.81

Table B.5: Coefficient on Interaction for Various Thresholds

B.5 Comparability of Exempt and Not Exempt Firms

Our empirical strategy is based on the differential performance of two types of firms in response to de-licensing. That is, exempt firms (those with assets lower than a threshold) which were not under licensing requirements provide trends in productivity that would have occurred even without de-licensing and hence can be used as a baseline for not exempt firms (those with assets above a threshold) which were under licensing. However, given that the definitions of these two types of firms are based on assets we are worried whether exempt firms even capture the basic trends in productivity and hence whether they can be used as a baseline. That is, are exempt (smaller) firms so different from not exempt (larger) firms that it is unreasonable to compare the two. We run some simple checks to analyze this issue.

In Figure B.3 we show the trends in average output per worker for exempt and not exempt firms. As we can see, exempt firms exhibit the same broad trends in productivity over time as not exempt firms particularly in the pre-reform period 1980-85.

In Table B.6 we show the regressions results for the individual groups of exempt and not exempt firms. The coefficient on the reform variable is positive and significant for not exempt firms while it is small and negative for the exempt firms. This is consistent with our findings in the pooled sample that not exempt firms which were under licensing to begin with perform better after de-licensing in their industry as compared with exempt firms in their industry. We would like to run a simple Chow-test on these two regressions to test pool-ability. However, since we

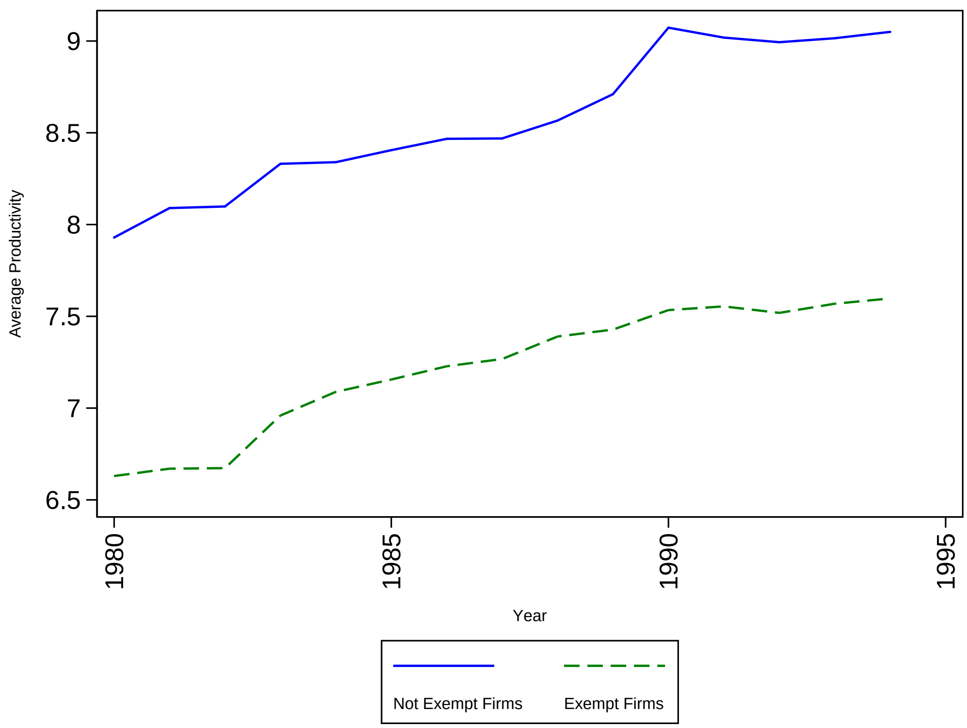

Figure B.3: Trends in Productivity-Exempt and Not Exempt Firms

	Baseline	Exempt Firms	Not Exempt Firms
NotExempt	0.612***		
	[0.097]		
De=1	-0.001	-0.058**	0.096*
	[0.0.025]	[0.022]	[0.059]
De*NotExempt	0.135**		
	[0.07]		
Constant	5.69***	5.69***	7.65***
	[0.18]	[0.18]	[0.28]
Observations	178371	162285	10012
R-squared	0.522	0.49	0.584
Industry-Year (2digit)	Yes	Yes	Yes
Industry FE (4 digit)	Yes	Yes	Yes
State FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Table B.6: Separate Regressions for Sub-samples have a large number of fixed effects in our basic model it is computationally very difficult to run the fully interacted, constrained model. But our analysis of the trends in productivity for exempt and not exempt firms over various dimensions (location, ownership etc) shows that both types of firms tend to more together over time. In Figure B.4 we show the time trends in productivity for exempt and not exempt firms for two-digit industries, in Figure B.5 for firms located in deemed backward and not backward states; in Figure B.6 for firms with different ownership structures and in Figure B.7 for firms with different organizational structures. These figures reveal that the basic trends in productivity for exempt and not exempt firms are broadly similar along several important dimensions particularly in the pre-reform period 1980-85. Thus, exempt firms can be used as a comparison group for not exempt firms. There are ex ante differences in the levels of productivity but these are generally constant over time.

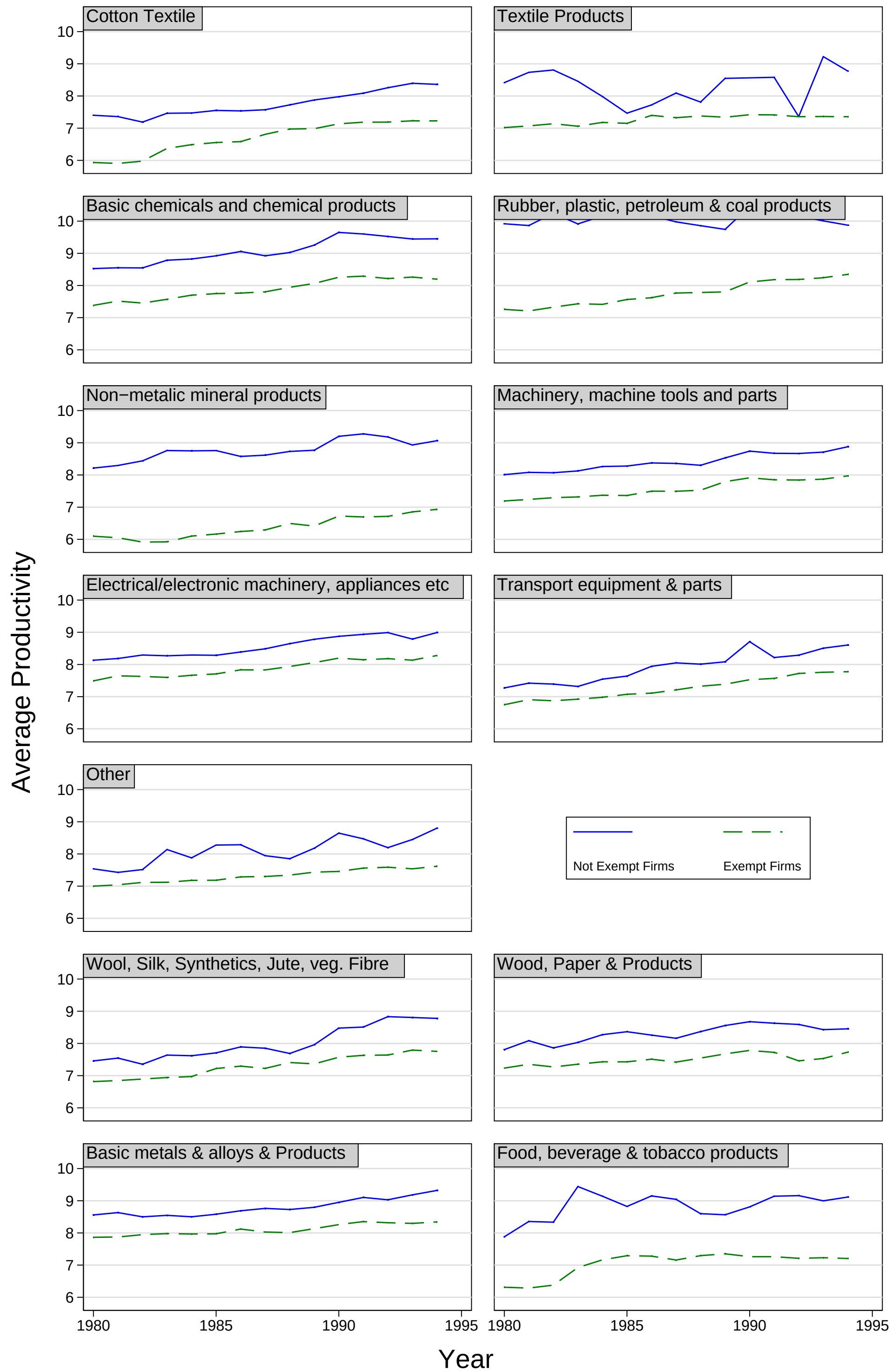

Figure B.4: Trends in Productivity over Industries

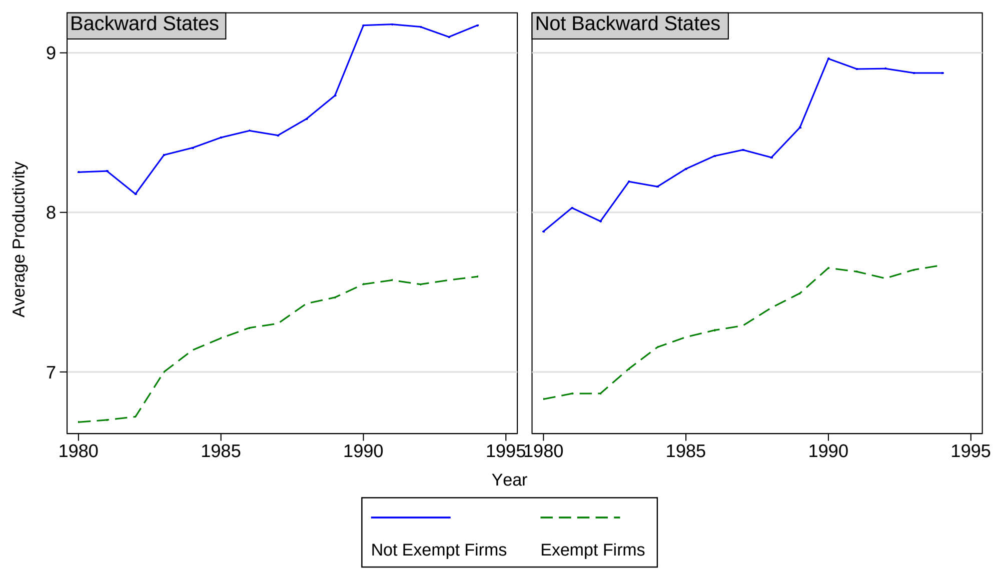

Figure B.5: Trends in Productivity over States

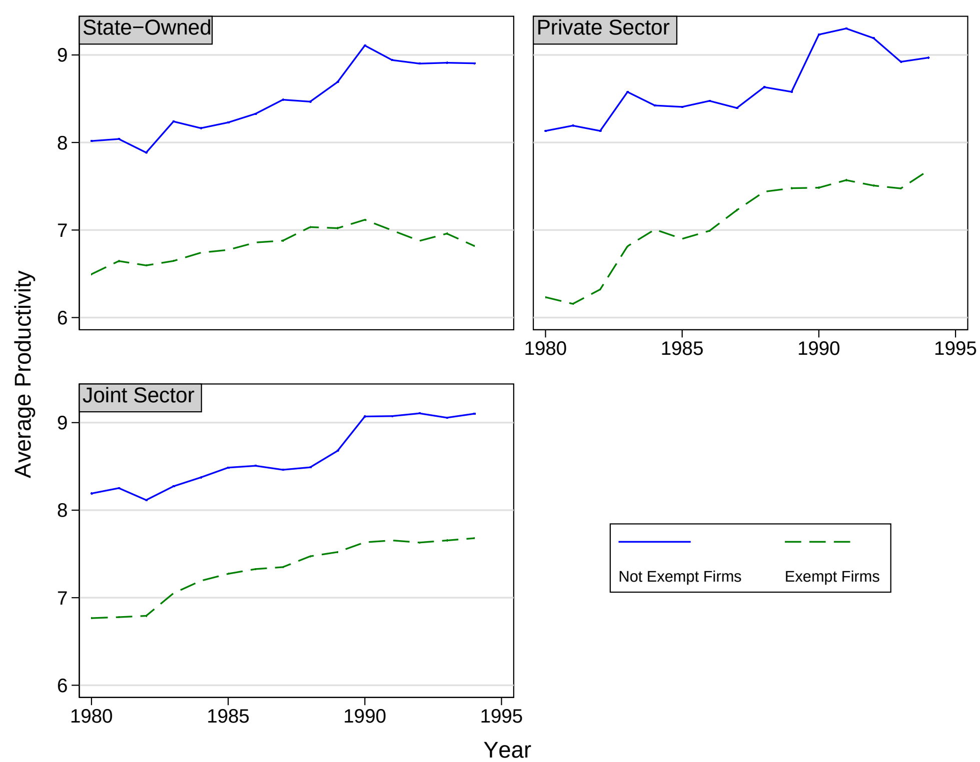

Figure B.6: Trends in Productivity over Ownership Structure

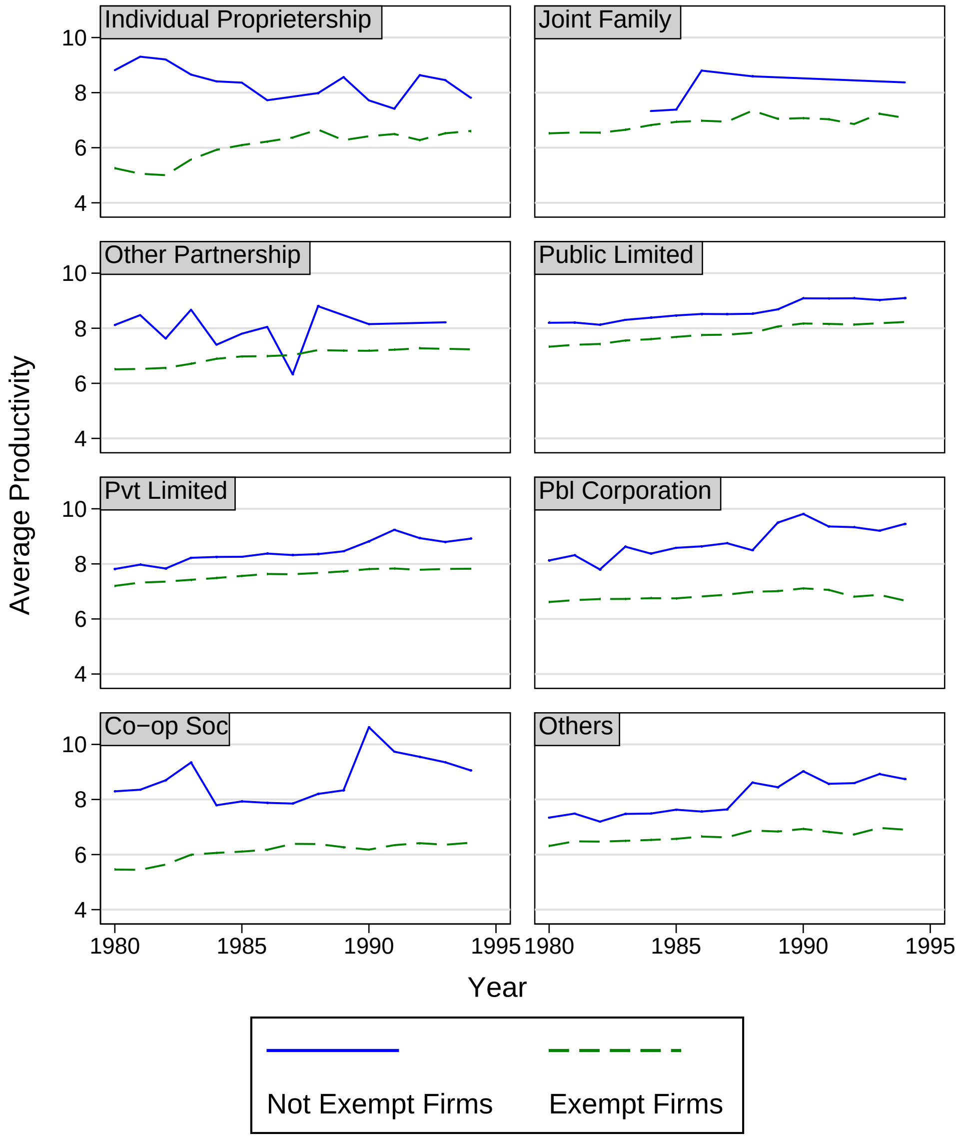

Figure B.7: Trends in Productivity over Organizational Structure

In order to get a better grasp on the problem of comparability of exempt and not exempt firms we also run our basic regressions but for bands of firms around the threshold. That is, we rank firms according to their assets and then regress productivity on exemption status, de-licensing and the interaction for the top 20%

of exempt firms and the bottom 20% of not exempt firms[14]. The results of these regressions are presented in Table B.7. Thus we see that the band of 20% of the firms around the threshold do not show any impact of the reforms. The coefficient on the interaction is positive and significant for 40% of the firms around the threshold and then increases as we add more and more firms. Note that an important reason for this is that when we select firms according to their position in the distribution of assets, we are not able to control the industries from which these firms are selected. This in turn means that we might not have even one firm from an industry that was deregulated.

As a further test of comparability, we run a series of tests for the 40^{th} percentile of firms around the threshold (this is the first percentile where we get a significant coefficient on the interaction of De_{jt} and $NotExempt_{it}$). We run separate regressions for Exempt and Not exempt firms within the 40^{th} percentile (reported in Table B.8) and then test whether the coefficients on key variables are the same for the two sets of firms.

[14]Optimally, we would like to be able to take bands of firms around the threshold according to how close they are to the threshold. That is, we would like to compare firms that spend 80% of the threshold amount and 120% of the threshold amount. However, as Table B.2 shows the distribution of firms around the threshold is quite sparse. Thus our strategy is a modified version of the standard regression discontinuity design strategy.

That is, our regression equations for firms in the 40^{th} percentile are

$$
\begin{aligned}
y_{ijts} = \beta_0 &+ \beta_1 De_{jt} + \delta_1 Ratio_{ts} + \delta_2 Backward_{ijts} + \delta_3 (Year = 1984)_t \\
&+ \delta_4 (Year = 1991)_t + \epsilon_{ijts} \text{ for Exempt firms} \\
y_{ijts} = \beta_0 &+ \beta_1 De_{jt} + \gamma_1 Ratio_{ts} + \gamma_2 Backward_{ijts} + \gamma_3 (Year = 1984)_t \\
&+ \gamma_4 (Year = 1991)_t + \mu_{ijts} \text{ for Not Exempt firms}
\end{aligned}
$$

Here $Ratio_{ts}$ is the ratio of average cost of capital to average wages in state s in year t, $Backward_{ijts} = 1$ if firm i was located in a backward state s in year t. The variables $(Year = 1984)_t$ and $(Year = 1991)_t$) are dummies for the respective years. All other controls like the full set of year fixed effects, controls on organization, ownership etc are included. The results for this regression are reported in Table B.8.

Now we test whether the coefficients on key variables are statistically similar for the two types of firms. For example, for the rent-wage ratio, our null hypothesis is that $\delta_1 = \gamma_1$. The results for these tests are presented at the bottom of Table B.8[15]. We find that exempt and not exempt firms have statistically similar coefficients for key variables like the rent-wage ratio, location of the firm (in a backward state or not) and to the year (there were major changes in years 1984, 1985 and 1991 and we would like to test if the average response in both types of firms is similar to these

[15] Our statistical program allowed us to store the separate regression results in one matrix and test the cross-model hypotheses. The test statistic reported is the same as that for a simple Chow test using explained sum of squares for the restricted and unrestricted models.

broad macroeconomic changes). Further, we also test the joint hypothesis that all the four coefficients are similar across the models and we find that is the case. Thus, our data shows that exempt and not exempt firms are comparable along important dimensions[16].

	10^{th}	20^{th}	30^{th}	40^{th}	50^{th}
NotExempt	0.163***	0.238***	0.282***	0.338***	0.403***
	[0.035]	[0.025]	[0.021]	[0.018]	[0.016]
De=1	-0.053	-0.012	-0.029	-0.016	-0.026
	[0.039]	[0.028]	[0.023]	[0.021]	[0.019]
De*NotExempt	-0.047	-0.014	0.035	0.057*	0.054*
	[0.061]	[0.044]	[0.036]	[0.031]	[0.028]
Constant	7.481***	7.439***	7.351***	7.304***	7.261***
	[0.038]	[0.028]	[0.025]	[0.021]	[0.019]
Observations	17249	34493	51728	68975	86231
R-squared	0.45	0.4	0.36	0.35	0.34
	60^{th}	70^{th}	80^{th}	90^{th}	
NotExempt	0.468***	0.545***	0.613***	0.683***	
	[0.015]	[0.014]	[0.014]	[0.014]	
De=1	-0.039**	-0.031*	-0.022	-0.016	
	[0.017]	[0.016]	[0.015]	[0.015]	
De*NotExempt	0.089***	0.093***	0.115***	0.116***	
	[0.026]	[0.024]	[0.023]	[0.022]	
Constant	7.189***	7.103***	7.013***	6.897***	
	[0.018]	[0.017]	[0.017]	[0.017]	
Observations	103466	120704	137933	155144	
R-squared	0.35	0.35	0.37	0.41	

Table B.7: Coefficient on Interaction for Various Percentiles of Firms. All regressions include year, state, industry and industry-year fixed effects. All controls are included. Robust standard errors are reported.

[16]We have also tried this test for ownership structure of the firm (results not reported) and we find that we cannot reject the hypothesis that the coefficients are identical across models.

	Pooled	Not Exempt Firms	Exempt Firms
NotExempt	0.348***		
	[0.020]		
De	-0.052***	0.057	-0.057***
	[0.017]	[0.049]	[0.017]
De*NotExempt	0.065**		
	[0.030]		
Rent-Wage ratio	-0.931***	-1.029***	-0.939***
	[0.041]	[0.148]	[0.042]
Backward State	-0.099***	-0.056*	-0.100***
	[0.009]	[0.029]	[0.010]
Constant	6.500***	7.776***	6.450***
	[0.039]	[0.204]	[0.041]
Observations	67921	4813	63108
R-squared	0.49	0.5	0.48
$H_o : \delta_1 = \gamma_1$ (Rent-Wage Ratio)			$F_{0.01}(1, \infty) = 0.56$
$H_o : \delta_2 = \gamma_2$ (Backward State)			$F_{0.01}(1, \infty) = 3.45$
$H_o : \delta_3 = \gamma_3$ (Year 1984)			$F_{0.01}(1, \infty) = 2.79$
$H_o : \delta_4 = \gamma_4$ (Year 1991)			$F_{0.01}(1, \infty) = 4.5$
$H_o : \delta_1 = \gamma_1, \delta_2 = \gamma_2, \delta_3 = \gamma_3, \delta_4 = \gamma_4$			$F_{0.01}(4, \infty) = 2.44$

Table B.8: Separate Regressions for the 40^{th} Percentile. All regressions include year and industry fixed effects. All controls are included. Robust standard errors are reported.

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