Strategic Complementarities between Trade and Industrial Policies. A Theoretical Investigation*

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Abstract

In this paper we use a two-sector Schumpeterian growth model based on Aghion et al. (2003a) and Acemoglu et al. (2003) 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 (modeled as a fall in the price that the firm is able to charge for its product) 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 complementarity 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.

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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 Kray (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 (2000)). 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.

We are particularly interested in the case of India vis 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 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. (2003a), Aghion et al. (2004)) must take into account the distortions created by industrial licensing. This paper tries to capture significant features of industrial licensing in India 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.

Following Aghion et al. (2003a), 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 keeping in mind the institutional features of Indian industrial policy this assumption is not likely to be valid and so we model the final goods sector as a monopoly. We find that our model gives substantially different results than the benchmark case.

The main result of our paper is that 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 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.

The paper contributes to the theoretical literature in three ways. Firstly, it investigates the importance of market structure in the sector that does investment on investment incentives of the firm. Secondly, 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. Thirdly, the strategic complementarity of foreign and domestic competition is an important result that points towards the importance of realistic modeling of the institutional environment in which firms operate.

An important 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.

The setup of the paper is as follows. Section 2 provides a brief survey of the literature. Section 3 sets up the theoretical model and sections 4 and 5 talk about the effects of different market structure assumptions. Section 6 is the conclusion.

2 Literature

There has been a recent stream of literature in IO and endogenous growth examining the relationship between product market competition and innovation. Aghion et al.(2001) analyzes 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.(2003b)uses 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 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 on 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. (2003a) 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.

3 Model

The model builds on Acemoglu et al.(2003), Aghion et al. (2003a) 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 produces varieties of the intermediate good (that differ in quality) and these are used by the final goods sector in production (which cares about the quantity and quality of the intermediate goods). At the beginning of each period, there is a monopolist in each variety of the intermediate good and this monopolist chooses inputs (capital and labor) to maximize profits, keeping in mind the derived demand of its product from the final goods sector. Within each 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. After observing the investment in quality (but within the same time period) by the domestic intermediate producer, the foreign firm decides whether or not to enter the domestic market.

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.

3.1 The environment

3.1.1 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:

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

Here L_{0t} is the number of production workers in the final goods sector at time t. $x_t(v)$ 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).

3.1.2 Intermediate Goods Sector

Following Acemoglu et al. (2003) and Aghion et al. (2003a), in each intermediate good sector v only one firm is active in each period (a monopolist). But as implied by the production function of the FG sector, the many varieties of the IG good compete in quality to be consumed by the FG sector. That is, the intermediate goods sector is monopolistically competitive. So the variable v refers both to an intermediate sector industry and to the intermediate firm that is active in that sector. 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:

$$x_t(v) = k_t(v)^{\beta} l_t(v)^{1-\beta} \tag{2}$$

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.

3.1.3 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

$$\bar{A}_t = (1+g)\bar{A}_{t-1} \tag{3}$$

Here g is the rate of growth of rate of global technological advance.

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.

That is, a domestic variety can either be one step below the frontier in period t or two steps below.

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.

$$c_t(v) = \frac{1}{2} {z_t}^2 \bar{A}_{t-1}(v)^{\frac{\delta}{1-\alpha}} \tag{4}$$

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 (2003a), 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 $\bar{A}_{t-3}$.

3.1.4 Entry into the Intermediate Goods Sector

We assume that entry by foreign firms 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. 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]. This means 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

[1] Note that the frontier itself advances at a rate of g (equation 3).

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. (2003a), 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.

Thus, the end of the period probability of entry into the market for v is Probability(Entry in period t)= 0 if DF is Advanced in t-1 and invested successfully in period t; μ else.

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

4 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–$p(v)$–is a measure of the threat of potential entry from domestic competitors into the IG sector while the parameter μ measures 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 which depends on $p(v)$– the price that it can charge. This 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 a 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.

4.1 The Benchmark Case: Competitive FG sector, Monopolist IG sector

Following Aghion et al (2003a), we first derive equilibrium investment in technology for the case where the FG sector is perfectly competitive. Then payment to inputs must equal the marginal product of inputs. Using the production function of the FG sector (equation 1), the price of the intermediate good v is

$$p_t(v) = \alpha {L_{Ot}}^{1-\alpha} \frac{A_t(v)^{\delta}}{x_t(v)^{1-\alpha}} \tag{5}$$

Similarly for labor,

$$w_t = (1-\alpha){L_{Ot}}^{-\alpha}\left[\int_0^1 A_t(v)^{\delta} x_t(v)^{\alpha} dv\right] \tag{6}$$

Note that we assume that wages are the same for both sectors-intermediate and final.

We can use equation 5 to get the derived demand for intermediate good v

$$x_t(v) = L_{Ot}\left[\frac{\alpha A_t(v)^{\delta}}{p_t(v)}\right]^{\frac{1}{1-\alpha}} \tag{7}$$

Note that the elasticity of demand for variety v with respect to its price is constant $\varepsilon = \frac{1}{1-\alpha}$.

The profit function of IG firm v can be written as

$$\pi_t(v) = Max_{k_t(v),l_t(v)}\{p_t(v)k_t(v)^{\beta} l_t(v)^{1-\beta} - k_t(v) - w_t l_t(v)\} \tag{8}$$
$$\text{s.t. } k_t(v)^{\beta} l_t(v)^{1-\beta} \geq L_{Ot}\left[\frac{\alpha A_t(v)^{\delta}}{p_t(v)}\right]^{\frac{1}{1-\alpha}}$$

Note that we assume that the IG firm is perfectly competitive in the market for labor and capital. 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

$$\pi_t(v) = \left[p_t(v) - \left(\frac{w\beta}{1-\beta}\right)^{-\beta} - \left(\frac{w\beta}{1-\beta}\right)^{1-\beta}\right] x_t(v) \tag{9}$$

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, $\frac{p_t(v)-\Omega}{p_t(v)} \equiv \varepsilon = \frac{1}{1-\alpha}$. This leads us to an important result that the price of each and every variety of intermediate good is equal.

$$p_t(v) = \frac{1}{\alpha}\Omega \equiv \chi \text{ for all varieties v} \tag{10}$$

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 1 we note that α is a measure of the 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.

The production of the final good is given by

$$y_t = \frac{\alpha^{\frac{1}{1-\alpha}}}{\alpha}\chi^{\frac{-\alpha}{1-\alpha}} L_{ot} A_t^* \tag{11}$$

where

$$A_t^* \equiv \int_0^1 A_t(v)^{\frac{\delta}{1-\alpha}} dv \tag{12}$$

is the average productivity in the IG industry.

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

$$\pi_t(v) = \alpha^{\frac{1}{1-\alpha}} (\chi - \Omega) \chi^{\frac{-1}{1-\alpha}} L_{Ot} A_t(v)^{\frac{\delta}{1-\alpha}} \tag{13}$$

4.1.1 Equilibrium Investment

In sections 3.1.3 and 3.1.4, 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 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

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

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. 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 4).

$$E\pi_t(v, Backward) = \alpha^{\frac{1}{1-\alpha}}(\chi-\Omega)\chi^{\frac{-1}{1-\alpha}}L_{Ot}[z(1-\mu)\bar{A}_{t-1}^{\frac{\delta}{1-\alpha}} + (1-z)(1-\mu)\bar{A}_{t-2}^{\frac{\delta}{1-\alpha}}] - \frac{1}{2}z^2\bar{A}_{t-2}^{\frac{\delta}{1-\alpha}} \quad (14)$$

This gives equilibrium intensity as

$$z_B = \alpha^{\frac{1}{1-\alpha}}(\chi-\Omega)\chi^{\frac{-1}{1-\alpha}}L_{Ot}(1-\mu)(1+g)^{\frac{\delta}{1-\alpha}} \quad (15)$$

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

$$E\pi_t(v, Advanced) = \alpha^{\frac{1}{1-\alpha}}(\chi-\Omega)\chi^{\frac{-1}{1-\alpha}}L_{Ot}[z\bar{A}_{t-1}^{\frac{\delta}{1-\alpha}} + (1-z)(1-\mu)\bar{A}_{t-2}^{\frac{\delta}{1-\alpha}}] - \frac{1}{2}z^2\bar{A}_{t-2}^{\frac{\delta}{1-\alpha}} \quad (16)$$

This gives equilibrium intensity as

$$z_A = \alpha^{\frac{1}{1-\alpha}} (\chi - \Omega) \chi^{\frac{-1}{1-\alpha}} L_{Ot}[(1+g)^{\frac{\delta}{1-\alpha}} - (1-\mu)] \tag{17}$$

Equations 15 and 17 can be used to analyze the effects of competition on investment in productivity-enhancing technology [3].

4.1.2 Comparative Statics

Analyzing the expressions for equilibrium investment in quality-enhancing technology we find that similar to Aghion et al. (2003a), 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. 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, $\frac{\partial z_A}{\partial \chi} > 0$[4].

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, $\frac{\partial^2 z_A}{\partial \mu \partial \chi} > 0$. The

[3]Note that the market clearing wage rate can be calculated using equation 6 $w_t = \frac{1-\alpha}{\alpha}\chi^{\frac{-\alpha}{1-\alpha}}A^*{}_t$ 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.

We can solve for 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 j 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 $L_{IG} = \int_0^1 (l_t(v))dv = \left[\frac{1-\beta}{\beta w_t}\right]^{\beta} \int_0^1 L_{Ot} \left[\frac{\alpha A_t(v)^{\delta}}{\chi}\right]^{\frac{1}{1-\alpha}} = \alpha^{\frac{1}{1-\alpha}} \left[\frac{1-\beta}{\beta w_t}\right]^{\beta} \chi^{\frac{-1}{1-\alpha}} A_t{}^* L_{ot}$. The labor demand for the FG sector can be found using full employment: $L_0 + L_{IG} = \bar{L}$. We get $L_O = \frac{1}{1+\alpha^{\frac{1}{1-\alpha}}\left(\frac{1-\beta}{\beta w}\right)^{\beta}\chi^{\frac{-1}{1-\alpha}}A^*}\bar{L}$.

[4]To see this note that after simplification, $\frac{\partial z_A}{\partial \chi} = (\chi - \Omega)\chi^{\frac{-1}{1-\alpha}} \frac{\partial L_{ot}}{\partial \chi} + L_{ot}\frac{\partial(\chi-\Omega)\chi^{\frac{-1}{1-\alpha}}}{\partial \chi}$. The second term is zero when evaluated at the profit-maximizing price $\chi = \frac{1}{\alpha}\Omega$ and the first term is strictly positive. Intuitively, as the price of intermediate goods rises, the final goods firm tries to shift out of intermediate goods and use more labor in its production process.

more monopoly power the IG sector has (higherχ), the more aggressive will be its response to the increased threat of foreign entry (higher μ).

4.2 Case: Monopolistic FG sector, Monopolistically Competitive IG 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 [5]. 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 $x_t(v)$ to solve

$$C(p(v),w,y) = Min_{L_{ot},x(v),v\varepsilon(0,1)} w_t L_{ot} + \int_0^1 p(v)x(v)dv \tag{18}$$

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

$$y_t \leq {L_{0t}}^{1-\alpha} \left[\int_0^1 A_t(v)^{\delta} x_t(v)^{\alpha} dv \right] \tag{19}$$

The details of the cost minimization are in appendix A. 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 producer does not take account of the effect of his actions on the average price (Tirole ??), 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 will charge a constant mark-up over costs. Thus similar to the perfectly competitive FG case, $p_t(v) = \chi$ for all varieties v.

Substituting this into the derived demand equation gives us

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

$$x_t(v) = \frac{\alpha w L_{ot}}{1-\alpha}\left[\frac{A_t(v)^{\frac{\delta}{1-\alpha}}}{\chi A^*}\right] = \left[\frac{w\alpha}{1-\alpha}\right]^{1-\alpha}\left[\frac{A(v)^{\frac{\delta}{1-\alpha}} y_m}{\chi^{1-\alpha} A^{*2-\alpha}}\right] \tag{20}$$

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

$$C(p(v), y) = \left[w\left(\frac{1-\alpha}{w\alpha}\right)^{\alpha} + \left(\frac{1-\alpha}{w\alpha}\right)^{\alpha-1}\right]\chi^{\alpha} A^{*\alpha-1} y_m \tag{21}$$

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

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

where $M \equiv w\left(\frac{1-\alpha}{w\alpha}\right)^{\alpha} + \left(\frac{1-\alpha}{w\alpha}\right)^{\alpha-1}$. Equation 20 and 22 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.

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

4.2.1 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 4.1.1, the equilibrium investment in productivity-enhancing technology by the intermediate goods producer is given by

$$z_B = (\chi - \Omega)\,\chi^{\alpha-1}\left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha}\frac{(1-\mu)(1+g)^{\frac{\delta}{1-\alpha}}}{A^{*2-\alpha}}y_m \tag{23}$$

$$z_A = (\chi - \Omega)\,\chi^{\alpha-1}\left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha}\frac{[(1+g)^{\frac{\delta}{1-\alpha}} - (1-\mu)]}{A^{*2-\alpha}}y_m \tag{24}$$

4.3 Comparative Statics

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 23 and 24, we see that the basic effect of the threat of foreign entry is the same as in the original model (Aghion et al (2003a)). 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 4.2 (equation 20), the derived demand for each variety is such that the IG monopolists in all varieties charge a common price χ. Note that even though there is no mechanism through which χ can change within this elementary model, we conduct an interesting thought experiment and allow χ to change. This is because 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.

Differentiating equilibrium investment (equations 23 and 24) with respect to χ 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*

$$\frac{\partial z_i}{\partial \chi} = \left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha} \frac{[(1+g)^{\frac{\delta}{1-\alpha}} - (1-\mu)]}{A^{*2-\alpha}} \left[\frac{y_m(\alpha\chi + (1-\alpha)\Omega)}{\chi^{2-\alpha}} + \frac{\chi - \Omega}{\chi^{1-\alpha}} \frac{\partial y_m}{\partial \chi}\right] < 0 \quad \textit{for } \chi > \bar{\chi} \tag{25}$$

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

[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. (2003a) 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.

[8]Details are presented in appendix B

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 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 11 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 22) (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 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. 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, $y_m \leq \bar{y}$ if and only if$A^* \leq \bar{A^*}$. Intuitively, the price of the intermediate goods

[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 this is 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.

[10] From equation 22, the elasticity of y with respect to χ is given by $\varepsilon_y = \frac{\alpha M \chi^{\alpha}}{2bA^{*1-\alpha}y_m}$.

matters to the final goods firm. But holding 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 20. If we look at equation 20 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 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 4.1.2 we found that $\frac{\partial z_i}{\partial \chi} > 0$ 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 (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 lower χ will spur investment in the intermediates sector.

If we analyze the equations for the derived demand for intermediate variety v in the two market structures (equations 7 and 20) 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 11). 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 analyse 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*

$$\frac{\partial^2 z_{Ad}}{\partial\chi\partial\mu} < 0 \, for \, \chi > \bar{\chi} \tag{26}$$

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

This is our main theoretical result and this points towards a strategic complementarity relationship between industrial and trade policy. That is, industrial deregulation (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. 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 $y_m < \bar{\bar{y}}$ or $\chi > \bar{\bar{\chi}}$.

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 gods sector producer. This provides an indirect measure of the market structure and competition in the FG sector. Using equations 23 and 24, 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.

That is

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

$$\frac{\partial z_i}{\partial y_m(.)} > 0, \quad i = A, B \tag{27}$$

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*

$$\frac{\partial^2 z_{Ad}}{\partial y_m \partial \mu} > 0 \tag{28}$$

That is, an advanced 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 (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.

5 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, it is akin to say, 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. In that case, labor will need to be diverted from the production of physical units of the intermediate good into R and D. So we can think of investment intensity z as the number of workers that were removed from production and into R and D (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

$$\pi_t(v) = \left(\frac{\chi - \omega}{\chi^{1-\alpha} {A^*}_t^{2-\alpha}}\right)\left(\frac{w\alpha}{1-\alpha}^{1-\alpha}\right) y_m - wz - \frac{1}{2} z^2 \bar{A}_{t-1}^{\frac{\delta}{1-\alpha}} \tag{29}$$

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

$$z_A = (\chi - \Omega)\chi^{\alpha-1}\left(\frac{w\alpha}{1-\alpha}\right)^{1-\alpha} \frac{[(1+g)^{\frac{\delta}{1-\alpha}} - (1-\mu)]}{{A^*}_t^{2-\alpha}} y_m - \frac{w}{\bar{A}_{t-1}^{\frac{\delta}{1-\alpha}}} \tag{30}$$

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 term with w reflects the marginal cost of each unit of z in terms of the cost of workers that need to be hired[11]. All the results regarding domestic competition, foreign competition and the relationship between the two remain essentially

[11] 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 fo 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

the same as the ones described in section 4.3. So the incentives to invest in quality in response to domestic and foreign competition change magnitude but not signs.

Now we take the special case where the production of the final good does not require labor. This is the case that is analyzed in Aghion et al. (2003a) and Aghion et al. (2004) and it is interesting to note that this particular case gives us very strong results. Now the production function for the final goods sector takes the form $y_t = \left[\int_0^1 A_t(v)^{\delta} x_t(v)^{\alpha} dv\right]$. Thus when the final goods sector is perfectly competitive, we get the derived demand for variety v as $x_t(v) = p(v)^{\frac{-1}{1-\alpha}} A_t(v)^{\frac{\delta}{1-\alpha}}$. After imposing $p(v) = \chi$ into this and plugging this into the profit function of the intermediate goods sector, we get

$$\pi_t(v) = \frac{\chi - \Omega}{\chi^{\frac{1}{1-\alpha}}} A_t(v)^{\frac{\delta}{1-\alpha}} \tag{31}$$

where Ω is the marginal cost of production in the intermediate sector as defined earlier. After maximization of expected profits, the equilibrium investment in quality-enhancing technology for advanced and backward firms is

$$z_A = \frac{\chi - \Omega}{\chi^{\frac{1}{1-\alpha}}} \left[(1+g)^{\frac{\delta}{1-\alpha}} - (1-\mu)\right] \tag{32}$$
$$z_B = \frac{\chi - \Omega}{\chi^{\frac{1}{1-\alpha}}} \left[(1-\mu)(1+g)^{\frac{\delta}{1-\alpha}}\right]$$

We find that the response of investment to a fall in χ is unambiguously negative. That is, only the Schumpeterian motive operates and a fall in the amount of surplus that the IG monopolist can appropriate will reduce incentives to invest in technology.

When the final goods sector is modeled as monopolistic then the first order conditions for cost minimization imply that derived demand for variety v is

$$x_t(v) = \left[\frac{y}{A^*}\right]^{\frac{1}{\alpha}} A(v)^{\frac{\delta}{1-\alpha}} \tag{33}$$

Profit maximization then allows us to solve for the output level y_m as an implicit equation of the

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.

price of inputs and average quality in the intermediate goods sector.

$$a - 2by_m = y_m^{\frac{1-\alpha}{\alpha}} \frac{\chi}{\alpha A_t^{*\frac{1-\alpha}{\alpha}}} \tag{34}$$

Note that y(.) is an increasing and convex function of χ. Now equilibrium investment is given by

$$z_A = \frac{\chi - \Omega}{A^{*\frac{1}{\alpha}}} \left[(1+g)^{\frac{\delta}{1-\alpha}} - (1-\mu)\right] y_m \tag{35}$$
$$z_B = \frac{\chi - \Omega}{A^{*\frac{1}{\alpha}}} \left[(1-\mu)(1+g)^{\frac{\delta}{1-\alpha}}\right] y_m$$

Now the response of investment z to a fall in χ is no longer unambigously negative. That is, there is a range of χ over which a monopolist producer of variety v will respond to lower price of his product by raising investment in technology.

$$\frac{\partial z_A}{\partial \chi} = \left[\frac{y(A_t^{*Ad}, \chi)}{A_t^{*Ad}}\right]^{\frac{1}{\alpha}} \left((1+g)^{\frac{\delta}{1-\alpha}} - (1-\mu)\right) \left[1 + \left(\frac{\chi - \Omega}{\alpha y(.)}\right) \frac{\partial y(.)}{\partial \chi}\right] < 0 \quad \text{for } \chi > \bar{\chi} \tag{36}$$

Thus similar to the general case analyzed in section 4.3, a fall in the price that a monopolist can charge for his good can lead to a raise in equilibrium investment. The key intuition behind this result remains that once we give some power to the final goods sector to decide its output level, it uses this output y_m to reward the intermediate goods sector for lowering the price of the input. All other results pertaining to strategic complementarity between foreign competition and domestic competition are identical to section 4.3.

6 Conclusions

The main conclusion of our paper is that market structure in the final goods sector matters. 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 Scale 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, entry de-regulation in the intermediate goods sector (modeled as a fall in the price of intermediates) has the effect of unambiguously lowering technological investment in the 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.

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A Appendix A

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

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

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

$$\frac{w}{p(v)} = \left(\frac{1-\alpha}{\alpha}\right) \frac{(\int_0^1 A_t(v)^{\delta} x_t(v)^{\alpha} dv)}{L_o A(v)^{\delta}} x(v)^{1-\alpha} \tag{A.2}$$

$$\frac{p(v)}{p(v')} = \left(\frac{A(v)}{A(v')}\right)^{\delta} \left(\frac{x(v')}{x(v)}\right)^{1-\alpha} \tag{A.3}$$

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

$$x(v') = \left(\frac{A(v')}{A(v)}\right)^{\frac{\delta}{1-\alpha}} \left(\frac{p(v)}{p(v')}\right)^{\frac{1}{1-\alpha}} \text{ for all v'} \tag{A.4}$$

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),

$$\int_0^1 A_t(v)^{\delta} x_t(v)^{\alpha} dv = \frac{x(v)^{\alpha} p(v)^{\frac{\alpha}{1-\alpha}}}{A(v)^{\frac{\alpha\delta}{1-\alpha}}} \left[\int_0^1 A(v)^{\frac{\delta}{1-\alpha}} p(v)^{\frac{-\alpha}{1-\alpha}} dv\right] \tag{A.5}$$

Using this expression in equation A.2 swe get the derived demand for variety v as

$$x(v) = \frac{\alpha w L_{ot}}{1-\alpha} \left[\frac{A(v)^{\frac{\delta}{1-\alpha}}}{p(v)^{\frac{1}{1-\alpha}}}\right] \bar{A}^{-1} \tag{A.6}$$

where $\bar{A} \equiv \int_0^1 A(v)^{\frac{\delta}{1-\alpha}} p(v)^{\frac{-\alpha}{1-\alpha}} dv$. Note that the elasticity of demand is constant and hence a profit maximising 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

$$x(v) = \frac{\alpha w L_{ot}}{1-\alpha} \left[\frac{A(v)^{\frac{\delta}{1-\alpha}}}{\chi A^*}\right] \tag{A.7}$$

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 A.7 to get an expression for derived demand for the intermediate good as a function of output y.

$$x(v) = \left[\frac{w\alpha}{1-\alpha}\right]^{1-\alpha} \left[\frac{A(v)^{\frac{\delta}{1-\alpha}} y}{\chi^{1-\alpha} A^{*2-\alpha}}\right] \tag{A.8}$$

So the cost function for the final goods monopolist is

$$\begin{aligned} C(p(v), y) &= Min_{L_{ot}, x(v), v\varepsilon(0,1)} w_t L_{ot} + \int_0^1 p(v) x(v) dv \\ &= \left[w\left(\frac{1-\alpha}{w\alpha}\right)^{\alpha} + \left(\frac{1-\alpha}{w\alpha}\right)^{\alpha-1}\right] \chi^{\alpha} A^{*\alpha-1} y \end{aligned} \tag{A.9}$$

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.

B Appendix B

To see this result note that

$$sign\left(\frac{\partial z_i}{\partial \chi}\right) = sign\left(\frac{\partial}{\partial \chi}\left((\chi - \Omega)\chi^{\alpha-1} y_m\right)\right) \tag{B.1}$$

Now

$$\frac{\partial}{\partial \chi}\left((\chi - \Omega)\chi^{\alpha-1} y_m\right) = \chi^{\alpha-2}\left[(\alpha(\chi - \Omega) + \Omega) y_m - \alpha(\chi - \Omega)\frac{M\chi^{\alpha}}{2bA^{*1-\alpha}}\right] \tag{B.2}$$

.

For the second term in the square brackets, we can use the equation for y_m to substitute for $\frac{M\chi^{\alpha}}{2bA^{*1-\alpha}} = \frac{a}{2b} - y_m$. Now

$$\frac{\partial}{\partial \chi}\left((\chi - \Omega)\chi^{\alpha-1} y_m\right) = \chi^{\alpha-2}\left[(2\alpha(\chi - \Omega) + \Omega) y_m - \alpha(\chi - \Omega)\frac{a}{2b}\right] \tag{B.3}$$

.

This expression is negative when

$$y_m < \frac{a\alpha(\chi - \Omega)}{2b(2\alpha(\chi - \Omega) + \Omega)} \equiv \bar{y} \tag{B.4}$$

Given that the supply function for the final goods sector y_m is monotonically decreasing in χ, this means that χ is less than a certain level. The exact value of the threshold $\bar{\chi}$ is given by the implicit equation

$$2\alpha\chi^{\alpha} - \alpha\Omega\chi^{\alpha-1} = \frac{a\alpha A^{*}}{M} \tag{B.5}$$