Firm Level Effects of Foreign Investment Policy

by Arunish Chawla

The London School of Economics and Political Science

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Declaration

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Abstract

In this thesis I investigate how the FDI Policy environment affects certain aspects of firm behaviour.

First, I introduce the option value of foreign direct investment into a framework of Dixit-Stiglitz type monopolistic competition. Starting from a pure trading equilibrium and solving for the optimal foreign investment rule gives a scale-up factor, which implies existence of a wedge between mark-up revenues and foreign investment costs. Greater volatility and risk aversion increase this scale-up over foreign investment costs implying a delay in the exercise of FDI option. The model is extended to include a Poisson jump process, which has policy implications for FDI reforms. This model explains 'wait and watch' behaviour of multinational firms better than a pure comparative advantage-trade cost framework does.

Second, I develop a model of firm heterogeneity with market power. Mark-ups are endogenous and responsive to toughness of market competition. It brings out potential gains in market power and profits as an additional reason for undertaking FDI in addition to reasons already enshrined in the literature as proximity-concentration trade-off. The model is used to analyse the interaction between profit maximizing behaviour of multinational firms and the welfare maximizing objective of the central planner. FDI is not an unambiguously welfare improving proposition. While multinational firms gain profits, host and home country may gain or lose welfare depending on how returns from foreign investment are distributed among the residents of the home and the host economies.

Third, I analyse the relationship between foreign investment policy and manufacturing firms' performance as estimated by multi-factor productivity against the backdrop of Indian liberalisation of the 1990's. Using a firm-year panel from 1989 to 2004, I obtain consistent estimates of firm's production functions and controlling for industrial delicensing and trade reforms, estimate the effect of foreign investment policy on measured productivity of manufacturing firms. I find liberalisation of foreign investment regime has significantly improved manufacturing firms' performance in India over this period. A particularly interesting feature of India's foreign investment regime has been encouraging adoption of foreign technology by domestic firms, while at the same time opening up these industry sectors to foreign direct investment. These two elements of the foreign investment regime have actually been complementary to each other.

To Bhavna and Rhea

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1 Introduction

Multinational enterprises are key players in the era of globalisation. Multinational activity today accounts for more than a quarter of global output and nearly two-thirds of world trade. Since the mid 1980's, world has seen an unprecedented increase in real FDI inflows (15-20 percent per year), which has been far greater than the real GDP growth (2.5 percent per year) and the real exports growth(5.5 percent per year) over the same period. This compares strikingly with the pre-1985 era, when real GDP, exports and FDI growths were more or less following closer trends (Navaretti and Venables, 2004). Within industries, multinational firms are larger than their national counterparts. In in a recent study of US firms Bernard, Jensen and Schott (2005) found evidence of extreme market concentration in favour of the large firms (top 1 of firms account for a much as 81 percent of US trade), and that this concentration has in fact been increased over time.[1]

As multinational firms continue to acquire greater economic power, political power remains concentrated in the hands of national governments. Policy makers around the world continue to have mixed feelings about the multinational firms; from welcoming them as bearers of foreign wealth and technology to seeing them as unwelcome threats to national identity. Understanding the interaction between the two remains a challenging area of theoretical and empirical research. This thesis is an attempt in that direction.

The second chapter introduces an option value of foreign direct investment into a framework of Dixit-Stiglitz type monopolistic competition. Starting from a pure trading equilibrium and solving for the optimal foreign investment rule gives a scale-up factor, which implies existence of a wedge between mark-up revenues and foreign investment costs. Greater volatility and risk aversion increase this scale-up over foreign investment costs, implying a delay in the exercise of FDI option. Growing market size facilitates early exercise. The model is extended to include a Poisson jump process, which has policy implications for FDI reforms. This model explains 'wait and watch' behaviour of multinational firms better than a pure comparative advantage-trade cost framework does.

[1] The time line for their study is year 1993 to 2000.

The third chapter is a model of firm heterogeneity and market power. Mark-ups are endogenous and responsive to toughness of market competition. It brings out potential gains in market power and profits as an additional reason for undertaking FDI in addition to reasons already enshrined in the literature as proximity-concentration trade-off. The model is used to analyse the interaction between profit maximizing behaviour of multinational firms and the welfare maximizing objective of the central planner. FDI is not an unambiguously welfare improving proposition. While multinational firms gain profits, host and home country may gain or lose welfare depending on how returns from foreign investment are distributed among the residents of the home and the host economies. This model also brings out the importance of multilateral investment regime and bilateral investment treaties in refining multiple Nash equilibria to ensure the most liberal FDI policy regime is implemented worldwide.

The fourth chapter contains an analysis of the relationship between foreign investment policy and manufacturing firms' performance as estimated by multi-factor productivity against the backdrop of Indian liberalisation of the 1990's. Using a firm-year panel from 1989 to 2004, I obtain consistent estimates of firm's production functions and controlling for industrial delicensing and trade reforms, estimate the effect of foreign investment policy, as practised in India during the 1990's, on measured productivity of manufacturing firms. I find liberalisation of foreign investment regime has significantly improved manufacturing firms' performance in the respective sectors. A particularly interesting feature of India's foreign investment regime has been encouraging adoption of foreign technology by domestic firms, while at the same time opening up these industry sectors to foreign direct investment. A case study of the motor vehicle industry shows these two elements of the foreign investment regime have actually been complementary to each other.

The last chapter concludes by summarizing the key insights of this thesis and the contributions it makes to theoretical and empirical research.

2 Multinational Firms, Monopolistic Competition and Foreign Investment Uncertainty

2.1 Introduction

More than two-thirds of world trade today is determined by activities of multinational enterprises, a phenomenon not well explained by the traditional trade theory. For many years the economics of relationship between trade and investment were studied as complements or substitutes (Mundell, 1957; Lipsey and Weiss, 1981; Blomstrom et al, 1988). More recent studies indicate such a generalization is not possible, and that both trade and investment flows are determined simultaneously by the location decisions of multinational firms (Markusen, 2002).

'New trade theory' has developed general equilibrium models for multinational firms in the presence of imperfect competition (Markusen and Venables, 1998; Markusen, 2002; Helpman, 1984). While the vertical multinationals are explained by factor proportion analysis, horizontal multinational activity is explained by the proximity-concentration trade-off (Brainard, 1993; Brainard, 1997). More recently, Export vs FDI cut off has been derived in the presence of firm heterogeneity (Helpman, Melitz and Yeaple, 2004).

Real life behaviour is somewhat more complex than what can be explained by a conventional cost-benefit analysis. While most of the work above is based on a standard Marshallian kind of economic analysis, evidence indicates that firm's investment decisions, and even more so, foreign investment decisions are undertaken in the face of uncertainty. Studies indicate that if we fail to take this into account, then, even for reasonable parameter values, we may be up to two times off the mark as compared to a routine cost-benefit analysis (Dixit and Pindyck, 1994).

Even when comparative advantage indicates foreign investment should flow in or when economic liberalization removes barriers to such investments, they do not automatically flow in. There is a considerable wait-and-watch, a kind of time lag or inertia followed by herd behaviour when foreign investments actually start flowing in. This implies existence of a value-for-waiting or in other words, some opportunity cost beyond what is accounted for in a pure comparative advantage-trade cost framework.

Almost simultaneously as the new trade theory was taking shape, a strand of literature was growing out of the core finance theory to model investment decisions of individual firms under uncertainty. Starting with the work of

McDonald and Siegel (1986) on the value of waiting to invest and Dixit's (1989) work on firm's investment decisions under uncertainty, a rich literature has developed on investment under uncertainty a la Dixit and Pindyck (1994). Baldwin and Krugman (1989) modelled hysteresis in trade under assumptions of large exchange rate shocks. Dixit (1989) applied it to exchange rate pass-through under perfect competition. Rafael and Vettas (2003) modelled Export and FDI for a single seller in the presence of growing demand. Their model showed that FDI is the preferred mode of production for proven demand, while exports is the preferred mode of production for uncertain demand.

I take a step forward from the existing literature and develop a model of many sellers (multinational firms) operating under foreign investment uncertainty within the framework of a Dixit-Stiglitz type monopolistic competition. I use option theory to derive an optimal foreign investment rule and model policy driven FDI liberalization as a mixed Poisson jump-Brownian motion stochastic process. Another useful feature of this model is that while investment under uncertainty literature is based on the theory of call options, I solve 'FDI option' as a put option, thereby also enriching the theory of real options.

Section 2 presents the underlying static model. Section 3 introduces foreign investment uncertainty and develops its inter-temporal counterpart. Section 4 elaborates some comparative experiments. Section 5 extends the model by introducing a mixed Poisson jump-Brownian motion stochastic process. Section 6 concludes.

2.2 The Static Model

There are two countries: i and j. There are two goods: Y, a homogeneous good, and X, a differentiated good with imperfectly substitutable varieties in the Dixit-Stiglitz fashion. Skilled labour (S) is the only factor of production and all costs are expressed in units of this factor.

Good Y (the homogeneous good) is produced by a perfectly competitive industry using a constant returns to scale technology:

$$Y_i = \frac{1}{a_y} S_{iy} \tag{1}$$

where a_y is the unit labour requirement and S_{iy} is the amount of skilled labour used in production of good Y. Its transport is costless and it is treated as numeraire (price normalized to one).

Good X, the differentiated good, is produced by a monopolistically competitive industry. Varieties of this good can be produced by national (indexed by n) or multi-national (indexed by m) firms. Let N_i^n, N_i^m,N_j^n ,N_j^m stand for the number of firms of each type operating in equilibrium, headquartered respectively in country i and j.

Sector X has a linear cost function with both fixed and variable costs.[2] Total production costs for a national firm in country j are given by:

$$S_{jx}^n = H^n + G^n + cX_{jj}^n + cX_{ji}^n \tag{2}$$

where c are the constant marginal costs, X_{jj}^n and X_{ji}^n are respectively the outputs for domestic and foreign markets. Further, H^n are the headquarter level fixed costs and G^n are the plant level fixed costs, both of which are at least partly irreversible or sunk.

Similarly, total production costs for a multinational firm located in country j are given by:

$$S_{jx}^m + S_{ix}^m = H^m + G^n + cX_{jj}^m + G_i^m + cX_{ji}^m \tag{3}$$

where first part on the right hand side are the costs of operation within the home country and the second part on right hand side are the costs of operating in the foreign country.

Headquarter costs of multi-national operation, H^m, are typically different from headquarter costs of national operation, H^n, because of the need for greater headquarter services and additional costs of creating trans-national networks. Similarly, costs of foreign investment, $G_{i\ or\ j}^m$, are different from a similar initiative by domestic firms, G^n, as almost all countries have specific FDI regimes, meaning thereby that routes and mechanisms prescribed for foreign investment are different from those prescribed for domestic firms. Costs of foreign investment are also different between the two countries ($G_i^m \neq G_j^m$) and depend on their local foreign investment environments.

Assuming diversified production,[3] wage (w) is pinned down by the numeraire sector in both the countries:

$$w = \frac{1}{a_y} \tag{4}$$

[2]Presence of fixed costs in the cost function implies economies of scale.

[3]I assume labour endowment and value of demand parameters is such that both countries produce both the goods. Symmetric countries always have diversified production.

Total incomes in both the countries depend on their respective factor endowments:

$$M_i = wS_i \tag{5}$$

$$M_j = wS_j \tag{6}$$

On the demand side, there is a representative consumer in each country with a Cobb-Douglas utility function, which for countries i and j are:

$$U_i = X_{ic}^{\beta} Y_{ic}^{1-\beta} \tag{7}$$

$$U_j = X_{jc}^{\beta} Y_{jc}^{1-\beta} \tag{8}$$

Here, X_{ic} is the CES aggregate of x-varieties in the familiar Dixit-Stiglitz fashion given by:

$$\begin{aligned} X_{ic} &= [N_i^n (X_{ii}^n)^{\alpha} + N_j^n (X_{ji}^n)^{\alpha} + N_i^m (X_{ii}^m)^{\alpha} + N_j^m \left(X_{ji}^m\right)^{\alpha}]^{\frac{1}{\alpha}}; \\ &\quad \text{such that } \{0 < \alpha < 1\}. \end{aligned} \tag{9}$$

Define $\epsilon = \frac{1}{1-\alpha}$ as the elasticity of substitution between any two x-varieties.[4] N, as before, is the number of firms of each type operating in equilibrium. This utility function permits two stage budgeting:

In the first stage budgeting, the consumer allocates his total income to goods X and Y through the following demand functions:

$$Y_{ic} = (1 - \beta) M_i \tag{10}$$

$$X_{ic} = \beta \frac{M_i}{e_i} = \frac{M_{ix}}{e_i} \tag{11}$$

Here, M_{ix} is the amount of country i's national income spent on good X, e_i is the unit expenditure function for X_{ic} (also called the price index) and as already mentioned, good Y is used as numeraire (i.e. its price is equal to one).

In the second stage budgeting, the consumer solves the sub-utility maximization problem for individual varieties. Demand for an individual variety is then a solution to the sub-utility maximization problem given by:

$$x_k = p_k^{-\epsilon} e_i^{\epsilon-1} M_{ix} \tag{12}$$

[4] I assume symmetry within each category of x-varieties in the CES function above.

where subscript k stands for an individual variety and the remaining variables are as defined above.

In large group monopolistic competition each individual firm takes the price index e_i and country income M_i as given. The proportional mark-up of price over variable costs is given by:

$$p = (\frac{\epsilon}{\epsilon - 1})\frac{c}{a_y} \tag{13}$$

where c is the units of labour used in producing one unit of the good (x-variety) and $1/a_y$ is the wage rate. This pricing equation comes from the first order condition, called the 'marginal revenue equals marginal cost condition'. The proportional markup of price over marginal costs is constant and independent of market shares. For constant marginal costs and equal wages, this implies each x-variety is produced for the same price $p_x = p$ in equilibrium. However, x-varieties produced by national firms are sold abroad for a higher price $p\tau$, where τ are the iceberg trade costs.

As in the trade cost literature, τ are the inclusive trade costs. They include not only transport costs but all intermediate costs like tariff barriers, non-tariff barriers, border costs, information costs, time costs, currency costs etc. According to the literature, trade costs are fairly large, an average estimate being 170% of the value of the output (Anderson and Wincoop, 2004). Currency costs are only a small proportion of it – about 8-14% out of a total 170%, and this includes both transaction and hedging costs. Trading horizon is typically short-term (few days to few weeks) and currency risks over short periods are easily hedged in financial markets today, say through the spot rate or a short-term forward, which is either costless or has costs which are small. I do not assume large exchange rate shocks as in Baldwin and Krugman (1989), but medium to long term exchange rate risk, which is not easy to hedge against in the forward foreign exchange market, matters for foreign direct investment among other sources of aggregate uncertainty mentioned in section 3 below. This is because the ability to limit risks posed by long term exchange rate shifts is either unavailable or is very expensive (Guay and Kothari, 2003). Further, the foreign exchange futures market is also illiquid beyond the short-term (Layard et al, 2002). As compared to a more straightforward trading decision, FDI typically takes place in the face of foreign investment uncertainty. This will be explicitly modelled later.

Production regime for the X-sector is determined by a set of conditions called the zero-profit conditions given below:

$$\begin{array}{rcll} pX_{ii}^n + pX_{ij}^n & \leq & wcX_{ii}^n + wcX_{ij}^n + w(H^n + G^n) & (N_i^n) \quad (14) \\ pX_{ii}^m + pX_{ij}^m & \leq & wcX_{ii}^m + wcX_{ij}^m + w(H^m + G^n) + wG_j^m & (N_i^m) \\ pX_{jj}^n + pX_{ji}^n & \leq & wcX_{jj}^n + wcX_{ji}^n + w(H^n + G^n) & (N_j^n) \\ pX_{jj}^m + pX_{ji}^m & \leq & wcX_{jj}^m + wcX_{ji}^m + w(H^m + G^n) + wG_i^m & (N_j^m) \end{array}$$

These are written as inequalities in the complementary slackness form, meaning thereby that an equation will hold with equality if the output of the corresponding firm is positive, otherwise the output of the corresponding firm is zero. These conditions relate markup revenues to investment costs and number of firms is the endogenous variable. Depending on whether markup revenues cover investment costs or not, firms decide whether to operate as a national firm exporting to the foreign market or undertake a foreign direct investment abroad i.e. become multinational.

Let us assume for a moment that each type of firm is active in equilibrium. Demand functions for varieties produced by each of these firms, as derived from the respective sub-utility maximization problems are given below:

$$\begin{array}{rcl} X_{ii}^n & = & X_{ii}^m = X_{ji}^m = p^{-\epsilon}e_i^{\epsilon-1}M_{ix} = \beta p^{-\epsilon}e_i^{\epsilon-1}M_i = \beta p^{-\epsilon}e_i^{\epsilon-1}wS_i \quad (15) \\ X_{jj}^n & = & X_{jj}^m = X_{ij}^m = p^{-\epsilon}e_j^{\epsilon-1}M_{jx} = \beta p^{-\epsilon}e_j^{\epsilon-1}M_j = \beta p^{-\epsilon}e_j^{\epsilon-1}wS_j \\ X_{ji}^n & = & p^{-\epsilon}\tau^{1-\epsilon}e_i^{\epsilon-1}M_{ix} = \beta p^{-\epsilon}\tau^{1-\epsilon}e_i^{\epsilon-1}M_i = \beta p^{-\epsilon}\tau^{1-\epsilon}e_i^{\epsilon-1}wS_i \\ X_{ij}^n & = & p^{-\epsilon}\tau^{1-\epsilon}e_j^{\epsilon-1}M_{jx} = \beta p^{-\epsilon}\tau^{1-\epsilon}e_j^{\epsilon-1}M_j = \beta p^{-\epsilon}\tau^{1-\epsilon}e_j^{\epsilon-1}wS_j \end{array}$$

Iceberg trade costs imply, if a quantity X_{ji}^n is shipped by a national (exporting) firm, only $\frac{X_{ji}^n}{\tau}$ arrives in the foreign country and is sold for a price $p\tau$. M_{ix} or M_{jx} is respectively the amount of national income spent on good X, which is further substituted out in terms of the demand parameters, the wage incomes and factor endowments.

It is possible to further simplify the zero-profit conditions above by using the pricing equation and Marshallian demand functions for individual x-varieties. Some algebra (see appendix A1) yields a simplified set of conditions, which determine the production regime for the X-sector, and these equations written compactly for country j firms are:

$$\begin{array}{rcll} \beta p^{1-\epsilon}\tau^{1-\epsilon}e_i^{\epsilon-1}S_i + \beta p^{1-\epsilon}e_j^{\epsilon-1}S_j & \leq & \epsilon(H^n + G^n) & (N_j^n) \quad (16) \\ \beta p^{1-\epsilon}e_i^{\epsilon-1}S_i + \beta p^{1-\epsilon}e_j^{\epsilon-1}S_j & \leq & \epsilon(H^m + G^n) + \epsilon G_i^m & (N_j^m) \end{array}$$

and similarly, for country i firms are:

$$\begin{aligned} \beta p^{1-\epsilon}e_i^{\epsilon-1}S_i + \beta p^{1-\epsilon}\tau^{1-\epsilon}e_j^{\epsilon-1}S_j &\leq \epsilon(H^n + G^n) & (N_i^n) \quad (17) \\ \beta p^{1-\epsilon}e_i^{\epsilon-1}S_i + \beta p^{1-\epsilon}e_j^{\epsilon-1}S_j &\leq \epsilon(H^m + G^n) + \epsilon G_j^m & (N_i^m) \end{aligned}$$

As before, all equations will not hold with equality at one time. If one of them holds with equality, the corresponding number of firms is positive, otherwise the corresponding number of firms is zero.

2.3 The Inter-temporal Model

For inter-temporal analysis it is necessary to specify the starting and the end points. Let us start at time $t = 0$ with a national production regime, where only exporting firms are operating in both the countries and there is diversified production. This implies existence of a pure trading equilibrium (no FDI) with both intra-industry and inter-industry trade. Let us assume the representative consumer lives, and that firms potentially operate, forever. National firms in the pure trading equilibrium have an option to undertake foreign direct investment and start multinational production abroad. At some time t^* between $t = 0$ and $t = \infty$ this option could be exercised and the production regime would switch from national to multinational, provided it is optimal to do so. I will explicitly solve for this optimal foreign investment rule.

As compared to a more straight-forward trading (export) decision, FDI is typically undertaken in the face of foreign investment uncertainty. This is an aggregate uncertainty arising from the foreign environment and could be because of statutory FDI policies, corporate governance/tax regimes, medium-to-long-term exchange rate risks, policy shifts like economic liberalization, incentive competition,[5] industry or economy-wide macro shocks, political instability etc. This uncertainty cannot be easily hedged and exists even when a multinational firm undertakes a foreign direct investment into a seemingly similar economy. It is this uncertainty which is of interest here and is represented by a stochastic shift variable R_i, multiplicative with the costs of foreign investment, say for country i:

$$G_i^m = GR_i \tag{18}$$

[5]Incentive competition refers to national governments competing with each other to offer investment incentives to multinational firms so as to attract FDI into their respective countries.

Notice the two components of foreign investment – a certain part (G) and an uncertain part (R_i). This being a real model (there is no money here), costs of uncertainty associated with 'trade-in-invisibles', which are an integral part of any foreign direct investment, are included in the process R_i. Such 'trade-in-invisibles' includes head-quarter services, royalty payments, repatriation of profits and cross-border investment flows, which are subject not only to the regulatory/capital controls, but also to medium to long term exchange rate risks.

In the first instance, I assume this stochastic shift variable follows a geometric Brownian motion, whereby the stochastic process underlying foreign investment uncertainty is given by:[6]

$$dR_i = \mu_i R_i dt + \sigma_i R_i dW_t \tag{19}$$

Here, μ_i is the drift, σ_i is the volatility and dW_t is a Gauss-Wiener process representing Brownian motion and at any instant satisfying $E(dW) = 0$ and $E(dW^2) = dt$.

An uncertainty which is equally faced by both national and multinational firms does not generate an option value between trading and FDI, but foreign investment uncertainty which is faced only by multi-national firms, implies existence of a real option, say for country j's exporting firms to either undertake a foreign direct investment in country i or to keep exporting as national firms as they were doing at time $t = 0$. I will henceforth call this the 'FDI option'.

To simplify exposition of this model, I will focus on country i and assume that country j follows a restrictive FDI regime and does not permit any foreign direct investment within its borders. Relaxing this assumption is trivial and the same formulation would apply to the other country.

For an *individual* firm in country j, production decision at any time t^*

[6] This is an important theoretical benchmark. I will later extend the model by introducing Poisson jumps and formulating a mixed Brownian motion-Poisson jump process, which provides a better way of modelling uncertainty related to FDI policy.

between $t = 0$ and $t = \infty$ is given by the present value formulation:

$$\int_{t^*}^{\infty} e^{-\rho t}(\beta p^{1-\epsilon}\tau^{1-\epsilon}e_{i_0}^{\epsilon-1}S_i + \beta p^{1-\epsilon}e_j^{\epsilon-1}S_j)dt \tag{20}$$

$$= \int_{t^*}^{\infty} e^{-\rho t}[\epsilon(H^n + G^n)]dt \qquad \text{(with no FDI)}$$

$$OR$$

$$E\int_{t^*}^{\infty} e^{-\rho t}(\beta p^{1-\epsilon}e_{i_1}^{\epsilon-1}S_i + \beta p^{1-\epsilon}e_j^{\epsilon-1}S_j)dt \qquad \text{(with FDI)}$$

$$= E\ [\int_{t^*}^{\infty} e^{-\rho t}[\epsilon(H^m + G^n)]dt + \epsilon GR_0 + \int_{t^*}^{\infty} e^{-\rho t}\epsilon(GR_i e^{(\mu_i - \frac{1}{2}\sigma_i^2)t}e^{\sigma W_t})dt]$$

where ρ is the (riskless) discount rate, β is the demand parameter, τ are the trade costs, $e_{i\ \mathrm{or} j}$ is the aggregate price index, e_{i_0} to $e_{i_1}$is the expected change in price index when FDI is undertaken in country i, $S_{i\ \mathrm{or} j}$ are the factor endowments, ϵ is the elasticity of substitution between any two x-varieties and $H^{n\ \mathrm{or}\ m}$ are the headquarter fixed costs. In writing the present value formulation, I use the stochastic differential equation 19 from above. Foreign investment costs are split into two parts - GR_0, the setup costs which are revealed at time t^* (hence $E[GR_{t^*}] = GR_0$, no discounting needed) and GR_i, the subsequent costs over which expectations are formed and need to be explicitly solved for.

An individual firm takes prices and incomes as given. It is already operating as a national firm in country j (the first equality above), but forms expectations over what would happen if it decided to switch from national to a multinational mode of production (the second equality above). 'OR' between the two equalities indicates existence of a 'real option' between the two choices.

The firms know their operating characteristics and market structure well. Demand parameters and total factor endowments are given and assumed not to change with time. All firms are identical (i.e. homogeneous) and rational. Thus, when it becomes optimal for one firm in country j to switch from a national to multinational mode of production, it also becomes optimal for other national firms in country j to do so. Under assumption of rational expectations, this forward looking behaviour implies an individual firm can fully anticipate the change in aggregate price index that would be caused by this switch in production regime from national to multinational, as the producer price of an individual x-variety, p, and the trade costs, τ, remain unchanged. This implies

$$E\{e_{i1}\} = e_{i1} = \left[N_i^n p^{1-\epsilon} + N_j^m p^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}} \tag{21}$$

Thus, expectation on left hand side of the second equation is easily taken care of, as rational expectation implies expected present discounted value of mark-up revenues is same as its present discounted value:

$$E\int_{t^*}^{\infty} e^{-\rho t}(\beta p^{1-\epsilon} e_{i_1}^{\epsilon-1} S_i + \beta p^{1-\epsilon} e_j^{\epsilon-1} S_j).dt$$

$$= \int_{t^*}^{\infty} e^{-\rho t}(\beta p^{1-\epsilon} e_{i_1}^{\epsilon-1} S_i + \beta p^{1-\epsilon} e_j^{\epsilon-1} S_j).dt$$

$$= \frac{\beta}{\rho} p^{1-\epsilon} e_{i_1}^{\epsilon-1} S_i + \frac{\beta}{\rho} p^{1-\epsilon} e_j^{\epsilon-1} S_j \tag{22}$$

The expectation on right hand side of the second equation is more tricky as it involves solving the stochastic integral:

$$E\int_{t^*}^{\infty} e^{-\rho t}\epsilon\{GR_i.e^{(\mu_i-\frac{1}{2}\sigma_i^2)t}\}\{e^{\sigma W_t}\}.dt \tag{23}$$

Using stochastic calculus (for details see Appendix A2), this expectation can be simplified because:

$$E\{GR_i.e^{(\mu_i-\frac{1}{2}\sigma_i^2)t}\}\{e^{\sigma W_t}\} = GR_i.e^{\mu t} \tag{24}$$

The expected present discounted value of fixed costs for a multinational firm potentially operating in country j can therefore be simplified to:

$$E\int_{t^*}^{\infty} e^{-\rho t}[\epsilon(H^m + G^n)].dt + \epsilon GR_0 + E\int_{t^*}^{\infty} e^{-\rho t}\epsilon(GR_i.e^{(\mu_i-\frac{1}{2}\sigma_i^2)t}.e^{\sigma W_t}).dt$$

$$= \frac{\epsilon}{\rho}(H^m + G^n) + \epsilon GR_0 + \frac{\epsilon GR_i}{\rho - \mu} \tag{25}$$

Present value of markup revenues and fixed costs for a national firm operating in country j (first part of equation 20 above) can be written as:

$$\int_{t^*}^{\infty} e^{-\rho t}(\beta p^{1-\epsilon}\tau^{1-\epsilon}e_{i_0}^{\epsilon-1}S_i + \beta p^{1-\epsilon}e_j^{\epsilon-1}S_j)dt = \frac{\beta}{\rho}p^{1-\epsilon}\tau^{1-\epsilon}e_{i_0}^{\epsilon-1}S_i + \frac{\beta}{\rho}p^{1-\epsilon}e_j^{\epsilon-1}S_j \tag{26}$$

and

$$\int_{t^*}^{\infty} e^{-\rho t}[\epsilon(H^n + G^n)]dt = \frac{\epsilon}{\rho}(H^n + G^n) \tag{27}$$

respectively.

Having simplified the integrals, we still need to take into account the opportunity cost of real option between exporting and FDI, as indicated by the term 'OR' in the decision making problem of an individual firm above. While an operating national firm knows the trade costs it saves fairly well (from its account books), the potential foreign investment costs are at best only an estimate.

Let us call the first state V(ex) and the second state V(fdi). By moving from state V(ex) to V(fdi) the firm not only gains mark-up revenues due to the trade costs saved, but also expects to lose the present value of foreign investment costs that potentially need to be incurred. The exercise of this option can be interpreted as a trade-off between the expected gain and loss in the value of the firm in moving from one state (exporting as a national firm) to the other (undertaking foreign investment as a multinational firm).

To simplify notation, let T be the present value of gain in mark-up revenues due to the saving of trade costs when a country j's exporting firm undertakes foreign direct investment into country i and let $\widehat{R}$ be the present value of foreign investment costs that will need to be incurred when this happens. Formally:

$$T = \frac{\beta}{\rho}p^{1-\epsilon}(\tau^{1-\epsilon}e_{i_0}^{\epsilon-1} - e_{i_1}^{\epsilon-1})S_i \tag{28}$$

$$\widehat{R} = \epsilon GR_0 + \frac{\epsilon GR_i}{\rho - \mu} \tag{29}$$

Let $F\left(\widehat{R},t;T\right)$ be the value of this option to switch production regime from exporting to FDI. Payoff from exercising this option at any time t is given by the function:

$$g\left(\widehat{R},t;T\right)=\max[T-\widehat{R},0] \tag{30}$$

Taking an analogy from the finance theory, this is like an American Put Option, a class of options that are typically harder to solve and do not have closed form solutions. Such option functions are called free boundary problems and they are essentially variational problems in stochastic mathematics. Fortunately, this real option is not exactly like its financial counterparts. I will use an original idea from Merton (1973), which states that if time to maturity is infinite, the option pricing function becomes time independent and a closed form solution exists. Such options are called 'perpetual puts' and its option pricing function is written as $F\left(\widehat{R},t=\infty\ ;T\right)$ or simply, $F\left(\widehat{R}\ ;T\right)$.

There are two equivalent ways of solving this problem - either through contingent claim analysis using the arbitrage theory or through stochastic dynamic programming. Because of its expositional neatness I will hereby use the arbitrage theory.

Using the second order Taylor series and Ito's lemma gives us the following partial differential equation for the option pricing function:

$$(\rho-\delta)RF^{'}(R)dt+\frac{1}{2}\sigma^2R^2F^{"}(R)dt=\rho Rdt \tag{31}$$

where $\mu=\rho-\delta$ (a la Dixit, Pindyck,1994). δ, which is sometimes called the convenience yield, is the difference between the drift term and the riskless rate of return.

To solve for the option value, the partial differential equation is combined with the following boundary conditions:

1. $F(\infty;T)=0$, a 'terminal' condition, which means this option is of no value, if the foreign investment costs tend to infinity.

2. $F(R^*;T)=T-R^*$, a 'value matching' condition, which describes the payoffs when it becomes optimal to undertake FDI abroad.

3. $\frac{\partial F(R^*;T)}{\partial R}=-1$, a 'smooth-pasting' or 'high contact' boundary condition, which implies that slope of payoff and option pricing function match at the exercise boundary and if not, it would not be optimal to exercise. There is thus a continuity or smooth pasting at the optimal exercise boundary.

The general solution to this differential equation is :

$$F\left(R,\infty;T\right) = a_1 R + a_2 R^{-\gamma} \tag{32}$$

where

$$\gamma = \frac{\frac{1}{2}\sigma^2 - (\rho-\delta) + \sqrt{\left((\rho-\delta) - \frac{1}{2}\sigma^2\right)^2 + 2\rho\sigma^2}}{\sigma^2} \tag{33}$$

is the positive root of the fundamental quadratic equation:

$$Q = \frac{1}{2}\sigma^2\left(\gamma\right)\left(\gamma - 1\right) + \left(\rho - \delta\right)\left(\gamma\right) - \rho = 0 \tag{34}$$

The first boundary condition implies $a_1 = 0$.
The second or value matching condition implies $a_2 = \left(T - R^*\right) R^{*\gamma}$
Now, from the smooth pasting condition, general solution evaluated at the optimal value, R^* is :

$$\frac{\partial F\left(R^*,\infty;T\right)}{\partial R} = -\gamma a_2 R^{*\,-\gamma-1} = -1 \tag{35}$$

Substituting for a_2 :

$$-\gamma\left(T - R^*\right) R^{*\gamma} R^{*\,-\gamma-1} = -1 \tag{36}$$

This can be simplified to:

$$T = \frac{1+\gamma}{\gamma}\widehat{R}^* \tag{37}$$

This gives us the 'optimal foreign investment rule', which is a deterministic, time-independent solution. As described earlier, T is the present value of gain in mark-up revenues (due to saving of the trade costs) and R^* is the present value of foreign investment costs that would need to be incurred at the optimal exercise boundary for this FDI option.

Intuitively, this rule says, 'uncertainty combined with irreversibility drives a wedge between the present value of gain in mark-up revenues due to the trade costs saved and a critical value of the foreign investment costs that need to be incurred'. The size of this wedge is equal to $\frac{1+\gamma}{\gamma}$. The wedge implies 'hysteresis', because by lowering the critical value of foreign investment costs it makes exercise of the FDI option less likely.

If volatility $\sigma \longrightarrow 0$ (which implies no uncertainty), the positive root $\gamma \longrightarrow \infty$ and the optimal scale-up factor $\frac{1+\gamma}{\gamma} \longrightarrow 1$, implying there is no 'hysteresis'. If on the other hand volatility $\sigma \longrightarrow \infty$, the positive root $\gamma \longrightarrow 0$ and the optimal scale-up factor $\frac{1+\gamma}{\gamma} \longrightarrow \infty$, implying the FDI option would not be exercised, no matter how small the foreign investment costs are or how big the gains from cutting trade costs are.

Thus, parameterized in time, the total effect of foreign investment uncertainty is determined through its effect on present discounted values of trade costs saved, the foreign investment costs incurred and through the opportunity cost of real option between exporting and FDI. 'Perpetual Put' makes our life simple, because we can solve for the equilibrium recursively at any point in time and the optimal foreign investment rule remains unchanged (a closed from solution exists).

Equilibrium conditions for country j firms can now be written in the complementary slackness form as follows:

$$\frac{\beta}{\rho}p^{1-\epsilon}\tau^{1-\epsilon}e_{i_0}^{\epsilon-1}S_i + \frac{\beta}{\rho}p^{1-\epsilon}e_j^{\epsilon-1}S_j \leq \frac{\epsilon}{\rho}(H^n + G^n) \qquad (N_j^n)$$

$$\frac{\beta}{\rho}p^{1-\epsilon}e_{i_1}^{\epsilon-1}S_i + \frac{\beta}{\rho}p^{1-\epsilon}e_j^{\epsilon-1}S_j \leq \frac{\epsilon}{\rho}(H^m + G^n) + (\frac{1+\gamma}{\gamma})[\epsilon GR_0 + \frac{\epsilon GR_i}{\rho-\mu}] \quad (N_j^m) \tag{38}$$

Aggregate price index, which is endogenous, may be further substituted out using the expressions below:

$$e_{i_0} = [N_i^n p^{1-\epsilon} + N_j^n(p\tau)^{1-\epsilon}]^{\frac{1}{1-\epsilon}}$$

$$e_{i_1} = [N_i^n p^{1-\epsilon} + N_j^m p^{1-\epsilon}]^{\frac{1}{1-\epsilon}}$$

$$e_j = [N_i^n(p\tau)^{1-\epsilon} + N_j^n p^{1-\epsilon}]^{\frac{1}{1-\epsilon}} \tag{39}$$

We can see that while foreign investment uncertainty is driven by an exogenous stochastic shift variable, the real option between exporting and FDI is an indicator function, meaning thereby that optimal foreign investment rule is deterministic, and so are the other endogenous variables, which after substituting out the price index, essentially mean the number of firms of each type operating in equilibrium. This defines the equilibrium production regime. If there was no uncertainty, there would be no option value, and hence, no scale-up over foreign investment costs, and we would be back to a standard Marshallian kind of revenue-cost analysis.

It is also pertinent to mention that, what is modelled here is only the option decision relating to switching of production regime from trading to FDI, after having started at time $t = 0$ with exporting (national) firms in both the countries. This has been called the 'FDI option'. It ceases to have an option value after it is exercised. The reverse is usually not a symmetric phenomenon, but rather a pure exit decision for which a separate option problem needs to be formulated. Such exit options have been adequately modelled in the literature (Dixit and Pindyck, 1994).

To summarize, we start at time $t = 0$ with a pure trading equilibrium and diversified production. Let us say that foreign investment environment in country i is not conducive to start with and trading (exporting) firms from country j, which are identical and rational, optimally decide to continue as national firms. These firms wait and watch, thereby retaining an option to undertake FDI abroad, which is valued in terms of its opportunity cost. Say later, because of some FDI reforms, foreign investment environment in country i becomes favourable and at some point in time, in accordance with the foreign investment rule, it becomes optimal for country j's exporting firms to exercise this option. Being identical and rational, they all rush to undertake FDI in country i. There will be both partial and general equilibrium effects. While partial equilibrium effects are reflected in the costs and savings for individual firms, general equilibrium effects are reflected in the changes in the aggregate price index and the type of firms operating in equilibrium. The producer price of an individual x-variety remains unchanged, as also the equilibrium wage, which is pinned down by the numeraire sector. The factor market undergoes a simultaneous adjustment as part of the skilled labour in country j freed up by its national firms starting multinational production abroad is used up in headquarter services, while the remaining shifts to the numeraire good sector Y whose production expands. Exactly the opposite happens in country i, where multinational production by country j firms attracts additional skilled labour to the X sector and the numeraire good sector contracts. I maintain the assumption that labour endowment and value of demand parameters is such that production remains diversified.

2.4 Comparative Experiments

We have seen above that foreign investment uncertainty drives a wedge between the trade costs saved and the foreign investment costs incurred, thereby delaying FDI into country i, beyond what is predicted by riskless cost-benefit analysis. This is 'hysteresis'.

I will now conduct some thought experiments to answer the questions of "when"- that is to analyze the effect of uncertainty on timing of foreign investment given comparative advantage and trade costs; and of "where", that is, in the presence of foreign investment uncertainty, where would it be optimal to undertake FDI amongst alternative locations, given some comparative advantage and trade costs?

Effect of Volatility : Let us say the foreign investment environment in country i is more risky as compared to the foreign investment environment in country j, that is $\sigma_i > \sigma_j$.

Volatility affects the optimal decision rule through scale-up factor

$$\frac{1+\gamma}{\gamma}. \tag{40}$$

By totally differentiating the fundamental quadratic with respect to volatility parameter σ holding drift constant (a mean preserving spread):

$$\frac{\partial Q}{\partial \gamma}\frac{\partial \gamma}{\partial \sigma} + \frac{\partial Q}{\partial \sigma} = 0 \tag{41}$$

Now, $Q(1) = -\delta$, i.e. fundamental quadratic valued at $\gamma = 1$ is negative. This implies the positive root γ is greater than one.

Further, $Q(0) = -\rho$, i.e. fundamental quadratic valued at $\gamma = 0$ is negative.

This helps us plot the fundamental quadratic, which is itself is a function of γ.

For $\sigma = 0.2, \rho = 0.05$ and $\delta = 0.03$ this plot is as follows:

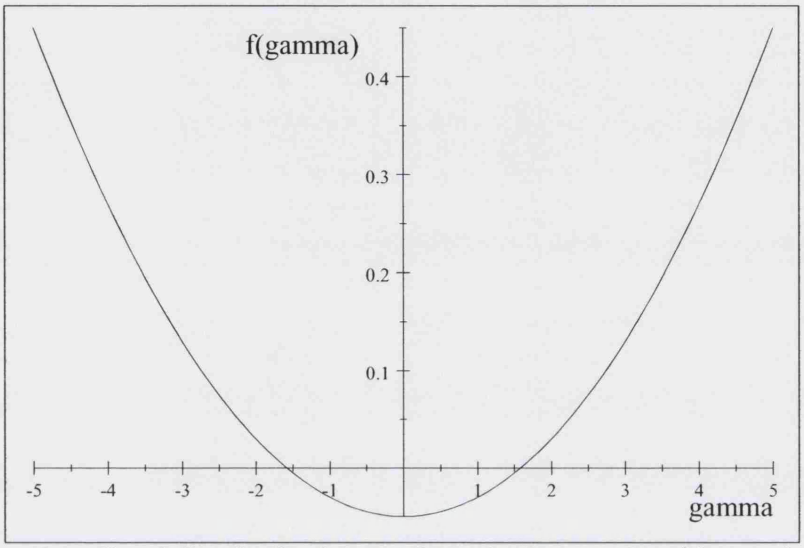

Figure 2.1: Graph for the fundamental quadratic equation (the stochastic process is geometric Brownian motion with drift).

The partial derivative $\frac{\partial Q}{\partial \sigma} = (\gamma)(\gamma - 1)\sigma$ is positive, given that σ is a positive parameter and γ, the positive root of the fundamental quadratic, is greater than 1. The partial derivative $\frac{\partial Q}{\partial \gamma} > 0$ (is also positive) as the fundamental quadratic is increasing at its positive root (see graph above). Thus, for the total differentiation equality to hold, $\frac{\partial \gamma}{\partial \sigma} < 0$, that is, the partial derivative of gamma with respect to the volatility parameter is negative. Therefore, if σ increases, γ decreases and the optimal scale-up factor $\frac{1+\gamma}{\gamma}$ increases.

In other words, comparing two countries i and j, if $\sigma_i > \sigma_j$, the cost of FDI option is higher in country i and we need either a higher saving of trade costs from country j to i, or in the presence of falling foreign investment costs, firms in country j need to wait longer for foreign investment costs in country i to fall low enough to trigger the FDI option.

We have proved the following:

Proposition 1 : *A mean preserving increase (higher volatility) in foreign investment uncertainty drives a greater wedge between trade costs that need to be saved and foreign investment costs that need to be incurred at the optimal trigger point between exporting and FDI.*

Effect of drift : The effect of drift is two fold - effect on the expected present value and effect on the opportunity cost of real option between exporting and FDI.

Again, by total differentiation,

$$\frac{\partial Q}{\partial \gamma}\frac{\partial \gamma}{\partial \delta} + \frac{\partial Q}{\partial \delta} = 0 \tag{42}$$

where $\delta = \rho - \mu$ is the difference between the discount factor (riskless rate) and the drift of the stochastic process as described above.

The partial derivative $\frac{\partial Q}{\partial \delta} = -\gamma$ is negative because γ is the positive root of fundamental quadratic defined above. That partial derivative $\frac{\partial Q}{\partial \gamma}$ is positive has already been proved above. Hence, for the total differentiation equality to hold, the partial derivative $\frac{\partial \gamma}{\partial \delta}$ must be positive.

Thus, a lower drift (lower μ) implies a higher δ, which from the partial derivative above means a higher γ. This in turn implies a lower wedge or a lower scale-up $(\frac{1+\gamma}{\gamma})$ between the trade costs saved and the foreign investment costs incurred. This is the opportunity cost or implicit insurance premium of holding the 'FDI option'.

Further, a lower μ also implies a lower $\frac{\epsilon G R_i(t_0)}{\rho - \mu}$ and hence lower expected present value of foreign investment costs given that both ρ and μ are positive fractions less than one (they are percentages) and that $\rho > \mu$ given the assumption of a convergent solution.

We have thus established the second proposition:

Proposition 2 : A lower drift of foreign investment uncertainty has two fold effect on the FDI decision of exporting firms. It has a direct effect through a decrease in the expected present value of foreign investment costs incurred and an indirect effect through a decrease in the size of wedge or optimal scale-up between the trade costs saved and the foreign investment costs incurred. Put together, they imply an increase in chances of early exercise of the FDI option.

Effect of Risk aversion: Till now the FDI-option was analyzed assuming firms are risk-neutral, a procedure called risk-neutral valuation. Suppose now that firms (investors and/or managers) are risk averse. While earlier, volatility affected the optimal decision of risk-neutral firms directly, it now has an additional effect through the 'drift' term.

The simplest way to allow risk-aversion is to replace riskless discount rate (ρ) with an appropriate risk-adjusted discount rate ($\overline{\rho}$) from the capital asset pricing model (Dixit and Pindyck, 1994). Risk-aversion essentially means allowing for returns to adjust as σ changes. Each unit increase in σ now requires an increase in risk-adjusted discount rate by a coefficient term containing the correlation coefficient and the market price of risk as given by the equation below (for details see Appendix A3):

$$\delta = \overline{\rho} - \mu = \rho + \phi\eta_{fm}\sigma - \mu \tag{43}$$

Here, ϕ is the market price of risk, η_{fm} is the correlation coefficient between the value of FDI option and the whole market portfolio, while μ, ρ and σ are the parameters as defined above. The meaning of the term δ now becomes clearer. It is the opportunity cost of delaying foreign investment and keeping the option to undertake FDI alive.

While volatility of the foreign investment costs mattered even for risk-neutral firms (Proposition 1 above), in the presence of risk-aversion it matters even more. For a 'put option' (unlike a call) the correlation coefficient is negative, as the positive deviations of uncertainty decrease (and not increase) the payoffs from exercising this option. Thus, a higher volatility, σ, implies a lower δ, which in accordance with the result above, further increases the wedge or optimal scale-up $\frac{1+\gamma}{\gamma}$ of trade costs over the foreign investment costs. We have thus established the third proposition:

Proposition 3 : *If firms are risk-averse, as compared to when they are risk-neutral, they will need either lower foreign investment costs or greater saving of trade costs before they can undertake FDI abroad. In the presence of falling foreign investment costs, this implies a greater wait and watch before the FDI option is exercised.*

Country Size and Income:

Since income is endogenous in general equilibrium, the variable of interest here is the total factor endowment S_i. Let us say, skilled factor endowment of country i is growing with time at a defined rate η:

$$S_i(t^*) = S_{io}e^{\eta t} \tag{44}$$

Equilibrium conditions for country j firms, in complementary slackness form, can now be written as follows:

$$\frac{\beta}{\rho-\eta}p^{1-\epsilon}\tau^{1-\epsilon}e_{io}^{\epsilon-1}S_{io} + \frac{\beta}{\rho}p^{1-\epsilon}e_j^{\epsilon-1}S_j \leq \frac{\epsilon}{\rho}(H^n + G) \qquad (N_j^n)$$

$$\frac{\beta}{\rho-\eta}p^{1-\epsilon}e_{i_1}^{\epsilon-1}S_{io}+\frac{\beta_j}{\rho}p^{1-\epsilon}e_j^{\epsilon-1}S_j \leq \frac{\epsilon}{\rho}(H^m+G)+(\frac{1+\gamma}{\gamma})[\epsilon GR_0+\frac{\epsilon GR_i}{\rho-\mu}] \quad (N_j^m) \tag{45}$$

This raises the strike price, and hence, payoffs from exercising the FDI option:

$$T=\frac{\beta}{\rho-\eta}p^{1-\epsilon}(\tau^{1-\epsilon}e_{i_0}^{\epsilon-1}-e_{i_1}^{\epsilon-1})S_{io} \tag{46}$$

Such a country then naturally becomes a more attractive destination for FDI. We have established the following:

Proposition 4 : *Country with a larger market size/greater endowment of skilled factors is more likely to attract foreign direct investment given a level of the trade costs saved and the foreign investment costs incurred. This is because it raises the strike price and hence, payoffs from exercising the FDI option.*

Compare this result with the conventional model, where positive effects of market size on foreign direct investment come through the scale economies (Markusen and Venables, 1998). Here, we not only have the usual scale effects due to increasing returns at the firm level, but also an additional effect due to increase in strike price and hence payoffs from exercising the FDI option.

I have focussed on the foreign investment uncertainty here for the simple reason that it is relevant to the facts-in-issue and is closely related to FDI policy in the real world. For simplicity, I have assumed there are no demand or productivity shocks. I will now proceed to extend the model by introducing Poisson jumps in the stochastic process, which offer a better way of modelling uncertainty related to policy and the impact of FDI reforms, as foreign investment liberalisation is popularly known in emerging economies today.

2.5 Poisson Jump Process

Geometric Brownian motion (with drift) is an important theoretical benchmark, but for more comprehensive analysis I will extend this model by formulating a mixed Brownian motion-Poisson jump process. Foreign investment uncertainty arises from a variety of sources, including but not limited to private sector expectations of public policy, sudden policy shifts like economic liberalisation/FDI reforms, changes in corporate tax/governance regimes; exchange rate costs related to repatriation of profits, royalty payments, headquarter services or cross-border investment flows; industry or economy wide macro-shocks, political instability etc. Among alternative stochastic processes mixed Brownian motion-Poisson jump process is the closest one can get to such policy related uncertainties.

Let us allow for the possibility of a downward jump ϕ that can suddenly bring down the foreign investment costs in country i. Let λ be the probability that such a downward jump can arrive in any time-period. If it arrives, the foreign investment costs would fall irreversibly to $1 - \phi$ times the original value. The stochastic shift process driving the foreign investment costs will now be represented by a mixed Brownian motion-Poisson jump process given below:

$$\begin{aligned} dR_i &= \mu_i R_i dt + \sigma_i R_i dW_t - R_i dq, \qquad (47) \\ \text{where } dq &= \phi \text{ with probability } \lambda \\ dq &= 0 \text{ with probability } 1 - \lambda \text{ in any time-period } dt \end{aligned}$$

and other terms are as described before.

The expected percentage change in foreign investment costs in country i is now given by :

$$E[dGR_i] = (\mu_i - \lambda\phi)GR_i.dt \qquad (48)$$

and expected variance of this change is :

$$Var[dGR_i] = \sigma^2(GR_i)^2 dt + \lambda\phi^2(GR_i)^2 dt \qquad (49)$$

As before we need to solve for the optimal foreign investment rule for an individual firm in two steps. First, find the expected present value of foreign investment costs and Second, find the scale-up factor that implies implicit insurance premium of holding the FDI option.

First, the expected present value of fixed costs for a firm holding this FDI option is given by (for details see Appendix A4):

$$\frac{\epsilon}{\rho}(H^m + G) + \epsilon GR_0 + \frac{\epsilon GR_i(t_0)}{\rho - \mu + \lambda\phi} \qquad (50)$$

Intuitively it says, a higher probability of FDI reforms (higher λ) or a higher impact of FDI reforms (higher ϕ implying a greater percentage fall in foreign investment costs) decrease the present value of foreign investment costs making foreign direct investment more likely.

Secondly, we need to solve for the opportunity cost of holding this FDI option.

The partial differential equation can now be written as:

$$(\rho-\delta)RF^{'}(R)dt+\frac{1}{2}\sigma^{2}R^{2}F^{''}(R)dt-\lambda[F(R)-F(R(1-\phi))]dt=\rho Rdt \quad (51)$$

The boundary conditions remain the same:

$$1.F\left(\infty;T\right)=0 \quad (52)$$

$$2.F\left(R^{*};T\right)=T-R^{*} \quad (53)$$

$$3.\frac{\partial F\left(R^{*};T\right)}{\partial R}=-1 \quad (54)$$

The general solution is again of the form

$$F\left(R,\infty;T\right)=a_{1}R+a_{2}R^{-\gamma} \quad (55)$$

As before, the first boundary condition implies

$$a_{1}=0 \quad (56)$$

The second or the value matching condition implies

$$a_{2}=\left(T-R^{*}\right)R^{*\gamma} \quad (57)$$

γ is now the positive solution (negative solution is ruled out by the boundary conditions) to the following characteristic non-linear equation:

$$\frac{1}{2}\sigma^{2}\left(\gamma\right)\left(\gamma-1\right)+\left(\rho-\delta\right)\left(\gamma\right)+\lambda(1-\phi)^{\gamma}-\left(\rho+\lambda\right)=0 \quad (58)$$

This equation does not have an analytic solution and so it needs to be solved numerically. For $\sigma=0.2$, $\rho=0.05$, $\delta=0.03$, $\lambda=0.05$ and $\phi=0.2$, the graph of this equation is drawn in Figure 2.2 (on page 44 in the appendix). $\gamma=1.8267$ is its positive solution.

This is the only part of this model that needs to be solved numerically. The remaining derivation required in obtaining the optimal foreign investment rule can be done analytically.

Smooth pasting implies

$$\frac{\partial F\left(R^{*},\infty;T\right)}{\partial R}=-\gamma a_2 R^{*\ -\gamma-1}=-1 \tag{59}$$

Substituting for a_2 gives:

$$-\gamma\left(T-R^{*}\right)R^{*\gamma}R^{*\ -\gamma-1}=-1 \tag{60}$$

Solving for the optimal scale-up factor again gives:

$$T=\frac{1+\gamma}{\gamma}\widehat{R}^{*} \tag{61}$$

As we can see, the optimal foreign investment rule or the scale-up over foreign investment costs remains the same. As before, it is a deterministic, time independent solution. However, γ now has different values obtained as a numerical solution to the characteristic non-linear equation 58 above.

As before, equilibrium conditions for country j's firms can be written in the complementary slackness form as follows:

$$\frac{\beta}{\rho}p^{1-\epsilon}\tau^{1-\epsilon}e_{i_0}^{\epsilon-1}S_i+\frac{\beta}{\rho}p^{1-\epsilon}e_{j_0}^{\epsilon-1}S_j\leq\frac{\epsilon}{\rho}(H^n+G) \qquad (N_j^n)$$

$$\frac{\beta}{\rho}p^{1-\epsilon}e_{i_1}^{\epsilon-1}S_i+\frac{\beta}{\rho}p^{1-\epsilon}e_{j_1}^{\epsilon-1}S_j\leq\frac{\epsilon}{\rho}(H^m+G)+(\frac{1+\gamma}{\gamma})[\epsilon GR_0+\frac{\epsilon GR_i(t_0)}{\rho-\mu+\lambda\phi}] \qquad (N_j^m) \tag{62}$$

I will again perform some comparative experiments. The difference is that now I will solve numerically for γ each time an exogenous parameter changes.

Effect of Volatility: As volatility of foreign investment uncertainty increases, the value of γ decreases. This solution for various values of σ is given in Table 2.1 below:

σ	ρ	δ	λ	ϕ	γ
0.05	0.05	0.03	0.05	0.2	3.3263
0.10	0.05	0.03	0.05	0.2	2.5772
0.15	0.05	0.03	0.05	0.2	2.1146
0.20	0.05	0.03	0.05	0.2	1.8267
0.25	0.05	0.03	0.05	0.2	1.6367
0.30	0.05	0.03	0.05	0.2	1.5046
0.35	0.05	0.03	0.05	0.2	1.4091
0.40	0.05	0.03	0.05	0.2	1.3378

This result is the same as in Proposition 1 above. Higher volatility implies a lower γ and therefore a higher wedge or higher scale-up over foreign investment costs i.e. to undertake FDI the firms need either a higher saving of transport costs or in the presence of falling foreign costs, they wait longer before the FDI option can be exercised.

Effect of Drift: An increase in δ, which implies a lower drift, leads to an increase in the value of γ as shown in Table 2.2 below:

σ	ρ	δ	λ	ϕ	γ
0.20	0.05	0.01	0.05	0.2	1.3432
0.20	0.05	0.02	0.05	0.2	1.5666
0.20	0.05	0.03	0.05	0.2	1.8267
0.20	0.05	0.04	0.05	0.2	2.1223

This decreases the optimal scale-up $\frac{1+\gamma}{\gamma}$ over the foreign investment costs. Besides, it also implies a lower expected present value of foreign investment costs (equation 50 above). Both these effects together imply the result in Proposition 2 above, meaning thereby that falling foreign investment costs increase the chances of an early exercise of the FDI option.

Probability of FDI reforms: A higher probability of FDI reforms, as measured by the factor λ, increases the value of γ as shown in Table 2.3 below:

σ	ρ	δ	λ	ϕ	γ
0.20	0.05	0.03	0.00	0.2	1.5811
0.20	0.05	0.03	0.05	0.2	1.8267
0.20	0.05	0.03	0.10	0.2	2.0887
0.20	0.05	0.03	0.15	0.2	2.3602
0.20	0.05	0.03	0.20	0.2	2.6356

This decreases the optimal scale-up $\frac{1+\gamma}{\gamma}$ over the foreign investment costs. Further, it decreases the expected present value of foreign investment costs (equation 50 above). The combined effect is summarized in Proposition 5 below:

Proposition 5: An increase in the probability of a sudden drop in foreign investment costs decreases the optimal scale-up over foreign investment costs and also decreases the expected present value of foreign investment costs. This dual effect facilitates foreign direct investment by increasing chances of an early exercise of the FDI option.

Impact of FDI reforms: A larger impact of FDI reforms as measured by the percentage parameter ϕ also increases the value of parameter γ as shown in Table 2.4 below:

σ	ρ	δ	λ	ϕ	γ
0.20	0.05	0.03	0.05	0.00	1.5811
0.20	0.05	0.03	0.05	0.10	1.7063
0.20	0.05	0.03	0.05	0.20	1.8267
0.20	0.05	0.03	0.05	0.30	1.9356
0.20	0.05	0.03	0.05	0.40	2.0280
0.20	0.05	0.03	0.05	0.50	2.1018

This decreases the optimal scale-up $\frac{1+\gamma}{\gamma}$ over foreign investment costs. Further, it decreases the expected present value of foreign investment costs (equation 50 above). The combined effect on foreign direct investment is summarized in Proposition 6 below.

Proposition 6: An increase in size of the percentage downward jump in foreign investment costs decreases the optimal scale-up over foreign investment costs and also decreases the expected present value of foreign investment costs. This dual effect facilitates foreign direct investment by increasing chances of an early exercise of the FDI option.

2.6 Summary

Real life behaviour of multinational firms is somewhat more complex than what can be explained by conventional comparative advantage-trade cost analysis. Almost all countries, including the developed ones, have specific FDI regimes which are driven by policy changes. Even when FDI reforms bring down foreign investment costs, multinational firms do not immediately rush in. There is a considerable 'wait and watch', a kind of time lag or inertia before investments actually start flowing in. This is more commonly seen in developing economies, where foreign investment uncertainty is expected to be high. This model shows that, by indulging in such cautious behaviour, multinational firms are actually seeking additional compensation for some real costs over and above what can be accounted for in a conventional cost-benefit analysis. Although, for rigorous exposition, this model is solved in a Dixit-Stiglitz framework, the idea behind this model is more general. For example, it could be applied to a sub-national context, where States Governments compete for inward investment within a framework of competitive federalism.

In this chapter, I first solve for the optimal foreign investment rule, which is a deterministic, time-independent solution. Foreign investment costs are scaled up by a factor, which depends on the parameters of foreign investment uncertainty. This implies 'hysteresis', because in the presence of falling foreign investment costs, multinational firms will wait longer than they would have in the absence of such uncertainty. Similarly, given comparative advantage and trade costs between alternative locations, firms prefer the ones with less uncertain foreign investment environments.

Greater volatility and risk aversion delay the exercise of FDI option, while growing market size (national income) facilitates its early exercise. A particularly interesting aspect of this paper is the mixed Poisson jump-Brownian motion process, which explicitly models policy driven FDI reforms. It shows how a sudden drop in foreign investment costs brought about by a policy shift, as also a greater probability of it, can facilitate early exercise of the FDI option.

To summarize, this paper enriches the existing general equilibrium models of multinational firms by providing a better explanation for their observed behaviour in uncertain foreign environments. It embeds the theory of real options into a framework of Dixit-Stiglitz type monopolistic competition. It explicitly solves for the policy driven FDI liberalization as a mixed Poisson jump-Brownian motion stochastic process. And further, while the investment under uncertainty literature is based on the theory of call options, I solve the 'FDI option' as a put option, thereby enriching the theory of real options.

2.7 Appendix A

2.7.1 A1 : Solving the Static Model

1) Zero profit condition for national firms in country j:

$$pX_{jj}^n + pX_{ji}^n \leq wcX_{jj}^n + wcX_{ji}^n + w(H^n + G) \qquad (N_j^n)$$

Bring the quantities produced of each variety to the left hand side:

$$(p - wc)X_{jj}^n + (p - wc)\,X_{ji}^n \leq w(H^n + G) \qquad (N_j^n)$$

Substitute using the mark-up or pricing equations :

$$\frac{p}{\epsilon}X_{jj}^n + \frac{p}{\epsilon}X_{ji}^n \leq w(H^n + G) \qquad (N_j^n)$$

Substitute using the marshallian demand functions:

$$\beta p^{1-\epsilon}e_j^{\epsilon-1}wS_j + \beta p^{1-\epsilon}\tau^{1-\epsilon}e_i^{\epsilon-1}wS_i \leq w\epsilon(H^n + G) \qquad (N_j^n)$$

Cancelling out wages from both sides gives the required equation :

$$\beta p^{1-\epsilon}e_j^{\epsilon-1}S_j + \beta p^{1-\epsilon}\tau^{1-\epsilon}e_i^{\epsilon-1}S_i \leq \epsilon(H^n + G) \qquad (N_j^n)$$

2) Zero profit condition for multinational firms in country j:

$$pX_{jj}^m + pX_{ji}^m \leq wcX_{jj}^m + wcX_{ji}^m + w(H^m + G) + wG_i^m \qquad (N_j^m)$$

Bring the quantities produced of each variety to the left hand side:

$$(p - wc)\,X_{jj}^m + (p - wc)\,X_{ji}^m \leq w(H^m + G) + wG_i^m \qquad (N_j^m)$$

Substitute using the pricing or mark-up equations:

$$\frac{p}{\epsilon}X_{jj}^m + \frac{p}{\epsilon}X_{ji}^m \leq w(H^m + G) + wG_i^m \qquad (N_j^m)$$

Substitute using the marshallian demand functions:

$$\beta p^{1-\epsilon}e_j^{\epsilon-1}wS_j + \beta p^{1-\epsilon}e_i^{\epsilon-1}wS_i \leq w\epsilon(H^m + G) + w\epsilon G_i^m \qquad (N_j^m)$$

Cancelling out wages from both sides gives us the required equation :

$$\beta p^{1-\epsilon}e_j^{\epsilon-1}S_j + \beta p^{1-\epsilon}e_i^{\epsilon-1}S_i \leq \epsilon(H^m + G) + \epsilon G_i^m \qquad (N_j^m)$$

The same can now be repeated for national and multinational firms in country i to get the results stated in equation 17.

2.7.2 A2 : Solving the Stochastic Integral

To solve for the expected present value of multinational operation, we need to solve the following stochastic integral:

$$E\int_{t^*}^{\infty} e^{-\rho t}\epsilon\{GR_i.e^{(\mu_i-\frac{1}{2}\sigma_i^2)t}\}\{e^{\sigma W_t}\}.dt$$

A crucial part of this expression is the expectation of the Wiener process $E_t\{e^{\sigma Wt}\}$,

I undertake a change of variable by defining $Z_t = e^{\sigma Wt}$.

By Ito's lemma

$$dZ_t = \sigma e^{\sigma W_t} dW_t + \frac{1}{2}\sigma^2 e^{\sigma W_t} dt$$

Writing it in the integral form :

$$Z_t = Z_0 + \sigma\int_0^t e^{\sigma W_s} dW_s + \int_0^t \frac{1}{2}\sigma^2 e^{\sigma W_s} ds$$

Taking expectation of both the sides and using the fact that $E[Z_0] = 1$ (because by definition $W_0 = 0$); and that $E[\int_0^t e^{\sigma W_s} dW_s] = 0$ (increments of Wiener process are independent of the observed past), this expectation simplifies to :

$$E[Z_t] = 1 + \int_0^t \frac{1}{2}\sigma^2 E[e^{\sigma W_s}]ds$$

I now define another change of variable $E[Z_t] = x_t$.

The expression is now equivalent to an ordinary differential equation $\frac{dx_t}{x_t} = \frac{1}{2}\sigma^2 x_s ds$ with initial condition $x_0 = 1$.

And its solution is $x_t = E[Z_t] = e^{\frac{1}{2}\sigma^2 t}$.

Substituting the changed variables back into the stochastic integral , the $\frac{1}{2}\sigma^2 t$ terms cancel out and the stochastic expectation simplifies to:

$$E\{GR_i.e^{(\mu_i-\frac{1}{2}\sigma_i^2)t}\}\{e^{\sigma W_t}\} = GR_i.e^{\mu t}$$

2.7.3 A3 : Effect of Risk Aversion

The simplest way to allow for risk-aversion is to replace riskless discount rate (ρ) with an appropriate risk-adjusted discount rate ($\overline{\rho}$) from the capital asset pricing model. If the firms undertaking FDI are risk-averse, then from the CAPM formula, the risk-adjusted rate of return for holding the FDI option would be:

$$\overline{\rho} = \rho + [E(\rho_m) - \rho] \frac{Cov\left(\frac{dF}{F}, \rho_m\right)}{Var(\rho_m)}$$

where ρ_m is the rate of return on the whole market portfolio, ρ is the risk-neutral rate and F is the option value function. The covariance-variance term is the correlation coefficient between the value of option and the whole market portfolio (also called the systematic risk or market beta). I will denote this by η_{fm}. The sign of covariance (correlation coefficient) could be positive or negative.

Multiplying and dividing the second term on right hand side by the volatility parameter σ gives:

$$\overline{\rho} = \rho + \frac{[E(\rho_m) - \rho]}{\sigma} \frac{Cov\left(\frac{dF}{F}, \rho_m\right)}{Var(\rho_m)}.\sigma$$

Since, $\frac{[E(\rho_m) - \rho]}{\sigma}$ is, by definition, the market price of risk (let us call it ϕ), the above equation becomes:

$$\overline{\rho} = \rho + \phi \eta_{fm} \sigma$$

Since, parameter δ has already been defined as the difference between the drift and the discount rate

$$\delta = \overline{\rho} - \mu = \rho + \phi \eta_{fm} \sigma - \mu$$

This gives us equation 43, which forms the basis for Proposition 3 above.

2.7.4 A4 : Present Value of Fixed Costs for the Poisson Jump Process

The stochastic shift process with Poisson jumps is given by

$$dR_i = \mu_i R_i dt + \sigma_i R_i dW_t - R_i dq$$

This implies dR_i could take the following different values, which along with their respective probabilities, are :

$$\begin{aligned} dR_i &= \mu_i + \sigma R_i\sqrt{dt} \text{ with probability } \frac{1}{2}(1-\lambda)\,dt \\ & \quad \mu_i - \sigma R_i\sqrt{dt} \text{ with probability } \frac{1}{2}(1-\lambda)\,dt \\ & \quad \mu_i - \phi R_i \text{ with probability } \lambda dt \end{aligned}$$

The Poisson jump is assumed to be much bigger than a single increment in the Wiener process.

We know from the properties of Brownian motion that $E[dW_t] = 0$ i.e. expected change in Wiener process for any time period dt is zero.

Expected change in foreign fixed costs over any time period dt is therefore given by the equation:

$$E[GR_i] = (\mu_i - \lambda\phi)\,GR_i.dt$$

The (strong) solution to the stochastic differential equation for mixed Poisson jump-Brownian motion process is:

$$GR_i = GR_{t=0}\int_0^t \exp[\left(\mu_i - \lambda\phi - \frac{1}{2}\sigma^2\right)t + \sigma W_t]dt$$

To solve for the expected foreign fixed costs, we need to solve the expectation of the stochastic exponential on right hand side:

$$E_t[GR_i] = E_t[GR_{t=o}\int_0^t \exp\{\left(\mu_i - \lambda\phi - \frac{1}{2}\sigma^2\right)t\}.\exp\{\sigma W_t\}.dt]$$

which implies

$$E_t[GR_i] = GR_{t=o}\int_0^t \exp\{\left(\mu_i - \lambda\phi - \frac{1}{2}\sigma^2\right)t\}.E_t[\exp\{\sigma W_t\}]dt$$

Solving the stochastic exponential as in the Appendix A2 above gives:

$$E_t[\exp\{\sigma W_t\}] = \exp(\frac{1}{2}\sigma^2 t)$$

We can now get rid of the expectation term on the right hand side as everything else is deterministic. Since

$$E_t\left[GR_i\right] = GR_{t=o}\int_0^t \exp\{(\mu_i - \lambda\phi)\,t\}dt$$

starting at a time t^* between $t = 0$ and $t = \infty$ and potentially operating forever, expected present value of fixed costs, for a country j multinational firm undertaking foreign direct investment in country i, is given by:

$$\begin{aligned}
& E_{t^*}\{\int_{t^*}^{\infty} e^{-\rho t}[\epsilon(H^m + G)].dt + \epsilon GR_0 + \int_{t^*}^{\infty} e^{-\rho t}\epsilon(GR_i.e^{(\mu_i - \lambda\phi - \frac{1}{2}\sigma_i^2)t}e^{\sigma W_t})dt\} \\
= & \int_{t^*}^{\infty} e^{-\rho t}[\epsilon(H^m + G)].dt + \epsilon GR_0 + E_{t^*}\{\int_{t^*}^{\infty} e^{-\rho t}\epsilon(GR_i.e^{(\mu_i - \lambda\phi - \frac{1}{2}\sigma_i^2)t}e^{\sigma W_t})dt\} \\
= & \frac{\epsilon}{\rho}(H^m + G) + \epsilon GR_0 + \frac{\epsilon GR_i}{\rho - \mu + \lambda\phi}
\end{aligned}$$

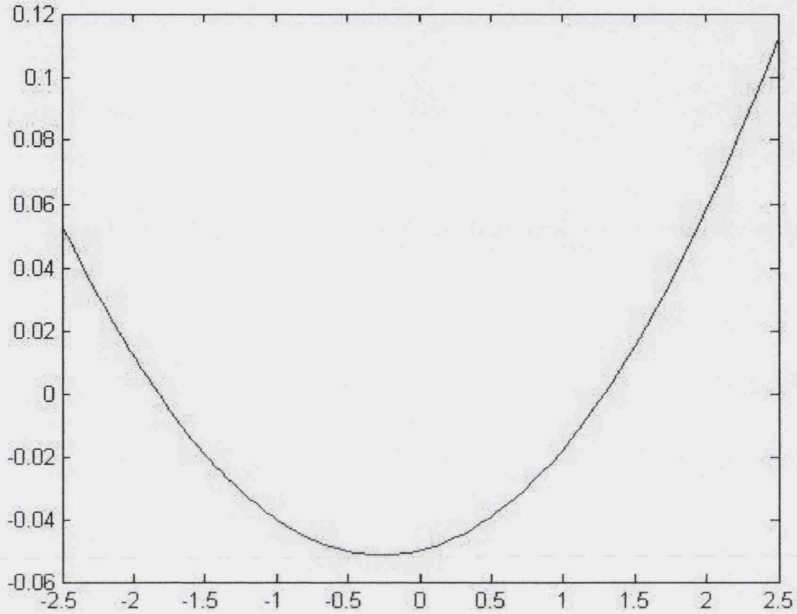

Figure 2.2: Graph for the characteristic equation of the mixed Poisson jump-Brownian motion stochastic process [parameter γ on the x-axis and function $f(\gamma)$ on the y-axis].

3 FDI Policy, Quantity Competition and Heterogeneous Firms

3.1 Introduction

The importance of multinational firms has increased over time. Since the mid 1980s, the world has seen an unprecedented increase in FDI flows, which have increased much faster than both world income and trade (Navaretti and Venables, 2004). According to UNCTAD figures, multinational activity now accounts for more than a quarter of global output and nearly two-thirds of world trade.

Though the relative importance of multinational firms varies by industry, at the firm level, multi-nationality is positively associated with firm size and trade barriers, but negatively associated with plant-level scale economies. At the industry level, multinational activity is significantly higher in sectors which have high R&D expenditures and high fixed costs (i.e. employ a larger number of non-production workers or have high advertisement/sales expenditure), produce new and/or complex goods or feature a high productivity dispersion (Helpman, Melitz, Yeaple, 2004).

In this chapter I develop a model of firm heterogeneity with market power. Firms' mark-ups are endogenous and directly proportional to their respective market shares. My model is characterized by a long run industry equilibrium where large and small firms coexist with varying degrees of market power; and the steepness of market power gradient varies one to one with the natural gradient of firm size and market shares in equilibrium. Strategic interaction between domestic and foreign firms generates profit shifting across firms. Market size has scale effects. Measured productivity differences across firms makes it optimal for them to charge different mark-ups directly through market competition, rather than indirectly as feedback through the demand side of the economy. My model brings out potential gains in market power as an additional reason for undertaking FDI in addition to reasons already enshrined in the literature as proximity-concentration trade-off. Pro-competitive effect of trade liberalisation is also a result of strategic interaction between the firms. When the model is extended to endogenous FDI with asymmetric countries, it leads to interesting interactions between profit maximizing behaviour of multinational firms and the commercial policy environment in which they operate.

I will first mention some stylized facts about the long run industry equilibrium. A particularly consistent feature of empirical studies is the presence of considerable heterogeneity in size as well as measured productivity in almost all manufacturing industries (Bernard, Eaton, Jensen and Kortum, 2003). This heterogeneity exists in virtually all performance measures including sales, productivity, capital/labour ratio, investment, R&D etc. Bart van Ark and Erik Monnikhof (1996) compared output and employment in manufacturing industries for five OECD countries over five decades and found that firms which employ more than 500 workers, constitute just 1.0 to 2.4 percent of the total number of firms operating within an industry, but account for the majority (54 to 67 percent) of output and value added in that industry. On the other hand, firms with less than 20 employees (i.e. small firms) account for as much as 60 to 85 percent of the total number of firms within the industry, but produce only 5 to 11 percent of total output and value added in that industry. A recent study of US firms by Bernard, Jensen and Schott (2005) found that top 1 percent of trading firms account for 81 percent of US trade and top 10 percent account for as much as 96 percent, and that this market concentration in favour of large firms has in fact increased over time.[7] Income inequality studies have famously talked about the Pareto principle (sometimes called the 80-20 rule), which says "20 percent of human population owns 80 percent of total assets and wealth". It appears from the empirical literature that heterogeneity amongst manufacturing firms is even more acute. Large firms not only produce more output, but they also have a higher value added and measured productivity per worker. Measured productivity includes mark-ups, which in empirical studies are often inferred from the price-cost margins (PCM). A standard interpretation of the PCM findings is that large firms, even more so in concentrated industries, tend to enjoy a higher market power (James Tybout, 2002).

Melitz (2003) modelled intra-industry reallocations of trade liberalisation in the presence of Dixit-Stiglitz type monopolistic competition. Firms' mark-ups in his model are constant, and intra-industry re-allocation effects are not generated directly through market competition, but indirectly through factor market effects for which his model assumes an inelastic labour supply. Market size affects the number of firms (or varieties) in equilibrium, but not average revenue or profit per firm. To compare, I develop a model of firm heterogeneity with market power. The mark-ups are endogenous, market size has scale effects and intra-industry reallocation effects are generated directly

[7]The time line of their study is year 1993 to 2000.

through strategic interaction amongst firms. This mechanism is consistent with extreme concentration of economic activity across firms as brought out by the empirical literature mentioned above.

Melitz and Ottaviano (2005) develop a model for analyzing the effects of market size on trade, which endogenizes mark-ups with the help of a specialized demand system (first developed by Ottaviano, Tabuchi and Thisse, 2002). The effect of market size now comes as a feedback through the demand side of the economy via price elasticity of residual demand, and this in turn depends on the number of varieties produced in equilibrium (also called "toughness" of competition). The dynamics of their model depend on the relative distance of variable/marginal costs from the zero-profit marginal cost cutoffs for which they do away with fixed costs of plant operation. The model I develop here also has endogenous mark-ups, and the market size affects mark-ups as well as firm scale. Further, my model is better suited for analysis of FDI policy as it is consistent with any demand system, strategic interaction generates profit shifting across firms and interaction of FDI policy with profit maximizing behaviour of multinational firms generates a spectrum of welfare effects for the home and the host economies.[8]

Bernard, Eaton, Jensen and Kortum (2003), henceforth BEJK (2003), developed a model of firm heterogeneity under Bertrand competition. This model also has endogenous mark-ups. However, because of the nature of market competition in their model, only one firm (the most efficient one) sells in one country in equilibrium. To compare, my model is based on Cournot competition and is characterized by an industry equilibrium where large and small firms coexist with varying degrees of market power, and the steepness of market power gradient varies one to one with natural gradient of firm size and market shares in equilibrium.

Helpman, Melitz and Yeaple (2004), henceforth HMY (2004), extend the Melitz (2003) model of trade to outward FDI for US firms and show that firm's choice of market access is driven by its relative productivity. Their model, like Melitz (2003), is based on monopolistic competition with CES preferences. Because their model is based on constant mark-ups, it is not possible to generate profit shifting effects of trade and FDI liberalisation on domestic firms, something my model is able to generate and is consistently

[8]In monopolistic competition models, FDI is unambiguously welfare improving as there is no profit shifting across firms and substitution of imports with foreign affiliate production lowers the price index in the host economy.

observed in the empirical literature (see for example, Aitken and Harrison, 1999; James Tybout, 2002 etc.).

This paper is organized as follows. Section 2 develops a baseline model for the closed economy. Section 3 extends it to an open economy with FDI. Section 4 compares the implications of this model to those of a standard model of proximity-concentration trade-off. Section 5 gives a brief account of FDI regimes. Section 6 analyses the interaction between profit maximizing behaviour of multinational firms and the commercial policy environment in which they operate. Section 7 concludes.

3.2 Closed Economy

This is a model of oligopolistic competition with firm heterogeneity, where profits are explicitly consumed and could potentially be redistributed. I first set up a baseline model for the closed economy and derive its equilibrium conditions.

Consider a country with population P, a proportion of which are entrepreneurs (E), the remaining are all workers (L):

$$P = L + E \tag{63}$$

There are two homogeneous good sectors: X and Y.

Entrepreneurship is specific to the X-sector. Each entrepreneur organizes and owns an X-sector firm. The supply of firms is limited by the population of entrepreneurs, as skills of workers and entrepreneurs are not inter-changeable.

Each worker maximizes a Cobb-Douglas utility

$$U_l = x^{\beta} y^{1-\beta} \tag{64}$$

subject to the budget constraint

$$px + y = w \tag{65}$$

where p is the price of good X and w is the wage rate.

Good Y is produced by self-employed workers using a constant returns to scale technology, where one unit of labour produces one unit of the good. Its market is competitive and transport costless. Good Y is treated as numeraire (its price set equal to one). Assuming diversified production, this normalizes the nominal wages to one.[9]

Profits are paid out in terms of the numeraire good Y. Entrepreneurs have a simple, linear utility function given by:

$$U_e = y \tag{66}$$

Good X is produced using an increasing returns to scale technology, represented by a cost function $C(x)$, that exhibits constant marginal costs (c) and fixed overhead costs (f), both using inputs of labour given by:

$$C(x) = f + cx\,(c) \tag{67}$$

All firms share the same fixed costs, but variable costs vary systematically with firm's productivity indexed by the reciprocal of marginal cost $\frac{1}{c}$. Each entrepreneur (firm) draws his (its) marginal cost (productivity) from a common distribution $g(c)$ with positive support over $(0, \infty)$. Productivity distribution is common knowledge and draws of productivity are observed by all firms.

An example of such a productivity distribution could be the Zipf distribution, which is a finite support, discrete power law distribution with the probability mass function:

$$f(k; s, N) = \frac{1/k^s}{\sum_{n=1}^{N} 1/n^s} \tag{68}$$

This rank-frequency formulation, also called the Zipf's law, predicts that out of a total population of N elements, the frequency of elements (or elements divided into class intervals) is inversely proportional to their rank k; and 's' is the slope parameter which defines degree of heterogeneity (see Figure 3.1 on page74). In the limiting case as s tends to zero, Zipf distribution tends to the discrete uniform distribution with a constant probability mass function 1/N.[10] And as N tends to infinity, the Zipf distribution tends to the Zeta

[9] Market clearing wage, under incomplete specialization, is determined by production technology in the competitive, constant returns to scale Y sector. I assume the demand parameters and factor endowments are such that production always remains diversified.

[10] In other words, homogeneously distributed firms can be seen as a special case of the more commonly observed heterogeneous firm distribution.

distribution, which is a discrete analogue of the Pareto distribution.[11] Axtell, 2001 analysed the Census data of US manufacturing firms from the year 1988 to 1997 and found that Zipf distribution fits the US data fairly well, and even though mean firm size increases from 1988 to 1997, the estimated value of the slope parameter remains remarkably constant.

Further, the assumption here is that X-sector firms play strategically a la Cournot. Hence, profit maximization yields the following pricing rule from first order conditions, which equates marginal revenue to the marginal cost:

$$\widehat{p}\left[1-\frac{x_i(c)}{X}\frac{1}{\eta}\right]=c \tag{69}$$

where, $\widehat{p}$ is the inverse demand function that a quantity setting firm takes as given, η is the price elasticity of aggregate demand, $x_i(c)$ is the quantity produced by an individual firm and X is the aggregate output of all firms in the industry. In other words, firm heterogeneity in this model implies each firm faces a firm specific demand elasticity $\epsilon_i(c)$, which is a function of its marginal cost/productivity draw as shown below:

$$\epsilon_i(c)=\frac{\eta X}{x_i(c)} \tag{70}$$

The above pricing rule can now be written in terms of the firm specific demand elasticity as follows:

$$\widehat{p}\left[1-\frac{1}{\epsilon_i(c)}\right]=c \tag{71}$$

Thus, firm heterogeneity in this model, through the firm specific demand elasticity, also implies that quantity setting by firms is a function of the marginal cost/productivity draws.

It is a property of the Cobb-Douglas utility functions that price elasticity of aggregate demand is one. This serves as a useful simplification device, as the proportional markup $m_i^p(c)$ for any individual X-sector firm is now simply equal to its market share:

$$m_i^p(c)=\frac{\widehat{p}-c}{\widehat{p}}=\frac{x_i(c)}{X}\frac{1}{\eta}=\frac{x_i(c)}{X} \tag{72}$$

[11]Pareto distribution is a continuous power law distribution often used to depict firm heterogeneity in monopolistic competition models like HMY(2004), Melitz and Ottaviano (2005) etc.

For quantity setting, all that a firm needs to know is the structure of its demand function, the draws of productivity (own and other firms) and the production technology (fixed costs). Firms which cannot cover fixed costs with their potential mark-up revenues set zero quantities for production, and firms, which can exceed them, set positive quantities for production. In particular, the profit function is given by:

$$\pi_i\left(c\right) = \max\{0, x_i\left(c\right) m_i(c) - f\} \tag{73}$$

where $x_i\left(c\right)$ is the firm's output, f is the fixed costs and $m_i(c)$ is the absolute markup defined below.

The same information that is needed for quantity setting is also sufficient for estimating profits. Only firms with cost draws $c < c^*$ find it profitable to produce in equilibrium. c^* is the zero profit cost cutoff, such that some firm with a cost draw $(c^* - \delta) < c^*$ produces with positive profits, whereas if another firm with a cost draw $(c^* + \delta) > c^*$ were to enter, it would earn negative profits and exit immediately. Thus, zero profits imply:

$$\pi\left(c^*\right) = x_i(c)m_i(c) - f = 0 \tag{74}$$

$m(c)$ the absolute mark-up is the gross profit per unit of output given by:

$$m(c) = \widehat{p} - c \tag{75}$$

Good X is consumed by workers alone. The Cobb Douglas utility implies the following inverse Marshallian demand function (for good X):

$$\widehat{p} = \beta \frac{L}{X} \tag{76}$$

Using equations 72 and 76 to substitute out the aggregate output of good X gives the following expression for the output of an individual X-sector firm:

$$x_i(c) = \beta L \left[\frac{\widehat{p} - c}{\widehat{p}^2}\right] \tag{77}$$

Substituting out output and absolute markup expressions in the zero profit condition (equation 74) gives:

$$\beta L \left[\frac{\widehat{p} - c^*}{\widehat{p}^2}\right] (\widehat{p} - c^*) = f \tag{78}$$

which is equal to:

$$\left(\frac{\widehat{p}-c^*}{\widehat{p}}\right)^2 = \frac{f}{\beta L} \tag{79}$$

Rearranging this yields the following expression for the cut-off cost/productivity level c^*:

$$c^* = \widehat{p}\left[1-\sqrt{\frac{f}{\beta L}}\right] \tag{80}$$

In a world that is Cournot, quantity setting firms are only required to know the structure of aggregate demand function, not the exact point on which the markets would potentially operate. The aggregate output is simply the by-product of quantity setting by individual firms. And once quantity setting has determined individual and total outputs, price (or relative price) of X is determined by market clearing.

Aggregate demand for good X is given by equation 76 above. Since Y is consumed by both workers and entrepreneurs, aggregate demand for good Y is the sum of their respective Marshallian demands:

$$Y = Y_L + Y_E \tag{81}$$

Aggregate demand of workers for good Y is derived from optimization of their Cobb-Douglas utilities:

$$Y_L = (1-\beta)L \tag{82}$$

Entrepreneurs have linear utility functions, hence, their total expenditure on good Y is simply equal to the total profits Π as stated below:

$$Y_E = \Pi = \sum_{i=1}^{n} \pi_i\,(c) \tag{83}$$

Labour market clearing requires:

$$L = L_x + L_y = \sum_{i=1}^{n}(f + c_i x(c_i)) + (1-\beta)L + \Pi \tag{84}$$

We can now use both the goods and the labour market clearing to solve for the equilibrium price of X. Using equations 81-84, the solution for the equilibrium price of X (see Appendix B1a for details) is obtained as follows:

$$p = \frac{\sum_{i=1}^{n} c_i}{n-1} \tag{85}$$

Here, p (without the hat) is the equilibrium price of X, n is the total number of firms producing positive output in equilibrium and $\sum_{i=1}^{n} c_i$ is the sum of their respective marginal costs. Define the industry (unweighted) average variable costs as:

$$AVC = \frac{\sum_{i=1}^{n} c_i}{n} \tag{86}$$

Equilibrium price of X is thus a markup over (unweighted) average variable costs:[12]

$$p = \frac{n}{n-1} AVC \tag{87}$$

Notice the role of constant 'one' in the denominator. Larger the number of firms operating in equilibrium, smaller would the proportional mark-up of price over average variable costs be and hence, closer the industry equilibrium would be to the competitive outcome.

Having solved for the equilibrium price of X, zero-profit cost cutoff c^* can be written as a function of the fundamentals (equilibrium price p, fixed costs f, demand parameter β and labour endowment L):

$$c^*(p) = p\left[1 - \sqrt{\frac{f}{\beta L}}\right] \tag{88}$$

I derive a few more results that would be useful during the course of this chapter. Ratios of outputs and mark-ups for any two X-sector firms producing in equilibrium are given by:

$$\frac{x(c_1)}{x(c_2)} = \frac{m(c_1)}{m(c_2)} = \frac{p - c_1}{p - c_2} \tag{89}$$

In other words, as productivity increases, not only do the firms become larger, but they also enjoy higher mark-ups. Equations 69, 72 and 89 together

[12] The weighted average variable costs are given by equations 90 and 91 read with Appendix B1b. Heterogeneity implies more productive (low cost) firms have greater weights (market shares); and hence, true markup of price over weighted average variable costs is greater than the difference between price and unweighted average variable costs. If, however, the firms were homogeneous, the unweighted and the weighted average would be the same.

imply that with firm heterogeneity, there is a natural gradation of firms in terms of their market shares (output) and market power (mark-up of price over marginal cost). It is for *both* these reasons that larger firms in this model enjoy higher profits.

Further, similar to Melitz (2003), it is possible to solve an aggregation problem and find out what the profits of an average productivity homogeneous firm would be such that the total number of firms and aggregate profits in the industry remain the same (proof: see Appendix B1b):

$$\pi(\bar{c}) = f\left[\left(\frac{p - \bar{c}(p)}{p - c^*(p)}\right)^2 - 1\right] \tag{90}$$

where $\pi(\bar{c})$ is the profit of an average productivity firm and $\bar{c}(p)$ is its weighted productivity given by:

$$\bar{c}(p) = p - \sqrt{p^2 + \frac{\sum_{i=1}^{n} c_i^2}{n} - 2p\frac{\sum_{i=1}^{n} c_i}{n}} \tag{91}$$

Thus, n number of homogeneous firms each earning a profit $\pi(\bar{c})$ would produce the same aggregate profit as the profits of individual heterogeneous firms added together:

$$n\pi(\bar{c}) = \Pi \tag{92}$$

What about the effects of market size? The number of entrepreneurs, and hence firms, increases proportionately with country's population (market size). Larger markets are associated with lower prices and mark-ups, while output per firm rises unambiguously, as direct effect of market size (through labour endowment L) outweighs its indirect effect through prices (proofs: see Appendix B1c). Thus, like Melitz and Ottaviano (2005), market size in this model affects both mark-ups and firm scale, but the difference is that here these effects are generated directly through market competition amongst firms rather than indirectly as feedback through a specialized demand system. Further, the effect of market size on cost cut-off is ambiguous as the effects of labour endowment and prices are in opposite directions (see equation 88 above).

These findings are consistent with the empirical literature. Campbell and Hopenhayn, 2002 studied the effects of market size on size distribution of establishments in thirteen retail industries across 225 US cities. They found that in nearly every industry they studied, establishments were larger in larger cities. They also found that is was only in four out of thirteen industries that dispersion of establishment sizes depended on market size, and there too, the relationship was ambiguous as a weakly positive relationship between market size and dispersion of establishment size existed only in three industries, while in the fourth industry this relationship was negative. Such findings are consistent with this model, as discrete firms imply, a change in the cost-cutoff may not always be large enough to affect the size distribution of operating firms. In general, Campbell and Hopenhayn (2002) observed that oligopoly based models are easier to reconcile with empirical facts than monopolistic competition based models are.

3.3 Open Economy with FDI

I will now extend the above analysis to an open economy with FDI. I assume there is no international trade and the firms can only serve the foreign market through FDI. This is a simplifying device to enable me focus on the endogenous decision of firms, whether or not to undertake the FDI, and what the welfare implications would be in light of the FDI policy environment in which they operate?

3.3.1 The Basic Setup

Let us assume there are two countries indexed by j (j=1,2). j' will denote the *other* country. Both countries follow a liberal FDI regime and freely permit foreign companies to operate within their respective boundaries. Superscript 'd' stands for domestic and 'f' for foreign production. Fixed costs of operating a foreign affiliate 'f_I ' are strictly higher than fixed costs of pure domestic production 'f_d' (for reasons like need for establishing a transnational network, for providing headquarter services etc. in addition to meeting the fixed costs of plant operation).[13]

$$f_I > f_d \tag{93}$$

Profit function for an individual firm i in country j is now given by the function:

$$\pi_{ij}(c) = \max\{0, \pi_{ij}^{d}(c)\} + \max\{0, \pi_{ij}^{f}(c)\} \tag{94}$$

[13]A pure domestic firm does not need a separate headquarter.

where $\pi_{ij}^{d}(c)$ are the profits from domestic production and $\pi_{ij}^{f}(c)$ are the profits from foreign affiliate production.

X-sector firms continue to play strategically a la Cournot.

$$\widehat{p}_j\left[1-\frac{x_{ij}}{X_j}\right]=c_{ij} \tag{95}$$

Markets are segmented in the sense that firms in each country play an independent quantity setting game, and prices may differ across the markets.[14]

Profits from domestic market sales (country j firms) are:

$$\pi_{ij}^{d}(c)=x_{ij}^{d}(c)\,m_{ij}^{d}(c)-f_d \tag{96}$$

Profits from foreign affiliate sales (country j' firms operating in country j) are:

$$\pi_{ij'}^{f}(c)=x_{ij'}^{f}(c)\,m_{ij'}^{f}(c)-f_I \tag{97}$$

Proposition 1: Higher fixed costs of multinational operations ensure partitioning of firms by multinational status such that $c_{fj'}^{*}<c_j^{*}$, where marginal cost (productivity) cutoff for domestic production is:

$$c_j^{*}=\widehat{p}_j\left[1-\sqrt{\frac{f_d}{\beta L_j}}\right] \tag{98}$$

and marginal cost (productivity) cutoff for foreign affiliate production is:

$$c_{fj}^{*}=\widehat{p}_j\left[1-\sqrt{\frac{f_I}{\beta L_j}}\right] \tag{99}$$

Proof: see Appendix B2a.

Let n_j be the number of firms operating in country j and n_{fj} be the number of firms successfully undertaking foreign direct investment abroad. Similarly, define $n_{j'}$ and $n_{fj'}$ for the *other* country.

[14] I am assuming the goods market arbitrage is not possible, that is consumers in one market cannot buy/sell goods in the other market to take advantage of the arbitrage opportunities.

As in the case of closed economy, we can solve for the equilibrium price (proof: see Appendix B2b)

$$p_j = \frac{\sum_{i=1}^{n_j} c_i + \sum_{i=1}^{n_{fj'}} c_i}{n_j + n_{fj'} - 1} \tag{100}$$

Since markets are segmented, price in the *other* country need not necessarily be the same, and is given by:

$$p_{j'} = \frac{\sum_{i=1}^{n_{j'}} c_i + \sum_{i=1}^{n_{fj}} c_i}{n_{j'} + n_{fj} - 1} \tag{101}$$

As in the case of a closed economy, these prices pin down the unique zero-profit cost (productivity) cutoffs: c_j^*, c_{fj}^*, $c_{j'}^*$, $c_{fj'}^*$.

Inward FDI has a two fold effect on the host economy, a pro-competitive effect and a business-stealing effect This is implied by the two propositions below:

Proposition 2: Inward FDI leads to a fall in equilibrium price in the host economy (pro-competitive effect). This also implies a fall in equilibrium cost (productivity) cutoff c_j^*.

$$p_j < p_{j_a}$$

$$c_j^* < c_j^{*a}$$

Proof: see Appendix B2c.

This effect is potentially welfare enhancing and its implications are further explored in the sub-section below.

Proposition 3: Given a level of productivity, for a firm that serves only the domestic market, domestic output, when the economy is opened to inward FDI, is lower, than under autarky. This also implies a fall in domestic profits of host country firms (business stealing effect).

$$x_{ij}^d(c) < x_{ij}^a(c)$$

$$\pi_{ij}^{d}(c) < \pi_{ij}^{a}(c)$$

Proof: see Appendix B2d.

Inward FDI increases market shares of foreign firms at the cost of producers in the domestic economy. This 'profit shifting' or 'business stealing' effect is the result of strategic interaction between domestic and foreign firms. It is not possible to generate this effects through monopolistic competition models of FDI like HMY(2004). As a result of this business stealing effect, fall in domestic sales profit of an individual firm in the host economy is given by:

$$\Delta\pi_{ij}^{d}(c) = \pi_{ij}^{a}(c) - \pi_{ij}^{d}(c) = \beta L\left[\left(1-\frac{c}{p_{j_a}}\right)^2 - \left(1-\frac{c}{p_j}\right)^2\right] \tag{102}$$

where p_{ja} is the equilibrium price under autarky and p_j is the price under open economy (with FDI).

At the same time, firms which successfully undertake affiliate production abroad generate additional profits from foreign affiliate sales given by:

$$\Delta\pi_{ij}^{f}(c) = \pi_{ij}^{f}(c) - 0 = \beta L_{j'}\left(\frac{p_{j'}-c}{p_{j'}}\right)^2 \tag{103}$$

Thus, total change in profit revenues for firms in country j are equal to:

$$\Delta\Pi_j = \sum_{i=1}^{n_{fj}} \Delta\pi_{ij}^{f}(c) - \sum_{i=1}^{n_j} \Delta\pi_{ij}^{d}(c) \tag{104}$$

Notice that at c_{fj}^{*}, the productivity cutoff for being a successful multinational, foreign profits are exactly equal to zero and there is loss of domestic profit revenues. Only firms with sufficiently high productivity gain overall profits, when additional profits generated by foreign affiliate sales outweigh the loss of profit revenues due to business stealing effect in the domestic economy. Aggregate profits for the host economy as a whole can thus also go in any direction depending on whether total profits generated by foreign affiliate sales outweigh the total loss of profits due to business stealing effect of inward FDI in the host economy.

Further, like in the case of a closed economy, it is possible to solve an aggregation problem for an open economy with FDI. Profits $\overline{\pi}_j$ for an average productivity homogeneous firm in country j would now be:

$$\overline{\pi}_j = f\left[\left(\frac{p_j-\overline{c}_j(p_j)}{p_j-c_j^{*}(p_j)}\right)^2 - 1\right] + pr_{fj}f_I\left[\left(\frac{p_{j'}-\overline{c}_{fj}(p_{j'})}{p_{j'}-c_{fj}^{*}(p_{j'})}\right)^2 - 1\right] \tag{105}$$

where $pr_j^f = n_{fj}/n_j$ is the proportion of country j firms undertaking foreign direct investment abroad, $\overline{c}_j(p_j)$ is the cost of an average productivity domestic firm selling in the domestic market and $\overline{c}_{fj}(p_{j'})$ is the cost of an average productivity country j multinational firm selling in the foreign market. As in the case of the closed economy, average costs are a function of the respective equilibrium prices.

Similarly, for country j' this expression would be:

$$\overline{\pi}_{j'} = f\left[\left(\frac{p_{j'} - \overline{c}_{j'}(p_{j'})}{p_{j'} - c^*_{j'}(p_{j'})}\right)^2 - 1\right] + pr_{fj'} f_I \left[\left(\frac{p_j - \overline{c}_{fj'}(p_j)}{p_j - c^*_{fj'}(p_j)}\right)^2 - 1\right] \quad (106)$$

In terms of the average profits, total change in profit revenues can also be expressed (respectively for country j and j') as follows:

$$\Delta\Pi_j = n_{fj}\pi_j^f(\overline{c}) - n_j \Delta\pi_j^d(\overline{c}) \quad (107)$$

$$\Delta\Pi_{j'} = n_{fj'}\pi_j^f(\overline{c}) - n_{j'} \Delta\pi_{j'}^d(\overline{c}) \quad (108)$$

3.3.2 Effects on Welfare

Let us assume the social welfare function $W(u)$ is utilitarian. All workers and entrepreneurs in this model are identical to each other. Hence, welfare of workers and entrepreneurs is given by:

$$W_w(u) = \sum_{l=1}^{L} u(w_l) \quad (109)$$

$$W_e(u) = \sum_{e=1}^{E} u(w_e) \quad (110)$$

Welfare of any individual worker is represented by the indirect utility function

$$u_w = (\beta)^\beta (1-\beta)^{1-\beta} (p_x)^{-\beta} (p_y)^{-(1-\beta)} w \quad (111)$$

Since wages and price of Y are normalized to one, total welfare for workers in country j is given by

$$W_w(u) = (\beta)^\beta (1-\beta)^{1-\beta} (p)^{-\beta} L_j = k(p)^{-\beta} L_j \quad (112)$$

Pro-competitive effect of inward FDI is a change in the utilities of workers given by:

$$\Delta W_w(u) = k\left(p_j^{-\beta} - p_{ja}^{-\beta}\right) L_j \tag{113}$$

In other words, change in aggregate welfare of workers is a function of change in the equilibrium price weighted by the consumption parameter β, a constant k (defined by equation 112 above) and market size L. As before, p_{ja} is the equilibrium price under autarky and p_j is the equilibrium price under open economy with FDI. Since, domestic price falls following the opening up to FDI, welfare of workers must rise.

Entrepreneurs have linear utility functions, hence, their aggregation is simpler. The effect of profit rents on entrepreneurs' welfare is equal to:

$$\Delta W_e(u) = \Delta y = \sum_{i=1}^{n_{fj}} \Delta\pi_{ij}^f(c) - \sum_{i=1}^{n_j} \Delta\pi_{ij}^d(c) = n_{jf}.\pi_{ij}^f(\bar{c}) - n_j.\Delta\pi_{ij}^d(\bar{c}) \tag{114}$$

where Δy is the change in consumption of good Y, $\Delta\pi_{ij}^f(c)$ are the profit revenues earned by country j multinational firms abroad and $\Delta\pi_{ij}^d(c)$ is the loss of profit revenues of domestic firms because of the business stealing effect of inward FDI in the host economy. Hence, there is an ambiguous change in the welfare of entrepreneurs as aggregate profits could either fall or rise.

Assuming there is no extra social weight on utility of workers, total change in welfare is given by:[15]

$$\begin{aligned} \Delta W(u) &= \Delta W_w(u) + \Delta W_e(u) \qquad (115) \\ &= L_j \left[\begin{array}{c} k\left(p_j^{-\beta} - p_{ja}^{-\beta}\right) + n_{jf}\beta\left(1 - \frac{\overline{c_f}}{p_{j'}}\right)^2 \\ -n_j\beta\left(\left(1 - \frac{\overline{c_a}}{p_{ja}}\right)^2 - \left(1 - \frac{\bar{c}}{p_j}\right)^2\right) \end{array} \right] \end{aligned}$$

As we can see, there are three welfare effects in this model. First, gain in workers utility due to pro-competitive effect of inward FDI and resulting fall in the domestic equilibrium price. Second, loss of profit revenues for the domestic firms due to the business stealing effect of inward FDI. Third,

[15] If there is an extra social weight on utility of workers, this can be captured by introducing a social weight parameter multiplying the aggregate utility of workers. This does not affect the results qualitatively.

there is a gain in profit revenues from the affiliate production in the foreign economy. The three effects together imply FDI is not an unambiguously welfare improving proposition. There could in fact be a loss in welfare, if the pro-competitive effect of inward FDI is very weak and domestic firms are not productive enough to earn sufficient profit rents abroad. A good example of such a scenario would be a developing economy, where domestic firms are not productive enough to invest abroad and inward FDI could drive domestic welfare either way. On the other hand, if the pro-competitive effect of inward FDI is strong enough to override the business stealing effect by itself, or the profit rents country j's multinationals earn abroad are so large that together with the pro-competitive effect of inward FDI they override the loss of profit revenues to inward FDI in the host economy, FDI would improve welfare.

3.4 Proximity-Concentration Trade-off

Brainard (1993) demonstrated a trade-off between proximity and concentration advantages, whereby higher trade costs and increasing returns at the corporate level relative to plant costs are associated with greater multinational activity. For reasons of analytical tractability, I will assume for this section that the two countries are symmetric (j=j'). A firm now has three possibilities: produce purely for domestic sales, produce for both domestic sales and export, or become multinational i.e. produce both for domestic and foreign market sales. As before, let f_d be the fixed costs of domestic production. Trade involves both fixed and variable costs. Let f_x be the total fixed costs of export production (including fixed costs of trade) and τ be the variable trade costs, which are assumed to be iceberg.[16] Let f_I be the total fixed costs of multinational operation, which include not only fixed costs of operating a foreign affiliate, but also fixed costs of providing headquarter services and creating trans-national networks.

Profits from domestic sales are given by

$$\pi_{ij}^{d}(c) = x_{ij}^{d}(c)\, m_{ij}^{d}(c) - f_d \tag{116}$$

Profits from export sales are given by

$$\pi_{ij}^{x}(c) = x_{ij}^{x}(c)\, m_{ij}^{x}(c) - f_x \tag{117}$$

[16]Since, f_x is strictly greater than f_d and iceberg trade costs, τ, are strictly greater than zero, exporters are more productive than pure domestic producers.

Profits from foreign affiliate sales are given by

$$\pi_{ij}^{f}(c) = x_{ij}^{f}(c)\, m_{ij}^{f}(c) - f_I \tag{118}$$

Profit function for an individual firm in country i is now given by:

$$\pi_{ij}(c) = \max\{0, \pi_{ij}^{d}(c) + \max\{0, \max\{\pi_{ij}^{x}(c), \pi_{ij}^{f}(c)\}\} \tag{119}$$

Similarly, output of an individual firm in country i is given by:

$$x_{ij}(c) = \max\{0, x_{ij}^{d}(c) + \max\{0, \max\{x_{ij}^{x}(c), x_{ij}^{f}(c)\}\} \tag{120}$$

It is a consistent finding in empirical literature that multinational firms are more productive than non-multinational exporters. As in the Helpman, Melitz and Yeaple (2004) model, this partitioning is achieved in this model by imposing an additional condition on the fixed costs of multinational operation:

Proposition 5: Given the stylized fact that multinational firms are more productive than non-multinational exporters, partitioning of exporting firms by FDI status can be achieved iff the following relationship is satisfied:

$$f_I > \left(\sqrt{f_x} + \frac{\tau - 1}{\tau}\sqrt{\beta L_j}\right)^2$$

Proof: see Appendix B3b.

The intuition is that compared to a pure trading operation, multinational operations involve high fixed activities like setting up a foreign plant, setting up/expanding the corporate headquarter, costs of creating transnational networks etc.

Partitioning of firms by export and multinational status also implies existence of three marginal cost/productivity cutoffs as defined in the proposition below:

Proposition 4: Relationship between the three marginal cost (productivity) cutoffs is given by:

$$4a)\quad c_{fj}^{*} = p_j\left[1 - \sqrt{\frac{f_I}{f_d}}\right] + c_j^{*}\sqrt{\frac{f_I}{f_d}} \tag{121}$$

$$4b) \quad c_{xj}^{*} = \frac{p_j}{\tau}\left[1-\sqrt{\frac{f_x}{f_d}}\right] + \frac{1}{\tau}\sqrt{\frac{f_x}{f_d}}c_j^{*} \tag{122}$$

$$4c) \quad c_{fj}^{*} = p_j\left[1-\sqrt{\frac{f_I}{f_x}}\right] + \tau\sqrt{\frac{f_I}{f_x}}c_{xj}^{*} \tag{123}$$

Proof: see Appendix B3a.

Thus, relative distance between the three cost cutoffs depends on the magnitude of fixed costs and iceberg (variable) trade costs. In this model, the relationship between the three cost cutoffs serves another useful purpose.

As will be evident from the condition 4c, higher (variable) trade costs imply a relatively higher cost cut-off (lower productivity) for undertaking a foreign direct investment; in other words, greater multinational activity. Further, we can rearrange condition 4a as follows:

$$4a) \quad c_{fj}^{*} = p_j - \left(p_j - c_j^{*}\right)\left[\sqrt{\frac{f_I}{f_d}}\right] \tag{124}$$

Now, given that for operating firms absolute mark-up $\left(p_j - c_j^{*}\right)$ is positive, lower corporate level fixed costs compared to pure plant level fixed costs (that is larger firm-level scale economies compared to plant-level scale economies) also implies a relatively higher cost cut-off (lower productivity) for undertaking a foreign direct investment, that is, greater multinational activity. This model therefore replicates the proximity-concentration trade-off within a framework of heterogeneous firms. In fact it goes a step further.

Proposition 6: Given a level of productivity above the threshold cutoff for FDI, for a firm that serves foreign markets through foreign direct investment, output and markup of foreign affiliate is greater than what its export output would have been had it chosen exporting as the mode of foreign market access i.e.

$$x_{ij}^{f}(c) > x_{ij}^{x}(c) \tag{125}$$

and

$$m_{ij}^{f}(c) > m_{ij}^{x}(c) \tag{126}$$

Proof: see Appendix B3c.

Given a level of fixed costs, at the level of cost cutoff threshold for FDI

$$\pi_{ij}^{f}\left(c_{fj}^{*}\right) = \pi_{ij}^{x}\left(c_{fj}^{*}\right) \tag{127}$$

whereas for a firm operating above this cutoff threshold for FDI

$$\pi_{ij}^{f}\left(c\right) > \pi_{ij}^{x}\left(c\right) \tag{128}$$

Thus, FDI leads not only to an increase in output, but also to an increase in endogenous mark-ups (market power), and due to both these reasons, to higher profits for erstwhile trading firms. Thus, firms undertake FDI not just for reasons enshrined in literature as proximity-concentration trade-off, but also because they hope to increase their market power, thereby earning higher profits.

3.5 A brief survey of FDI Policies

National Governments care about FDI inflows, and given the disparity of opinion that exists over positive and negative effects of inward FDI, design policies with actual and potential multinational behaviour in mind. While many countries have explicit FDI regimes, others have commercial policy regimes, which among other things, attempt to modulate behaviour of multinational firms in line with some domestic objectives. Another common feature of the foreign investment environment worldwide has been the so called 'incentive competition' between national governments to attract FDI into their respective countries.

To write a comparative discourse on FDI regimes of individual countries would be a voluminous exercise beyond the scope of this chapter. For reasons of brevity, I give an overview of such policies by classifying them into two broad categories:

3.5.1 FDI policies that affect the distribution of profits between the two countries

Such policies usually take the form of caps or limits on foreign equity ownership for any entity/firm incorporated within the boundaries of a country. They vary from a complete ban on foreign ownership at one extreme to unrestricted foreign ownership at the other. Further, within a country such equity limits vary from industry to industry, and within a particular industry, they vary over time. Such restrictions are usually severe in strategic sectors. Even when countries, by law, have liberal FDI regimes, nationalist fervour and domestic politics may force the Government to interfere with foreign ownership and hence, distribution of profits from foreign investment between the countries. Transfer pricing is another strategy, internal to a multinational firms, whereby firms set prices on their internal transactions in such a way that it moves earnings between the subsidiaries.

Another very important element of FDI policies are laws applicable to capital taxation and how they regulate mobile capital and multinational enterprise. Multinational firms, in general, are affected by tax systems of both the home and host economies. Multinational investment is also affected by tax treaties, if any, between the home and the host countries. If capital taxes are source based, entire tax income from profits is retained by the host economy. If, on the other hand, they are residence based, entire tax income from multinational investment is retained by the home economy. While earlier studies (Wheeler and Mody, 1992) found tax differentials have negligible effect on FDI flows, consensus emerging from recent studies (Hines,1999; Devereux and Griffith, 1998) is that taxes do matter for choice of multinational location. In any case, such elements of the commercial policy environment directly affect the distribution of profit-incomes between the countries in a similar way as the foreign equity cap does. Hence, foreign equity cap is used here in a generic sense and is thought of as capturing a variety of policies that affect the distribution of profit incomes between the countries.

3.5.2 FDI Policies that affect the costs of foreign investment

A complete ban on foreign investment, like non-tariff trade barriers, is equivalent to an infinitely high fixed cost of foreign investment. Most FDI regimes prescribe routes for foreign investment which are more tortuous than those for domestic investment. This increases fixed costs of foreign investment both directly and indirectly (in terms of the opportunity cost of time-cost over-runs). Political and economic instability adds to fixed costs of foreign investment by increasing the option value of uncertainty. Financial subsidies, which essentially take the form of government grants, also play some role in the choice of multinational location, especially between relatively similar economies. Providing subsidized infrastructure or public services, including preferential treatment for foreign exchange, all fall into the category of FDI policies of this type.

Similarly, there could be subsidy policies that tend to make foreign investment more attractive by bringing down the variable cost of operating a foreign affiliate. Falling into this category are tax holidays, which take the form of exemptions from indirect taxes for specified periods; exemptions from import and/or export duties. Some countries go a step further and provide cheap electricity and subsidized inputs/raw materials to multinational entrants. Such policies are commonly implemented as an incentive package in special economic zones, a strategy successfully implemented by many countries in East and South-East Asia.

It is straight forward to model FDI policies of the second type, as they are basically subsidies that bring down fixed or variable costs of foreign investment. I will concentrate, in the next section on FDI policies of the first type i.e. policies which affect the distribution of profit incomes between the countries and are commonly summarized by the term 'FDI regimes'.

3.6 FDI Regimes and Welfare

I now return to the asymmetric countries framework of Section 3. Welfare effects of FDI depend on the interaction between profit maximizing behaviour of multinational firms and the welfare maximizing objectives of the central planner (national government).

3.6.1 Unilateral FDI with Policy

Let us assume country j=2 follows a restrictive foreign investment regime and does not permit any foreign direct investment within its borders.[17] Country j=1 permits FDI, but regulates it with a policy regime. It is the central planner which decides and implements the policy regime. Fixed costs of operating a foreign affiliate are borne entirely by the foreign entrepreneurs.

As before, inward FDI in country 1 has a 'pro-competitive' effect, by lowering the price of good X and a 'business stealing' effect by taking away some profits and market shares of country 1's domestic firms. Country 1's firms in this case cannot earn multinational profits abroad. If the pro-competitive effect overrides the business stealing effect, the central planner would welcome inward FDI. If not, the central planner may like to intervene through a policy regime.

[17]Equivalently, none of the country 1 firms are productive enough to invest abroad.

Let us assume country 1's central planner imposes an ownership restriction λ, which prescribes the percentage upper limit of equity that can be owned by a foreign entrepreneur (remaining is equally distributed between the domestic entrepreneurs). Assuming foreign entrepreneurs exhaust all profit-making opportunities, the host country (country 1) would still gain welfare (from inward FDI), if the value of this policy parameter is above the threshold defined below:

Proposition 7: In cases where business stealing effect of inward FDI is stronger than its pro-competitive effect, for the host country to be welfare neutral to inward FDI the level of equity cap λ should be such that

$$1-\lambda=\frac{\left[n_1\beta\left(\left(1-\frac{\bar{c}_{1a}}{p_{1a}}\right)^2-\left(1-\frac{\bar{c}_1}{p_1}\right)^2\right)-k\left(p_1^{-\beta}-p_{1a}^{-\beta}\right)\right]}{\left[pr_{f2}n_2\beta\left(1-\frac{\bar{c}_{2f}}{p_1}\right)^2\right]} \tag{129}$$

and if lower (higher $1-\lambda$) than this, welfare for the home country would improve unambiguously.

Proof: see Appendix B4a.

If the pro-competitive effect is stronger than the business stealing effect, the above proposition implies a value of $\lambda \geq 1$ (i.e. no policy intervention needed as inward FDI is unambiguously welfare improving). At the other extreme, would be a floor value, $\lambda = \underline{\lambda}$, below which the foreign entrepreneur would lose all management control and any policy prescription below this level would practically shut out inward FDI from the host economy. This floor level could be interpreted as the cut-off between direct and portfolio investment.[18] Hence, upper and lower limits for this policy parameter are $[\underline{\lambda} \leq \lambda \leq 1]$ and any FDI policy would work only between these two extremes.

As already mentioned, effects similar to ownership restrictions can be achieved through capital taxation, assuming capital taxes are retained and redistributed within the host economy.[19] The floor value of the policy parameter, $\underline{\lambda}$, would in this case be interpreted as the highest capital taxation rate $(1-\underline{\lambda})$ that would practically drive out foreign direct investment from the host economy.

[18]The UN defines management control in this case as owning 10 percent or more of the ordinary shares or voting power of an incorporated firm or its equivalent for an unincorporated firm; while lower ownership shares are known as portfolio investment.

[19]In this case, capital taxes are redistributed to the domestic entrepreneurs in the form of numeraire good Y.

3.6.2 Bilateral FDI with Policy

Let us introduce a modification to the above scenario. Say now, the central planner in country 2 permits FDI, which may be either welfare improving (pro-competitive effect stronger than business stealing effect with $\lambda_2^* = 1$); or potentially welfare decreasing (pro-competitive effect weaker than business stealing effect), but regulated by a welfare neutral policy regime λ_2^* such that $\lambda_2^* \in [\underline{\lambda}, 1]$. Let us assume for a moment that county 1's central planner takes λ_2^* as given. Welfare neutral solution for country 1's central planner would now be as follows:

Proposition 8: Taking the stated FDI Policy of country 2, λ_2^*, as given, the welfare neutral solution of FDI Policy, λ_1^*, for country 1's central planner would be:

$$1 - \lambda_1^* = \frac{n_1 \Delta \pi_1^d (\bar{c}) - k \left(p_1^{-\beta} - p_{1a}^{-\beta} \right) L_1 - pr_{f1} n_1 \pi_1^f (\bar{c}) . \lambda_2^*}{pr_{f2} n_2 \pi_2^f (\bar{c})} \tag{130}$$

Proof: see Appendix B4b.

In other words, the welfare neutral FDI policy now depends on the policy regime of the other country. There could in fact be three cases:

Case 1: If the pro-competitive effect is, by itself, stronger than business-stealing effect in both the countries, inward FDI is, by itself, unambiguously welfare improving for both the countries and free FDI would be the optimal policy for both the countries (i.e. $\lambda_1, \lambda_2 = 1$).

Case 2: If the pro-competitive effect is stronger than the business-stealing effect in one country, but weaker than it in the other; the unambiguously welfare improving country would permit free FDI (i.e. $\lambda_j = 1$), while the other country would take this policy parameter as given and fix its policy parameter at the welfare neutral level λ^* as given by the proposition 8 above. If even the floor value $\underline{\lambda}$ is welfare losing for the other country, its central planner would restrict all FDI and we would be back to the world of unilateral FDI described earlier.

Case 3: If FDI is potentially welfare decreasing in both the countries (pro-competitive effect weaker than the business stealing effect), central planners in the two countries would play a policy game over division of multinational profits between the two countries and the optimal solution would be a Nash equilibrium in FDI policies. In this case, the net welfare effect of FDI in country 1 would be:

$$\Delta W_1^{fdi} = k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right)L_1 - n_1\Delta\pi_1^d(\bar{c}) + \lambda_2 pr_{f1}n_1\pi_1^f(\bar{c}) + (1-\lambda_1)pr_{f2}n_2\pi_2^f(\bar{c}) \tag{131}$$

and the net welfare effect of FDI in country 2 would be:

$$\Delta W_2^{fdi} = k\left(p_2^{-\beta} - p_{2a}^{-\beta}\right)L_2 - n_2\Delta\pi_2^d(\bar{c}) + \lambda_1 pr_{f2}n_2\pi_2^f(\bar{c}) + (1-\lambda_2)pr_{f1}n_1\pi_1^f(\bar{c}) \tag{132}$$

Of the four terms on the right hand side of respective welfare functions, the first is the pro-competitive effect, the second is the business stealing effect and the last two terms are the division of multinational profits between the two countries. Notice that λ_1 and λ_2 are competitive in the sense that they have opposite effects on each country's welfare. Welfare functions show that bilateral FDI policy is essentially a question of dividing total multinational profits between the two countries. But competitive policy actions potentially erode the incentives for multinational firms to invest abroad. If country 1 decreases the value of its policy choice parameter λ_1 in a unilateral attempt to improve its welfare, it would simultaneously decrease welfare in country 2.

Further, total potentially welfare decreasing effect of inward FDI for the two countries together, is the aggregate difference between the business stealing effects and the pro-competitive effects for the two countries as given below:

$$n_1\Delta\pi_1^d(\bar{c}) + n_2\Delta\pi_2^d(\bar{c}) - k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right)L_1 - k\left(p_2^{-\beta} - p_{2a}^{-\beta}\right)L_2 \tag{133}$$

There could now be three further sub-cases:

Case 3a: If the total multinational profits are insufficient to cover the total potentially welfare decreasing effect of inward FDI, the autarky equilibrium will Pareto dominate and would be the unique policy solution.

Case 3b: If the total multinational profits are equal to the total potentially welfare decreasing effect of inward FDI, Nash equilibrium would be a combination of welfare neutral FDI policies λ_1^* and λ_2^*, which are the minimum payoffs the respective central planners would find acceptable. Any unilateral deviation (for example decreasing λ_1 below λ_1^*) would make FDI a welfare losing proposition for the other country and would invite retaliatory action threatening to push the countries back into autarky. Intuitively, it says that if the FDI is a potentially welfare decreasing proposition for *both* the countries, the best the two country's central planner can do together is to have a welfare neutral FDI regime so that no country looses welfare in moving from autarky to FDI.

The reaction functions of the two central planners can be derived (for details see Appendix B4c) as follows:

$$\lambda_1^*(\lambda_2) = \frac{pr_{f2}n_2\pi_2^f(\bar{c}) + k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right)L_1 - n_1\Delta\pi_1^d(\bar{c})}{pr_{f2}n_2\pi_2^f(\bar{c})} + \frac{pr_{f1}n_1\pi_1^f(\bar{c})}{pr_{f2}n_2\pi_2^f(\bar{c})}\lambda_2 \tag{134}$$

and

$$\lambda_2^*(\lambda_1) = \frac{pr_{f1}n_1\pi_1^f(\bar{c}) + k\left(p_2^{-\beta} - p_{2a}^{-\beta}\right)L_2 - n_2\Delta\pi_2^d(\bar{c})}{pr_{f1}n_1\pi_1^f(\bar{c})} + \frac{pr_{f2}n_2\pi_2^f(\bar{c})}{pr_{f1}n_1\pi_1^f(\bar{c})}\lambda_1 \tag{135}$$

Notice that λ_1^* and λ_2^* are not negatively, but positively related. The two country's reactions functions are positively sloped in (λ_1, λ_2) space; they in fact have equal slopes and overlap each other (for details see Appendix B4c).

This implies we do not have a unique Nash equilibrium, but a sequence of equilibria given by pairs of optimal values λ_1^* and λ_2^* that lie on the interval $\lambda_1^*, \lambda_2^* \in [\underline{\lambda}, 1]$ and solve the system of simultaneous equations represented by reaction functions above. Autarky equilibrium would be an additional Nash equilibrium as it gives equivalent payoffs.

Case 3c: If the total multinational profits are greater than total potentially welfare decreasing effect of inward FDI, the policy game would be played over sharing this surplus. Assuming for simplicity that two countries have equal bargaining power (like in equal vote based WTO system), Nash equilibrium would be a combination of FDI policies λ_1^* and λ_2^*, such that each country get half of this surplus, which I will denote by Ω. The reaction functions of the two central planners would now be given by (for details see Appendix B4c):

$$\lambda_1^*(\lambda_2) = \frac{pr_{f2}n_2\pi_2^f(\bar{c}) + k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right)L_1 - n_1\Delta\pi_1^d(\bar{c}) - \Omega/2}{pr_{f2}n_2\pi_2^f(\bar{c})} + \frac{pr_{f1}n_1\pi_1^f(\bar{c})}{pr_2^f n_2\pi_2^f(\bar{c})}\lambda_2 \tag{136}$$

and

$$\lambda_2^*(\lambda_1) = \frac{pr_1^f n_1 \pi_1^f(\bar{c}) + k\left(p_2^{-\beta} - p_{2a}^{-\beta}\right) L_2 - n_2 \Delta \pi_2^d(\bar{c}) - \Omega/2}{pr_{f1} n_1 \pi_1^f(\bar{c})} + \frac{pr_{f2} n_2 \pi_2^f(\bar{c})}{pr_{f1} n_1 \pi_1^f(\bar{c})} \lambda_1 \tag{137}$$

As before, the two reactions functions are positively sloped in (λ_1, λ_2) space, have equal slopes and overlap each other. Again there is no unique Nash equilibrium, but a sequence of equilibria given by pairs of optimal values λ_1^* and λ_2^* that lie on the interval $\lambda_1^*, \lambda_2^* \in [\underline{\lambda}, 1]$ and solve the system of simultaneous equations represented by reaction functions above. The only difference compared to Case 3b is that autarky equilibrium is now Pareto dominated by these equilibria.

As far as the two central planners are concerned, the multiple equilibria in Case 3b and Case 3c are Pareto equivalent (because the aggregate country welfare remains unchanged between them). The problem remains, can we find a focal point to refine these equilibria further? Or in other words, if the two countries have to agree to a common policy rule, what should such a common policy rule be?

3.6.3 FDI Policy and Investment Regimes

We have seen in the Case 3b and Case 3c above that although FDI is potentially welfare decreasing for both the countries, they could still agree to a policy rule $\lambda_1^*, \lambda_2^* \in [\underline{\lambda}, 1]$, which is welfare neutral for both the countries when simultaneously opened up to inward FDI. But there is no unique solution, rather a sequence of multiple equilibria that are Pareto equivalent. We need some mechanism or process that leads the players (in this case both country's central planners) to refine these equilibria further and reach a unique, mutually agreed solution.

One way to refine these equilibria is to have a rule based international investment regime overseen by some international watchdog like the WTO that forces both countries to select the most liberal amongst the multiple Pareto equivalent equilibria. The other way could be, for both countries to enter into a bilateral investment treaty, that selects the most liberal amongst the multiple Pareto equivalent equilibria. The most liberal FDI equilibrium in this case would be the highest optimal value pair λ_1^*, λ_2^* that lies on the interval $[\underline{\lambda}, 1]$.

A plausible explanation for the driving force behind the two central planners to enter into a bilateral investment treaty could be lobbying by multinational firms to choose the least restrictive amongst alternative FDI policies possible. This is not an explicit model of lobby formation, but it is reasonable to expect so if the lobbying power of firms is proportional to the profits they make. Multinational firms in this model are larger and make larger profits than purely domestic firms, while workers, who earn a wage income, are indifferent between the two modes of production. In the real world, FDI is regulated by a few rules agreed under the international investment regime (also called the trade related investment measures or TRIMS), while the bulk of FDI is covered by bilateral investment treaties between mutually investing (i.e. bilateral FDI) countries.

3.7 Summary

This is a model of firm heterogeneity with market power. The mark-ups are endogenous and responsive to toughness of market competition. The model is characterized by a long run equilibrium where small and large firms coexist with varying degrees of market power and steepness of market power gradient varies one to one with the natural gradient of firm size and market shares in equilibrium. Market size has firm scale effects and the model is consistent with stylized facts as reported in the literature.

In this chapter, I first setup a baseline model for the closed economy, which is then extended to open economy with endogenous FDI. It not only explains profit shifting or business stealing effect of inward FDI in the host economy, but it also brings out potential gains in market power and profits as additional reasons for undertaking FDI in addition to reasons already enshrined in literature as proximity-concentration trade-off. When extended to analysis of FDI policy regimes, this model leads to a rich interaction between profit maximizing behaviour of multinational firms and the commercial policy environment in which they operate.

FDI is not an unambiguously welfare improving proposition. While firms maximize their individual profits, overall welfare effect depends on how returns from foreign investment are distributed between the residents of the home and the host economies. Anecdotal evidence also suggests that this is what the national governments attempt to do with their respective FDI policy regimes. This paper provides a formal basis for the same. This model also brings out the utility of multilateral investment regime and bilateral investment treaties in refining multiple Nash equilibria to ensure that most liberal FDI policy regime is implemented worldwide.

To summarize, this model provides a useful alternative to monopolistic competition models of firm heterogeneity to study intra-industry reallocation effects of FDI and to analyse the welfare implications of FDI Policy. It can be used in a variety of settings and is clearly the most appropriate for industries where a small number of domestic and foreign firms interact strategically.

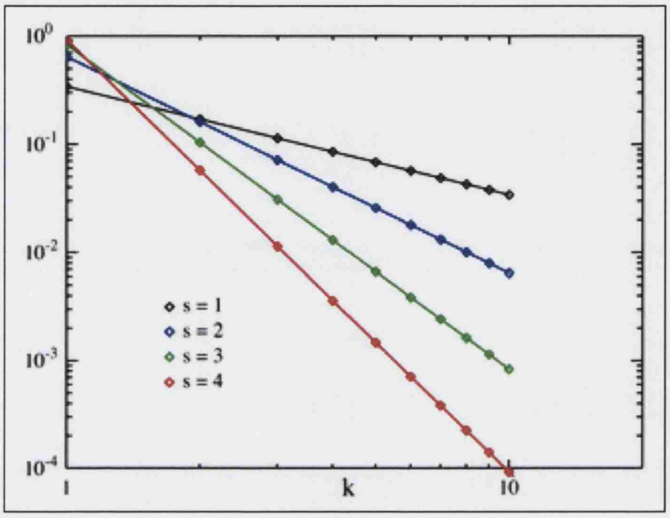

Figure 3.1: Probability mass function of Zipf Distributions for different values of the slope parameter 's'. A larger value of the slope parameter implies greater firm heterogeneity, that is greater relative frequency for firms that lie in a class interval with a higher rank.

3.8 Appendix B

3.8.1 B1 : Closed Economy

B1a) Solving for Equilibrium Price:

There are two ways to solve for the equilibrium price.

Method 1: Use goods market clearing and the Walras' Law:

In equilibrium, total demand for good X must equal its supply:

$$\frac{\beta L}{p} = \sum_{i=1}^{n} x_i\left(c\right)$$

Substituting out the output supply function for an individual firm

$$\frac{\beta L}{p} = \sum_{i=1}^{n} \beta L \frac{\left(p - c_i\right)}{p^2}$$

simplifying further yields

$$p = \sum_{i=1}^{n} \left(p - c_i\right)$$

or

$$p = np - \sum_{i=1}^{n} c_i$$

rearranging which yields

$$p = \frac{\sum_{i=1}^{n} c_i}{n-1}$$

Method 2: Using the labour market clearing condition and the production technology

$$L = L_x + L_y$$

$$L = \sum_{i=1}^{n} \left(f + c_i . x_i\left(c\right)\right) + \left(1 - \beta\right) L + \Pi$$

Expanding further

$$L=\sum_{i=1}^{n}\left(f+c_i.\beta L\left(\frac{p-c_i}{p^2}\right)\right)+(1-\beta)L+\sum_{i=1}^{n}\left[\beta L\left(\frac{p-c_i}{p}\right)^2-f\right]$$

which is equal to

$$L=nf+\beta L\sum_{i=1}^{n}c_i\left(\frac{p-c_i}{p^2}\right)+L-\beta L+\beta L\sum_{i=1}^{n}\left(\frac{p-c_i}{p}\right)^2-nf$$

simplifying further yields

$$p^2=\sum_{i=1}^{n}c_i\,(p-c_i)+\sum_{i=1}^{n}(p-c_i)^2$$

expanding the terms in brackets

$$p^2=p\sum_{i=1}^{n}c_i-\sum_{i=1}^{n}c_i^2+np^2+\sum_{i=1}^{n}c_i^2-2p\sum_{i=1}^{n}c_i$$

simplifying further yields

$$p=\frac{\sum_{i=1}^{n}c_i}{n-1}$$

Thus, both methods give the same result for equilibrium price.

B1b) Solving the Aggregation Problem:

$$\Pi=\sum_{i=1}^{n}\pi_i\,(c)=\beta L\left(\frac{p-c_1}{p}\right)^2-f+\ldots\ldots\ldots.+\beta L\left(\frac{p-c_n}{p}\right)^2-f$$

which implies

$$n.\pi\,(\bar{c})=\frac{\beta L}{p^2}\left[np^2+\sum_{i=1}^{n}c_i^2-2p\sum_{i=1}^{n}c_i\right]-nf$$

which is equal to

$$n\left[\frac{\beta L}{p^2}(p-\overline{c})^2 - f\right] = \frac{\beta L}{p^2}\left[np^2 + \sum_{i=1}^{n} c_i^2 - 2p\sum_{i=1}^{n} c_i\right] - nf$$

Solving for $\overline{c}$:

$$\overline{c} = p - \sqrt{p^2 + \frac{\sum_{i=1}^{n} c_i^2}{n} - 2p\frac{\sum_{i=1}^{n} c_i}{n}}$$

Solving for $\pi(\overline{c})$:

$$\pi(\overline{c}) = x(\overline{c})\, m(\overline{c}) - f$$

From the zero profit cutoff

$$\pi(c^*) = x(c^*)\, m(c^*) - f = 0$$

Using the ratios

$$\pi(\overline{c}) = \left(\frac{p-\overline{c}}{p-c^*}\right) x(c^*) \left(\frac{p-\overline{c}}{p-c^*}\right) m(c^*) - f$$

This implies

$$\pi(\overline{c}) = f\left[\left(\frac{p-\overline{c}(p)}{p-c^*(p)}\right)^2 - 1\right]$$

where both $\overline{c}$ and c^* are the functions of equilibrium price p.

B1c) Effect of Market Size:
Number of entrepreneurs increases proportionately with market size.
(i) For the same average productivity

$$\frac{\sum_{i=1}^{n} c_i}{n} = \frac{2\sum_{i=1}^{n} c_i}{2n}$$

The effect of introducing a constant 1 in the denominator

$$\frac{2\sum_{i=1}^{n} c_i}{2(n-1)} > \frac{2\sum_{i=1}^{n} c_i}{2n-1}$$

This implies

$$p_s > p_l$$

where p_s is the price in the smaller and p_l is the price in the larger market.

(ii) For a firm with a given productivity level c_i

$$p_s - c_i > p_l - c_i$$

that is, firms operating in larger markets have smaller mark-ups.

'Toughness of competition' effect of an increase in number of firms is a robust prediction of oligopoly models (Sutton, 1998).

(iii) Output rises unambiguously.

Given the output function:

$$x_i(c) = \beta L \left[\frac{p - c_i}{p^2} \right]$$

Thus, direct effect of market size (L) on output of an individual firm is positive.

To compute the indirect effect through price, define

$$f(p) = \frac{p - c_i}{p^2}$$

Its first order derivative

$$\frac{df(p)}{dp} = -\frac{1}{p^2} + \frac{c_i}{p^3} = \frac{c_i - p}{p^3}$$

is negative because $c_i < p$ (otherwise no firm would produce a positive output) and price p is strictly greater than zero. The sign of the derivative implies that in larger markets, as price is lower, outputs of individual firms are higher. Thus, both direct and indirect effects imply that firms in larger markets have unambiguously higher outputs.

3.8.2 B2 : Open Economy with FDI

B2a) Partitioning of Firms by Multinational Status:
Zero profit cutoff for domestic production in country j is:

$$\pi_{ij}^{d}(c) = x_{ij}^{d}(c)\, m_{ij}^{d}(c) - f_d = 0$$

Rearranging this yields:

$$c_j^* = p_j \left[1 - \sqrt{\frac{f_d}{\beta L_j}}\right]$$

Zero profit cutoff for foreign affiliate production in country j is:

$$\pi_{ij'}^{f}(c) = x_{ij'}^{f}(c)\, m_{ij'}^{f}(c) - f_I = 0$$

Rearranging this yields:

$$c_{fj'}^* = p_j \left[1 - \sqrt{\frac{f_I}{\beta L_j}}\right]$$

Given the assumption that

$$f_I > f_d$$

$$c_{fj'}^* < c_j^*$$

i.e. multinational operators are more productive then domestic firms.
This proves Proposition 1.

B2b) Solving for the Equilibrium Price (Open Economy with FDI):
Again, there are two ways to solve for the equilibrium price.
Method 1: Use goods market clearing and Walras' Law:
In equilibrium, total demand for good X must equal its supply:

$$\frac{\beta L_j}{p_j} = \sum_{i=1}^{n_j} x_i(c) + \sum_{i=1}^{n_{fj'}} x_i(c)$$

Substituting out the output supply function

$$\frac{\beta L_j}{p_j} = \beta L_j \sum_{i=1}^{n_j} \frac{p_j - c_i}{p_j^2} + \beta L_j \sum_{i=1}^{n_{fj'}} \frac{p_j - c_i}{p_j^2}$$

simplifying further

$$p_j = n_j p_j + n_{fj'} p_j - \sum_{i=1}^{n_j} c_i - \sum_{i=1}^{n_{fj'}} c_i$$

rearranging yields

$$p_j = \frac{\sum_{i=1}^{n_j} c_i + \sum_{i=1}^{n_{fj'}} c_i}{n_j + n_{fj'} - 1}$$

Method 2: Using the labour market clearing condition and production technology

$$L_j = L_{jx} + L_{jy}$$

This is equal to

$$L_j = \sum_{i=1}^{n_j} \left(f_d + c_i . x_i\left(c\right)\right) + \sum_{i=1}^{n_{fj'}} \left(f_I + c_i . x_i\left(c\right)\right) + \left(1 - \beta\right) L_j + \Pi_j$$

where

$$\Pi_j = \beta L_j \sum_{i=1}^{n_j} \left(\frac{p_j - c_i}{p_j}\right)^2 - n_j f_d + \beta L_j \sum_{i=1}^{n_{fj'}} \left(\frac{p_j - c_i}{p_j}\right)^2 - n_{fj'} f_I$$

Substituting out the output supply function, the profit function and then cancelling out the fixed costs terms

$$\begin{aligned} L_j &= \beta L_j \sum_{i=1}^{n_j} c_i \frac{p_j - c_i}{p_j^2} + \beta L_j \sum_{i=1}^{n_{fj'}} c_i \frac{p_j - c_i}{p_{j^2}} \\ &+ \left(1 - \beta\right) L_j + \beta L_j \sum_{i=1}^{n_j} \left(\frac{p_j - c_i}{p_j}\right)^2 + \beta L_j \sum_{i=1}^{n_{fj'}} \left(\frac{p_j - c_i}{p_j}\right)^2 \end{aligned}$$

Simplifying further yields

$$p_j^2 = \sum_{i=1}^{n_j} c_i \left(p_j - c_i\right) + \sum_{i=1}^{n_{fj'}} c_i \left(p_j - c_i\right) + \sum_{i=1}^{n_j} \left(p_j - c_i\right)^2 + \sum_{i=1}^{n_{fj'}} \left(p_j - c_i\right)^2$$

Expanding the brackets, cancelling out common terms and rearranging yields

$$p_j = \frac{\sum_{i=1}^{n_j} c_i + \sum_{i=1}^{n_{fj'}} c_i}{n_j + n_{fj'} - 1}$$

Thus, both methods give the same solution for equilibrium price.

Repeat the same for the other market

$$p_{j'} = \frac{\sum_{i=1}^{n_{j'}} c_i + \sum_{i=1}^{n_{fj}} c_i}{n_{j'} + n_{fj} - 1}$$

B2c) Pro-competitive Effect of Inward FDI:

Partitioning of firms by multinational status implies

$$\frac{\sum_{i=1}^{n_j} c_i}{n_j} > \frac{\sum_{i=1}^{n_{fj'}} c_i}{n_{fj'}}$$

Adding the same term to the numerator and denominator on both sides

$$\frac{\sum_{i=1}^{n_j} c_i + \sum_{i=1}^{n_j} c_i}{n_j + n_j} > \frac{\sum_{i=1}^{n_{fj'}} c_i + \sum_{i=1}^{n_j} c_i}{n_{fj'} + n_j}$$

Subtracting 1 from denominator on both sides

$$\frac{\sum_{i=1}^{n_j} c_i + \sum_{i=1}^{n_j} c_i}{n_j + n_j - 1} > \frac{\sum_{i=1}^{n_{fj'}} c_i + \sum_{i=1}^{n_j} c_i}{n_{fj'} + n_j - 1}$$

This implies

$$\frac{2\left(\sum_{i=1}^{n_j} c_i\right)}{2n_j - 1} > \frac{\sum_{i=1}^{n_{fj'}} c_i + \sum_{i=1}^{n_j} c_i}{n_{fj'} + n_j - 1}$$

Further, since

$$\frac{2\left(\sum_{i=1}^{n_j} c_i\right)}{2n_j - 2} > \frac{2\left(\sum_{i=1}^{n_j} c_i\right)_i}{2n_j - 1} > \frac{\sum_{i=1}^{n_{fj'}} c_i + \sum_{i=1}^{n_j} c_i}{n_{fj'} + n_j - 1}$$

and

$$\frac{\sum_{i=1}^{n_j} c_i}{n_j - 1} = \frac{2\left(\sum_{i=1}^{n_j} c_i\right)}{2n_j - 2}$$

It has been proved that

$$\frac{\sum_{i=1}^{n_j} c_i}{n_j - 1} > \frac{\sum_{i=1}^{n_{fj'}} c_i + \sum_{i=1}^{n_j} c_i}{n_{fj'} + n_j - 1}$$

In other words,

$$p_j^a > p_j$$

i.e. equilibrium price under autarky is higher than equilibrium price under open economy with FDI.

Moreover, from equation 98, the zero-profit cutoff cost (productivity) also falls

$$c_j^* < c_j^{*a}$$

This may cause the exit of least productive domestic firms. In case it happens, it further lowers the average marginal cost of domestic firms $\frac{\sum_{i=1}^{n_j} c_i}{n_j}$, thereby further lowering the equilibrium price from the expression above.

These results were described in Proposition 2 as "pro-competitive" effects of inward FDI.

B2d) Business Stealing Effect of Inward FDI:

Proposition 3 flows from proposition 2.

Output function for an individual firm can be written as

$$x_{ij}(c) = \frac{\beta L_j}{p_j}\left[1 - \frac{c}{p_j}\right]$$

Fall in equilibrium price implies the term inside the bracket as well as the term outside the bracket on the right hand side decline implying an decrease in the output and market share of domestic firms, as the economy in opened up to FDI.

Similarly, profit function can be written as

$$\pi_{ij}(c) = \beta L_j \left[1 - \frac{c}{p_j}\right]^2 - f_d$$

Fall in equilibrium price also implies a fall in firm profits.

In other words, inward FDI has a "business stealing" effect on domestic firms, by causing exit of least productive domestic producers and by stealing market shares and shifting profits away from firms that continue to operate in the domestic economy.

3.8.3 B3 : Proximity-Concentration Trade-off

B3a) Relationship between the Three Cost Cutoffs:

From the zero-cutoff profit conditions for domestic and foreign affiliate production we get

$$\frac{x_{ij}^{f}\left(c_{fj}^{*}\right)m_{ij}^{f}\left(c_{fj}^{*}\right)}{x_{ij}^{d}\left(c_{j}^{*}\right)m_{ij}^{d}\left(c_{j}^{*}\right)}=\frac{f_I}{f_d}$$

which implies

$$\frac{p_j-c_{fj}^{*}}{p_j-c_j^{*}}=\sqrt{\frac{f_I}{f_d}}$$

Rearranging yields

$$p_j-p_j\sqrt{\frac{f_I}{f_D}}=c_{fj}^{*}-c_j^{*}\sqrt{\frac{f_I}{f_d}}$$

Therefore,

$$c_{fj}^{*}=p_j\left[1-\sqrt{\frac{f_I}{f_d}}\right]+c_j^{*}\sqrt{\frac{f_I}{f_d}}$$

Similarly, relationship between export and domestic productivity cutoff can be derived as follows:

$$\frac{p_j-\tau c_{xj}^{*}}{p_j-c_j^{*}}=\sqrt{\frac{f_x}{f_d}}$$

$$p_j-p_j\sqrt{\frac{f_x}{f_d}}=\tau c_{xj}^{*}-c_j^{*}\sqrt{\frac{f_x}{f_d}}$$

$$c_{xj}^{*}=\frac{p_j}{\tau}\left[1-\sqrt{\frac{f_x}{f_d}}\right]+\frac{1}{\tau}\sqrt{\frac{f_x}{f_d}}c_j^{*}$$

This leaves the relationship between foreign investment productivity cutoff and export productivity cutoff, which is derived as follows:

$$\frac{p_j-c_{fj}^{*}}{p_j-\tau c_{xj}^{*}}=\sqrt{\frac{f_I}{f_x}}$$

$$p_j-p_j\sqrt{\frac{f_I}{f_x}}=c_{fj}^{*}-\tau c_{xj}^{*}\sqrt{\frac{f_I}{f_x}}$$

$$c_{fj}^* = p_j\left[1-\sqrt{\frac{f_I}{f_x}}\right]+\tau\sqrt{\frac{f_I}{f_x}}c_{xj}^*$$

B3b) Partitioning between Trade and FDI:

Proposition 5: The sufficient condition for partitioning of exporting firms by FDI status is

$$c_{fj}^* < c_{xj}^*$$

At c_{xj}^*

$$\frac{\beta L_j}{p_j^2}\left(p_j-\tau c_{xj}^*\right)^2 = f_x$$

This implies

$$c_{xj}^* = \frac{1}{\tau}\left[p_j\left(1-\sqrt{\frac{f_x}{\beta L_j}}\right)\right]$$

At c_{fj}^*

$$\frac{\beta L_j}{p_j^2}\left(p_j-c_{fj}^*\right)^2 = f_I$$

This implies

$$c_{fj}^* = \left[p_j\left(1-\sqrt{\frac{f_I}{\beta L_j}}\right)\right]$$

For the sufficient condition to be satisfied

$$\left[p_j\left(1-\sqrt{\frac{f_I}{\beta L_j}}\right)\right] < \frac{1}{\tau}\left[p_j\left(1-\sqrt{\frac{f_x}{\beta L_j}}\right)\right]$$

Rearranging yields:

$$f_I > \left(\sqrt{f_x}+\frac{\tau-1}{\tau}\sqrt{\beta L_j}\right)^2$$

Hence proved.

B3c) Proof of Proposition 6: Writing out the output functions:

$$x_{ij}^f(c) = \frac{\beta L_j}{p_j^2}\left[p_j - c\right]$$

$$x_{ij}^{x}(c) = \frac{\beta L_j}{p_j^2}\left[p_j - \tau c\right]$$

Absence of (variable) trade costs implies

$$x_{ij}^{f}(c) > x_{ij}^{x}(c)$$

and

$$m_{ij}^{f}(c) > m_{ij}^{x}(c)$$

Multiplying both sides of the above two equations yields

$$x_{ij}^{f}(c)\, m_{ij}^{f}(c) > x_{ij}^{x}(c)\, m_{ij}^{x}(c)$$

Given a level of fixed costs satisfying Proposition 5 above, at the threshold cost (productivity) cut-off between exporting and FDI

$$\pi_{ij}^{f}\left(c_{fj}^{*}\right) = \pi_{ij}^{x}\left(c_{fj}^{*}\right)$$

which implies

$$x_{ij}^{f}\left(c_{fj}^{*}\right) m_{ij}^{f}\left(c_{fj}^{*}\right) - f_I = x_{ij}^{x}\left(c_{fj}^{*}\right) m_{ij}^{x}\left(c_{fj}^{*}\right) - f_x$$

But since fixed costs don't increase with output and given that profit is a quadratic function of variable costs, for the firms with productivity above this cut-off threshold:

$$x_{ij}^{f}(c)\, m_{ij}^{f}(c) - f_I > x_{ij}^{x}(c)\, m_{ij}^{x}(c) - f_x$$

which implies

$$\pi_{ij}^{f}(c) > \pi_{ij}^{x}(c)$$

Hence proved.

3.8.4 B4 : FDI Regimes and Welfare

B4a) Proof of Proposition 7: Only country 1 permits FDI.

This has a pro-competitive effect on the host economy given by

$$\Delta W_w(u) = k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right) L_1$$

There is also a business stealing effect,

because of loss of market shares of domestic producers, given by:

$$\sum_{i=1}^{n_j} \Delta\pi_{ij}^d(c) = n_j \Delta\pi_j^d(\bar{c}) = n_1 \beta L_1 \left(\left(1 - \frac{\bar{c}_{1a}}{p_{1a}}\right)^2 - \left(1 - \frac{\bar{c}_1}{p_1}\right)^2\right)$$

But since the national government of country 1 can implement an independent FDI Policy λ_1, it can retain a part of the profits country 2 multinational firms earn abroad by operating affiliates in country 1. This is given by:

$$(1-\lambda_1)\sum_{i=1}^{n_{fj}} \Delta\pi_{ij'}^f(c) = (1-\lambda_1)\, n_{fj'} \pi_{ij'}^f(\bar{c}) = (1-\lambda_1)\left[pr_{f2} n_2 \beta L_1 \left(1 - \frac{\bar{c}_{2f}}{p_1}\right)^2\right]$$

Country 1 is welfare neutral, when the retained multinational profits and the pro-competitive effect are large enough to offset the total loss of profit revenues by the domestic firms. This implies:

$$\sum_{i=1}^{n_j} \Delta\pi_{ij}^d(c) = (1-\lambda_1)\sum_{i=1}^{n_{fj'}} \Delta\pi_{ij'}^f(c) + k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right) L_1$$

By rearranging and substitution:

$$\begin{aligned}
(1-\lambda_1) &= \frac{n_j \Delta\pi_j^d(\bar{c}) - k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right) L_1}{n_{fj'} \pi_{ij'}^f(\bar{c})} \\
&= \frac{n_1 \beta \left(\left(1 - \frac{\bar{c}_{1a}}{p_{1a}}\right)^2 - \left(1 - \frac{\bar{c}_1}{p_1}\right)^2\right) - k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right)}{pr_{f2} n_2 \beta \left(1 - \frac{\bar{c}_{2f}}{p_1}\right)^2}
\end{aligned}$$

B4b) Proof of Proposition 8:

Now suppose country 2's central planner also permits FDI and it is regulated by a given policy regime λ_2^*. In this case, country 1's multinational firms also earn profit rents abroad by operating affiliates in country 2. Country 1 would now be welfare neutral when:

$$\sum_{i=1}^{n_j} \Delta\pi_{ij}^d(c) = (1-\lambda_1)\sum_{i=1}^{n_{fj}} \Delta\pi_{ij'}^f(c) + k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right)L_1 + \overline{\lambda_2}\sum_{i=1}^{n_{ij}} \Delta\pi_{ij}^f(c)$$

By rearranging and substitution (in the same way as proof for Proposition 7 above) we get:

$$1-\lambda_1 = \frac{n_1\Delta\pi_1^d(\overline{c}) - k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right)L_1 - \overline{\lambda_2}pr_{f1}n_1\pi_1^f(\overline{c})}{pr_{f2}n_2\pi_2^f(\overline{c})}$$

B4c) For Case 3b (Section 3.6.2): The best the two countries can do together is to share the total multinational profits through suitable FDI policies in such a way that gap between the business stealing and pro-competitive effects of inward FDI is fully covered within each country. This implies for country 1:

$$k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right)L_1 - n_1\Delta\pi_1^d(\overline{c}) + \lambda_2.pr_{f1}n_1\pi_1^f(\overline{c}) + (1-\lambda_1)pr_{f2}n_2\pi_2^f(\overline{c}) = 0$$

and for country 2:

$$k\left(p_2^{-\beta} - p_{2a}^{-\beta}\right)L_2 - n_2\Delta\pi_2^d(\overline{c}) + \lambda_1.pr_{f2}n_2\pi_2(\overline{c}) + (1-\lambda_2)pr_{f1}n_1\pi_1^f(\overline{c}) = 0$$

Rearranging the first of these equations yields the following reaction function for country 1:

$$\lambda_1^*(\lambda_2) = \frac{pr_{f2}n_2\pi_2^f(\overline{c}) + k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right)L_1 - n_1\Delta\pi_1^d(\overline{c})}{pr_{f2}n_2\pi_2^f(\overline{c})} + \frac{pr_{f1}n_1\pi_1^f(\overline{c})}{pr_{f2}n_2\pi_2^f(\overline{c})}\lambda_2$$

and rearranging the second equation yields a similar reaction function for country 2:

$$\lambda_2^*(\lambda_1) = \frac{pr_{f1}n_1\pi_1^f(\overline{c}) + k\left(p_2^{-\beta} - p_{2a}^{-\beta}\right)L_2 - n_2\Delta\pi_2^d(\overline{c})}{pr_{f1}n_1\pi_1^f(\overline{c})} + \frac{pr_{f2}n_2\pi_2^f(\overline{c})}{pr_{f1}n_1\pi_1^f(\overline{c})}\lambda_1$$

The two reaction functions are positively sloping in (λ_1, λ_2) space. They have equal slopes given by:

$$\frac{\Delta\lambda_2}{\Delta\lambda_1} = \frac{pr_{f2}n_2\pi_2^f(\bar{c})}{pr_{f1}n_1\pi_1^f(\bar{c})}$$

Now, the hypothesis is that the two country's reaction functions overlap.

The welfare equations for the two countries be rearranged as follows:

$$k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right)L_1 - n_1\Delta\pi_1^d(\bar{c}) + pr_{f2}n_2\pi_2^f(\bar{c}) = pr_{f2}n_2\pi_2^f(\bar{c})\lambda_1 - pr_{f1}n_1\pi_1^f(\bar{c})\lambda_2$$

$$-[k\left(p_2^{-\beta} - p_{2a}^{-\beta}\right)L_2 - n_2\Delta\pi_2^d(\bar{c}) + pr_{f1}n_1\pi_1^f(\bar{c})] = pr_{f2}n_2\pi_2^f(\bar{c})\lambda_1 - pr_{f1}n_1\pi_1^f(\bar{c})\lambda_2$$

The right hand side of the two equations are equal.

If the two equations were to overlap in (λ_1, λ_2) space, their left hand sides should be equal as well, that is:

$$\begin{aligned} & k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right)L_1 - n_1\Delta\pi_1^d(\bar{c}) + pr_{f2}n_2\pi_2^f(\bar{c}) \\ = & -[k\left(p_2^{-\beta} - p_{2a}^{-\beta}\right)L_2 - n_2\Delta\pi_2^d(\bar{c}) + pr_{f1}n_1\pi_1^f(\bar{c})] \end{aligned}$$

which is equal to

$$\begin{aligned} & \left[n_1\Delta\pi_1^d(\bar{c}) + n_2\Delta\pi_2^d(\bar{c})\right] - \left[k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right)L_1 + k\left(p_2^{-\beta} - p_{2a}^{-\beta}\right)L_2\right] \\ = & \ pr_{f1}n_1\pi_1^f(\bar{c}) + pr_{f2}n_2\pi_2^f(\bar{c}) \end{aligned}$$

But this is actually true, since all it is saying is that gap between pro-competitive and business stealing effects of inward FDI for both countries together must be fully covered by total multinational profits, which is the starting assumption behind Case 3b. Hence, our hypothesis that the two functions overlap in (λ_1, λ_2) space is true, because the reaction functions are simply the rearranged welfare equations for the two countries given above.

The implication is that we do not have a unique Nash equilibrium, but infinitely many solutions which constitute multiple Nash equilibria that are Pareto equivalent. This is shown in the graph below:

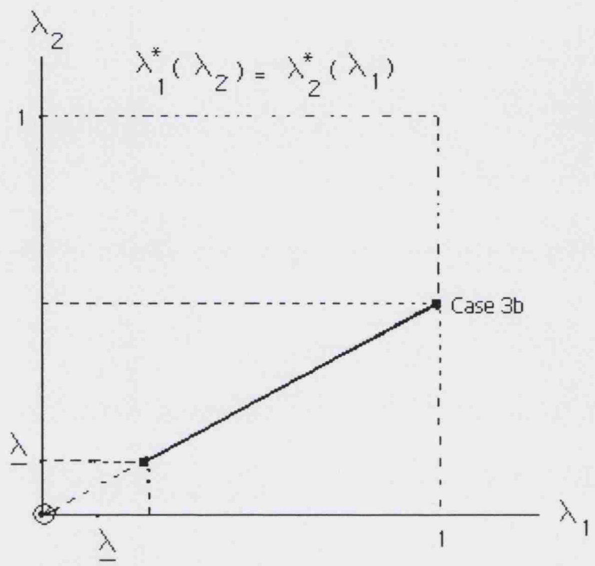

Figure 3.2: Graphs for the two reaction functions $\lambda_1^*(\lambda_2) = \lambda_2^*(\lambda_1)$: Case 3b

A similar exercise can now be repeated for the Case 3c. Let the welfare surplus generated by total multinational profits be denoted by Ω.

$$\begin{aligned}\Omega &= \left[k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right)L_1 + k\left(p_2^{-\beta} - p_{2a}^{-\beta}\right)L_2\right] - \\ &\quad \left[n_1\Delta\pi_1^d(\bar{c}) + n_2\Delta\pi_2^d(\bar{c})\right] + pr_{f1}n_1\pi_1^f(\bar{c}) + pr_{f2}n_2\pi_2^f(\bar{c})\end{aligned}$$

With equal bargaining power, this surplus is equally divided between the two countries.

The welfare equations for the two countries now are:

$$k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right)L_1 - n_1\Delta\pi_1^d(\bar{c}) + \lambda_2 pr_{f1}n_1\pi_1^f(\bar{c}) + (1-\lambda_1)pr_{f2}n_2\pi_2^f(\bar{c}) = \Omega/2$$

and

$$k\left(p_2^{-\beta} - p_{2a}^{-\beta}\right)L_2 - n_2\Delta\pi_2^d(\bar{c}) + \lambda_1 pr_{f2}n_2\pi_2^f(\bar{c}) + (1-\lambda_2)pr_{f1}n_1\pi_1^f(\bar{c}) = \Omega/2$$

Rearranging these yields the two reaction functions:

$$\lambda_1^*(\lambda_2) = \frac{pr_{f2}n_2\pi_2^f(\bar{c}) + k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right)L_1 - n_1\Delta\pi_1^d(\bar{c}) - \Omega/2}{pr_{f2}n_2\pi_2^f(\bar{c})} + \frac{pr_{f1}n_1\pi_1^f(\bar{c})}{pr_{f2}n_2\pi_2^f(\bar{c})}\lambda_2$$

and

$$\lambda_2^*(\lambda_1) = \frac{pr_{f1}n_1\pi_1^f(\bar{c}) + k\left(p_2^{-\beta} - p_{2a}^{-\beta}\right)L_2 - n_2\Delta\pi_2^d(\bar{c}) - \Omega/2}{pr_{f1}n_1\pi_1^f(\bar{c})} + \frac{pr_{f2}n_2\pi_2^f(\bar{c})}{pr_{f1}n_1\pi_1^f(\bar{c})}\lambda_1$$

Again the two equations are positively sloping in (λ_1, λ_2) space and have equal slopes given by:

$$\frac{\Delta\lambda_2}{\Delta\lambda_1} = \frac{pr_{f2}n_2\pi_2^f(\bar{c})}{pr_{f1}n_1\pi_1^f(\bar{c})}$$

Moreover, it can be shown in the same way as in Case 3b, that they overlap each other.

Again the hypothesis is that the two country's reaction functions overlap.

The welfare equations for the two countries can be rearranged as follows:

$$k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right)L_1 - n_1\Delta\pi_1^d(\bar{c}) + pr_{f2}n_2\pi_2^f(\bar{c}) - \Omega/2 = pr_{f2}n_2\pi_2^f(\bar{c})\lambda_1 - pr_{f1}n_1\pi_1^f(\bar{c})\lambda_2$$

$$-[k\left(p_2^{-\beta} - p_{2a}^{-\beta}\right)L_2 - n_2\Delta\pi_2^d(\bar{c}) + pr_{f1}n_1\pi_1^f(\bar{c}) - \Omega/2] = pr_{f2}n_2\pi_2^f(\bar{c})\lambda_1 - pr_{f1}n_1\pi_1^f(\bar{c})\lambda_2$$

The right hand side of the two equations are equal.

If the two equations were to overlap in (λ_1, λ_2) space their left hand sides should be equal as well, that is:

$$\begin{aligned} & k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right)L_1 - n_1\Delta\pi_1^d(\bar{c}) + pr_{f2}n_2\pi_2^f(\bar{c}) - \Omega/2 \\ = & -[k\left(p_2^{-\beta} - p_{2a}^{-\beta}\right)L_2 - n_2\Delta\pi_2^d(\bar{c}) + pr_{f1}n_1\pi_1^f(\bar{c}) - \Omega/2] \end{aligned}$$

which is equal to

$$\begin{aligned} & \left[n_1\Delta\pi_1^d(\bar{c}) + n_2\Delta\pi_2^d(\bar{c})\right] - \left[k\left(p_1^{-\beta} - p_{1a}^{-\beta}\right)L_1 + k\left(p_2^{-\beta} - p_{2a}^{-\beta}\right)L_2\right] + \Omega \\ = & \; pr_{f1}n_1\pi_1^f(\bar{c}) + pr_{f2}n_2\pi_2^f(\bar{c}) \end{aligned}$$

But this is true, since all it is saying is that total multinational profits generate a welfare surplus Ω after taking care of the potentially welfare decreasing effect of inward FDI represented by the excess of business stealing effect over the pro-competitive effect, which is the starting assumption behind Case 3c. Hence, our hypothesis that the two functions overlap in (λ_1, λ_2) space is true as reaction functions are simply the rearranged welfare equations for the two countries given above. Again, this implies, we do not have a unique Nash equilibrium, but infinitely many solutions constituting the multiple Nash equilibria that are Pareto equivalent.

Graphs for the reaction functions in Case 3c is shown in Figure 3.3 below. Compare with the Figure 3.2 above. Notice that reaction functions in both Case 3b and Case 3c have the same slope, but different intercepts. Reaction functions in Case 3b pass through the origin, meaning thereby that autarky is also a Nash Equilibrium in Case 3b (but not in Case 3c).

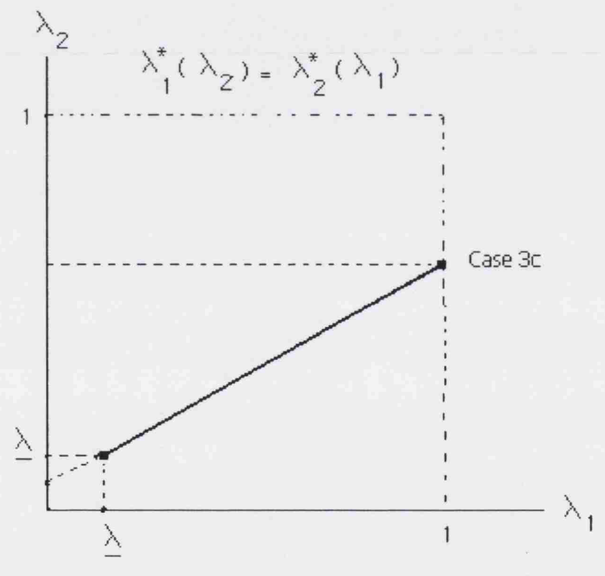

Figure 3.3: Graphs for the two reaction functions $\lambda_1^*(\lambda_2) = \lambda_2^*(\lambda_1)$: Case 3c

4 Productivity and Foreign Investment Policy : Evidence from Indian Liberalisation

4.1 Introduction

National governments implement a variety of FDI policies with the purported aim of gaining from foreign investment like technology spillovers, capital formation, employment generation, creation of incentives for investment in basic infrastructure, for investment in skilled/higher education etc. With capital becoming more freely mobile across borders, one of the principal attractions of foreign direct investment remains inflow of advanced technology and/or efficient management practices from foreign to domestic firms. At the same time, entering foreign firms compete out domestic firms by causing exit of least productive firms and by stealing market shares from the erstwhile operating firms. Which of these effects will dominate has implications for the framing of FDI policies in the host economy. No wonder, FDI liberalisation has been at least as heatedly debated as trade liberalisation amongst policy makers the world over.

Empirical evidence on whether FDI liberalisation increases firm level efficiency is mixed. Multinational firms may, in principle, have both positive and negative effects on local firms, where likelihood of a positive effect depends on the size of technology gap and the extent of vertical linkage between the foreign and the domestic firms (Navaretti and Venables, 2004). Aitken and Harrison (1999) studied productivity effects of inward FDI on a sample of Venezuelan manufacturing plants from 1976-1989. They found a positive relationship between increased foreign equity participation and plant level performance, but domestic firms in sectors with high FDI actually recorded lower productivity levels. If they drop inputs as independent variables, the industry level FDI reduces the output of domestic firms and they conclude, this is the channel through which the negative effect of FDI on measured productivity of domestic firms operates. Javorcik (2004) investigated the same hypothesis on a sample of manufacturing plants in Lithuania from 1996-2000 and found that positive spillovers from FDI were more likely to be vertical rather than horizontal in nature. This is because, for horizontally competing firms, business stealing effect of foreign investment is stronger than the technology transfer effect on measured productivity of domestic firms; whereas for domestic firms, which provide intermediate inputs to foreign affiliates, technology transfer effect predominates as increase in demand goes hand in hand with foreign affiliates privately benefiting from increased productivity of their suppliers. Contrast this with the studies of UK firms like Haskel, Pereira and Slaughter (2007) or Griffith, Redding and Simpson (2003), which find evidence of positive horizontal FDI spillovers for a sample of manufacturing plants in the UK. To summarize, technological proximity is the key determinant of MNE's spillovers to local firms and firms in developed countries are better placed to benefit from horizontal technology spillovers than similarly placed firms in developing countries.

India's 1991 liberalisation offers a unique opportunity. Ostensibly a response to balance of payment crisis, it was a tectonic policy shift, centrally managed and triggered by the IMF structural adjustment programme. So rapid and unexpected was this policy intervention and the events that unfolded after Rajiv Gandhi's assassination, that it is reasonable to assume that firms could not have acted in anticipation of these reforms.

Trade liberalisation, industrial delicensing and foreign investment liberalisation were the three main pillars of this fairly comprehensive package of structural reforms. Since these reforms were not uniform across industries and time, I will use the industry-time variation to identify effects of change in foreign investment policy on firm level performance controlling for industrial delicensing and trade reforms. This issue is of immense policy importance given the fact that having built a broad consensus for economic reform, FDI liberalisation still excites passionate and acrimonious debates in the Indian polity; and that these in recent times have gone to the extent of threatening the very survival of party in power.

Krishna and Mitra (1998) investigated the effects of trade liberalisation in India on market discipline and productivity growth. They found Indian liberalisation, as a whole, had a pro-competitive effect on manufacturing firms in four industry sectors along with a weaker effect on productivity growth. Balakrishnan, Pushpangadan and Babu (2000) and Topalova (2004) analysed productivity effects of trade liberalisation using a firm-year panel of Indian manufacturing industries. While Balakrishnan et al used a shorter post-liberalisation period (till 1997) and did not find any significant productivity effect of trade liberalisation, Topalova used a longer post-liberalisation firm panel and found a positive productivity effect for trade liberalisation. Kathuria (2000) studied productivity spillovers from foreign to domestic firms in a panel of 368 Indian firms between 1976-89 and found that spillovers from foreign to domestic firms were positive only if the domestic firms invested a significant amount in R&D activities.[20]

Now, a few words on the measures of productivity. The simplest measures of productivity are measures of labour productivity, like value added per employee, output per employee etc. But their drawback is that they are affected by the use of other factors of production (like capital and materials), which are not taken into account. A standard way of taking into account the effect of all factors of production is to estimate multi-factor productivity, also called the TFP or Total Factor Productivity. This involves estimation of a Hicks neutral productivity shift parameter. The simplest way to do this is to estimate production function in a log linear form using ordinary least squares (OLS). In recent times, as firm level panel data sets have become more widely available, better and more consistent methods have evolved, for example, the Blundell-Bond method, which uses a System GMM Estimator or the Olley-Pakes method, which allows for endogeneity of inputs (capital), selection (exit) and (quasi) permanent differences across firms. Levinsohn-Petrin is a variant of the Olley-Pakes method, which allows for the use of inputs like materials or energy to solve the endogeneity problem.[21] This makes Levinsohn-Petrin method easier to use with the balance sheet data and though computationally involved, it produces robust estimates of the production function. Many recent works like Fernandes (2003), Topalova (2004), Blalock and Gertler (2004), Alvarez and Lopez (2005) etc. have used this technique.

This paper is organized as follows. Section 2 details the foreign investment policy in India. Section 3 describes the empirical strategy along with the data sets used. Section 4 discusses the results. Section 5 concludes.

4.2 Foreign Investment Policy: the Indian Case

After Independence, India opted for a mixed economy. This basically meant a market economy, where the State and the private sector would coexist, but the State would occupy the 'commanding heights'. In the name of a 'socialistic pattern of society', this led to an extensive system of licences and regulatory controls, commonly called the 'license raj'. The philosophy of this era is outlined in the Industrial Policy Resolution of 1948, which reserved a

[20] This increases their proximity to the technology frontier.

[21] Compare this with the Olley-Pakes method, which uses investment as a proxy to solve this problem.

sphere for the private sector and a sphere for the public sector. The foreign investment philosophy of the times is summed up by the following words:

"that as a rule, the major interest in ownership and effective control should always be in the Indian hands. In all cases, however, the training of suitable Indian personnel for the purpose of eventually replacing the foreign experts will be insisted upon."

Thus began a prolonged era of import substitution, where foreign capital was looked upon with suspicion.

After India became a republic, the Industries Development and Regulation (IDRA) Act of 1951 was promulgated to give effect to this philosophy, and the Industrial policy resolution of 1956 continued the same attitude towards foreign capital.

Alongside all this, a complex legal and institutional framework was evolved under the Foreign Exchange Regulation (FERA) Act and the Monopolies and Restrictive Trade Practices (MRTP) Act to ensure a marginal and highly circumscribed role for foreign investment in the economy. FERA restricted foreign equity participation to 40 percent, ostensibly to restrict outflow of foreign exchange arising from dividend and royalty payments. The ideological bias was clearly against 'foreign' control and in favour of 'self reliance'.

The political upheavals of the mid 1970's brought the Janata Party Government to power in 1977. They promulgated the Industrial Policy Resolution of 1977. Approach to foreign capital, however, remained the same and the obsession with self reliance continued. This is evident from the following statement in this policy resolution:

"In case where foreign technological know-how is not needed, existing collaborations will not be renewed. As a rule, majority interest in ownership and effective control should be in Indian hands though the Government may make exceptions in highly export-oriented and/or sophisticated technology areas."

Within three years, the Congress Party was back in power and it brought back its own Industrial Policy Resolution. There was minor liberalisation in the Industrial Policy Resolution of 1980, whereby 100% export oriented units and a few high priority industries were exempted from 40% foreign equity restrictions and licensing procedures for MRTP companies were simplified, but the structure of regulatory controls, by and large, remained intact and the inflow of foreign investment remained minuscule.

Rajiv Gandhi came to power in 1984 with the vision of modernising India.[22] The period between 1985-90 was a period of attitudinal change. It was a period of slow liberalisation within the framework of existing laws. Although the importance of foreign capital and technology in industrial development was recognized (especially in the computer and information technology industries), the emphasis on self reliance continued. Even though no new Industrial Policy was formulated, it was clearly felt that public sector had spread into *"too many areas where it should not be"*. The driving philosophy of this period was to expand the role of the "domestic private sector". In the words of Mr Rajiv Gandhi himself:

"We will develop our public sector to do undertake jobs the private sector cannot do. But we will be opening up more to the private sector so that it can expand and the economy can grow more freely."

Regulations and controls on private enterprise under the IDRA and MRTP Acts were eased. Some industries, hitherto subject to compulsory licensing, were delicensed. As energy pent up in the private Indian enterprise was unleashed, GDP began to grow faster. But the biggest contribution this era made was to the mood of the Indian nation and to the attitude of its polity, which set the platform for major policy reforms ahead.

While it is true that late 1980's are known for mini-liberalisation, they also became known for fiscal indiscipline and a deteriorating current account. After the assassination of Mr Rajiv Gandhi, and the brief political turmoil that followed, a reformist Congress Government came to power in early 1991. Undertaken as part of an IMF structural adjustment programme, the 'Liberalisation Revolution' that followed dwarfed anything of its kind seen on the Indian landscape so far. Taking advantage of the balance of payment crisis, it first shook the external sector by undertaking major devaluation of currency, made the rupee convertible on *current* account and replaced the import control order with a foreign trade development and regulation ordinance. This was followed by sustained structural reforms, which have continued with industry-time variation till date. The three major components of these structural reforms are discussed below:

Firstly, all industries were delicensed except a small list reserved for the public sector (defence, atomic energy, railways and minerals) and a list of eighteen industries called the Schedule II industries for which compulsory

[22] He was an airline pilot who came to power after his mother's assassination!

licensing was retained under the provisions of Industries Development and Regulation Act,1951. This list of industries reserved for compulsory licensing was progressively reduced over the next decade.

Secondly, tariff barriers were significantly reduced over the 1990's. Auxiliary and additional duties were abolished and the overall trade regime was progressively simplified to bring it in conformity with the WTO framework.

Thirdly, a major shake-up of foreign investment policy was announced through a series of policy resolutions/notifications between July, 1991 and July, 1992. The most significant of these changes was to permit majority foreign ownership (i.e. 51 percent foreign equity) in 52 out of 100 four-digit manufacturing industries, even if they were not 100 percent export oriented units. This, for the first time since independence, sent powerful signals to foreign investors that no matter what changes occurred in the Indian polity, their ownership control over the foreign affiliate will not be taken away. Another particularly interesting feature of this policy was that, in the *same* industries in which majority foreign ownership was allowed, domestic firms were allowed an 'automatic approval'[23] if they wanted to enter into a foreign technology agreement or collaboration abroad. This meant that Indian firms wanting to upgrade their technology and enter into a foreign technology collaboration simply had to submit an application to the Secretariat of Industrial Approvals, Department of Industrial Policy & Promotion and the *only* scrutiny the Government would do is to see that their manufacturing item belongs to the list of liberalised foreign investment industries. If yes, a copy of the approval would be sent to the Reserve Bank of India and this will ensure they get the promised foreign exchange on priority basis.[24] It was not mere coincidence, but part of a conscious strategy, that these two elements of the foreign investment regime were implemented together, by the *same* sub-department of the Government and through the *same* policy resolutions/notifications. And because these two elements of the foreign in-

[23]Automatic approval of foreign technology agreement/collaboration (FTA) should not be confused with 'automatic route' for both foreign direct investment (FDI) and foreign technology approval (FTA). The automatic route meant that subject to certain limitations, applications for FDI and FTA could be submitted directly to the Reserve Bank of India (India's Central Bank) rather than to the Foreign Investment Promotion Board (an inter-ministerial group within the Government).

[24]In the Indian setup, where Government never introduced capital account convertibility and retained tight capital controls, this was a strong inducement to domestic firms to update their technology and modernize as their respective industry sectors were opened to foreign investment and competition.

vestment policy were so closely related, unless otherwise stated, FDI policy variable here will be used in the generic sense, that is, it will include both foreign direct investment and foreign technology agreement. I will, later in the paper, take the case of motorcar industry and try to distinguish between these two using an alternate strategy.

To summarize, from the erstwhile position of a supreme regulator the Government of India became a facilitator of foreign direct investment as well as the adoption of foreign technology by domestic firms. Out of a total of 26,531 approvals granted by Department of Industrial Policy and Promotion, Ministry of Commerce and Industry, Government of India between Aug,1991 and January, 2005 18,867 were 'foreign direct investment' approvals for foreign firms and 7,664 were 'foreign technology approvals' for domestically operating firms. Moreover, industries which attracted high foreign direct investment were also the industries in which foreign technology approvals for domestically operating firms was high.

Till very recently, Indian policy makers have resisted the temptation of offering outright subsidies to foreign investors (popularly called 'incentive competition') as has been in vogue in South-East and East Asia. The Indian psyche, in this regard, has been to support domestic industry, while at the same time open up these industry sectors to foreign direct investment. The aim of this paper is to investigate, what effect, if any, this policy had on the productivity of manufacturing firms.

4.3 Data, Methodology and Estimation Strategy

The firm level database was obtained from the Centre for Monitoring Indian Economy (henceforth CMIE). It is called 'Prowess' and contains information compiled from the balance sheet and income-expenditure statements of nearly 10,000 large and medium-sized Indian firms.[25] This includes firms listed on the Indian stock exchange as well as others submitting their financial reports to the Registrar for Companies in India.

The number of manufacturing firms represented in this database is about 4900. Distribution of these firms by year and ownership is summarized in Table 4.1. The database starts with 1090 manufacturing firms in 1989, steadily

[25] These firms account for 75 percent of corporate taxes and over 90 percent of excise duties collected in India.

increasing up to 3302 in 1995 and then fluctuating around the same level till 2004. The exit rates are low (one to five percent per year), possibly because of the rigidity of bankruptcy laws in India (see Topalova, 2004). The time line for this study is 1989 to 2004 and the aim is to analyse the productivity effects of foreign investment liberalisation over and above the effects of industrial delicensing and trade reforms.

Firms were classified by their economic activity into 4-digit industries as per the 1998 version of the National Industries Classification for India (henceforth called NIC-98). The nominal variables were deflated and capital revalued at replacement costs using the perpetual inventory method as described in Appendix C2.

Industrial delicensing details were compiled from the notifications issued by Department of Industrial Policy and Promotion, Ministry of Commerce and Industry, Government of India. Industrial delicensing dummy equals one if the industry is delicensed (from the year of delicensing onwards), and 0 otherwise. Delicensing variable thus varies across time and industries.

Import tariff barriers were compiled from the Custom Tariff Manuals, Government of India. Many earlier studies have used only the basic tariff. Since it underestimates the height of tariff barriers, I use basic, additional and countervailing duties in accordance with the formula described in Appendix C3.[26] I developed an improved electronic version of the mapping between harmonised system (hs) of product classification and National Industries Classification (NIC) for India, the earlier attempt being made by Debroy and Santhanam (1993).

Foreign Investment Policy was laid out by a series of statutory resolutions, official notifications/press notes issued by Department of Industrial Policy and Promotion, Ministry of Commerce and Industry, Government of India from time to time. Foreign Investment Liberalisation was an important element of structural reforms in the year between 1991 and 1992. The policy resolution issued at that time stated as follows:

"*in view of the advancement in India's industrial economy, the relationship between domestic and foreign industry needs to be much more dynamic than it has been in the past, in terms of both technology and investment.*"

Thus, while admitting that foreign investment policy has been restrictive in the past, the FDI liberalisation was effected as follows:

"*In order to invite foreign investment in high priority industries, requir-*

[26]The same formulation was used by Aghion, Burgess, Redding and Zilibotti (2006).

ing large investments and advanced technology, it has been decided to provide approval for direct foreign investment up to 51 percent foreign equity in such industries. There shall be no bottlenecks of any kind in this process. This group of industries has generally been known as the Appendix-1 Industries and are areas in which FERA companies are also allowed to invest on discretionary basis."

And *simultaneously* to encourage adoption of foreign technology by domestic firms it was decided that:

"With a view to injecting the desired level of technological dynamism in the industry Government will provide automatic approval for technology agreements related to high priority industries within specified parameters."

As stated in this policy resolution, technology and investment were seen as two essential components of the foreign investment liberalisation. Which industries were to be subject to this treatment was determined by the perception of policy makers regarding requirements of large investments and advanced technology. These changes were brought about so quickly that the administrative department in Government of India did not even have the time undertake a formal study or constitute a High Level Committee to delve into relevant issues as a precursor to these decision.[27] This permitted little time for lobbying, which may be a virtue as far as this analysis in concerned. Subsequent reform, by and large, increased the permitted level of foreign equity or further simplified investment procedures, while extending the foreign investment liberalisation to service sector industries.

Although 51 percent foreign equity was prominently mentioned in this policy resolution, the liberalisation had as much to do with procedural reforms and relaxation of foreign exchange controls as with foreign equity, and that foreign technology agreements (FTA) and foreign direct investment (FDI) were its integral parts. Thus, here, the FDI policy is denoted by a generic foreign investment policy variable, which is 1 if the manufacturing industry was subject to foreign investment liberalisation (from the year of liberalisation onwards), and 0 otherwise.

I also explored alternative measures of FDI. Amount of FDI inflow suffers from the drawback that it is not related to management ownership, and can

[27]The standard practice in Government of India has been to constitute a High Level Committee, whenever a major policy reform is contemplated. Such a committee then studies the issue in details and submits its recommendations before the major policy reform is implemented. In this case, the speed of the reform and exigencies of the time precluded policy makers from undertaking such an exercise.

also be misleading because, what proportion of capital should a firm mobilise across the border is an endogenous decision of the firm (Lipsey et al). Ratio of foreign to total number of operating firms or foreign to local sales cannot be used, because the Prowess database includes only large and medium firms, not the smaller firms operating in that industry.

As already mentioned, I include in this study, the three main pillars of structural policy reforms implemented in India during the 1990's. Following existing literature (Topalova, 2004 and others) all policy variables are effected in the year following the one in which the respective announcement is made.

The analysis is done in two stages. In the first stage, Total Factor Productivity (TFP) if computed using two alternative methods. Then in the second stage, measured productivity is related to changes in sectoral policy.

TFP is first estimated by ordinary least squares (OLS) as the Hicks neutral productivity parameter of a log linearized Cobb-Douglas production function of the form:

$$Y = AK^{\beta_1}M^{\beta_2}L^{\beta_3}E^{\beta_4} \tag{138}$$

where Y represents total output as a function of the total factor productivity (A), capital input (K), labour input (L), material input (M), energy input (E) and the respective input shares β_1, β_2, β_3 and β_4. All variables are real and capital is expressed in terms of its replacement cost. TFP is the difference between the actual and predicted output.

Since estimates obtained by ordinary least squares can be biased by correlation between choice of firm inputs and unobserved firm level productivity shocks, I further obtain consistent estimates of TFP using a semi-parametric estimation technique developed by Levinsohn and Petrin (2003). This method uses intermediate inputs as a proxy to correct for simultaneity in firms' production function.[28] The first step in this method uses the following estimation equation:

$$y^j_{it} = \beta_1 k^j_{it} + \beta_2 m^j_{it} + \beta_3 l^j_{it} + \beta_4 e^j_{it} + \omega^j_{it} + \epsilon^j_{it} \tag{139}$$

where y denotes log output, k denotes log capital, l denotes log labour, m denotes log material, e denotes log energy (power & fuel) for a firm i in industry j over time t, ω_{it} is the firm specific time varying productivity shock that is potentially observed by firms before making their input decisions at

[28] Olley-Pakes uses investment. This is not always readily available. Moreover, the firms may not invest every time period as the investment tends to be 'lumpy'.

time t (i.e. correlated with firm's choice of inputs) and ϵ_{it} is the productivity shock that is not observed or predictable by firms before making their input decisions at time t (i.e. uncorrelated with firm's choice of inputs). Details of this multi-step estimation procedure are given in Appendix C1.

Since production function is estimated for firms in each industry separately, to make the estimated multi-factor productivity comparable across industries a productivity index is calculated. This is the logarithmic deviation of firm's productivity from the median productivity for that industry in the base year (taken here as 1991, the year in which liberalisation process was initiated).

The next stage in this analysis is to relate foreign investment policy to productivity using productivity estimates from stage one. As already explained, foreign investment liberalisation in India came as a package amongst a host of structural reforms under the liberalisation 'revolution' of the 1990's. To isolate the effect of foreign investment policy on productivity, I explicitly control for industrial delicensing and tariff reforms along with relevant firm characteristics like age, age-squared, ownership, firm size etc. The baseline econometric specification is as follows:

$$pr_{it}^{j} = \alpha + \beta for_{t}^{j} + \gamma X + \tau_t + f_i + \nu_{it}^{j} \tag{140}$$

Here, pr is the productivity index for firm i in industry j at time t and for is the foreign investment policy variable as explained above. X is the matrix of control variables containing age of the firm, squared age of the firm, ownership characteristics (dummy), firm size category (dummy), industrial delicensing (dummy) and import tariffs (continuous variable). τ_t is the year dummy and f_i are the firm's fixed effects. It is an unbalanced panel for year (time) and firm (id). To decide whether fixed or random effects model is more appropriate in this framework, I conduct the Hausman Specification Tests, results for which are explained in the section below.

4.4 Results and Discussion

4.4.1 Productivity Index

The productivity index is not the absolute value of multi-factor productivity, but logarithmic deviation from the median productivity for that industry in the base year (1991). The purpose of productivity index has already been explained. When average productivity index, computed for all manufacturing industries as a whole, is plotted against time (years), the graphs are as contained in Figure 4.2 and 4.3. These plots of productivity, although obtained through different techniques (ordinary least squares and Levinsohn-Petrin), are remarkably similar in appearance.

These graphs indicate two waves of increase in productivity. In April,1991 general elections were held and a reformist Congress government came to power. As already mentioned, it unleashed on India's economic horizon the most comprehensive structural reforms ever. This government remained in power till 1996, and as evident from the graphs, manufacturing firms' performance improved steadily. Mid-1996 to Mid-1999 was the period of political instability, with shaky coalition governments in Delhi and as many as three mid-term elections were held. In this period, the reform process slowed down, and we find from the graphs, the manufacturing firms' performance more or less fluctuated around the same level. After general elections in1999, again a pro-reformist and stable BJP Government came to power in Delhi.[29] It continued in office till 2004 providing an investor friendly environment and surely, we see the effect in the graphs in the form of improving performance of manufacturing firms till 2004. Thus, it is important that if we want to investigate the impact of foreign investment policy on measured productivity of manufacturing firms, we must control for the time-specific macro shocks as I will do in this case.

In Table 4.2, I compare the production function estimates obtained from Ordinary Least Squares (ols) with those obtained using the Levinsohn-Petrin (levpet) technique. The coefficients are estimated at the level of 4-digit industries. The coefficients for labour and materials are more or less similar with mean values of 0.24 and 0.60 respectively and a similar pattern across industries. The OLS estimated coefficients for capital (mean value 0.08) are smaller than similar estimates obtained using the Levinsohn-Petrin technique (0.15) and the two sets of estimates show less correlation across industries. Largely because of the differences in estimation of capital coefficients, returns to scale estimates from OLS (mean value 1.001) are smaller than those obtained using the Levinsohn-Petrin technique (mean value 1.211). This difference is the effect of correction for simultaneity in firm's production function.

[29]Indian National Congress (INC) and Bhartiya Janata Party (BJP) are the two main political parties in India.

4.4.2 FDI Policy and Productivity

The productivity index is regressed on foreign investment policy variable controlling for industrial delicensing, tariff liberalisation and firm characteristics namely age, age-squared, ownership (private domestic, private foreign, public enterprises, joint and cooperative sectors), firm size (three categories by 50th and 90th percentile of real sales); time dummies (to control for time variant macro-shocks) and firm fixed effects (to control for time invariant firm specific heterogeneity) using the baseline specification in equation 140 above. The time span for this data is 1989-2004. I first do the Hausman Specification Tests (see Table 4.3), which reject the random effects model in favour of the fixed effects model. Hence, only the results of fixed effects model are reported here in Table 4.4. Ownership and firm size category dummies are dropped in the fixed effects model.

Columns (1) and (2) are the regressions where productivity is estimated using the preferred Levinsohn-Petrin technique. For comparison, I run similar regressions in columns (3) and (4) for productivity estimates obtained by the ordinary least squares.

Since micro-data is combined with policy variables at the aggregate (industry) level, greater care is needed with the treatment of the variance-covariance matrix (Moulton, 1990). To ensure that standard error estimates for coefficients of policy variables are reliable, I cluster them at the level of 4-digit (nic98 classification) industries and correct them for heteroskedasticity. As a robustness check, I also report an alternative set of bootstrapped standard errors.

Coefficients for the foreign investment policy variable are positive and significant implying that liberalised foreign investment sectors have experienced a significantly greater increase (an additional 7 percent) in measured productivity compared to the non-liberalised foreign investment sectors. Results for the Levinsohn-Petrin method are stronger than those for ordinary least squares.

Coefficients for Industrial delicensing and tariff barriers are not significantly different from zero indicating that they have been per se productivity neutral over this period.

A large part of industrial delicensing in India was undertaken in the mid 1980's (i.e. before the database starts in year 1989). The productivity effect of remaining industrial delicensing (at the firm level) does not seem to be significant in this database.

Also compare with the existing literature on trade liberalisation and productivity. The results in literature have been varied over this issue; for example, while Topalova (2004) found a negative and significant coefficient on tariff barriers indicating a positive productivity growth effect, Balakrishnan et al (2000) found trade liberalisation has no significant effect on total factor productivity of Indian manufacturing firms.

The explanation for this is straightforward. It is established in theory that changes in measured productivity are a sum of changes in mark-ups and pure technological progress (spillovers). The structural economic reforms undertaken in India in the early 1990's included industrial delicensing, trade reforms and foreign investment liberalisation as its three main pillars. While foreign direct investment (FDI) and foreign technology agreements (FTA) are directly related to technology, industrial delicensing and tariff barriers are per se not. Moreover, in the Indian case, foreign direct investment and foreign technology agreements go hand in hand. Here, when all major elements of the structural reform process are included in the specification, foreign investment liberalisation shows a significantly positive productivity growth effect, industrial delicensing and tariff liberalisation remain productivity neutral. While, no doubt the overall effect of Indian liberalisation on measured productivity is positive, earlier researchers while trying to tease out the effect of tariff liberalisation from the overall impact of economic liberalisation, did not account for all (major) elements of structural reform, thereby committing an omitted variable bias.

To further ensure reliability of these results, I run a simple correlation experiment between the three policy variables. I find that correlations between them are weak (correlation coefficient is 0.279 between foreign investment and industrial delicensing variable; -0.438 between tariff barriers and foreign investment policy variable; and -0.326 between tariff barriers and industrial delicensing variable). Thus, we can be reasonably confident of policy variables being separately identified in this model.

Age shows a typical non-linear relationship with productivity. The squared age corrects for it and demonstrates a small, but significantly positive productivity growth effect.

4.4.3 Endogeneity of Policy Reforms

The Indian liberalisation of the 1990's was a centrally executed technocratic reform triggered by largely unexpected shocks, namely, the sudden rise to power of the Narasimha Rao-Manmohan Singh combine, the macro-economic crisis facing the country at that time and the adoption of the IMF structural adjustment programme. At least the 1991-92 wave of liberalisation, which constituted the bulk of structural reform, was too rapid to afford any reasonable opportunity for lobby formation. Therefore, the concern that firms may have acted in anticipation of these reforms or lobbied to influence the pattern of reforms seems to be of limited importance.

A potentially more serious issue is the possible selection of industries for liberalisation of foreign investment and industrial licensing. This concern would be adequately addressed, if it were possible to identify valid instruments, namely, variables that are correlated with policy reforms, but not directly with firms' measured productivity. Since this did not appear feasible, I conducted a few experiments a la Aghion, Burgess, Redding and Zilibotti (2006), which suggest that endogeneity is at least not a first order issue (see Table 4.5).

In particular, I ran cross-section regressions (column 1 and 2) of the year in which an industry is liberalised for foreign investment or delicensed under the Industrial Development and Regulation Act on productivity growth during the period 1989-91 (i.e. prior to such liberalisation). I find no evidence of any relationship between pre-reform productivity growth and when an industry is delicensed or liberalised for foreign investment. In column 3 of the table, I run a similar experiment for trade liberalisation by regressing percentage point reduction in import tariffs between 1992-2004 on productivity growth during the period 1989-91 and again find no association between pre-reform productivity growth and the size of future reductions in tariff. Thus, none of these experiments detects any evidence of systematic differences in productivity across industries that are correlated with future foreign investment, industrial licensing or trade liberalisation. Earlier researchers have held similar views about the Indian economic liberalisation of the 1990's (Topalova, 2004; Krishna and Mitra, 1998; Balakrishnan et al, 2000 among others).

As an additional robustness check, I estimate a difference-in-differences model for the productivity effect of foreign investment liberalisation. Total period (1989-2004) is divided into three parts: pre-liberalisation (1989-91), period of liberalisation reforms (1992-98) and post-liberalisation (1999-04). This is because foreign investment liberalisation and industrial delicensing for the manufacturing sector was undertaken between the period 1992 to 1998. Although number of firms in the database fluctuate from year to year (see table 4.1 for details), approximately 1300 firms in the database span the three time periods together. These firms belong not only to the industries which were subject to foreign investment lineralisation, but also to industries which were not subject to this change. The specification estimated is as follows:

$$\Delta pr^j_{it} = \beta_0 + \beta_1 \Delta for^j_t + \beta_2 \Delta del^j_t + \beta_2 \Delta tariff^j_t + \epsilon_{it} \quad (141)$$

where Δpr^j_{it} is the difference (change) in a firm's average productivity between the post-liberalisation and the pre-liberalisation periods, Δfor^j_t is the change in foreign investment policy status between the post-liberalisation and the pre-liberalisation periods, while $\Delta tariff^j_t$ is the change in average tariff barrier between the post-liberalisation and the pre-liberalisation periods. β_0 is the time related change common to all firms, while $\beta_1, \beta_2, \beta_3$ are the coefficients of the respective policy change variables mentioned above. The results are given in table 4.6. The results are similar to the fixed effects model, though quantitatively different. The foreign investment policy now has a 17 percent positive productivity growth effect on firms subject to foreign investment liberalisation, while industrial delicensing and tariff barriers do not have a significant productivity growth effect as before.

4.5 An example of Motor Vehicle Industry

Motor vehicle industry is a typical FDI intensive industry. It is also called the 'industry of industries',[30] and has been the focus of policy-makers the world over.

It has already been shown, that in the policy variable, it is not possible to distinguish between foreign direct investment (FDI) and foreign technology agreements (FTA) as they were liberalised together as part of a conscious strategy. Here, I study the case of motor vehicle industry, and using alternate strategy, try to distinguish between FDI and FTA.

Since policy changes apply uniformly to all firms within the motor industry, I use one stage estimation procedure a la Aitken and Harrison (1999). This estimation equation is:

$$y_{it} = \alpha + \beta_1 for\_eq + \beta_2 fta + \beta_3 k_{it} + \beta_4 m_{it} + \beta_5 l_{it} + \beta_6 e_{it} + \tau_t + f_i + \epsilon_{it} \quad (142)$$

[30]Motor car industry has also been the source of many path breaking revolutions like the assembly line and just-in-time techniques.

where y denotes output (sales), k denotes capital, m denotes materials, l denotes labour, e denotes power & fuel for firm i in year t. All these variables are expressed as log real values of expenditure. fta is a firm level indicator for whether a firm participates in a foreign technology agreement, which is 1 from the year onwards in which foreign technology agreement/collaboration is undertaken, and 0 otherwise. for_eq is the foreign *promoter's* equity share in a firm, which is a time varying, firm level measure of foreign investment activity. τ_t represents year dummies, which control for time variant macro shocks. f_i are the firm fixed effects, which control for time invariant heterogeneity or firm characteristics that could possibly determine, which firms undertake technology agreements/collaborations abroad. The inclusion of firm fixed effects implies that coefficients β_1 and β_2 capture the relationship between changes in productivity and changes in foreign ownership or foreign technology agreement status. All direct foreign investments in the motor vehicle industry during this period were greenfield ventures.

The promoters equity details were compiled from the stock exchange data as well as from the respective company reports. Details of foreign technology agreement were compiled from actual approval records of the Department of Industrial Policy and Promotion, Government of India. All firms in the motor vehicle industry were subject to the same foreign investment policy, same industrial licensing policy and same trade policy reforms.

Since inputs are included as regressors on the right hand side, the sign and magnitude of coefficients $\beta_1$and β_2 capture the correlation between productivity and foreign direct investment and foreign technology agreements respectively. The standard errors were clustered by firms and corrected for heteroskedasticity (see Table 4.6). FDI (foreign promoters equity) was found to be statistically significantly correlated with productivity in both the specifications. FTA (Foreign Technology Agreement) was found to be statistically significantly correlated with productivity in at least one specification.

I then re-run these regressions after including an interaction term:

$$\beta_3 \left(for\_eq * fta\right) \tag{143}$$

This interacts foreign promoters' equity with the foreign technology agreement (FTA) dummy. The coefficient of the interaction term is positive and significant, suggesting a greater increase in productivity for domestically operating foreign firms that participate in the foreign technology agreements.

It appears the policy of simultaneously liberalising foreign technology agreements and foreign direct investment is complementary as far as firms' performance and measured productivity in the motor vehicle industry is concerned.

4.6 Summary

This paper provides an analysis of the relationship between foreign investment policy and the performance of Indian manufacturing firms against the backdrop of structural reforms undertaken by Government of India during the 1990's. I use a firm-year panel from the 'Prowess' database, which is a publicly available database of large and medium sized firms in India. With the help of recently developed techniques of estimating production functions, total factor productivity is computed firm and year wise. This method, called the Levinsohn-Petrin technique, uses intermediate inputs to correct for simultaneity in firm's production function. These results are compared with estimates obtained from ordinary least squares (OLS). I find both the methods give similar estimates for labour and materials coefficients; but capital coefficients and returns to scale estimates obtained using OLS are lower than similar estimates obtained using the Levinsohn-Petrin technique.

While in the first stage of this study, multi-factor productivity was computed separately for firms within each industry; in the second stage, it was made comparable across industries by computing a productivity index and relating changes in multi-factor productivity to various elements of policy reforms undertaken by Government of India over the same period. Foreign investment liberalisation was found to have a significant and positive effect on the performance of Indian manufacturing firms, with the foreign investment liberalised industries experiencing between seven to sixteen percent larger growth in multi-factor productivity as compared to the non foreign investment liberalised industries. The productivity effect of industrial delicensing and trade liberalisation was not found to be significantly different from zero over this period.

Foreign investment policy, as practised in India during this period, included two essential components - permitting majority foreign equity in direct investments and automatic approval of foreign technology agreements. An alternative policy has been the so called 'incentive competition', whereby national governments offer liberal subsidies to potential multinational entrants for bringing in foreign direct investment into their respective countries. The latter has been widely practised in South-East and East Asia. Indian policy makers seem to have resisted this temptation, at least till very recently, and instead pursued a combined policy of opening up to foreign direct investment, while at the same time encouraging adoption of foreign technology by domestic firms. An analysis of motor vehicle industry shows both elements of the foreign investment regime are in fact complementary to each other.

Another popular comparison is often made between India and China. While it is true that China, during this period, attracted greater FDI inflows, India over the same period, attracted greater portfolio investments and the ratio of market capitalisation of listed firms to its GDP has been higher. Last year, Indian firms invested so much abroad that FDI outflow matched the FDI inflow. Indian foreign investment liberalisation is a paradigm that treats foreign technology and direct investment as inseparable from each other and such a policy is bound to have implications beyond the mere mention of FDI inflow figures. At least one important implication of this paradigm, namely, its positive effect on measured productivity and performance of manufacturing firms is elucidated by this study.

4.7 Appendix C

4.7.1 C1 : Estimating the Production Function

Levinsohn-Petrin Method:

The following is a step-wise approach to estimating production functions using intermediate inputs to control for unobservables:

Take the logarithmic expression of a Cobb-Douglas technology from section 4:

$$y_{it}^j = \beta_l k_{it}^j + \beta_m m_{it}^j + \beta_k l_{it}^j + \beta_e e_{it}^j + \omega_{it}^j + \epsilon_{it}^j$$

where the variables are as defined earlier.

Stage 1:

1. Run a regression of y_{it}^j on m_{it}^j and k_{it}^j to obtain an estimate of the function $E\left(y_{it}^j | m_{it}^j, k_{it}^j\right)$ using locally weighted least squares.

2. Run a regression of l_{it}^j on m_{it}^j and k_{it}^j to obtain an estimate of the function $E\left(l_{it}^j | m_{it}^j, k_{it}^j\right)$.

3. Run a regression of e_{it}^j on m_{it}^j and k_{it}^j to obtain an estimate of the function $E\left(e_{it}^j | m_{it}^j, k_{it}^j\right)$.

4. Construct $Y\left(e_{it}^j, k_{it}^j\right) = y_{it}^j - E\left(y_{it}^j | e_{it}^j, k_{it}^j\right)$ using the estimate of conditional expectation from regression in step 1. This will be the dependent variable for step 5.

Similarly, difference out the predicted mean for other explanatory variable to get a new set of regressors that are net of materials and capital variation, that is

$X_l\left(m_{it}^j, k_{it}^j\right)$ and $X_e\left(m_{it}^j, k_{it}^j\right)$.

5. Run a no-intercept OLS regression of constructed dependent variable Y on a vector of constructed independent variables X_l and X_e.

This completes the first stage. The key estimated parameters from this stage are the production function parameters on all variable inputs except the input proxy, that is

$\widehat{\beta_l}$ and $\widehat{\beta_e}$.

Stage 2:

1. Compute the estimate of $\phi_{it}^j\left(m_{it}^j, k_{it}^j\right)$ by using the estimated parameters from step1. Save the estimate $\widehat{\phi_{it}^j}()$

2. Choose a candidate value for $(\beta_{m,}\beta_k)$, say $(\beta^*_{m,}\beta^*_k)$. A good starting value could be the OLS estimates of Cobb-Douglas production function.

3. Compute $\widehat{\omega^j_{it} + \epsilon^j_{it}} = y^j_{it} - \beta^j_{lit} - \beta^*_m.m^j_{it} - \beta^*_k.k^j_{it} - \widehat{\beta}_e.e^j_{it}$. Call this variable "A".

4. Compute $\widehat{\omega^j_{it-1}} = \widehat{\phi^j_{it-1}} - \beta^*_m.m^j_{it} - \beta^*_k.k^j_{it}$. Call this variable "B".

5. Regress "A". on "B" again using locally weighted least squares. Call the new variable of predicted values "C" which is an estimate of $E\left[\omega^j_{it}|\omega^j_{it-1}\right]$.

6. Compute $\left(\widehat{\xi^j_{it} + \epsilon^j_{it}}\right)$ by substituting "C" $=E\left[\omega^j_{it}|\omega^j_{it-1}\right]$ from step 5 to obtain

$$\xi^j_{it}\widehat{+}\epsilon^j_{it}\left(\beta^*_{m,}\beta^*_k\right) = y^j_{it} - \beta^j_{lit} - \beta^*_m.m^j_{it} - \beta^*_k.k^j_{it} - \widehat{\beta}_e.e^j_{it} - E\left[\omega^j_{it}|\omega^j_{it-1}\right]$$

7. Finally, obtain estimates of remaining parameters of the production function, that is $\left(\widehat{\beta}_{m,}\widehat{\beta}_k\right)$ by minimizing the GMM criteria function (i.e. distance between observed moments and zero). This entails repeated iterations over the previous six steps. Default iteration is 50.

4.7.2 C2 : Estimating the Production Function (Treatment of Variables)

Prowess is a database of large and medium sized, primarily listed, Indian firms compiled by the Centre for Monitoring Indian Economy, Mumbai (Bombay) starting in the year 1989. This firm level data is compiled from the balance sheet and income-expenditure statements of firms submitted to the statutory authorities. The variables used for estimating the production function are: value of output (sales), gross fixed assets (capital), salaries and wages (labour), expenditure on materials, and power and fuel expenses.

Following Topalova (2004) the value of output (sales), and power and fuels were converted into real terms using the industry specific wholesale price indices; expenses on materials using the manufacturing wholesale price index; while salaries and wages were deflated using the wholesale price index (unskilled and semi-skilled wages in the organised sector in India are linked, by law, to the wholesale price index).

Labour inputs have been used in different ways across studies depending upon the data availability. In balance sheet data like the Prowess, the salaries and wages are reported not only more reliably, but also more regularly than the labour employment figures.[31] For studies like this one, where productivity is not used in the absolute sense, but only in a relative sense through the industry normalised productivity index, it does not make much difference to the final outcome. This is because the difference between estimating production function using salaries and wages, and estimating it using the employment figures is, that in the latter, log of wages, which is subsumed in the absolute multifactor productivity term, gets subtracted out during computation of the relative productivity measure.

The task of measuring capital employed by the firm in its production process is more difficult. The balance sheet data reports firm's capital in terms of its book value, which is based on a historical cost rather than its true replacement value. The task of converting it to its replacement value involves computing a revaluation factor as explained below:

Gross fixed assets (GFA) at historic cost is defined as

$$GFA_t^h = P_t I_t + P_{t-1} I_{t-1} + P_{t-2} I_{t-2} + \ldots\ldots$$

where P_t is price of capital, I_t denotes investment and t the time-period.

[31] Contrast this with the census type data of manufacturing firms, where employment figures are both reliable and reported regularly.

Define $g = I_t/I_{t-1}$ as the constant growth rate of investment and $\pi = P_t/P_{t-1}$ as the constant rate at which price of capital changes. Using geometric series the above expression can be simplified as

$$GFA_t^h = P_t I_t + \frac{P_t}{\pi}\frac{I_t}{g} + \frac{P_t}{\pi^2}\frac{I_t}{g^2} + \ldots\ldots = P_t I_t \frac{(1+g)(1+\pi)}{(1+g)(1+\pi)-1}$$

Gross fixed assets (GFA) at replacement cost is defined as

$$GFA_t^r = P_t I_t + P_t I_{t-1} + P_t I_{t-2} + \ldots\ldots$$

which again using geometric series can be simplified as

$$GFA_t^r = P_t I_t + P_t \frac{I_t}{g} + P_t \frac{I_t}{g^2} + \ldots\ldots = P_t I_t \frac{(1+g)}{g}$$

The revaluation factor is defined as the ratio of the value of asset at replacement cost to the value of asset at historic cost:

$$R^G = \frac{GFA_t^r}{GFA_t^h} = \frac{(1+g)(1+\pi)-1}{g(1+\pi)}$$

If we assume the capital stock has a *finite* economic life of τ years, the equivalent expression obtained from the literature (Balakrishnan et al, 2000) is:

$$R^G = \frac{\left[(1+g)^{\tau+1}-1\right](1+\pi)^{\tau}\left[(1+g)(1+\pi)-1\right]}{g\left(\left[(1+g)(1+\pi)\right]^{\tau+1}-1\right)}$$

The life of capital is taken as twenty years ($\tau = 20$), which is the benchmark life span for the machinery. Parameters g and π are obtained from a series on gross capital formation available on the Reserve Bank of India web site. This information is used to compute the revaluation factor using the above formula. Because of the parameter τ in the formula, the revaluation factor for every firm in its base year (the first year a firm appears in the database) depends on the age of the firm, which is the base year minus the year of incorporation. Once a firm's capital is revalued in its base year, subsequent year's revalued capital is obtained using the actual year by year growth rate of gross fixed assets for that firm in the data. The capital revalued at replacement cost is finally deflated using the wholesale price index for machinery and machine tools.

4.7.3 C3 : A Note on Trade Barriers

Tariff rates are compiled from the *Custom Tariff* of India Manuals published by and on behalf of the Central Board of Excise and Customs, Department of Revenue, Ministry of Finance, Government of India. Although many studies in the past have used the basic rate of custom duty, this underestimates the height of tariff barriers. I use *applied tariff* as a measure of tariff barriers. This is computed from a combination of basic, auxiliary and countervailing duties according to the formula given below:

$$\begin{aligned} Applied\ Tariff &= Basic + Auxiliary \\ &+ \frac{(100 + basic + auxiliary) * countervailing\ duty}{100} \end{aligned}$$

Data were collected for the rates of duty for the years 1988, 1992, 1997 and 2003 at the level of six digit product classification of the harmonized System (HS). I develop an improved electronic version of the mapping between HS product classification system and the National Classification of India (NIC87) by working on an article by Debroy and Santhanam in the Foreign Trade Bulletin, India, 1993. As a second step, I map NIC87 classification to the NIC98 classification using a correspondence table supplied by the Central Statistical Organisation, India. The applied tariffs are computed at the level of 4-digit NIC98 industries as an arithmetic average of applied tariffs for all the products mapped to the respective 4-digit industry. Since all policy variables are applied with a lag, applied tariffs for 1988 are applied to year 1989, applied tariffs for year 2003 to year 2004 and all tariffs in between are calculated by linear interpolation.

In 1991 India introduced a policy of treating all products not mentioned on prohibited, canalised and restricted lists as being on the open general list by default. The subsequent changes in the product items mentioned on the restricted list (about 300 hs items) have been narrower than 4-digit industry sectors. The Export-Import Policy of 1988-1991 was itself a result of some liberalisation since mid 1980's and therefore procedurally quite close to the Export-Import Policy of 1992-97. The prohibited and canalised items were the same in 1988-1991 as they were in 1992-97 or subsequently. In addition to prohibited and canalised items, materials and capital goods in the period 1988-91 were divided between restricted, limited permissible and open general lists. The difference between limited permissible and open general lists was only a difference in procedures. Even in open general list, license were subject to satisfying some conditions and in both, export oriented units were allowed to import freely subject to tariff barriers. There is no simple or even agreed way of calculating to what extent these procedures increase the height of tariff barriers. Subject to this approximation, I use applied tariffs as a measure of trade barriers over the period 1989 to 2004.

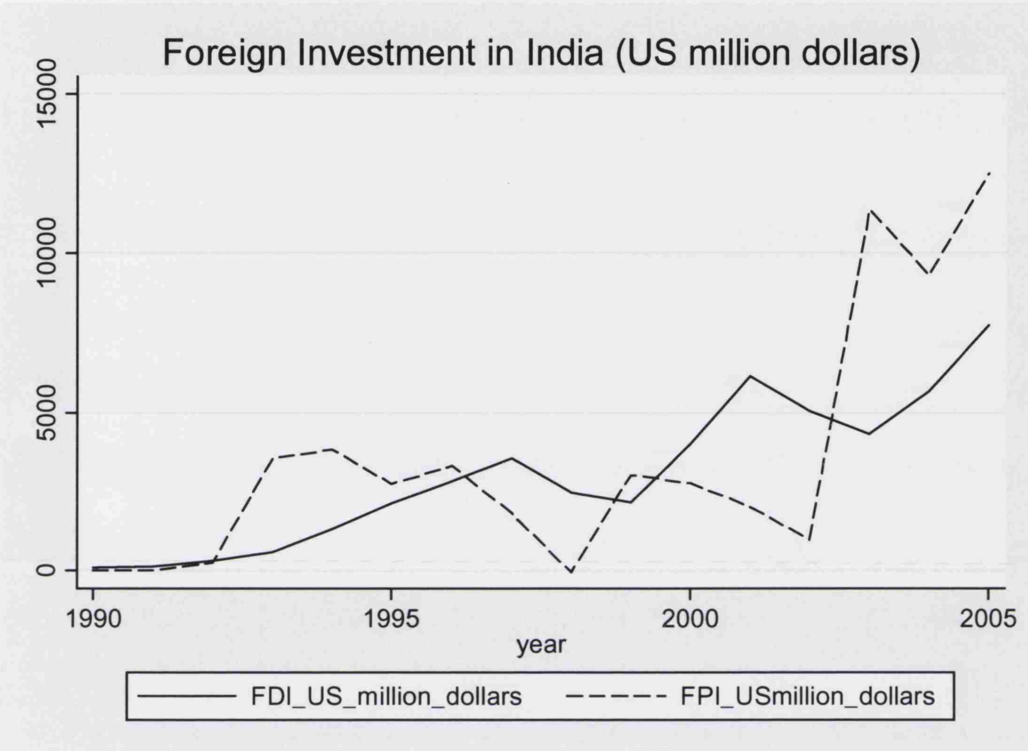

Figure 4.1: Trends in Foreign Investment In India (1990-2005)
FDI: Foreign Direct Investment
FPI: Foreign Portfolio Investment

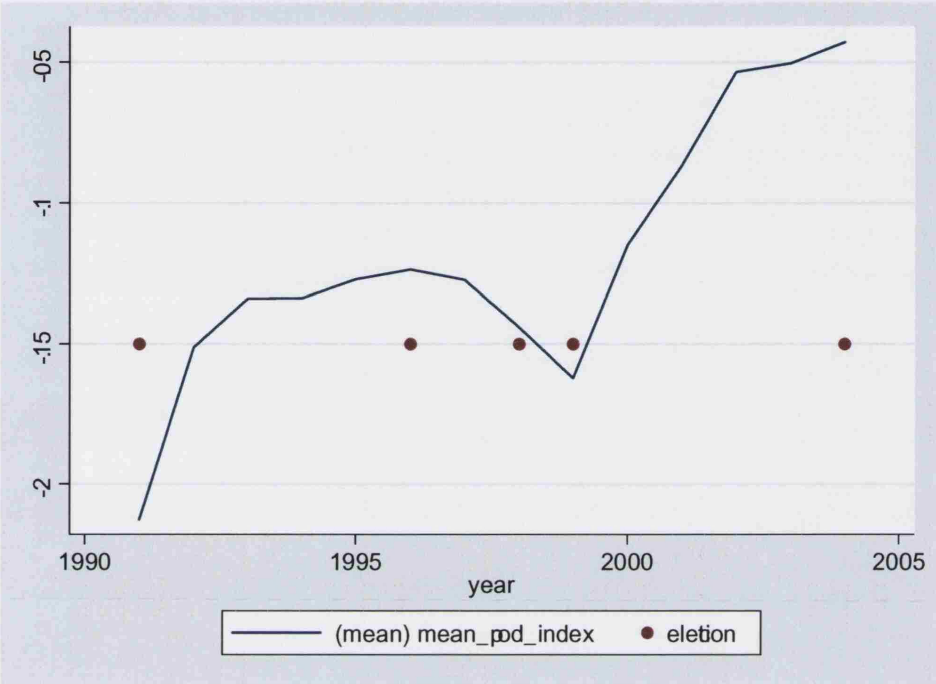

Figure 4.2: Productivity Index for Indian Manufacturing Industries related to timing of elections. TFP estimated by OLS.

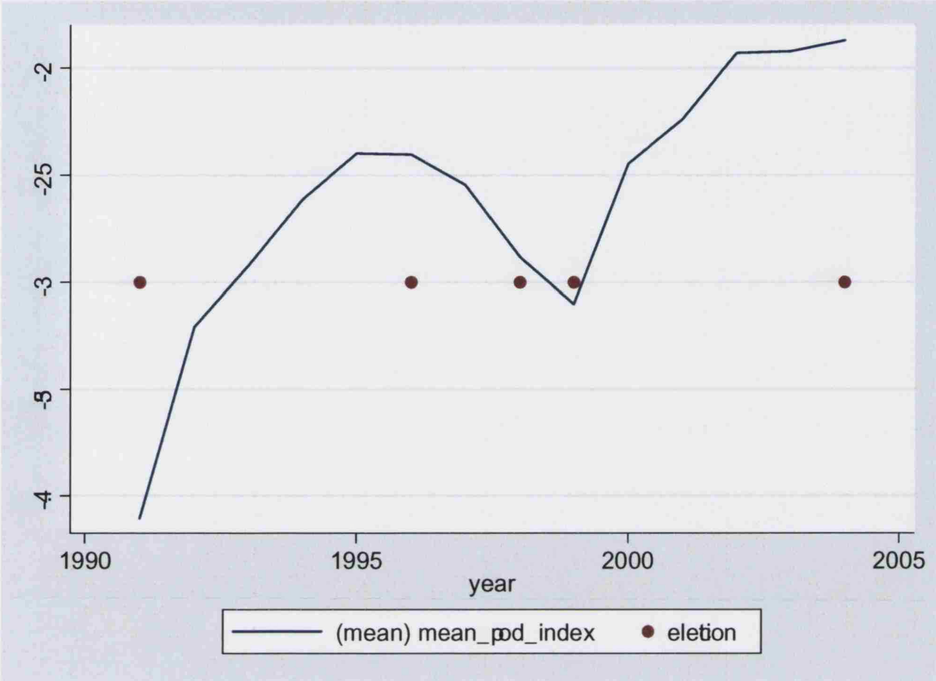

Figure 4.3: Productivity Index for Indian Manufacturing Industries related to timing of elections. TFP estimated by Levinsohn-Petrin Method.

Table 4.1: Distribution of Firms by Year and Ownership

Year	Central Govt.	State Govt.	Private (Indian)	Private (Foreign)	Co-operative	Joint Sector	Total
1989	70	12	873	124	2	9	1,090
1990	72	14	972	135	2	8	1,203
1991	73	14	957	104	2	8	1,158
1992	82	13	1,509	189	2	10	1,805
1993	83	15	1,845	203	2	12	2,160
1994	86	18	2,428	215	2	16	2,765
1995	87	22	2,943	231	2	17	3,302
1996	87	26	3,067	233	2	16	3,431
1997	87	23	3,026	241	2	18	3,397
1998	86	16	3,027	247	2	19	3,397
1999	79	25	3,210	256	2	18	3,590
2000	80	28	3,342	273	2	18	3,743
2001	79	31	3,284	261	2	17	3,674
2002	81	28	3,349	253	2	17	3,730
2003	90	40	3,424	244	2	16	3,816
2004	90	40	3,226	235	2	15	3,608
Total	1,312	365	40,482	3,444	32	234	45,869

Table 4.2: Comparing Estimates of Production Functions by Ordinary Least Squares (ols) and Levinsohn-Petrin (levpet) Methods

	Capital Coefficient		Labour Coefficient	
	ols	levpet	ols	levpet
Mean	0.079	0.148	0.245	0.246
Std. Dev.	0.074	0.143	0.140	0.144
Minimum	-0.367	0.01	-0.10195	-0.096
Maximum	0.345	0.98	0.978	0.870
Correlation	0.18	0.18	0.97	0.97
Observations	45491	45503	45491	45503

	Materials Coefficient		Returns to Scale	
	ols	levpet	ols	levpet
Mean	0.606	0.604	1.001	1.211
Std. Dev.	0.122	0.124	0.049	0.274
Minimum	0.236	0.262	0.743	0.836
Maximum	1.275	1.316	1.273	2.951
Correlation	0.97	0.97	0.16	0.16
Observations	45491	45503	45491	45503

Table 4.3: Hausman Specification Tests
Fixed vs Random Effects Model

(1) Regressions with TFP Estimated by Ordinary Least Squares:

Coefficients	(b) Fixed	(B) Random	(b-B) Difference	Sqrt (diag(V_b-V_B)) S.E.
Fdi_variable	0.0318776	0.0287861	0.0030915	0.0027956
Tariff_barrier	0.0000688	0.0001367	0.0030915	0.0001046
Delicensing	0.0024834	-0.002582	0.0050654	0.0033063
Age	0.0017397	-0.0010088	0.0027486	0.0017546
Age-square	0.0003685	6.32e-06	0.0003622	0.0000925
b = consistent under Ho and Ha; obtained from xtreg B = inconsistent under Ha, efficient under Ho; obtained from xtreg				
Test: Ho: difference in coefficients not systematic chi2(19) = (b-B)'[(V_b-V_B)^(-1)](b-B) = 87.99 Prob>chi2 = 0.0000				

(2) Regressions with TFP Estimated by Levinsohn-Petrin Method:

Coefficients	(b) Fixed	(B) Random	(b-B) Difference	Sqrt (diag(V_b-V_B)) S.E.
Fdi_variable	0.0630923	0.0464668	0.0166255	0.002079
Tariff_barrier	0.0007377	0.000546	0.0001917	0.0000837
Delicensing	0.0432538	0.0348677	0.0083861	0.0025067
Age	-0.0096166	-0.0048547	-0.0047618	0.0019624
Age-square	0.0012681	0.0000254	0.0012427	0.0001057
b = consistent under Ho and Ha; obtained from xtreg B = inconsistent under Ha, efficient under Ho; obtained from xtreg				
Test: Ho: difference in coefficients not systematic chi2(18) = (b-B)'[(V_b-V_B)^(-1)](b-B) = 85.22 Prob>chi2 = 0.0000				

Table 4.4: Effects of Foreign Investment Policy on Manufacturing Sector Productivity in India
Firm Year Panel (1989-2004), Fixed Effects Model.

	(1)	(2)	(3)	(4)
Dependent Variable	Productivity Index (levpet)	Productivity Index (levpet)	Productivity Index (ols)	Productivity Index (ols)
Foreign_Investment_Policy	0.0696(0.0276)**	0.0696(0.0301)**	0.0325(0.0182)*	0.0325(0.0188)*
Industrial Delicensing	0.0294(0.0338)	0.0294(0.0329)	-0.0013(0.0188)	-0.0013 (0.0193)
Tariff Barriers	0.0010(0.0007)	0.0010(0.0007)	-0.0002(0.0007)	-0.0002(0.0006)
Age	-0.0076(0.0071)	-0.0076(0.0063)	0.0008(0.0037)	0.0008 (0.0026)
Age-square	0.0013(0.0004)***	0.0013(0.0004)***	0.0004(0.0002)**	0.0004(0.0002)*
Ownership	dropped	dropped	dropped	dropped
Firm size	dropped	dropped	dropped	dropped
Year Dummies	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Standard Errors	Robust and Clustered(by industry)	Bootstrapped and Clustered (by industry)	Robust and Clustered(by industry)	Bootstrapped and Clustered (by industry)
TFP estimated by	Levinsohn-Petrin Method	Levinsohn-Petrin Method	Ordinary Least Squares	Ordinary Least Squares
Rho	0.99	0.99	0.99	0.99
R-squared (within)	0.03	0.03	0.01	0.01
No of Observations	34393	34393	38035	38035

Coefficients with standard errors in brackets. ***, ** and * denote statistical significance at 1, 5 and 10 percent levels respectively.

Table 4.5: Selection of Industries for Policy Liberalisation.

Dependent Variable	(1) Year of Foreign Investment Liberalisation	(2) Year of Industrial Delicensing Reform	(3) Tariff Reduction 1992-2004
Productivity Growth 1989-91	-0.020	-0.096	-0.006
	(0.110)	(0.117)	(0.006)
Standard Errors	Robust	Robust	Robust
Observations	70	31	81
R-squared	0.0002	0.008	0.011
Correlation Coefficient	-0.014	-0.091	-0.108

Columns 1 and 2 are based on cross-section regressions of the first year in which an industry is foreign investment liberalised or de-licensed under the Industrial Development and Regulation Act on productivity growth over the period 1989-91. Industries which were never de-licensed or liberalised for foreign investment are excluded from the regressions. The productivity here is Total Factor Productivity as estimated by Levinsohn-Petrin Method. Column 3 is a cross-section regression of percentage point reduction in tariffs on productivity growth over the period 1989-91. Standard errors are heteroscedasticity robust. ***, ** and * denote statistical significance at 1, 5 and 10 percent levels respectively.

Table 4.6: Productivity Effects of Foreign Investment Liberalisation (Difference-in-Differences Approach).

Dependent Variable	(1) Productivity Growth (levpet)	(2) Productivity Growth (levpet)	(3) Productivity Growth (levpet)	(4) Productivity Growth (levpet)
Foreign_Investment_Policy	0.158(0.065)**	0.155(0.068)**	0.155(0.093)*	0.155(0.080)*
Industrial Delicensing	-0.005(0.032)	-0.005(0.028)	-0.005(0.061)	-0.005(0.050)
Change in Tariff Barriers	0.0009(0.0006)	0.0009(0.0005)	0.0009(0.0009)	0.0009(0.0010)
Standard Errors	Robust and Clustered (by firm)	Bootstrapped and Clustered (by firm)	Robust and Clustered (by industry)	Bootstrapped and Clustered (by industry)
TFP Estimated by	Levinsohn-Petrin Method	Levinsohn-Petrin Method	Levinsohn-Petrin Method	Levinsohn-Petrin Method
R-squared	0.008	0.008	0.008	0.008
No of Observations	1293	1293	1293	1293

(1)Productivity Growth is the difference between average firm's productivity before liberalisation (1989-1991) and the average firm's productivity after liberalisation (1999-2004). (2) Foreign Investment Policy and Industrial Delicensing variables are 1 for firms in the industries that underwent foreign investment liberalisation or industrial delicensing between 1992-1998. (3) Change in Tariff Barriers is the difference in the average tariff before liberalisation (1989-1991) and the average tariff after liberalisation (1989-1991). (4) Coefficients with standard errors in brackets. (5) ***, ** and * denote statistical significance at 1, 5 and 10 percent levels respectively.

Table 4.7: Foreign Direct Investment vs Foreign Technology Agreement
(A Case Study of Motor Vehicle Industry).

Dependent Variable	Log_sales (1)	Log_sales (2)	Log_sales (3)	Log_sales (4)
Foreign Equity (fdi)	0.006(0.002)***	0.014(0.007)*	-0.005(0.002)**	-0.006(0.009)
Foreign Tech. Ag.(fta)	0.142(0.050)***	-0.468(0.392)	-0.843(0.284)***	-0.468(0.308)
Fdi * Fta			0.008(0.003)**	0.593(0.193)***
log_capital	-0.0009(0.040)	-0.009(0.047)	-0.0009(0.040)	-0.0009(0.047)
log_labour	0.139(0.059)**	0.139(0.059)**	0.139(0.059)**	0.139(0.048)***
log_materials	0.941(0.042)***	0.941(0.043)***	0.941(0.042)***	0.941(0.041)***
log_energy	0.041(0.043)	0.041(0.049)	0.041(0.044)	0.041(0.052)
Year dummies	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Standard Errors	Robust and Clustered(by firm)	Bootstrapped and Clustered (by firm)	Robust and Clustered(by firm)	Bootstrapped and Clustered (by firm)
R-squared	0.99	0.99	0.99	0.99
No of Observations	325	325	325	325

Coefficients with standard errors in brackets.
***, ** and * denote significance at 1, 5 and 10 percent levels respectively.

Table 4.8: (I) SECTORS ATTRACTING HIGH FDI INFLOWS:

Amount Rupees in crore (US $ in million)

Rank	*Sector*	*Amount of FDI Inflows*				*% age of total FDI Inflows (in rupee terms)*
		2002-03 (April-March)	**2003-04 *(April-March)***	***2004-05 (April-Jan.)***	***Cumulative Total (from August 1991 to January 2005)***	
1.	**Electrical Equipments** (including computer software & electronics)	3,075 **(644)**	2,449 **(532)**	2,988 **(655)**	16,918 **(3,977)**	15.37 **(15.15)**
2.	**Transportation Industry**	2,173 **(455)**	1,417 **(308)**	925 **(203)**	12,442 **(2,980)**	11.30 **(11.35)**
3.	**Telecommunications** (radio paging, cellular mobile, basic telephone services)	1,058 **(223)**	532 **(116)**	703 **(155)**	11,428 **(2,718)**	10.38 **(10.35)**
4.	**Fuels (Power + Oil Refinery)**	551 **(118)**	521 **(113)**	730 **(160)**	10,532 **(2,481)**	9.57 **(9.45)**
5.	**Services Sector** (financial & non-financial)	1,551 **(326)**	1,235 **(269)**	1.192 **(261)**	**9,326** **(2,300)**	8.47 **(8.76)**
6.	**Chemicals** (other than fertilizers)	611 **(129)**	94 **(20)**	962 **(210)**	6,654 (1,708)	6.05 **(6.51)**
7.	**Food Processing Industries**	177 **(37)**	511 **(111)**	195 **(43)**	4,540 **(1,142)**	4.12 **(4.35)**
8.	**Drugs & Pharmaceuticals**	192 **(40)**	502 **(109)**	1,347 **(293)**	3,556 **(836)**	3.23 **(3.18)**
9.	**Metallurgical Industries**	222 **(47)**	146 **(32)**	901 **(197)**	2,155 **(506)**	1.96 **(1.93)**
10.	**Consultancy Services**	122 **(26)**	257 **(56)**	1,159 **(252)**	1,884 **(411)**	1.71 **(1.57)**

(II) SECTORS-WISE FOREIGN TECHNOLOGY TRANSFER APPROVALS:

Rank	*Sector*	*No. of Technical Collaborations approved*	*% age of total*
1.	Electrical Equipments (including computer software & electronics)	1,245	16.24
2.	Chemicals (other than fertilizer)	863	11.26
3.	Industrial Machinery	859	11.21
4.	Transportation Industry	689	8.99
5.	Metallurgical Industry	365	4.76
6.	Other sectors	3,643	47.54
Total of all Sectors		**7,664**	**100.00**

Source: Department of Industrial Policy & Promotion, Ministry of Commerce & Industry, Government of India.

5 Conclusions

In this thesis, I theoretically and empirically investigated how FDI Policy affects certain aspects of firm behaviour. The insights offered by its three main chapters are as follows:

In the **second chapter**, I developed a general equilibrium model of multinational firms operating under monopolistic competition and foreign investment uncertainty. Starting from a pure trading equilibrium and solving for the optimal foreign investment rule gave a scale-up factor, which implied existence of a wedge between markup revenues and foreign investment costs. Greater volatility and risk aversion increased this scale-up over foreign investment costs implying a delay in the exercise of FDI option, while growing market size (national income) facilitated early exercise. The model was extended to a mixed Poisson jump-Brownian motion process, which modelled policy driven FDI reforms. It showed how a sudden drop in foreign investment costs brought about by a policy shift, as also a greater probability of it, could facilitate early exercise of the FDI option. This model implied 'hysteresis', which explained 'wait and watch' behaviour of multinational firms better than a pure comparative advantage-trade cost framework does. While investment under uncertainty literature is based on the theory of call options, I solved 'FDI option' as a put option, thereby also enriching the theory of real options.

In the **third chapter**, I developed a model of long run industry equilibrium with firm heterogeneity and market power. Mark-ups in this model were endogenous and responsive to toughness of market competition. It brought out potential gains in market power and profits as an additional reason for undertaking FDI in addition to reasons already enshrined in the literature as proximity-concentration trade-off. The model was used to analyse the interaction between profit maximizing behaviour of multinational firms and the welfare maximizing objective of the central planner (national government). In this framework, FDI was not found to be an unambiguously welfare improving proposition. While multinational firms gained profits, host and home countries could gain or lose welfare depending on how returns from foreign investment are distributed amongst the residents of the home and the host economies. This model brought out the importance of multilateral investment regime and bilateral investment treaties in refining multiple Nash equilibria to ensure the most liberal FDI policy regime is implemented worldwide.

In the **fourth chapter**, I carried out an empirical investigation into the relationship between foreign investment policy and manufacturing firms' performance as estimated by multi-factor productivity against the backdrop of Indian liberalisation of the 1990's. Using a firm-year panel from 1989 to 2004, I obtained consistent estimates of firm's production functions, and controlling for industrial delicensing and trade reforms, estimated the effects of foreign investment liberalisation on measured productivity of manufacturing firms. Foreign investment liberalisation was found to have significantly improved the performance of Indian manufacturing firms. A particularly interesting feature of India's foreign investment policy over this period has been encouraging adoption of foreign technology by domestic firms, while at the same time opening up these industry sectors to foreign direct investment. The joint effect of foreign investment and technology liberalisation was estimated as between seven to seventeen percent increase in measured productivity of manufacturing firms over this period. A case study of the motor vehicle industry showed these two elements of the foreign investment regime have actually been complementary to each other.

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