“The Impact of Trade on Managerial Incentives and Productivity” *

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Abstract

This paper examines the importance of trade-induced managerial incentives as a source of productivity gains. I introduce a principal-agent problem in a trade model with monopolistic competition and firm level heterogeneity, in which firms provide incentives to their managers to reduce costs. The model shows that trade liberalization, given by a reduction in trade costs, induces stronger managerial incentives among firms productive enough to export and weaker incentives for firms not productive enough to export. Among the exporters, the increase in incentives is higher for low-productive exporters than high-productive exporters. Examination of U.S. manufacturing firms yields evidence consistent with the model. I find that between 5% and 8% of the industry productivity growth during the 1993-1998 period can be attributed to productivity gains through managerial incentives.

Keywords: Heterogeneous Firms, Incentives, Productivity, Competition, Trade Liberalization

JEL: F12, F16, F61, O4

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1 Introduction

Studies of the relationship between trade and productivity often find major improvements in productivity as a result of trade liberalization.[1] These gains are thought to come through two main channels: the reallocation of economic activity across firms within an industry, and endogenous within-firm productivity growth. The relative importance of these two channels is still the subject of debate, as are the precise mechanisms by which productivity growth within firms occurs.[2]

This paper explores the role of managerial incentives in within-firm productivity growth following trade liberalization. I embed a principal-agent problem in a model of trade with heterogeneous firms. The principal (firm owner) offers compensation contracts to the manager in order to incentivize the manager to exert effort in productivity-enhancing activities.[3] In this environment, I derive the optimal incentive scheme for a manager as a function of a firm's initial productivity, the competitiveness and market size of both the domestic and foreign market, and trade costs. I show that the effect of an increase in competition on incentives is proportional to the firm's demand response to such changes. The higher the marginal increase in demand given a change in the competitive environment, the greater the marginal value of incentives.

A bilateral reduction in trade costs affects managerial incentives in two ways. First, there is a *scale effect*: a reduction in trade costs increases export sales and therefore revenues of exporting firms and induces the most productive non-exporting firms to enter the export market. The higher the firm revenue, the greater is a firm's incentive to invest in cost reductions, and therefore the stronger incentives it will provide to its managers. Second, there is a *competition effect*: a reduction in trade cost increases competition in both the domestic and foreign markets, reducing each firm's market share and revenues. Hence, it is optimal for the owner to provide lower incentives. The net effect of these two countervailing forces depends on the initial productivity level of the firm. For firms in the middle-to-upper

[1] Pavcnik (2002) documents firm and industry productivity gains from trade liberalization in Chile. Trefler (2004) finds that the Canada-U.S. free trade agreement is associated with significant gains in plant and industry labor productivity. Bernard, el al. (2006) finds similar effect following a reduction in U.S. trade cost. Amiti and Konings (2007) show that reductions of both output and input tariffs lead to significant gains in firm productivity.

[2] Trefler (2004) finds that within-plant productivity gains are bigger than industry gains, while Bernard et al. (2006) finds the opposite. Pavnick (2002) finds that around one-third of the increase in aggregate productivity caused by the Chilean trade liberalization is attributed to within-plant productivity gains.

[3] The manager's main task is to improve efficiency of his company by reducing production cost. For example, he can close down unprofitable divisions, reorganize the company, lay off redundant workers, experiment with new technologies, develop new products, etc.

range of the productivity distribution, the scale effect dominates. This effect is even stronger for firms in the middle, because firms in the middle range of the productivity distribution experience greater relative revenue improvement than firms in the top or upper range. For less productive firms, the competition effect dominates.[4]

Given these incentives schemes, a bilateral reduction in trade cost generates efficiency gains for firms in the middle-to-upper range of the productivity distribution and efficiency losses for firms in the low range of the productivity distribution. The largest gains accrue to firms in the middle of the distribution. At the aggregate level, the net effect depends on the shape of the initial productivity distribution.

I use data on U.S. manufacturing firms from 1993 to 2005 to examine the predictions of the model. First, I asses how firm incentives respond to a greater degree of openness to trade. As an exogenous measure of openness to trade I use U.S. import and export tariffs, measured both at the 4-digit SIC industry level and at the firm level.[5] The identification strategy relies on tariff variation across firms and industries for a given year and across years, and that these variations are arguably exogenous to the compensation scheme of managers. To measure managerial incentives I use the sensitivity of CEO wealth to a one percent change in the firm's stock price, which in the executive compensation literature is known as the 'CEO delta'.[6] This sensitivity is seen as aligning the incentives of managers with the interest of shareholders (i.e. the firm's owners). Higher delta means that managers work harder or more efficiently because they share gains and losses with shareholders. However, another effect of increased delta is to expose managers to more risk.[7] Thus, CEO delta is a good proxy for managerial incentives in the model.

Consistent with the model's predictions, I find that a reduction in tariffs induces a higher CEO delta for firms in the middle-to-upper range of the firm-productivity distribution, and a lower delta for firms in the low range of the distribution. In particular, the average reduction in export tariffs[8] increases the CEO delta by 8.6% for the mean firm,[9] implying a $49,000

[4]Note that firms in the middle-to-upper range of the productivity distribution are mostly exporters, but also some high productive non-exporters.

[5]Import tariffs (export tariffs) are the tariffs that the U.S imposes on (or faces from) its main trading partners per industry and year, weighted by the importance of each trading partner in the base year, 1993. I constructed firm level import and export tariff measures using the weighed average of the different four-digit SIC industries where the firms operates.

[6]I use the approach adopted by Core and Guay (2002) to calculate the CEO delta.

[7]Coles, Daniel and Naveen (2004) point out that another effect of increased delta is to expose the managers to more risk. If managers are undiversified with respect to firm-specific wealth, they are exposed to more risk than the shareholders who have a diversify portfolio.

[8]Tariffs in this period decrease from 6.2% to 2.3%.

[9]For the median firm, the increase in incentives is around 8%

increase in the sensitivity of the manager's wealth to a one percent change in the stock price (from \$570,000 to \$619,000). For firms in the bottom 3 percent of the productivity distribution, this sensitivity decreases by 5%, or \$28,500. For firms in the 90th percentile, the CEO delta increases by 6% or by \$34,000. I use the elasticities of managerial incentives with respect to tariffs in the analysis below.

At the aggregate level, I find that between 5% and 8% of the aggregate productivity growth during the 1993-1998[10] trade liberalization period can be attributed to within-firm productivity growth through managerial incentives. To obtain this result, I use the elasticities of incentives with respect to tariffs calculated above. Note that these elasticities depend on each firm's base productivity, which I measure as the productivity in 1993. I then calculate the elasticity of firm productivity with respect to incentives, where I use one-year lagged compensation and tariffs as instruments for incentives. This exercise gives me the response of each firm's productivity to a change in managerial incentives caused by a reduction in tariffs. To obtain the aggregate estimates, of 5% and 8%, I aggregate all firms' responses by weighting them by their market share in 1993. These estimates capture the variation in incentives given a reduction in tariffs during the period analyzed, while omitting other factors that could possibly affect incentives, such as a reduction in non-tariff barriers, increases in foreign demand of domestic goods, and decreases in transportation costs, among others. Hence, this aggregate estimate can be considered a lower bound of the overall effect of incentives on productivity gains from trade.

This study is related to several streams of literature. First, it fits into recent literature on the effects of trade on endogenous productivity. According to this literature firms can affect their productivity via decisions regarding innovation and technology adoption, the range of products produced and how production is organized (Atkeson et al. 2010; Bernard et al. 2007; Caliendo et al 2012). This paper complements this literature by providing a novel and important channel -managerial incentives- through which trade can impact firm and industry productivity. Second, this paper is one of the first to examine the link between competition and incentives in a general equilibrium framework with heterogeneous firms[11]. So far Raith

[10]This period includes NAFTA (effective since in January 1994) and the Uruguay Round Agreements (effective since January 1995)

[11]There are two recent papers that have these components but with caveats. Yu (2012), incorporates incentive contracts in a framework with heterogeneous firms, however since managerial effort is chosen before the owner realized his marginal cost all firms end up having the same managerial incentives and effort. In addition, Chen (2014), incorporates a bargaining game in a Melitz (2003) model, however the model does not provide unique predictions for the effort and productivity changes for exporters after trade liberalization, it only provides this predictions for non-exporters. The predictions for the non-exporters are consistent with my model.

(2003), Schmidt (1997) and Hart (1983), have analyzed the relationship between domestic competition and incentives with homogeneous firms. In their model the effect of an increase in competition over incentives is exactly the same for all firms, which is inconsistent with what is observed in the data. Including firm heterogeneity is not only relevant for a proper estimation of the firm's response to competition but also more generally to estimate the industry's response.

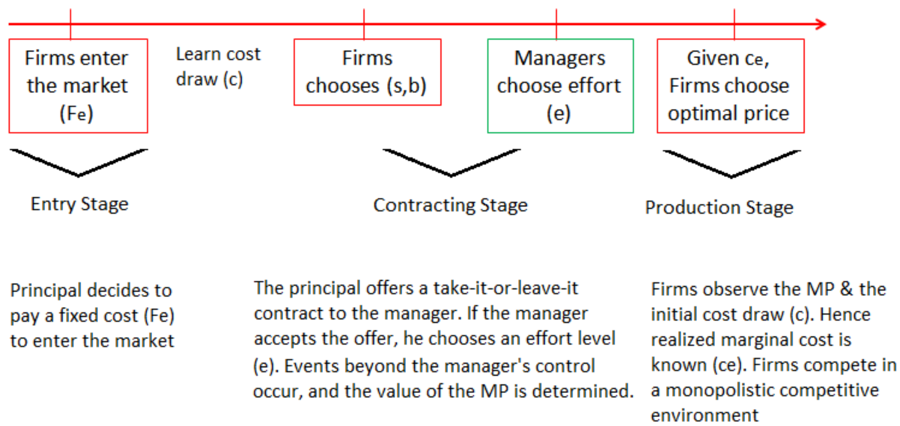
In addition, this paper contributes to the literature on executive compensation by considering trade openness and trade competition as an important determinant of managers' incentive scheme. This paper is the first to examine the relation between total equity incentives (measured as the CEO delta) and openness to trade. It complements a recent paper by Guadalupe and Cunat (2009) which shows that pay level and incentives (measured as higher pay inequality among the top executives of the firm) increase when firms face greater import competition. Finally, the paper contributes to the vast theoretical literature on the effects of trade policy on gains from trade (Melitz, 2003 Bernard et at 2011, Arkolakis et al, 2012). The general consensus in this literature is that foreign competition both reduces the domestic market share of import-competing firms and reallocates domestic market share from inefficient to efficient firms (between effect); by assumption these models do not allow for endogenous productivity (within-firm effect). In my model, I incorporate managerial incentives in a model of trade based on Melitz and Ottaviano (2008) in order to allow for endogenous productivity changes while at the same time maintaining the between effect. In that way, I am able to decompose aggregate productivity growth into these two components and measure the importance of each of these channels for the gains from trade.

The rest of this paper is organized as follows. The next section presents and solves the closed-economy model. Section III presents the two country model. Section IV derives the empirical predictions on the effects of trade liberalization on managerial incentives. Section V presents the empirical strategy and examines the predictions of the model. The last section concludes.

2 The Model

In this section I introduce the principal-agent incentive problem in a monopolistic competitive model of trade with firm heterogeneity based on Melitz and Ottaviano (2008). Goods are differentiated, with each variety being produced by a single firm. Firms are heterogeneous in their productivity and use constant returns to scale production technology at marginal cost

Figure 1: Time-structure of the model



c_e (in units of labor). My main departure from the standard model is that the firm owners face an incentive provision problem, where the manager needs to be induced to provide effort in productivity-enhancing activities.

The timing of the events is as follows. First, in the entry stage, the principal (the firm owner, or shareholders) decides whether or not to enter the market. Entering firms have to pay a fixed entry cost f_e to observe their marginal cost draw of c (or the inverse of the firm productivity draw $c = 1/\varphi$). Then, in the contracting stage, the owner of the firm hires an agent (the manager) on a competitive market for managers, who are assumed to be identical. The manager's main task is to improve efficiency of his company by reducing the production cost. For example, he can close down unprofitable divisions, reorganize the company, lay off redundant workers, experiment with new technologies, develop new products, etc. I define this set of activities as the managerial project (MP). The success of the managerial project in improving firm efficiency is determined by the effort the manager exerts, which is unobservable to the principal.

The firm owner's problem is to design the optimal incentive-compatible contract based on contractible measures. If the manager accepts the offer he will choose a level of effort to exert. Once the manager exerts effort, the firm observes its own realized marginal cost c_e, and the realized marginal cost of other competitors in the market. Given this cost, in the production stage, the firm owner decides whether to stay in the market, enter the export market, or drop out. The time-structure of the model is shown in Figure 1. To ease exposition, I consider first the closed-economy case and then extend the model to the open economy.

2.1 Consumers

There are L consumers in the economy. Each consumer either supplies one unit of labor in the market and receives w_p or becomes a manager and receives wage w_M. In equilibrium, workers and managers have the same expected utility even though they have different wages.[12] Consumers have identical preferences that display love of variety and risk-aversion, and give rise to demands with variable elasticity,

$$U = -exp(-r[q_0^c + \alpha \int\limits_{i\epsilon\Omega} q_i^c di - \frac{1}{2}\gamma \int\limits_{i\epsilon\Omega} (q_i^c)^2 di - \frac{1}{2}\eta \left(\int\limits_{i\epsilon\Omega} q_i^c di \right)^2 - \psi(e)]), \tag{1}$$

where q_0^c and q_i^c represent the individual consumption levels of the numeraire good and each variety i. Ω denotes the set of differentiated varieties. The degree of product differentiation between varieties is $\gamma > 0$, as γ increases, consumers prefer to diversify their consumption across varieties. The parameters $\alpha > 0$ and $\eta > 0$ index the substitution pattern between the differentiated varieties and the numeraire good. Consumers have a coefficient of risk aversion $r > 0$ and a $\psi(e)$ cost of effort function . The market demand for each variety is then given by

$$q_i \equiv Lq_i^c = \frac{\alpha L}{\eta N + \gamma} - \frac{L}{\gamma}p_i + \frac{\eta N}{\eta N + \gamma}\frac{L}{\gamma}\bar{p} \qquad \forall i\epsilon\Omega^*, \tag{2}$$

where $\Omega^* \subset \Omega$ is the subset of varieties that are produced and consumed ($q_i^c > 0$); $\bar{p}$ is the average price of the consumed varieties[13] and N is the measure of consumed varieties in Ω^*. Since marginal utilities are bounded,[14] consumers can demand zero of a particular good. In other words, there is a choke price level p^*, where, if a good has a price lower than this price, $p_i < p^*$, then the good will have positive demand; otherwise it will have zero demand[15]. This maximum price is defined by,

$$p^* \equiv \frac{\gamma\alpha + \eta N\bar{p}}{\eta N + \gamma} \tag{3}$$

The price elasticity of demand is $\varepsilon_i \equiv |(\partial q_i/\partial p_i)(p_i/q_i)| = [p^*/p_i - 1]^{-1}$ which depends

[12] Managers have higher wage since they exert higher effort in the company, and consequently have a higher disutility for exerting that effort. In equilibrium these two effects cancel each other, and thus the expected utility of the manager is the same as the expected utility of the worker.

[13] $\bar{p} = \int_{i\epsilon\Omega^*} E[p_i]di$

[14] The introduction of the numeraire good implies that marginal utilities are bounded, hence a consumer may have zero demand for some goods. I assume that the consumption of the numeraire good q_o^c is always positive.

[15] The set Ω^* is the largest subset of Ω that satisfies $p_i \leq p_{Max}$

negatively on p^* and positively on the price of the good p_i. p^* is a sufficient statistics that measures the competitiveness of the environment, a lower p^* means a tougher competitive environment. The competitiveness of the environment therefore increases with the number of varieties produced N and decreases with the average price $\bar{p}$.

Given the utility in (1) and residual demand for each variety (2), the indirect utility function is:

$$\widetilde{V}(p, I, e) = -exp^{-r(I-\psi(e)+0.5(\eta+\frac{\gamma}{N})^{-1}(\alpha-\bar{p})^2+0.5\frac{N}{\gamma}\sigma_p^2)},$$

where I is the consumer's income. If the consumer is a worker his income is certain and equal to the production wage w_p ; if the consumer is a manager his income is uncertain and equal to the manager's wage $w_M(c)$.

2.2 Production and Firm Behavior

Labor is the only factor of production. Consumers supply labor inelastically in a competitive market. The numeraire good is produced under constant returns to scale at marginal cost equal to one; its market is also competitive. These assumptions imply a wage for production workers w_p equal to one. To enter the differentiated product sector firms have to pay a fixed cost f_E, that represents the investment in product development and production start-up costs. Subsequent production exhibits constant returns to scale at a marginal cost c_e. Labor used is a linear function of output, $l = c_e q$. The realized marginal cost of the firm c_e is defined as:

$$c_e = g(c, v)$$

and

$$v = \delta e + u_i,$$

where $c \in [c_m, c_M]$ with $c_M \leq 1$, is the initial marginal cost draw that each firm learns after making the irreversible investment f_E, v represents the realized value of the managerial project, $e \geq 0$ denotes manager effort, $\delta > 0$ is a parameter that measures the expected return of the effort, and u_i is a project specific shock drawn from a truncated normal distribution that lies between $[-\kappa, \kappa]$ with zero mean and variance σ_i^2 identically and independently distributed across firms.

Assumption 1. *The realized marginal cost of the firm $c_e = g(c, v)$ is continuously differentiable in c and v and satisfies:*

(a) $g'(c) > 0$ *and* $g'(v) < 0$

(b) $g(c, v) \geq 0 \; \forall u \epsilon [-\kappa, \kappa]$ *and* $c \in [c_{min}, c_{max}]$

(c) $\frac{\partial g}{\partial c \partial v} < 0$

Assumption $A1b$ requires that the realized marginal cost is always non-negative, no matter how large is the error term u. Assumption $A1c$ defines how the manager's effort impacts the firm's final efficiency. Assumption $A1c$ implies that an additional unit of managerial effort leads to a larger improvement in efficiency for a less productive firm than for a more productive firm. For example, when two identical talented managers are hired by different firms, one a low efficient firm and the other a highly efficient firm, then the marginal productivity gain of one additional unit of managerial effort is higher for the former than the latter. A manager has to spend more hours of effort in order to increase even further the productivity of the highly efficient firm than to increase the productivity for the inefficient firm.[16]

For expositional purposes and without loss of generality, I solve the model for the realized marginal cost function $c_e = g(c, v) = c[1 - v]$ where $E[c_e] = c[1 - \delta e]$ and $Var[c_e] = \sigma^2$ .This implies that the agent commits to a level of effort $e \epsilon [0, \frac{1-u_i}{h}]$. The functional form on c_e suggest that the elasticity of the marginal cost with respect to the management project is[17],

$$\varepsilon_{c_e, v} = \frac{-v}{1 - v}$$

which is increasing in the value of the management project v and is independent on the initial level of marginal cost.

Once firms know their realized cost c_e , they can determine their output $q(c_e) = \frac{L}{2\gamma}[c_D - c_e]$, price $p(c_e) = \frac{1}{2}[c_D + c_e]$, and profit $\pi(c_e) = \frac{L}{4\gamma}[c_D - c_e]^2$, as a function of the choke price $c_D = p^*$ and the realized marginal cost of the firm c_e. As expected, lower-cost firms set lower prices and earn higher revenues, obtaining higher profits than firms with higher costs.

[16]This is related to the work of Bloom et al. (2011), where management practices where given to a set of textile firms in india in expectation of an increase in productivity and profitability. If the same set of practices where given to a superstar, this will have no effect on firm's profitability or productivity, as superstars, already have these skills.

[17]The elasticity of final firm productivity $\varphi_e = \frac{1}{c_e}$ with respect to the management project v is exactly the same as the elasticity of marginal cost with respect to v .

The contracting problem of the firm owner is to design a manager compensation package that motivates the manager to exert effort on the managerial project, without exposing him to too much risk. As is standard in the theoretical literature of corporate governance and executive compensation, I only consider linear compensation contracts[18]. The firm's owner offers the manager a compensation contract of the form:

$$w_M = s + b(c_D - c_e),$$

where $\{s, b\}$ are chosen contracting parameters, s is the non-performance-based compensation component, b is the manager's incentive scheme (manager's performance-pay) and $(c_D - c_e)$ is a sufficient statistic summarizing the performance of the firm relative to other firms in the industry. The higher this difference, the higher the firm output, mark-up and profits. I treat $(c_D - c_e)$ as observable and contractible. If instead I choose to contract on outputs or markups the results are exactly the same up to a constant.

2.3 Manager's Optimization Problem

Given a contract $\{s, b\}$ managers simultaneously choose effort levels to maximize their expected constant absolute risk-averse preferences (CARA),

$$E_u[\widetilde{V}(p, I, e)] = E_u[-exp^{-r(w_M - \psi(e) + Z)}],$$

where $Z \equiv 0.5(\eta + \frac{\gamma}{N})^{-1}(\alpha - \bar{p})^2 + 0.5\frac{N}{\gamma}\sigma_p^2$. Following Chalioti (2014), if the manager has CARA preferences towards risk, linear contracts, and the random term u follows a truncated normal distribution symmetric around the mean, then the manager's maximization problem is to choose the effort e that maximizes the certainty equivalent of his utility given by,

$$\max_e E[w_M] - \frac{r}{2}Var[w_M] - \psi(e)$$

where $\psi(e)$ is the manager's cost of effort function, which I assume to take the simple quadratic form, $\psi(e) = \frac{\theta e^2}{2}$, where $\theta > 1$. Hence the optimal effort e^* is given by,

$$e^* = \frac{b}{\theta}\delta c \tag{4}$$

[18]Note that this linear contract is not the optimal contract given our assumptions but is the one that gives a simple and intuitive closed-form solution for the wage scheme (See Bolton and Dewatripont, 2005). There are a few papers that have attempt to explore non-linear type of contracts (Huang and Suarez, 1997; Hemmer, Kim and Verrecchia, 2000).

Managers accept any contract (s, b) with an expected utility of at least their reservation utility, given by the utility of the production worker $-exp^{-r(w_p+Z)}$. Hence the participation constraint of the manager is,

$$E_u[-exp^{-r(w_M-\psi(e)+Z)}] \quad \geq \quad -exp^{-r(w_p+Z)},$$

which corresponds to

$$E[w_M] - \frac{r}{2}Var[w_M] - \psi(e) \geq \bar{U}, \tag{5}$$

where $\bar{U} = w_p - \frac{\Omega_i}{r}$, w_p is the worker salary and $\Omega_i = \frac{\Phi(\frac{\kappa+\sigma^2 rbc}{\sigma})-\Phi(\frac{-\kappa-\sigma^2 rbc}{\sigma})}{\Phi(\frac{\kappa}{\sigma})-\Phi(\frac{-\kappa}{\sigma})}$. Additional details about (5) are available in the Appendix.

2.4 Firm's Optimization Problem

The shareholder's (firm owner's) problem is to choose a contract $\{s, b\}$ that maximizes firm profit net of manager's cost, subject to satisfying the manager's participation constraint (PC) and incentive compatibility constraint (IC). Formally the firm owner's problem is given by,

$$\underset{s,b}{max} E_u[\Pi(c_e)] = E_u[\frac{L}{4\gamma}[c_D - c_e]^2 | c_e \leq c_D] P(c_e \leq c_D) - E[w_M] \tag{6}$$

subject to

$$\underset{e}{max} E_u[w_M] - \frac{r}{2}Var[w_M] - \frac{\theta e^2}{2} \ (IC) \tag{7}$$

$$E_u[w_M] - \frac{r}{2}Var[w_M] - \frac{\theta e^2}{2} \geq \bar{U} \ (PC) \tag{8}$$

The concavity of the profits and manager's utility, CARA preferences and the (truncated) normality of the random terms allow us to use the first-order approach and replace the incentive compatibility constraint (7) with (4). Since the managers market is perfectly competitive and frictionless, the participation constraint (**??**) must bind in equilibrium. If it did not, the principal could increase profits by decreasing s while still satisfying the participation constraint. From the binding participation constraint we can determine the value of s for the manager, $s = \bar{U} - \frac{b^2}{2\theta}[\delta^2 c^2 - \theta r \sigma^2] - b(c_D - c)$. Given s and equation (11) we obtain the manager compensation $w_M = \bar{U} + \frac{b^2}{2\theta}[\delta^2 c^2 + \theta r \sigma^2] + cbu_i$

Using the Leibniz integral rule we derive the first-order condition of the firm owner's problem:

$$\int_{-\kappa}^{min\{\kappa,\frac{c_D-c[1-\delta e]}{c}\}} \frac{\partial[\frac{L}{4\gamma}[c_D-c_e]^2]}{\partial c_e}\frac{\partial c_e}{\partial e}\frac{\partial e}{\partial b}dG(u)=\frac{\partial E[w_M]}{\partial b}, \tag{9}$$

where $G(u)=\frac{\Phi(\frac{\mu}{\sigma})-\Phi(\frac{-\kappa}{\sigma})}{\Phi(\frac{\kappa}{\sigma})-\Phi(\frac{-\kappa}{\sigma})}$ is the truncated normal distribution with bounds $[-\kappa,\kappa]$. The right and left hand sides of equation (9) represent the marginal cost and marginal benefit associated with an additional unit of incentives. The left-hand side can be decomposed into three terms. The first term represents how firm profit varies with the realized marginal cost c_e; this term is negative (the lower the firm's final marginal cost the higher the firm's profit) but the magnitude of this term decreases with the initial marginal cost draw c. Hence firms that are initially more productive (lower c) benefit more from a reduction in their realized marginal cost c_e. The second term captures how the realized marginal cost varies with respect to the level of effort, this term is negative as higher effort reduces the final marginal cost c_e. Given assumption 1, the magnitude of the second term increases with the initial cost draw c, i.e. the higher the initial productivity of the firm, the lower the marginal effect of one additional unit of effort. The third term shows how manager's effort responds to a higher level of incentives b; this term is positive. Hence, in equilibrium the optimal level of incentives is determined by the interaction of these three components.

To guarantee that there exists a unique interior closed-form solution I make the following restrictions:

Assumption 2. *(a)* $(\theta r\sigma^2+\delta^2)\theta 2\gamma > L\delta^4$ *and (b)*$\kappa=\frac{(c_D-c)}{c}\ \forall\ c<c_D$

(A2a) guarantees the concavity of the profit function in terms of the incentives b. (A2b) means that the bound of the random noise is small for firms with high marginal cost draw; this is to avoid large random cost differences[19].

Lemma 1. *Given assumption (A2a) and (A2b), the optimal incentive scheme for the manager is:*

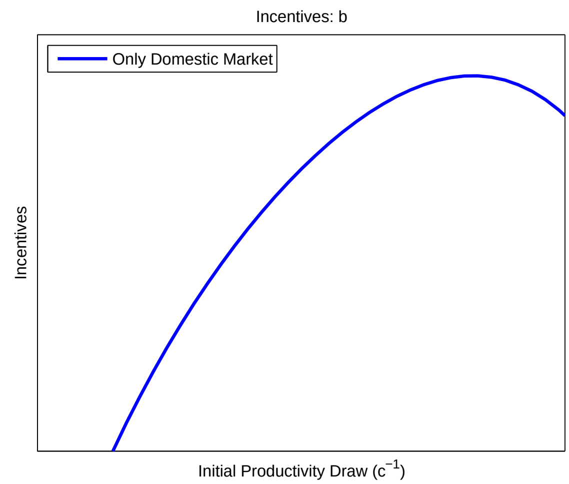
$$b^*(c)=\frac{L\delta^2[c_D-c]}{(\theta r\frac{\sigma^2}{c^2}+\delta^2)2\gamma-\frac{L\delta^4c^2}{\theta}}; \tag{10}$$

Proof: see appendix.

Incentives $b(c)$ are increasing in the market size L, decreasing in the disutility parameter of effort θ, decreasing in the risk-aversion parameter r, and non-monotonic in the initial marginal cost draw c (or the initial productivity draw $\varphi=c^{-1}$, see figure 2). The logic is

[19]This assumption is common in financial economics literature see Xavier Vives (1999, Ch. 8)

Figure 2: Equilibrium level of Incentives



as follows: for low to middle levels of firm productivity the first term on the left-hand side in equation 9 dominates, hence incentives are increasing with firm's initial productivity. For high levels of firm's initial productivity, the second term on the left-hand side in equation 9 dominates, thus we see a decrease in the incentive scheme. See appendix for details. This theoretical result is empirically examined in section 5.

Lemma 2. *Given assumption (A2) and (A3), the optimal level of effort for the manager is:*

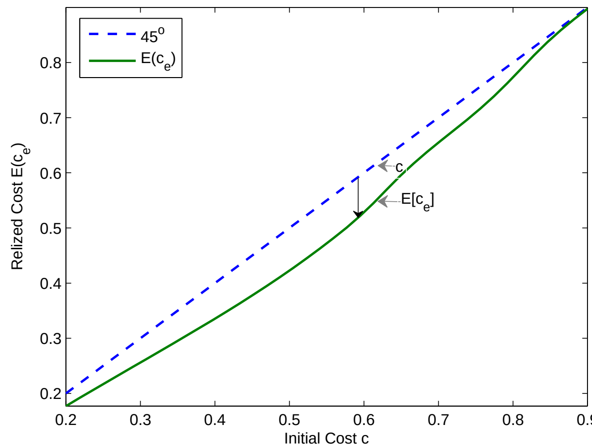
$$e^*(c) = \frac{Lc\delta^3[c_D - c]}{(\theta r\frac{\sigma^2}{c^2} + \delta^2)2\theta\gamma - L\delta^4 c^2} \tag{11}$$

see Appendix for proof. Given the manager's effort we can obtain the expected value of the firm's realized marginal cost $E[c_e]$. Figure 3 shows the expected realized marginal cost

$$E[c_e] = c[1 - e^*(c)],$$

as a function of the initial cost draw. In a model with no incentives the expected final marginal cost $E[c_e]$ is the same as the initial marginal cost draw c (since there is no effort). In a model with incentives, the expected realized marginal cost is weakly less than initial marginal cost draw, $E[c_e] \leq c$, depending on the size of the managerial effort. In figure 3, we can observe that the relative decrease in the firm's marginal cost is higher for firms in the middle of the productivity distribution than firms in the extremes of the distribution.

Figure 3: Expected realized Cost (c_e)



2.5 Equilibrium with Free Entry

In the contracting stage, firms hire a manager until the expected profit of doing so is zero (i.e when equation (12) equals to zero). Firms with $c \leq \hat{c}$ hire a manager; $\hat{c}$ represents the marginal cost of a firm where the expected profit of hiring a manager is equal to zero, this is:

$$\begin{aligned} \hat{c}\epsilon E_u[\Pi(\hat{c}, e(\hat{c}))] &= 0 \leftrightarrow \\ E_u[\frac{L}{4\gamma}[c_D - \hat{c}[1 - e^*(\hat{c})\delta - u]])]^2 - E_u[w_M] &= 0 \end{aligned} \quad (12)$$

Firms enter the market until the expected value of entry equals the fixed entry cost. That is, firms enter the market until the free entry condition (13) is satisfied:

$$\int_{c_{min}}^{\hat{c}} E_u[\Pi(c)]dF(c) = f_E, \quad (13)$$

where f_E is the fixed entry cost that the firm has to pay upfront in order to receive the marginal cost draw c and $\int_{c_{min}}^{\hat{c}} E_u[\Pi(c)]dF(c)$ is the expected value of entering the market. Given a marginal cost technology $F(c)$, we can solve for the cost cutoffs c_D and therefore for $\hat{c}$, which is monotone on c_D, from equations (12) and (13) in terms of the fundamentals of the model,

$$c_D = f(\overset{-}{L}, \overset{+}{\gamma}, \overset{+}{f_E})$$

see appendix for proof. The variables c_D and $\hat{c}$ index the competitiveness of the market. The larger the market size L or the lower the entry cost f_E , the 'tougher' is the competitive environment of the industry (lower c_D and $\hat{c}$). The intuition is the following: when market size increases, expected profits of entering the market increase, new firms enter the market, which increases the degree of domestic competition. The cutoffs c_D and $\hat{c}$ also determine the number of entrants and the number of surviving firms in the market N. From equation (3) we have that, $N = \frac{2\gamma}{\eta}\frac{\alpha - c_D}{c_D - \bar{c_e}}$ and the number of entrants is given by $N_E = N/F(\hat{c})$.

Furthermore, a lower value of c_D and $\hat{c}$ imply a lower realized cost of surviving firms, lower $\bar{c_e}$,lower average price $\bar{p}$ and higher average mark-ups $\bar{\mu}$. Given c_D,$\hat{c}$ and the optimal effort for each firm $e(c)$, we can rewrite the average price and markup in terms of surviving firm's average realized costs $\bar{c_e}$:

$$\bar{p} = \frac{1}{2}[c_D + \bar{c_e}]\,; \bar{\mu} = \frac{1}{2}[c_D - \bar{c_e}],$$

where $\bar{c_e} = \frac{\int_{c_{min}}^{\hat{c}} c[1-he(c)]dF(c)}{F(\hat{c})}$. Managerial effort by affecting the average cost of the firm, leads to lower prices and therefore higher consumer welfare. Welfare can be evaluated using the indirect utility function:

$$U = I^c + 0.5(\eta + \frac{\gamma}{N})^{-1}(\alpha - \bar{p})^2 + 0.5\frac{N}{\gamma}\sigma_p^2 \tag{14}$$

An equilibrium in this economy is a vector of wages $\{w_p\}$, a vector of marginal cost cutoffs $\{\hat{c}, c_D\}$, and a measure of entrants $\{N_E\}$ such that: (i) equations (12) and (13) are satisfied; (ii) the measure of entrants is given by $N_E = N/F(\hat{c})$ where N is $N = \frac{2\gamma}{\eta}\frac{\alpha - c_D}{c_D - \bar{c_e}}$; and (iii) wages are consistent with the labor market clearing condition:

$$N_E^h \int_{c_m}^{\hat{c}_l} p_{l,D}(c_e) q_{l,D}(c_e) F_D(c) \quad + p_0 q_0 = \quad w_l L_l,$$

where $F_D(c) = \frac{kc^{k-1}}{\hat{c}^k - c_m^k}$ is the distribution of cost draws for the surviving firms.

2.6 Parametrization of Technology

All of the results derived so far hold for any distribution of cost draws, $F(c)$. However, in order to simplify the analysis we follow Melitz and Ottaviano (2008) in assuming that productivity draws $1/c$ follow a bounded Pareto distribution with lower productivity bound $1/c_M$ upper productivity bound $1/c_m$ and shape parameter $k \geq 1$. This implies a distribution of cost draws given by,

$$F(c) = 1 - [\frac{1-(\frac{c}{c_M})^k}{1-(\frac{c_m}{c_M})^k}] = \frac{c^k - c_m^k}{c_M^k - c_m^k}, \qquad c\epsilon[c_m, c_M], \tag{15}$$

where the shape parameter k indicates the dispersion of cost draws. When $k = 1$, the cost distribution is uniform on $[c_m, c_M]$. As k increases, the relative number of high marginal cost firms (low productivity firms) increases and the cost distribution is more concentrated at these higher marginal cost (low productivity) levels.

2.7 Closed Economy Analysis

To examine the relationship between competition, managerial incentives and productivity, we discuss some of the comparative statics predictions that arise from the theoretical framework. I begin by examining how changes in the competitive environment affect a firm's managerial incentives b , effort e, and the cutoffs $\hat{c}$ and c_D . I then show how these components affect aggregate productivity growth. In contrast to previous theoretical models, the model here has two channels through which competition affects the average performance in the economy: changes in the cutoffs of productivity c_D (as in Melitz 2003 and Melitz-Ottaviano 2008) which determine exit/entry of firms into the market, and changes in the level of incentives and effort b and e, which affect within-firm productivity.

We use numerical methods to obtain the solution for the cutoffs c_D from equations (12) and (13), and show results for the baseline parameters in Table 1.

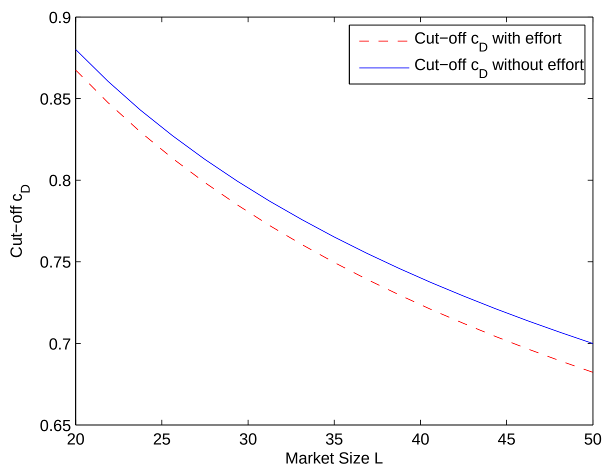
2.7.1 Increasing Market Size (L)

First we analyzed the effect of market size over the production cut-off c_D . Figure 4 displays the relationship between the cut-off c_D and market size L for two scenarios, one where firm owners provide incentives (red line) and one in which they do not (blue line). Both lines show that the production cut-off is decreasing with market size, consistent with the previous literature on heterogeneous firms (Melitz, 2003; Melitz and Ottaviano, 2008; Arkolakis et

Table 1: Parameters for numerical solution

Parameters	Baseline
γ	0.5
f_e	1
c_M	1
c_m	0.2
k	2
r	5
θ	25
h	1

Figure 4: Market size and entry cut-off c_D with managerial incentives



al., 2012). Figure 4 reveals that the production cut-off is lower in the presence of managerial incentives. This is due to the fact that in this model surviving firms have the option to increase their productivity through managerial incentives, making each firm more productive, and hence the industry more competitive (lower c_D) than without managerial incentives.

Figures 5 and 6 show the effect of an increase in the market size on incentives. An increase in market size leads to stronger incentives for sufficiently high-productive firms and lower incentives for low-productive firms.

Intuitively, an increase in market size leads to two effects that work in opposite directions. First, an increase in market size makes the demand faced by each firm more elastic, making

Market size and entry cut-off c_D with managerial incentives it easier for each firm to increase its demand by cutting its price. In this environment, it is optimal for firms to provide stronger incentives to the manager in order to reduce marginal costs. Second, as a firm's rivals charge lower prices, average price in the industry $\bar{p}$ falls, resulting in a decrease in the firm's demand. A lower demand leads the owner of the firm to provide weaker incentives. In previous literature, the net effect of these two forces was ambiguous. Here the net effect depends on the initial cost draw c of the firm. For firms with low cost draw the first effect dominates, otherwise the second effect dominates.

Figure 6 shows the percentage change in the expected realized cost when market size increases. Firms with low cost draw experience a lower realized marginal cost. These firms are providing higher incentives to their manager, which makes the manager exert higher effort (e.g. in cutting production costs, increasing operational efficiency, etc.), thus lowering firm's realized cost. In particular, firms in the middle of the distribution of the cost draws are the ones providing stronger incentives, and therefore the ones experiencing higher reduction in the expected realized cost.

3 Open Economy Model

We now extend the closed-economy model to a two country setting, Home, H and Foreign F. In both countries there is a continuum of consumers with mass L_H and L_F respectively, who share identical preferences leading to the inverse demand function (2). Markets are assumed to be segmented, although firms can produce in one market and sell in the other, incurring a per-unit trade cost. The cost of sending a unit with cost c_e to country l , where $l = H, F$, is $\tau_l c_e$ where $\tau_l > 1$. In this model, countries differ both in market size L_l and trade costs τ_l. Let $p^*_{l,}$ denote the price threshold for positive demand in market l. Then (3) implies,

$$p^*_{l,} = \frac{\gamma\alpha + \eta N_l \bar{p}_l}{\eta N_l + \gamma}, l = H, F, \tag{16}$$

where N_l is the total number of firms/varieties selling in country l (including domestic firms and foreign exporters), and $\bar{p}_l$ is the average price (across both domestic and foreign firms) in country l. Since markets are segmented and firms produce under constant returns to scale (no fixed cost), firms independently maximize the profits earned from domestic and exports sales. As in the case of the closed economy, only firms earning non-negative profits in a market (domestic or foreign) choose to sell in that market, hence $c_{l,D} = p^*_{l,}$ and $c_{l,X} = \frac{p^*_{j,}}{\tau_j} = \frac{c_{j,D}}{\tau_j}$, where $c_{l,D}$ represents the choke price in the domestic market, and $c_{l,X}$ the choke price in the foreign market. Profit maximization allows us to write the output, prices and profit levels

Figure 5: Incentives given a 25% increase in L

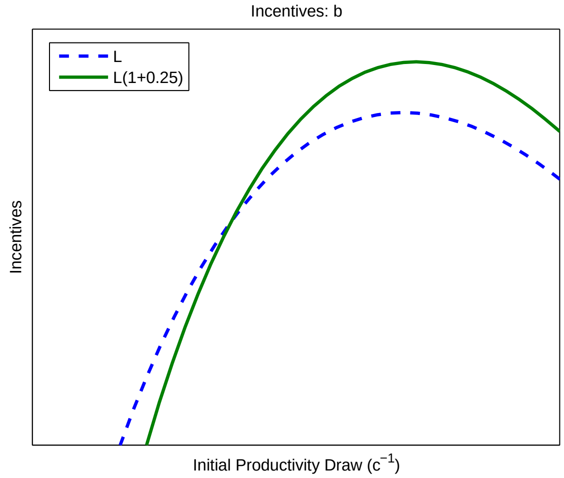
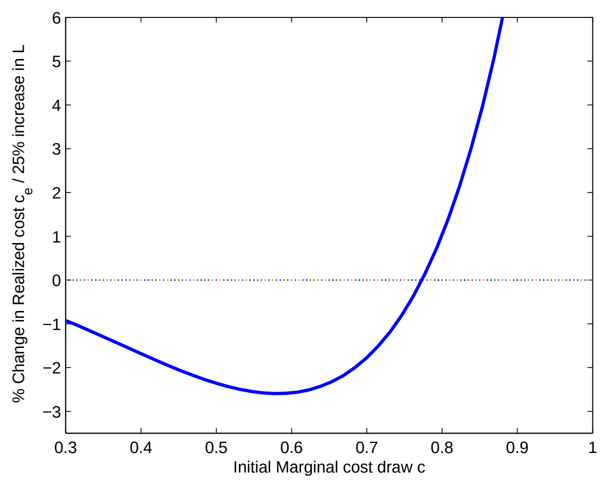


Figure 6: %△Expected realized cost c_e given 25% increase in L



as a function of the choke price and the realized marginal cost of the firm c_e:

$$p_{l,D}(c_e) = \frac{1}{2}[c_{l,D} + c_e] \qquad q_{l,D}(c_e) = \frac{L_j}{2\gamma}[c_{l,D} - c_e] \tag{17}$$

$$p_{l,X}(c_e) = \frac{1}{2}[c_{l,X} + c_e] \qquad q_{l,X}(c_e) = \frac{L_j}{2\gamma}\tau_j[c_{l,X} - c_e] \tag{18}$$

$$\pi_{l,D}(c_e) = \frac{L_l}{4\gamma}[c_{l,D} - c_e]^2 \pi_{l,X}(c_e) = \frac{L_j}{4\gamma}(\tau_j)^2[c_{l,X} - c_e]^2, \tag{19}$$

where $p_{l,D}(c_e)$ and $q_{l,D}(c_e)$ represent the profit maximizing price and quantity of a firm producing in country l with cost c_e. Such a firm may also decide to export output $q_{l,X}(c_e)$ at the price $p_{l,X}(c_e)$.

3.1 Optimal Incentive Contract

As in the closed economy case the firm owner's problem is to choose an incentive contract (s, b) to maximize profits net of manager's cost, subject to satisfying the manager's participation constraint (PC) and incentive compatibility constraint (IC). The firm owner's optimal contracting problem can be written as follows:

$$Max_{s,b}\ E[\Pi(c_e)] = E[\pi_{l,D}(c_e)|c_e \leq c_D]P(c_e \leq c_{l,D}) + E[\pi_{l,X}(c_e)|c_e \leq c_{l,X})]P(c_e \leq c_{l,X}) - E[w_M] \tag{20}$$

subject to

$$\max_{e} E_u[w_M] - \frac{r}{2}Var[w_M] - \frac{\theta e^2}{2} \qquad (IC) \tag{21}$$

$$E_u[w_M] - \frac{r}{2}Var[w_M] - \frac{\theta e^2}{2} \ \geq \ \bar{U}\ (PC) \tag{22}$$

Equation (20) can be rewritten as

$$E[\Pi(c_e)] = \int_{-\kappa}^{min\{\kappa, \frac{c_{l,D}}{c}-1+\delta e\}} \frac{L_l}{4\gamma}[c_{l,D}-c_e]^2 dG(u) + \int_{-\kappa}^{min\{\kappa, \frac{c_{l,X}}{c}-1+\delta e\}} \frac{L_j}{4\gamma}\tau_l^2[c_{l,X}-c_e]^2 dG(u) - w_M,$$

where $w_M = \bar{U} - \frac{rb^2}{2}\sigma^2 - 0.5\theta e^2$. The firm now has the option to sell to the foreign market, hence the marginal benefit of incentives is higher, particularly for firms that have a higher probability of exporting $P(c_e \leq c_{l,X})$. Furthermore, when we move from autarky to trade, the intensity of competition in the domestic market is higher ($c_{l,D}$ lower), meaning that the least productive firms exit the market, i.e. those with $c_e > c_{l,D}$. In figure 7 we observe how a firm incentives scheme changes when going from autarky to trade. Opening up to trade has two effects on incentives. First, the possibility of selling goods abroad, and therefore expanding revenues, increases the marginal value of incentives. Second, the increase in domestic competition (lower c_D) reduces firm's revenues, and therefore reduces the marginal value of incentives. The first effect dominates for the most productive firms while the second effect dominates for the less productive firms as figure (7) shows.

For some range of c values a closed form solution for $b(c)$ can be found. For low values of marginal cost, this is for all c that satisfies $\frac{c_{l,X}-c}{c} > \kappa$ [20], the expected firm profit becomes:

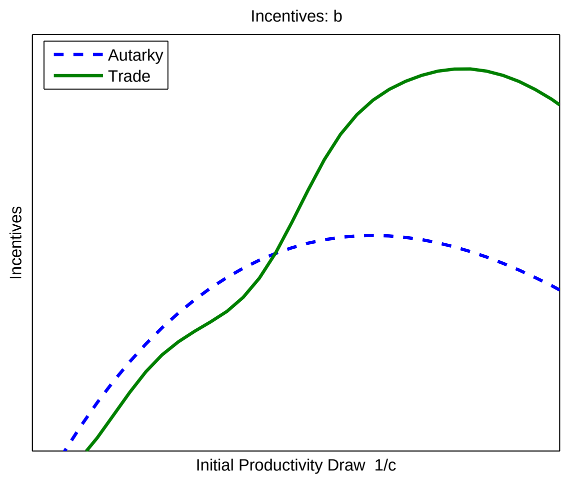
$$E_u[\quad \Pi(c_e) \quad] = E[\frac{L_l}{4\gamma}[c_{l,D} - c_e]^2] + E[\frac{L_j}{4\gamma}\tau_l^2[c_{l,X} - c_e]^2 - \hat{U} + \frac{rb^2}{2}\sigma^2 + 0.5\theta(e^2)$$

and we can find a closed form solution for $b^*(c)$

$$b^{*trade}(c) = \frac{\delta^2\theta[L_h(c_{l,D} - c) + L_f\tau_l^2(c_{l,X} - c)]}{[2\theta\gamma(\theta r\frac{\sigma^2}{c^2} + \delta^2) - L_h\delta^4c^2 - L_f\delta^4\tau^2c^2]} \tag{23}$$

For high values of marginal cost, i.e. $c \geq 2c_{l,X}$ [21] then $b^{*trade}(c)$ is equal to the incentives scheme of the closed economy case, the only difference is that the level of competition with trade is higher than in autarky ($c_{l,D} < c_D$).

Figure 7: Incentives and Trade



3.2 Equilibrium with Free Entry and Trade

Entry is unrestricted in both countries. Firms choose a production location prior to entry and paying the sunk cost f_E. In order to focus the analysis on the effect of trade liberalization episodes on firm incentives and firm productivity, we assume that countries have the same

[20] $c_{l,X}$ is the choke marginal cost to enter the foreign economy

[21] The general formula is that $c \geq \frac{c_{l,X}}{(1-e_{max})}$, but in our case $e_{max} = 0.5$

entry cost f_E and cost distribution $F(c)$. The zero cutoff profit condition implies that there exists a $\hat{c}_l$ where $l = \{H, F\}$ such that the expected profit of hiring a manager is equal to zero:

$$\hat{c}_l \epsilon E_u[\Pi(\hat{c}_l)] \quad = \quad 0 \iff \tag{24}$$

$$E[\pi_{l,D}(\hat{c}_l, b^*)|c_e \leq c_D]P(c_e \leq c_{l,D}) + E[\pi_{l,X}(\hat{c}_l, b^*)|c_e \leq c_{l,X})]P(c_e \leq c_{l,X}) - E[w_M] = 0$$

In the entry stage firms decide to enter the market until the value of entering the market equals the sunk cost f_E,

$$\int_{c_m}^{\hat{c}_l} E_u[\Pi(c)]dF(c) - f_E = 0 \tag{25}$$

we can thus solve for the cutoff in the two countries $c_{h,D}$ and $c_{f,D}$ as well the corresponding $\hat{c}_h(\overset{+}{c}_{h,D})$ and $\hat{c}_f(\overset{+}{c}_{f,D})$ since we have a system of four equations: one zero cutoff profit condition as in (24) and one free entry condition as in (25) for both countries home H and foreign F. In equilibrium the effect of market size and trade costs on the cutoffs is

$$c_{l,D} = f(\overset{-}{L}_l, \overset{+}{\tau}_l, \overset{+}{\tau}_j, \overset{-}{L}_j), \tag{26}$$

(see proof in Appendix) where L_l is the market size in the economy l and τ_l is the trade cost that economy l faces by the foreign economy j. Hence a reduction in export trade cost for the home economy (lower τ_l) leads to a higher level of competition in the domestic market, lower $c_{l,D}$.

We determine the number of firms selling in home market N_h using the threshold price equation (16). N_h is comprised of domestic producers and exporters. Given a positive mass of entrants N_E^l in both countries, there exists $F(c_{l,D})N_E^h$ domestic producers and $F(c_{f,X})N_E^f$ exporters selling at home, satisfying:

$$F(c_{l,D})N_E^h + F(c_{f,X})N_E^f = N^h \tag{27}$$

Thus, a trade equilibrium is a vector of wages $\{w_{p,l}\}$, a vector of marginal cost cutoffs $\{\hat{c}_l, c_{l,D}\}$, measure of entrants $\{N_D^l\}$, where $l = H$, F, such that (i) the zero profit condition and the free entry condition are satisfied; (ii) the measure of entrants in each country l satisfies equation (27) and (iii) wages are consistent with the labor market clearing condition:

$$N_E^h \int_{c_m}^{\hat{c}_l} p_{l,D}(c_e) q_{l,D}(c_e) F_{l,D}(c) \quad + N_E^f \int_{c_m}^{\hat{c}_l} p_{j,X}(c_e) q_{j,X}(c_e) F_{j,D}(c) + p_0 q_0 = \quad w_l L_l,$$

where $F_{l,D}(c) = \frac{kc^{k-1}}{\hat{c}_l{}^k - c_m^k}$ is the distribution of cost draws for the surviving firms.

4 Open Economy Analysis

The analysis of the impact of trade focuses on two effects, the impact of trade in the cutoff $c_{l,D}$, and the impact of trade on individual firm incentives and manager's level of effort, which ultimately determines the firm realized marginal cost c_e. The equilibrium cutoff c_D in autarky is less than the cutoff with trade $c_{l,D}$. This happens since the expected profits of entering the market increase with trade (25), which attracts more firms into the market making it more competitive than in autarky, resulting in $c_{l,D}^{trade} < c_D^{autarky}$, as seen in Figure 7. I proceed to analyze the incentives response to trade in different open economy scenarios[22]. Since the response of effort is proportional to incentives, effort is omitted in the graphical analysis.

4.1 Market size effects

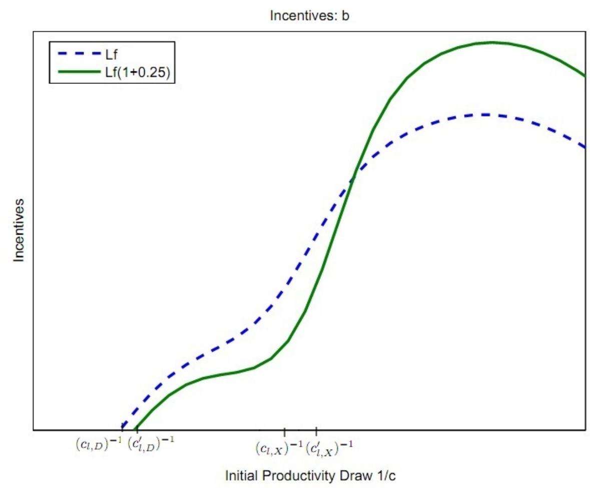
An increase in the foreign market size L_f, increases the provision of incentives for the most productive firms while decreases the provision of incentives for the less productive firms in the home market. The logic is as follows: on the export side a larger trading partner represents increased export market opportunities, inducing higher revenues for exporting firms. The higher the firm revenue, the greater is a firm's incentive to invest in cost reductions, and therefore the stronger incentives it provides to its manager. On the importer side, a larger trading partner represents higher level of import competition, domestic market share and thus revenue decreases, making it less appealing to invest in cost-reduction initiatives. There is a trade off between these two opposing effects in the home market; at the end the first effect dominates for the more productive firms, exporters, and the second effect dominates for the less productive firms, non-exporters.

In addition, the increase in market size in the foreign country leads to an increase in competition in the foreign market. Therefore, potential exporters find it harder to break

[22]The numerical simulations are based in the baseline parameters in Table 1 and are robust to other choice of the parameters' values.

into that market. This implies that the productivity cutoff to enter the export market in the new equilibrium $(c'_{l,X})^{-1}$ is higher than the previous productivity cutoff $(c_{l,X})^{-1}$ as depicted in Figure 8.

Figure 8: Increase in Foreign Market Size

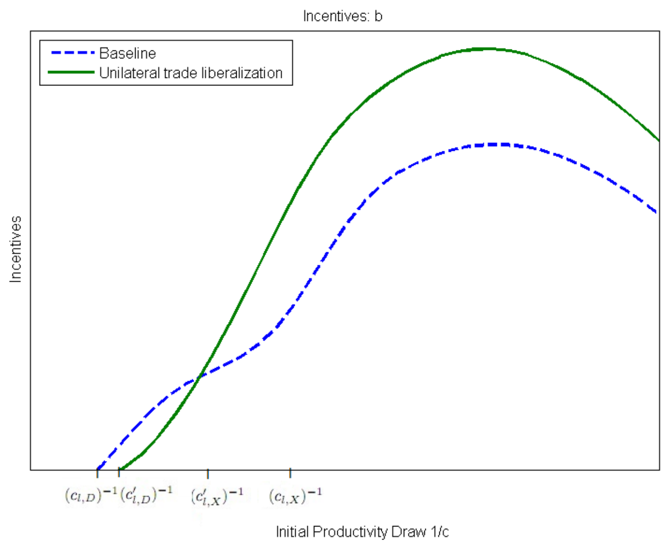


4.2 Unilateral trade liberalization

A unilateral trade barrier reduction by the foreign market (lower τ_h) leads to an increase in managerial incentives for firms in the middle-to-upper range of the productivity distribution while it leads to lower incentives for firms in the low range of the distribution for the home economy.

On one hand, a decrease in τ_h means that it is cheaper for domestic firms to enter the export market $(c'_{l,X})^{-1} \leq (c_{l,X})^{-1}$. Firms that were only producing for the domestic market start to export, while exporters expand their market share in the foreign country. This increase in revenue increases the marginal value of cost-reducing initiatives and leads to higher provision of managerial incentives and higher managerial effort. On the other hand, the level of competition at home increases $(c_{l,D})^{-1} \leq (c'_{l,D})^{-1}$. Lower export barriers imply that expected profits of entering the domestic market are higher (see equation 25), new firms enter the market increasing the level of domestic competition. As previously mentioned, a higher level of domestic competition decreases the domestic market share and thus revenues, lowering the value of cost-reducing initiatives. The first effect dominates for firms in the middle-to-upper range of the productivity distribution (exporters and high-productive non-exporters) while the second effect dominates for the low productive firms (non exporters). The effects are displayed in Figure 9.

Figure 9: Unilateral Trade Liberalization



4.3 Bilateral trade liberalization

When the reduction in tariffs is bilateral, firms in the middle-to-upper range of the productivity distribution[23] increase their provision of managerial incentives, while those in the low range lower them. For firms in the very top range of the distribution the effect is ambiguous.

Symmetric bilateral trade liberalization increases competition in both markets, thus lowers $c_{l.D}$ and $c_{f,D}$. The increase in domestic competition lowers domestic revenues. The lower a firm's revenues, the smaller is a firm's incentive to invest in cost-reductions initiatives, as managerial incentives. Since non-exporters' only revenue comes from the domestic market, non-exporting firms reduce their provision of incentives.

For exporters, there are two additional opposite effects. First, there is a scale effect: exporters expand their sales in the foreign market since exports become less costly ($\frac{\partial r_{l,X}}{\partial \tau_h} < 0$). The higher the revenue of a firm, the greater is a firm's incentives to invest in cost reductions,

[23]Exporters and high-productive non-exporters

and therefore the stronger incentives it provides. Second, there is a competition effect: higher competition in the foreign market, lower $c_{f,D}$, induces a reduction in foreign market revenues $\frac{\partial r_{l,X}}{\partial c_{f,D}} > 0$ which inclines the firm owner to switch to a lower-powered incentive scheme. The first effect dominates for firms in the middle range of the productivity distribution, while for the very top productive firms these two effects counterbalance each other leading to a neutral or negative effect on incentives[24] (see Figure 10).

The intuition behind this last result relies on the magnitude of the sensitivity of the firm's export revenue to a change in trade costs $\frac{\partial r_{l,X}}{\partial \tau_h} = -\frac{L_f}{2\gamma}\tau c_e^2$ relative to the sensitivity of firm's export revenues to change in foreign competition $\frac{\partial r_{l,X}}{\partial c_{f,D}} = \frac{L_f}{2\gamma}c_{f,D}$. The former is smaller the lower the firm's realized marginal cost c_e, whereas the latter is independent of the firm's marginal cost. Thus, for firms at the middle of the productivity distribution (relatively low productive exporters), the scale effect dominates, implying a higher increase in firm's revenue given a decrease in trade cost. For firms at the top, these two effects balance each other out, leading to neutral or negative change in firm's revenue.

Figure 10 shows the effect of a symmetric bilateral trade liberalization on incentives. The effect for the low productive firms is negative, for the middle firms is positive, and for the high productive firms in almost neutral. Figure 11 shows the effect of asymmetric trade liberalization where the reduction in export trade costs was twice the reduction in import trade costs, as we have seen for the U.S. in the period of analysis 1993-2005. In this case, trade liberalization induces high-powered incentive schemes for both medium to high productive firms, but the effect is stronger for the medium productive firms.

4.4 Decomposing Aggregate Productivity

The expected aggregate productivity is decomposed into two components, the within-firm and between-firm component. The within-firm component captures the contribution of firm productivity improvements from managerial incentives and effort to aggregate productivity growth. The between-firm component, captures the selection effect and market share reallocation from less efficient firms to more efficient firms. We use expected average cost as a proxy for average industry efficiency. The unweighted average firm marginal cost is,

[24]Depending on the sensitivity of the response of the production cutoff $c_{f,D}$ with a decrease in trade costs.

Figure 10: Symmetric Bilateral Trade Liberalization $\Delta\tau_h = \Delta\tau_f$

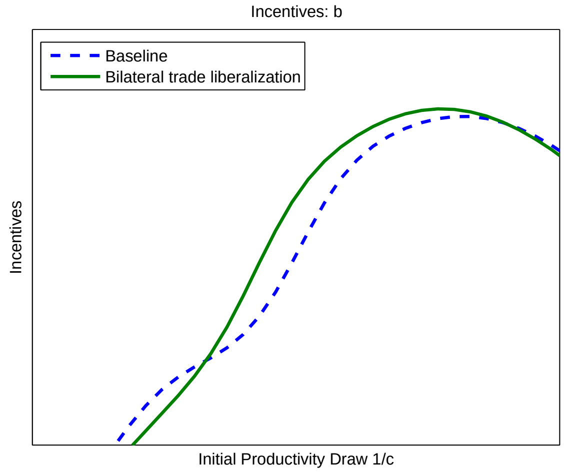
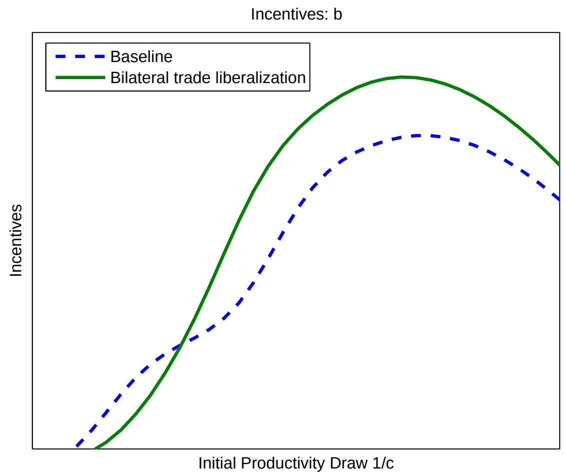


Figure 11: Asymmetric Bilateral Trade Liberalization $\Delta\tau_h = 2\Delta\tau_f$



Where $\Delta\tau_h$ is the change that in trade cost that the home country faces in the foreign economy and $\Delta\tau_f$ is the change in trade cost that the home country impose to goods coming from abroad.

$$\overline{c_e} = \int_{c_m}^{\hat{c}_l} E[c_e] dF_D(c) = \underbrace{\int_{c_m}^{\hat{c}_l} c dF_D(c)}_{Between} - \underbrace{\int_{c_m}^{\hat{c}_l} \delta e(c) c F_D(c)}_{Within}, \tag{28}$$

where the distribution of cost draws for the surviving firms is given by $F_D(c) = \frac{kc^{k-1}}{\hat{c}^k - c_m^k}$. Given this decomposition, we can analyze the competitive effects of market size and trade liberalization on aggregate industry productivity. We argue that an increase in market size L or a reduction in trade costs τ_l leads to a decrease in aggregate marginal costs (or a proportional increase in aggregate productivity). By pure selection effect (between-firm component) the increase in competition (lower c_D and $\hat{c}$) implies that the less productive firms exit the market making aggregate productivity greater than before. In addition, as previously mentioned, an increase in market size or a reduction in trade cost induces the more productive firms to provide stronger incentives to their managers. This increases managerial effort and thus increases the expected firm productivity[25].

I provide a numerical decomposition of the aggregate industry cost where the weight for each firm is given by its market share $\frac{q(c_e)}{Q}$. Table2 shows the decomposition of the aggregate industry cost for different levels of market size using our baseline parameters from Table 1. The results from Table 2 support our previous claim, that the aggregate industry cost of the economy decreases with market size. Moreover, we observe that the relative importance of the within-firm component increases with the level of market size, while the opposite holds for the between-firm component. This result is consistent with empirical estimations of aggregate productivity changes (see Melitz and Polanec, 2012) in which the within component becomes more important than the between component.

Finally in Table 3 we present the results when the source of change in the competitive environment is (i) a bilateral reduction of 10% in trade cost (ii) a unilateral reduction of 10% in export trade cost (τ_h) and (iii) an increase of 25% in foreign market size. Furthermore, in the next section (particularly in 5.4) we provide empirical estimates of the importance of the managerial incentive channel in explaining within-firm productivity growth.

[25]The opposite holds for the less productive firms. The increase in productivity by the more productive firms outweighs the decrease in productivity by the less productive firms. Hence the result is within-firm component increase due to an increase in the market size.

Table 2: Aggregate Cost Change Relative to L=20

L	%△Between[26]	%△Within		%△c_e
20	0	0		0
25	-5.91%	-1.97%	=	-7.88%
30	-11.8%	-3.74	=	-15.58%
35	-15.7%	-5.32%	=	-21.1%

Table 2 shows the decomposition of the percentage change in the aggregate cost relative to the baseline case ($L = 20$).

Table 3: Aggregate Cost Change in the Open Economy case

	%△Between	%△Within	%△c_e
$\%\triangle\tau_f = \%\triangle\tau_h = -10\%$	-4.09%	-0.31%	-4.4%
$\%\triangle\tau_h = -10\%$	-7.38%	-0.82%	-8.2%
$\%\triangle L_f = 25\%$	-4.42%	-2.12%	-6.54%

Table 3 shows the decomposition of the percentage change in the aggregate cost given three scenarios. In the first row, both imports and export tariffs decrease. Leading to a decrease in aggregate cost of 4.4%, around 7% on this decrease in aggregate cost is attributed to within-firm growth through managerial Incentives. In the second row, only export tariffs decrease, leading to a decrease in the aggregate cost of 8.2%, around 10% of this decrease in the aggregate cost is attributed to within-firm productivity changes through managerial incentives.

5 Empirical Analysis

In this section I examine (i) the effect of tariff reduction on managerial incentives and (ii) the importance of the managerial incentives channel on aggregate productivity growth. I use two types of data: Firm level data from Compustat and CRSP from 1993-2005[27], and tariff data from UNCTAD TRAINS data set.

5.1 Data Description

5.1.1 Managerial Incentives Measure

Managerial incentives are measured by total equity incentives (incentives in the form of stocks and options). Those are the main part of CEO compensation and dominate other forms like salary, bonus, and other short and long term payouts. To compute equity incentives I use the approach of Core and Guay (1999, 2002), who measure the dollar change (in millions) in CEO compensation if the stock price increases by one percent. The worth of a CEO holding

[27] To be included in the sample, data must be complete across Annual Industrial, Execucomp and Segments database in Compustat and CRSP

of stock options is approximated with the number of exercisable and unexercisable options reported for each CEO in a given year. Then, following Core and Guay (2002) I measure the option value using the modified Black-Scholes option pricing formula. As seen in Table 4, a one percent increase in the firm stock price results in a mean increase in CEO's wealth of $570,000, while the median increase is $200,000. The distribution of the CEO delta is heavily skewed to the right; log-transforming this variable corrects this skewness. Hence, I use log delta as the measure of incentives in the regression analysis.

5.1.2 Trade Liberalization Measures

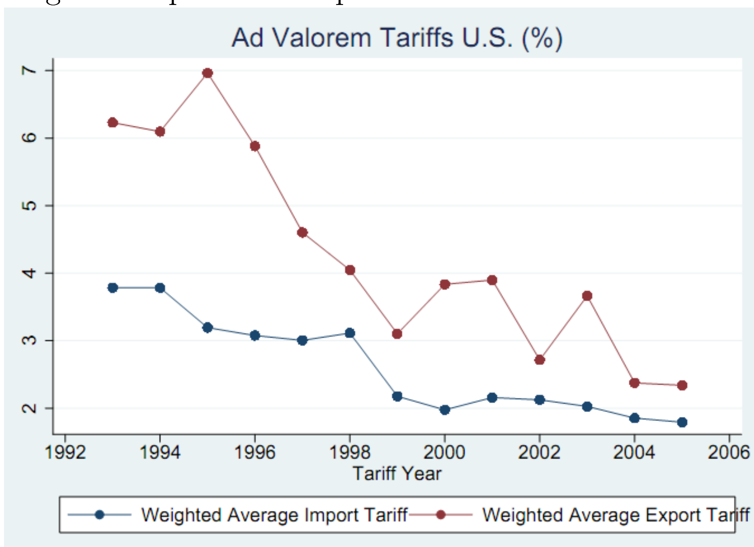
To control for trade liberalization I use export tariffs and import tariffs. Export tariffs are those imposed on the U.S. by the rest of the world[28] measured both at the 4-digit SIC industry level and at the firm level. Import tariffs are those imposed by the U.S. on the rest of the world, also measured at the industry and firm level. At the industry level export tariffs are constructed as a weighted average of export tariffs imposed by U.S. main trading partners, where the weights are based on U.S. export share to each country in a given industry for our base year 1993. At the firm level, export tariffs are a weighted average of tariffs in every industry in which the firm operates (firms declared their segments in Compustat segment data). The weights are given by the fraction of total sales associated with each 4-digit SIC in the the base year. Import tariffs are constructed the same way as export tariffs. To avoid endogeneity concerns regarding the variation in weights over time, we use weights in a base year, 1993. In addition to export tariffs, exchange rates are used as a measure of exposure to trade. The exchange rate index at the 4-digit industry level, is defined as the weighted average of the real effective exchange rate (taken from IFS-IMF). The weights are the exports to each trading partner as a share of total U.S. exports in a given industry for the base year 1993. The identification strategy relies on the fact that there is enough variation in tariffs and exchanges rates across industries, firms and years, and that tariffs and exchange rates are arguably exogenous to executive compensation.

Figure 12, shows the variation in average tariffs per year. In the period analyzed, there is a higher variation in export tariffs than in import tariffs. This can be attributed in part to the fact that in 1993 (pre-NAFTA) U.S. tariffs to Mexico where around 2.1% while Mexican duties imposed on the U.S. were 12%. Table 11 reports the average tariff across two-digit SIC industries over the 1993-2005 period. Ad-valorem tariffs vary substantially across industries,

[28] I define the rest of the world as the top 10 main trading partners of the U.S. which represents over 80% of the total U.S. imports and exports.

are higher in labor-intensive goods (as apparel and leather), and lower in capital intensive goods (as petroleum and paper). Over time tariffs decline for all industries, although the pace of decline varies significatively across industries.

Figure 12: Weighted Import and Export Tariff for the United States 1993-2005



5.1.3 Productivity Measure

To measure firm-level productivity we estimate TFP (total factor productivity). We log the Cobb-Douglas production function $Y_{it} = AL_{it}^{\beta_l} K_{it}^{\beta_j} M_{it}^{\beta_m}$ and obtain

$$y_{it} = \beta_o + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \omega_{it} + \epsilon_{it}, \tag{29}$$

all the variables in minuscules are in natural logs, y_{it} is the sales of firm i in period t deflated by the industry-level producer price index, l_{it} is the employment level, k_{it} is the capital stock[29] deflated by the non-residential private fixed investment, and m_{it} is the expenditure in materials deflated by the material cost deflator[30]. I use Olley-Pakes methodology to estimate equation (29). This procedure controls for the sample selection bias and the simultaneity bias between variable inputs and productivity shocks. I obtain separately the coefficients

[29] Measured as the gross property plant and equipment. As a robustness check we also use the perpetual inventory method to produce an estimate of the stock of fixed capital/assets in existence and in the hands of the firms by estimating how many of the fixed assets installed as a results of gross fixed capital formation undertaken in previous years have survive to the current period. To calculate this, we use gross property plant and equipment, depreciation and capital expenditures measures. See http://faculty.apec.umn.edu/rsmith/documents/CreateCapitalStock.pdf for more details.

[30] All the deflators are taken from the NBER-CES Manufacturing Industry Database

of equation (29) for firms in each 2-digit SIC industry. Using these estimates, I follow Pavcnik (2002) in constructing a firm-level productivity index that is transitive (to be able to compare productivity measures across firms in different industries) and insensitive to the units of measurement. I obtain such an index by subtracting from an individual firm's productivity the productivity of a reference plant in a base year,

$$logprod_{it} = logtfp_{it} - logtfp_{92,I},$$

where $logtfp_{it} = y_{it} - \hat{\beta}_l l_{it} + \hat{\beta}_k k_{it} + \hat{\beta_m} m_{it}$ and $logtfp_{92,I}$ is the productivity of a reference firm[31] for industry I (industry where firm i produces). Since we want to use the square of productivity in our regression, and *logprod* is negative for some firm's value, we normalized $logprod_{it}$ by adding a constant so all of its value are positive, the normalized variable is tfp_{it}. Table (4) provides descriptive statistics for this index.

Table 4: Descriptive Statistics (1993-2005)

	Obs	Mean	S.D.	0.25	0.50	0.75	Max
Firm Characteristics							
Productivity Index (*logprod*)	7685	0.32	0.87	-0.11	0.15	0.47	5.38
Assets ($M)	7685	4803.92	17798.8	348.39	862.7	3087.57	50014
Sales ($M)	7685	4190.73	12942.1	345.12	901.8	3081.14	50100
Market Capitalization ($M)	7685	5483	18255	373	976	3148	344490
hindex4	7685	0.47	0.27	0.25	0.36	0.61	1
R&D/K	7685	0.22	0.78	0.01	0.09	0.22	28.18
Productivity Index (tfp)[32]	7685	5.32	0.87	5.04	5.15	5.47	10.38
CEO Characteristics							
Tenure	7687	7.04	6.44	3	5	9	50
Delta ($M)	7687	0.57	1.18	0.08	0.20	0.5	16.93
Holdings (%)	7681	2.78	6.13	0.07	0.30	2.11	33.26
Cash Compensation($M)	7687	1.19	1.03	0.54	0.86	1.5	16.01

5.2 Incentives and Productivity

In this section I examine the non-monotonic relationship between incentives and firm's productivity as indicated by the model and shown in figure 2. To determine the relationship between incentives and firm's productivity , I define the following specification,

[31]Reference firm is the firm with the mean output and mean input in year 1993, $logtfp_{92,I} = \bar{y_{it}} - \hat{\beta}_l \bar{l_{it}} + \hat{\beta}_k \bar{k_{it}} + \hat{\beta_m} \bar{m_{it}}$, where the bar over the variable represents a mean over all firms in industry for year 1993.

$$Incentives_{ijkt} = \beta_0 + \beta_1 tfp_{jt-2} + \beta_2 tfp_{jt-2}^2 + \gamma_1 Z_{jt} + \gamma_2 Z_{kt} + \delta_k + \delta_t + \delta_i + \epsilon_{ijkt} \quad (30)$$

where $Incentives_{ijkt}$ represent the incentives for the CEO i , working at firm j in industry k at time t. Lag productivity is used as a proxy for the firm productivity draw. The squared term on lag productivity is included to test for the non-linearity between incentives and firm's initial productivity displayed in figure **2**.[33] To avoid endogeneity problems between incentives and productivity I include two-lags of productivity and estimate equation (30) using difference-GMM. Industry level controls Z_{kt} are defined as follows. Industry entry cost is the level of entry costs in a 4-digit SIC industry given by the natural log of the weighted average of the 'gross value of cost of property, plant and equipment', weighted by each firm's market share in the industry. Industry market size, is the level of market size in an industry, given by the natural log of sales by four-digit SIC code. Industry mark-up, is the weighted average of firm's sales divided by firm's cost of goods sold, weighted by firm's market share. I also control for industry fixed effects δ_k, year fixed effects δ_t, and finally executive fixed effects δ_i.

I estimate specification (30) using two methods: OLS and Difference-GMM. For the latter method I estimate equation (30) with one-lag for productivity instead of two lags in order to solve for potential endogeneity of lag productivity and incentives. The Arellano and Bond (1991) Difference-GMM procedure transforms the regression (30) by taking the first difference to eliminate all observables and unobservables that do not vary over time. Then it instruments the endogenous variables in first differences with its past levels and past level of other covariates. In that sense lag-productivity is instrumented with lag values of incentives in addition to lag values of the explanatory variables. Unlike instrumental variables approach, difference-GMM does not require strict exogeneity of instruments, instruments need only be predetermined or weakly exogenous[34].

Results are in Table 5. Column 1 in table 5 shows a non-monotonic relationship between lag productivity and incentives. The coefficient on lag productivity is positive suggesting a monotone relationship, while the coefficient of lag productivity square is negative suggesting a non-monotonic relationship for high values of lag productivity. This is consistent with the model prediction (see figure 2). In addition, in Column 2 the non-monotonic relationship

[33] We also test for cubic term but find no significance. We also use one-lag productivity instead of two-lags and the results do not vary significatively.

[34] The Arellano and Bond estimator was designed for small time period and large panels, as in our case.

still holds even when controlling for industry factors. It is also observed that an increase in market size or a decrease in industry entry cost both raise managerial incentives; this is consistent with the model and with previous literature (Raith, 2003; Karuna 2007). Column 4 reports the estimates of the difference-GMM methodology. The set of instruments used for productivity are lagged value of firm's assets, firm's employment, cash compensation, stock prices and incentives. The Arellano-Bond two step estimator yields a lagged productivity value of 0.61 and a lagged productivity square value of -0.043, both significant. The standard errors in parenthesis are the Windmeijer (2005) robust standard errors. The validity of the instruments and of the specification can be assessed by looking at two tests. The Arellano-Bond test fails to reject the null of no second-order autocorrelation, and the two-step Sargan test for over-identification fails to reject the null that the instruments as a group are exogenous. Thus the proposed specification and instruments are validated.

5.3 Trade Liberalization and Incentives

In this section I examine the impact of tariff reduction on incentives. In turn, I use these estimates in the next section 5.4 in order to analyze the importance of the managerial incentives channel for aggregate productivity growth.

To examine the prediction of the model regarding trade liberalization and incentives in section 4.3, I specify the following equation:

$$\begin{aligned} Incentives_{ijkt} &= \beta_0 + \beta_1 \tau^x_{jt} + \beta_2 \tau^x_{jt}.tfp_{t-2} + \beta_3 \tau^x_{jt}.tfp^2_{t-2} + \beta_4 tfp_{t-2} + \beta_5 tfp^2_{t-2} + \\ & + \gamma_1 Z_{jt} + \delta_k + \delta_t + \delta_i + \epsilon_{ijkt} \end{aligned} \tag{31}$$

where τ^x_{jt} are export tariffs imposed to the US by its main exporting partners (as described in section 5.1.2). The model indicates that the impact of a reduction in trade cost on incentives is larger for firms in the middle of the productivity distribution than for firms at the top of the distribution, while the effect for firms at the bottom of the distribution is negative. To examines this, we interact export tariffs with firm lag productivity and firm lag productivity squared. A negative and significant coefficient of the interaction term β_2 implies that given a reduction in trade cost, more productive firms provide higher incentives than less productive firms. A positive and significant coefficient of the interaction term β_3 means that this effect weakens for firms in the top tier of the productivity distribution. Thus firms at the middle are the ones providing the highest incentives. As in equation (30), in equation (31) I include firm/CEO level controls like assets, market capitalization, CEO cash compensation and industry, year and executive fixed effects.

Results are reported in Table 6. Column 1 shows the estimates of incentives as a function of export tariffs. This suggest that a fall of export tariffs of 10% increase incentives by 4.2%, resulting in a mean increase in CEO delta of $23,940. To see if the decrease in export tariffs affects firms differently- depending on firm's initial productivity -we take a look at the signs of the interaction terms β_2 and β_3 in equation (31). The marginal effect on incentives given a change in tariffs is $\frac{\partial Incentives}{\partial \tau^x} = \beta_1 + \beta_2 tfp_{t-2} + \beta_3 tfp_{t-2}^2$. Column 2 indicates that β_2 is negative and significant, while β_3 is positive and significant, suggesting that firms in the middle of the productivity distribution are the ones providing higher incentives. Column 3 includes firm controls in the estimation. The interaction coefficients β_2 and β_3 keep their signs and are still significant. Given the coefficients in column 3 we compute $\frac{\partial Incentives}{\partial \tau^x}$ for different productivity percentiles, these estimates are shown in figure 15. It follows that firms between the 35th-85th percentile of the productivity distribution (productivity index tfp_{jt} between 5 and 5.5), are the ones that provide stronger incentives to their managers given a reduction in tariffs, while firms below the 10th percentile (firms with productivity index below 4.3) provide weaker managerial incentives given a reduction of tariffs, consistent with our theoretical predictions.

I also estimate regression (31) using import tariffs τ^m . The hypothesis is that the sole reduction in import tariffs, generates higher competition in the domestic industry (without any gains from exporting), which weakens the provision of incentives across all firms. Firms lose market share both in the domestic and foreign market since the foreign market also becomes more competitive. Using the coefficients in columns 6 to compute the elasticity of incentives with respect to import tariffs we find that an import tariff reduction decreases incentives for all values of firm productivity ($\frac{\partial Incentives}{\partial \tau^m} > 0$) .

One caveat of the data is that the variation in import and export tariffs is highly correlated for this time period[35], as seen in figure 12. Thus, independent estimates of import tariffs would be imprecise and might capture some export tariff variations, and vice versa. When both import and export tariffs are included (in column 4 and 7) only the coefficient on export tariffs, and the interaction of export tariffs with productivity are significant, while the coefficient of import tariffs and its interaction are insignificant. This analysis shows that there is a substantial influence of export tariffs on managerial incentives.

As a robustness check, I estimate equation (31) using value added per worker and real

[35]A simple OLS regression between log of export tariffs and log of import tariffs leads to a coefficient of 0.74, significant at the 1% level

output as alternative measures for firm productivity tfp. Results are shown in table 8. The coefficient on β_1 is significant and positive while that on β_2 is significant and negative, meaning that a reduction in export tariffs affects positively incentives only for firms above certain level of value added per worker, or above a certain level of real output. In addition, as an alternative measure of openness to trade, we present estimates of the effect of a decrease in real exchange rate on firm's incentives. Results are presented in table 7. In column 2, the positive coefficient on exchange rate and the negative coefficient on the exchange rate interacted with lag productivity suggests that a dollar devaluation decrease incentives for low productive firms, while it increases incentives for high productive firms. The positive coefficient on the exchange rate interacted with the squared of lag productivity implies that firms in the middle of the productivity distribution are the ones experiencing stronger increase in incentives as a results of a dollar devaluation, as previously suggested.

Table 5: Incentives and Productivity

Dependent Variable: Log(Incentives)	(1)	(2) Fixed Effects	(3)	(4) Difference-GMM
Lag Productivity	0.836***	0.906***	0.821***	0.614**
	(0.246)	(0.269)	(0.246)	(0.261)
Lag Productivity^2	-0.071***	-0.069***	-0.070***	-0.043**
	(0.021)	(0.023)	(0.021)	(0.021)
Segment Entry Cost		-0.194**	-0.171**	
		(0.088)	(0.081)	
Segment Sale		0.252*	0.076	
		(0.135)	(0.116)	
Segment Mark-up		0.102*	0.075	
		(0.052)	(0.047)	
Assets	0.087		0.095	1.27***
	(0.064)		(0.064)	(0.312)
Market Capitalization	0.343***		0.342***	-0.14
	(0.041)		(0.041)	(0.097)
Cash Compensation	0.206**		0.202**	1.378***
	(0.093)		(0.091)	(0.143)
Year fixed effects	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	
Executive fixed effects	yes	yes	yes	
Observations	7258	7307	7257	6133
R2-Adjusted	0.816	0.797	0.816	0.816
Arellano-Bond test for AR(2) p-value				0.160
Hansen J Statistic p-value				0.319

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Robust standard errors corrected for clustering at the firm level are in parentheses. Log(Incentives)=natural log of the sensitivity of the total value of stock and options held by the CEO to a 1% change in stock price. Lag(Productivity) = 2-Lag value of the Productivity Index. Segment Entry Cost= level of entry costs in industry, is the natural log of weighted average of gross value of cost of property, plant and equipment for firms in industry, weighted by each firm's market share in industry. Segment Sale = level of market size in industry, natural log of sales by four-digit SIC code. Segment Mark-up: Average across all firms in the 4-digit SIC industry, of firm's sales divided by firm's cost of goods sold. Assets= Log of firm's total assets. Market Capitalization= Lag value of log of firm's market capitalization. Cash compensation = Log of total compensation for the executive (TDC1 in Execucomp) including salary, bonus, Other annual, etc. Difference-GMM estimation reports Windmeijer (2005) robust standard errors at the firm level. Instruments are lagged values of the explanatory variables and log incentives, log of sales, log of employment, stock price, 2-digit SIC code and year fixed effects. The Arellano-Bond test for AR(2) is a test of lack of serial correlation of order 2 in the error term. A p-value less than 0.10 rejects the validity of the instruments.

5.4 Incentives and Aggregate Productivity Growth

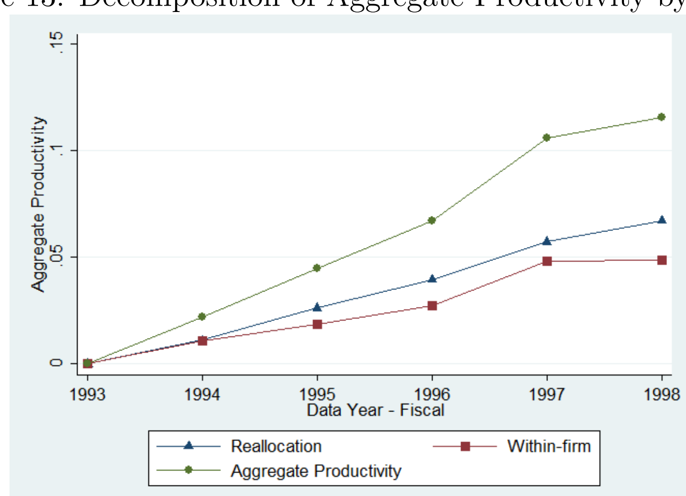
In this section we measure the importance of the managerial incentives on the aggregate productivity growth. In order to do this, first we calculate the aggregate productivity growth of the sample. Following Olley and Pakes (1996) I decomposed the aggregate productivity in two components, the reallocation component and the within-firm component:

$$TFP_t = \sum_i s_{it}\varphi_{it} = \bar{\varphi}_t + \sum_i (s_{it} - \bar{s}_t)(\varphi_{it} - \bar{\varphi}_t), \tag{32}$$

where $\bar{s}_{it}$ and $\bar{\varphi}_{it}$ represent the unweighted average share of output and the unweighted average productivity respectively. The reallocation component is measured by the covariance between productivity and output. The larger this covariance, the higher is the share of sales that goes to more productive firms. The within-firm component is measured by the unweighted average of firm productivity.

Figure **13** shows the aggregate productivity growth from 1993-1998 with its two components given by equation (32), and normalized by the base year 1993. I focus on the period 1993-1998 to estimate the effect of a reduction in tariffs on productivity growth through managerial incentives. This is a period of significant tariff variations for the U.S, it includes NAFTA and the 1995 Uruguay Round. Over this period aggregate productivity has increased 11.1% in total: 6.1% due to reallocation of resources from the less to more efficient producers and 5% due to increased productivity within plants.

Figure 13: Decomposition of Aggregate Productivity by Year



I use the coefficients in table 6 (Column 3 and 7) to estimate, for each firm in the

Table 6: Incentives and Tariffs

Dependent Variable: Log(Incentives)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Export Tariff	-0.421***	2.393**	1.694*	-0.386***			2.661**
	(0.0950)	(1.103)	(0.978)	(0.105)			(1.065)
Export Tariff* Lag Productivity		-0.906**	-0.631*				-1.003***
		(0.369)	(0.325)				(0.364)
Export Tariff* Lag Productivity^2		0.082***	0.057**				0.090***
		(0.031)	(0.027)				(0.031)
Import Tariff				-0.050	2.155*	1.889*	-0.403
				(0.098)	(1.268)	(1.127)	(1.187)
Import Tariff* Lag Productivity					-0.814*	-0.712*	0.151
					(0.450)	(0.385)	(0.432)
Import Tariff* Lag Productivity^2					0.076*	0.068**	-0.013
					(0.042)	(0.035)	(0.040)
Lag Productivity		1.605***	1.231***		1.185***	0.985**	1.616***
		(0.484)	(0.446)		(0.454)	(0.415)	(0.310)
Lag Productivity^2		-0.124***	-0.103***		-0.089**	-0.084***	-0.125***
		(0.037)	(0.034)		(0.035)	(0.032)	(0.024)
Assets			0.101			0.010*	
			(0.065)			(0.065)	
Market Capitalization			0.355***			0.357***	
			(0.045)			(0.045)	
Cash compensation			0.032			0.032	
			(0.026)			(0.025)	
Year fixed effects	yes	yes	yes	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes	yes	yes	yes
Executive fixed effects		yes	yes		yes	yes	yes
Observations	7244	6455	6412	7244	6455	6412	6455
R2-Adjusted	0.08	0.801	0.820	0.084	0.800	0.820	0.801

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Robust standard errors corrected for clustering at the firm level are in parentheses sample[36], the percentage increase in incentives (CEO delta) given the average reduction in export tariffs of 0.43 log points (from 6.2% in 1993 to 4% in 1998). That is, we use the coefficients of table 6 to estimate

$$\%\Delta Delta = \underbrace{(\beta_1 + \beta_2 tfp_{93} + \beta_3 tfp_{93}^2)}_{\varepsilon_{delta,\tau}}.\%\Delta\tau$$

Once this is obtained we use Bulan, Sanyal and Yan (2007) estimates of the elasticity of productivity with respect to CEO delta[37], to estimate each firm's productivity response ($\%\Delta pr_i = \varepsilon_{tfp,delta}.\%\Delta Delta$) to the percentage change in incentives already computed in the previous step. See results in table 9. Given this, we construct the counter-factual productivity of the firm, $\tilde{\varphi}_i = \varphi_{i,93}(1 + \frac{\%\Delta pr_i}{100})$. The measure $\tilde{\varphi}_i$ is the firm productivity in 1993 plus the within-firm productivity growth resulting from the changes in incentives by virtue of a decrease in tariffs. Given $\tilde{\varphi}_i$ we can compute the following statistic,

$$\lambda_{tfp} = \frac{(\sum_i s_{i93}\tilde{\varphi}_i - TFP_{93})/TFP_{93}}{(TFP_{98} - TFP_{93})/TFP_{93}}.100$$

where λ_{tfp} represents the importance (in percentage terms) of managerial incentives on aggregate TFP growth in the period analyzed. λ_{tfp} varies from 5.9% to 7.63%[38] depending on the coefficients used for the elasticity of productivity with respect to CEO delta ($\varepsilon_{tfp,delta}$), and the coefficients (β_1,β_2, β_3)from table 6. Furthermore, I proceed in a similar fashion to measure the importance of managerial incentives on the within-firm component λ_{within}. The estimates suggest that managerial incentives explain between 13% and 16.8% of the within-firm productivity growth over the period of analysis. Note that these estimates may understate the contribution of the managerial incentives channel if we also account for the response of incentives to changes in exchange rates, dismantling of non-tariff barriers, or increase in foreign demand for domestic goods. Hence these estimate can be considered as a lower bound of the overall effect of incentives on productivity gains from trade.

In addition, as a robustness check, I produce my own estimates of the elasticity of firm productivity with respect to CEO delta, using lagged tariffs as an instrument for CEO delta (see appendix for details). The estimated elasticities are shown in table 10, and are similar

[36]The sample includes those firms that operated during the entire 1993-1998 period.

[37]Bulan, Sanyal and Yan (2007) in table 5, column 3, shows us an elasticity of 0.060, for delta less than \$2.26M (95th percentile) and an elasticity of 0.043 for delta less than \$3.34M (97th percentile).

[38]Using the coefficients of Table 6 column 7, and the $\varepsilon_{tfp,delta} = 0.06$ we obtain a λ of 7.63; with a $\varepsilon_{tfp,delta} = 0.043$ we obtain a λ of 7%. Using the coefficients on column 3, I obtain a λ of 6.1% with $\varepsilon_{tfp,delta} = 0.06$ and a λ of 5.9% with $\varepsilon_{tfp,delta} = 0.043$

to previous estimates of Bulan, Sanyal and Yan (2007). I re-estimate the λ_{tfp} with these elasticities and found that λ_{tfp} ranges from 5.81% to 7.11%, consistent with the above results.

6 Conclusions

Recent studies in trade support the role of trade liberalization in increasing productivity. The precise mechanisms by which trade triggers firm productivity improvements, however, still need to be analyzed and measured. In this paper, I study a novel mechanism, managerial incentives, as the link between trade and firm productivity gains. I introduce a principal-agent incentive problem in a trade model with monopolistic competition and heterogeneous firms in which trade-induced incentives become the driver of productivity gains from trade. In this environment, as trade liberalizes, firm owners reshape incentive schemes offered to their managers while managers respond by changing their effort to reduce marginal costs.

I show that the level of managerial incentives depends on the firm's initial productivity, the level of competition in the domestic economy, the level of competition in the foreign economy, market size, and trade costs.

The model predicts that the effect of trade liberalization on managerial incentives is heterogeneous across firms and depends on how each firm's expected revenue responds to the degree of trade exposure. In particular, a bilateral reduction in trade costs induces stronger managerial incentives for firms in the middle-to-upper range of the firm productivity distribution, while it induces weaker incentives for firms in the lower range of the distribution. Managers that receive higher incentives exert higher effort, increasing the firm's expected final productivity. This implies that trade liberalization, in the form of lower trade costs, generates productivity gains for middle-to-high productive firms and productivity loses for low productive firms. The aggregate productivity effect depends on the shape of the initial marginal cost distribution F.

An empirical examination of the model, shows that the effect of a reduction in tariffs on managerial incentives (measured as the CEO delta) is positive and stronger for firms in the middle of the productivity distribution than for firms at the top, while for firms at the bottom the effect is negative, consistent with the model's predictions. At the aggregate level, I find that trade-induced managerial incentives explain between 13% and 16% of the within-firm productivity growth in the U.S. manufacturing sector over the period 1993-1998, and between 5% and 8% of the aggregate productivity growth over this period.

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Appendix

Proof of equation 5

Manager’s accept any contract (s, b) with an expected utility of at least his reservation utility, which is the utility of the production worker $-exp^{-r(w_p+Z)}$. Hence the participation constraint of the manager is given by

$$E_u[-exp^{-r(w_M-\psi(e)+Z)}] \quad \geq \quad -exp^{-r(w_p+Z)}$$

Following Chalioti (2014), if the agent has CARA preferences towards risk, linear contracts are used, and the random term follows a truncated normal distribution symmetric around the mean, can be re-write the above inequality as:

$$\begin{aligned}
-exp^{-r(s+b(c_D-che)-\psi(e)+Z)}E[exp^{-rbcu_i}|u_i\epsilon[-\kappa,\kappa]] &\geq -exp^{-r(w_p+Z)}\\
-exp^{-r(s+b(c_D-che)-\psi(e)+Z)}exp^{\frac{r^2b^2\sigma^2}{2}}\quad\Omega_i &\geq -exp^{-r(w_p+Z)}\\
exp^{-r(s+b(c_D-che)-\psi(e))}exp^{\frac{r^2b^2\sigma^2}{2}}\quad\Omega_i &\leq exp^{-r(w_p)}\\
r(s+b(c_D-che)-\psi(e))+\frac{r^2b^2\sigma^2}{2} &\geq r(w_p)-\Omega_i\\
E[w_M]-\frac{r}{2}Var[w_M]-\psi(e) &\geq w_p-\frac{\Omega_i}{r}
\end{aligned}$$

where $\Omega_i = \frac{\Phi(\frac{\kappa+\sigma^2 rbc}{\sigma})-\Phi(\frac{-\kappa-\sigma^2 rbc}{\sigma})}{\Phi(\frac{\kappa}{\sigma})-\Phi(\frac{-\kappa}{\sigma})}$.

Proof of Lemma 1:

Using assumption (A3) the $min\{\kappa, \frac{c_D-c[1-he]}{c}\}=\kappa$. Then firm expected net profit (6) is:

$$\frac{L}{4\gamma}[c_D^2-2c_DE(c_e)+E(c_e^2)]-\bar{U}-\frac{b^2}{2\theta}[h^2c^2+\theta r\sigma^2]-cbE(u_i)$$

Taking expectations over u_i :

$$\frac{L}{4\gamma}[c_D^2-2c_Dc(1-he)+c^2(1-2he+h^2e^2+\sigma^2)]-\bar{U}-\frac{b^2}{2\theta}[h^2c^2+\theta r\sigma^2]$$

Given (4) and under assumption (A2), this expression is strictly concave in b. Each firm maximizes the previous expression with respect to b, which leads to:

$$b^*(c)=\frac{Lh^2(c_D-c)}{(\theta r\frac{\sigma^2}{c^2}+h^2)2\gamma-\frac{Lh^4c^2}{\theta}} \tag{33}$$

Proof of non-monotonicity of $b(c)$ with respect to initial productivity draw c:

$$\begin{aligned}
\frac{\partial b}{\partial c} &> 0 \iff 2c_D > 4c^2h^2(c_D-c)(\gamma-Lh^2c^2)+3c\\
\frac{\partial b}{\partial c} &< 0 \iff 2c_D < 4c^2h^2(c_D-c)(\gamma-Lh^2c^2)+3c
\end{aligned} \tag{34}$$

Since we now that $c\epsilon[c_{min},c_{max}]$ with $c_{min}>0$ and $c_{max}\leq 1$. For the case that $c\to 0$, $\frac{\partial b}{\partial c}>0$, and $c\to 1$ $\frac{\partial b}{\partial c}<0$.

Proof of $c_D = f(\overset{-}{L}, \overset{+}{\gamma}, \overset{+}{f_E})$

The expected profit of entry net of fixed entry cost is

$$\int_{c_{min}}^{\hat{c}} E_u[\Pi(c)]dF(c) - f_E \tag{35}$$

The derivative of (35) with respect to c_D is

$$\int_{c_{min}}^{\hat{c}} \frac{\partial E_u[\Pi(c)]}{\partial c_D} dF(c) + E[\Pi(\hat{c})]\frac{\partial \hat{c}}{\partial c_D} > 0 \tag{36}$$

Where the first term of the right-hand side is positive $\frac{\partial E_u[\Pi(c)]}{\partial c_D} > 0$ and the second term of the right-hand side of (36) is 0 since $E[\Pi(\hat{c})] = 0$ by definition of $\hat{c}$. Hence expected net profit of entry is increasing in c_D. Moreover, (35) is increasing in market size L, and decreasing in the product differentiation parameter γ and fixed entry cost f_E. Hence c_D must be decreasing in market size L , and increasing in γ and f_E.

Proof of $c_{l,D} = f(\overset{-}{L_l}, \overset{+}{\tau_l}, \overset{+}{\tau_j}, \overset{-}{L_j})$

In the open economy, the expected profit of entry net of fixed entry cost is

$$\int_{c_{min}}^{\hat{c}_l} E_u[\Pi(c)]dF(c) - f_E \tag{37}$$

The derivative of (37) with respect to $c_{l,D}$ is

$$\int_{c_{min}}^{\hat{c}_l} \frac{\partial E_u[\Pi(c)]}{\partial c_{l,D}} dF(c) + E[\Pi(\hat{c}_l)]\frac{\partial \hat{c}_l}{\partial c_D} > 0$$

Where the first term of the right-hand side is positive $\frac{\partial E_u[\Pi(c)]}{\partial c_{l,D}} > 0$, given $c \leq \hat{c} < c_{l,D}$ and the second term of the right-hand side is 0 since $E[\Pi(\hat{c}_l)] = 0$ by definition of $\hat{c}_l$. Hence expected net profit of entry is increasing in $c_{l,D}$. Moreover, (37) is increasing in domestic market size L_l, and foreign market size L_j , and decreasing in tariffs τ_l, τ_j. Hence $c_{l,D}$ must be decreasing in market size L_l and L_f and increasing in tariffs τ_l, τ_j.

Elasticity of productivity with respect to CEO delta

As a robustness check, I produce my own estimates of the elasticity of firm productivity with respect to CEO delta using the following specification,

$$tfp_{jt} = \alpha_0 + \alpha_1 tfp_{j,t-1} + \alpha_2 Incentives_{jt} + \alpha_3 X_{jt} + \delta_t + \epsilon_{ijkt}$$

where all the variables are in logs, and X_{it} is the vector of firm level controls. There are two main problems when running this regression using OLS; (i) the presence of the lagged dependent variable tfp_{t-1} gives rise to autocorrelation and (ii) the variable $Incentives_{jt}$ is assumed to be endogenous, thus these regressor may be correlated with the error term leading to biased estimates. To solve this problem we use Arellano-Bond difference GMM methodology. The set of instruments for the endogenous variables ($tfp_{j,t-1}$ and $Incentives_{jt}$) include (in addition to the controls X_{jt}) lagged values of export and import tariffs, and the interaction between export tariffs and firm's sales per worker. Results are shown in table 10. Our estimates elasticity of productivity with respect to incentives, are similar to previous estimates of Bulan, Sanyal and Yan (2007)[39]. We use the estimated elasticity of productivity with respect to incentives ($\varepsilon_{tfp,delta} = \alpha_2$) to re-estimate λ_{tfp} and found that λ_{tfp} ranges from 5.81% to 7.11%.

[39]See Table 5 in their paper

Table 7: Incentives and Exchange Rates

Dependent Variable: Log(Incentives)	(1)	(2)
Real exchange rate	9.806	10.563*
	(6.320)	(5.366)
Real exchange rate * Lag Productivity	-4.377**	-4.114**
	(2.201)	(1.856)
Real exchange rate * Lag Productivity^2	0.435**	0.377**
	(0.195)	(0.162)
Lag Productivity	20.053**	18.898**
	(9.709)	(8.190)
Lag Productivity^2	-1.967**	-1.723**
	(0.849)	(0.709)
Assets		0.083
		(0.077)
Market Capitalization		0.346***
		(0.051)
Cash compensation		0.215**
		(0.103)
Year fixed effects	yes	yes
Industry fixed effects	yes	yes
Executive fixed effects	yes	yes
Observations	6802	6755
R2-Adjusted	0.800	0.820

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%.

Robust standard errors corrected for clustering at the sic 4 digit level are in parentheses

Table 8: Incentives and Alternative Productivity Measures

Dependent Variable: Log(Incentives)	(1)	(2)	(3)	(4)
Export Tariff	33.109***	23.01***	1.033***	0.7253***
	(7.204)	(6.09)	(0.377)	(0.1867)
Lag value added per worker	5.650***	4.43***		
	(1.206)	(1.01)		
Lag value added per worker^2	-0.145***	-0.12***		
	(0.031)	(0.03)		
Export Tariff *Lag value added per worker	-3.533***	-2.42***		
	(0.771)	(0.65)		
Export Tariff *Lag value added per worker^2	0.094***	0.06***		
	(0.021)	(0.02)		
Lag real output			0.332*	-0.0242
			(0.195)	(0.09)
Lag real output^2			-0.019	-0.005
			(0.013)	(0.0065)
Export Tariff *Lag real output			-0.246**	-0.1303***
			(0.110)	(0.0598)
Export Tariff *Lag real output^2			0.010	0.003
			(0.008)	(0.005)
Assets		0.07		-0.196***
		(0.07)		(0.0533)
Market capitalization		0.36***		0.9673***
		(0.044)		(0.0264)
Cash compensation		0.19**		0.0814*
		(0.09)		(0.0453)
Year fixed effects	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes
Executive fixed effects	yes	yes	yes	yes
Observations	6563	6520	6876	6848
R2-Adjusted	0.797	0.816	0.790	0.813

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Robust standard errors corrected for clustering at the firm level are in parentheses

Table 9: Response of Incentives and Productivity given a reduction in export tariffs

	$\Delta\tau_x = -0.43$ log points	
	%ΔIncentives	%Δpr (productivity)
Mean	3.05	0.40
5%	-0.42	-0.06
10%	1.39	0.18
25%	2.78	0.37
50%	3.78	0.50
75%	4.38	0.58
90%	4.69	0.62

Table 10: Productivity and Incentives

	(1)	(2)	(3)
Dependent Variable:	Log Productivity	Log Productivity	Log Productivity
Lag Productivity	0.173*	0.185**	0.141*
	(0.0911)	(0.0920)	(0.0848)
Incentives1	0.0374*		
	(0.0217)		
Incentives2		0.0362*	
		(0.0217)	
Incentives3			0.0460*
			(0.0259)
Assets	0.0280	0.0222	0.00909
	(0.0416)	(0.0411)	(0.0379)
Cash Compensation	0.0896	0.0938	0.0510
	(0.0621)	(0.0640)	(0.0554)
Observations	5774	5774	5453
Arellano-Bond test for AR(2) p-value	0.148	0.158	0.164
Hansen J Statistic p-value	0.562	0.042	0.128

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Difference GMM estimation. All Robust standard errors (Windjemeijer, 2005) are reported in parenthesis. All columns contain year fixed effect (since the Difference-GMM takes the first difference of the variables firm fixed effects are canceled out). Instruments are lagged values of the explanatory variables, in addition in the first column the set of instruments included lag export tariffs, two lag export tariff and lag market capitalization, in the second column they includes the set of instruments in column 1 plus lag import tariffs and two lag import tariff. In the third column they include lagged values of export tariffs, the interaction between export tariffs and sales per worker, sales per worker, and market capitalization.

Table 11: Ad Valorem U.S. Tarifs by two-digits SIC industry and year

Two Digit SIC Industry		Tariff rate (Imports)					Tariff rate (Exports)				
		1993	1995	1998	2003	2005	1993	1995	1998	2003	2005
20	Food	3.3	3.0	3.8	2.1	2.1	11.6	15.5	15.0	14.8	11.5
22	Textile	10.6	9.5	9.5	6.0	5.7	11.6	13.1	6.1	5.7	3.5
23	Apparel	12.4	10.6	11.5	8.3	8.1	13.2	15.0	11.4	10.1	5.8
24	Lumber	0.9	0.6	1.3	0.3	0.3	3.9	3.8	2.8	2.7	1.9
25	Furniture	2.9	1.4	1.2	0.3	0.3	3.8	8.2	2.4	2.5	0.8
26	Paper	0.6	0.5	1.2	0.2	0.1	5.3	6.2	3.9	2.9	0.7
27	Printing	1.0	0.8	0.9	0.2	0.1	1.5	2.8	1.2	0.9	0.2
28	Chemicals	4.1	2.9	3.2	1.9	1.9	6.6	6.5	4.1	3.8	2.7
29	Petroleum	0.8	0.5	0.3	0.0	0.3	2.5	2.9	1.7	1.6	0.6
30	Rubber	7.2	5.9	5.7	4.2	4.0	8.0	9.3	4.7	4.6	2.4
31	Leather	10.3	9.6	8.9	8.0	8.0	13.4	12.6	8.8	7.7	5.7
32	Stone	6.0	4.8	4.3	3.1	2.9	5.8	6.8	3.7	3.7	2.0
33	Primary Metal	3.3	2.6	2.9	0.7	0.5	5.0	5.4	3.3	3.9	1.3
34	Fabricated Metal	3.5	2.8	2.5	1.5	1.5	6.4	8.1	3.1	3.0	1.4
35	Industrial Machinery	2.4	1.9	1.3	0.7	0.7	4.8	5.1	2.8	2.3	1.5
36	Electronic	3.8	2.6	2.2	1.1	1.1	6.2	6.4	3.5	2.7	1.6
37	Transportation	2.5	3.5	3.7	2.8	2.1	6.5	8.4	3.3	2.8	2.2
38	Instruments	4.8	3.8	2.4	1.3	1.2	5.6	5.1	3.1	2.4	1.7
39	Miscellaneous	5.2	3.1	2.5	2.0	2.0	6.6	6.0	3.7	3.7	2.0
Average		4.5	3.7	3.7	2.6	2.5	7.2	8.3	5.3	4.9	3.2
Average W		3.8	3.2	3.1	2.0	1.8	6.2	7.0	4.0	3.7	2.3

Figure 14: Predicted Incentives as a Function of Lag productivity

Figure 15: Elasticity of Incentives with respect to tariffs: $\frac{\partial(Incentives)}{\partial(\tau^x)} = \beta_1 + \beta_2 tfp_{t-2} + \beta_3 tfp_{t-2}^2$ in 1993