Openness and Productivity: a Model of Trade and Firm-Owners' Effort[1]

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October 23, 2006

[1] I wish to thank Manoj Atolia, Ana Fernandes, Dave Hummels, Barry Ickes, Steve Martin, Dave Richardson, Jim Tybout, Stephen Yeaple, and seminar participants at the Econometrics Society Summer Meeting, the Midwest International Trade Meetings, the Federal Reserve Bank of New York, and at Brandeis, Michigan State, Missouri, Oregon State, Penn State, Purdue and Syracuse, for very useful comments and discussions.

Abstract

This paper asks the questions: when countries open up, what are the incentives of firm *owners* to invest in the productivity of their firms? Why do they wait until the country opens up to do so? Motivated by actions of actual firm owners facing import competition in Portugal, I set up a simple model in which firm owners maximize the utility of profits and leisure. This utility can be easily interpreted as the need to have time to enjoy consumption goods. The model can explain why firm owners wait for the impact of import competition to invest in productivity. The key insight is that with openness the price of leisure increases, causing firm owners to decrease leisure, putting more effort into productivity and therefore getting more income in return. I then adapt the model to consider one further insight: when countries open up, the real price of a consumption basket goes down because consumers enjoy more variety. This again motivates firm owners to work harder in seeking better technologies. In the concluding section I argue that the two models have very different scopes of applicability.

1 Introduction

Recent empirical studies suggest that openness to international trade drives up *within*-plant or *within*-firm productivity. A first guess for the mechanism at play might be learning-by-exporting. However, nothing in this literature guarantees (and indeed a portion of it argues against) the hypothesis that firms learn when they export. This has motivated theoretical explanations for industry-wide productivity gains that are based on reallocation effects, with no single firm gaining in productivity.[1] By design, these explanations leave open the question about why individual firms gain in productivity when their countries open up. As a preview of the empirical literature, consider the following summary by Pavcnik (2002): "Using plant-level panel data on Chilean manufacturers, I find evidence of *within* plant productivity improvements that can be attributed to a liberalized trade for the plants in the import-competing sector" (her emphasis). The two key points are that individual plants gain in productivity; and that the effect seems concentrated on the import side, not the export side.

This paper addresses the question of how incentives for innovation change when countries open up to import competition. Such "innovation upon openness" poses at least two puzzles. First, if improvements in the firms' production processes were profit-increasing, why were those improvements not enacted earlier? When productivity improves in a firm immediately after an increase in openness, most likely the productivity gains were already accessible before the increase. It is simply that the firm *chooses* not to implement them earlier. If that is so, the increase in openness does not shift the firm's technology frontier. Rather, it shifts its *incentives* to move towards the production frontier.[2]

The second puzzle, stemming from the IO literature, is that it is hard to understand how increased competition can induce innovation, since competition reduces the rents that are often taken to be the very rewards to the innovation. Take for example the Schumpeterian view that competition is detrimental to innovation, precisely because fiercer competition depresses the rewards to would-be innovators (Schumpeter 1942, and also Aghion and Howitt 1992), a negative position however that has been questioned by empirical IO evidence (see Blundell, Griffith and van

[1] See the papers by Melitz (2003) and Bernard, Jensen and Schott (2003).

[2] The very last sentence in MacDonald's (1994) paper is quite telling: he states that the higher prices permitted by higher levels of protection "may allow for higher costs." But this begs the question: even if protection "allows for higher costs," why do profit-maximizing firms take advantage of that license? Why would they not take advantage of cost reductions anyway, but wait to do so until they face import pressure?

Reenen 1999 and Aghion et al. 2004). Thus, both the empirical trade literature and the empirical IO literature seem to agree that competition increases innovation. The challenge to theorists is to understand how the incentives to innovate rise when rents are decreasing.

I concentrate on the incentives of firm owners to innovate. Firm owners are modeled just as all other consumers in the economy who, following Becker (1965), optimize some combination of consumption goods and leisure. Therefore, the incentives of firm owners to "work hard" depend on the prices of those goods and therefore may change when the country opens up. The essential margin in the model is therefore between the leisure of firm owners and their income, a margin that is tied up with a constraint that specifies that they can spend some of their leisure in order to increase their productivity, and therefore their income.[3] To see why the utility function can reasonably contain terms for both consumption and leisure, consider a harried executive who buys himself home theaters and yachts but has little time to enjoy them. He pays the same for those goods as his neighbor retiree, but his enjoyment is certainly smaller. The key here is that, as Becker recognizes, many goods have a time dimension: you cannot consume them instantaneously. Rather, you need a time input to actually enjoy them. Then, it is not sufficient to list a person's consumption bundle in order to know his utility. We also need to know how much time he has to enjoy that consumption bundle. The assumption of leisure in the utility is consistent with results by Patterson (1991). Using UK data on consumption and prices for 19 goods and services, four liquid assets and leisure (where the price of leisure is the wage), he finds that restricting the system to only the 19 goods and services causes a number of violations of the General Axiom of Revealed Preferences. Even though the number of violations is relatively small, it is further reduced (in one specification, to zero) by inclusion of the liquid assets and leisure. In other words, the latter "consumption" categories help bring consumers' decisions in line with the principles of utility maximization, of which GARP is a direct consequence.

An important assumption of the model is that firm owners are simply workers

[3] The trade-off between income and leisure, which will play the central role in this paper, is a key concern in the business cycle literature (see Kydland 1995 and Ríos-Rull 1993, for example), but it has not been used, to my knowledge, in the literature of international trade. Leisure is also an important concept in labor economics, for instance in the theory of home production (see the survey by Gronau 1986), which draws directly from Becker's work. For an application of leisure to the theory of endogenous growth, see Ladrón-de-Guevara, Ortigueira and Santos (1999), where countries with high levels of human capital have a high price for leisure, causing people to work harder and therefore the country to grow faster.

who decide to start up a firm. This will imply that, in equilibrium, the marginal worker is indifferent about being a firm owner. As a consequence, if workers gain with openness (and they do, through lower prices and higher variety) then *everyone* gains.[4]

With this set-up, I identify two mechanisms with which openness increases the relative "price" (or opportunity cost) of leisure, thus motivating firm owners to substitute some additional consumption for some loss of leisure. First, market integration leads to more varieties being produced, increasing the competitive pressure put on firm owners in the sense of increasing the elasticity of demand for their goods. As a result, firm owners work harder, making their firms more likely to increase in productivity, and reducing prices for everyone. Therefore, the effect is unambiguously welfare increasing. Second, the increase in variety reduces the real price of consumption goods for consumers that love variety, increasing the shadow value of income, which again motivates firm owners to work harder. Some anecdotal evidence suggests that this may be a useful avenue for research.

One such motivating evidence is the experience of several Portuguese firms that faced an onslaught of competition from low-wage countries during the 1990s. They had two general types of response: some firms closed down; but others upgraded the quality of their products, and innovated. Personal interviews with a few Portuguese managers revealed surprising attitudes about why their firms waited for import competition in order to innovate. Firm owners claimed that they were "comfortable" with the profits that they were making before import competition became severe, and therefore they did not need to innovate.[5]

Can we rationalize this sort of behavior as a form of optimization, even though this may collide with straight profit-maximization? And in doing so, can we shed some light on the incentives to innovate when countries open up? The answer to both questions is yes. The comments from firm owners already suggest an avenue towards answering the first question: they were clearly maximizing something, but whatever that might be it was not the profits of their firms. We must acknowledge that firms are not the disembodied entities that for so long populated trade theory.

[4] The notion of workers deciding endogenously to become "managers" is used by Lucas (1978) to study the decision of marginal managers (those with middling talent) whether to be self-employed or to work for someone else. With increasing real wages (which as we will see is what happens with openness in my model), marginal managers decide to work for more talented managers, increasing the average size of firms. Here, I am interested in a different margin, that between effort and leisure of those workers that *have* decided to become managers.

[5] I thank my brother José Trindade, an investment banker, for arranging the interviews with some of his clients, and with himself.

Rather firms are run by people, whose set of incentives, even if one leaves aside possible questions of asymmetric information, may not be perfectly aligned with straight profit maximization.[6]

To answer the second question, note that a firm owner with leisure in the utility function (which she shares with all the consumers in the economy) will have the usual substitution effect. As the country opens up, and the "price" of leisure relative to consumption increases, she substitutes out of leisure by working harder, innovating, getting higher expected income, and more expected consumption. Thus the paper illustrates the often expressed (but not often formalized) intuition that openness serves as a wake-up call to managers that live the "good life," or, more formally, that produce at a point below their firms' technological frontier. The question then is: why does the relative price of leisure go up when the country opens up? As we shall see, openness increases productivity, but only in the cases when the increased number of varieties increases the elasticity of substitution among different varieties. This reverses the usual stance of the endogenous growth literature that an increasing elasticity of substitution, by decreasing the rents accruing to innovators, is detrimental to innovation. The reason, as eloquently put by Aghion et al. (2004) in the context of an endogenous growth model, is that the incentives to innovate depend not only on the post-innovation rents, but also on the *difference* between the post- and pre-innovation rents. Increased competition renders pre-innovation rents increasingly small - as some Portuguese executives found out when the country opened up - spurring firm owners to innovate.

In a later section, I adopt the model to study an additional mechanism. There, I define leisure to be a consumption good in itself, rather than just an input to the consumption of other goods (the easiest way to do this is to have an additive leisure term in the utility). When countries open up, a major gain for consumers that love variety is an increase in the number of varieties available. Feenstra (1994) made that point, with more recent work by Broda and Weinstein (2003). As a consequence, real prices decrease, changing incentives towards income, and away from leisure, which again makes firm owners work harder towards higher productivity.

[6] I claim no authorship of this notion, which indeed is quite old. For example, a formulation that is quite similar to mine can be found in Machlup (1967) who states (although disapprovingly): "Entrepreneurs and managers cannot be expected to have an inelastic demand for leisure; indeed, one must assume that this demand is income-elastic so that higher profit expectations will cause them to sacrifice some income for some leisure." But it is in the *trade* literature that the importance of this concept is usually missed (for an application of the theory of the firm to trade, although in a completely different context, see Antràs 2003).

The second model is one way to rationalize Chinese trade policy in the last two decades. While internally the Chinese government was encouraging the remarkable buildup of private enterprise, in its trade policy it gradually opened up not only to producer goods, but also to virtually all consumer goods (including politically sensitive ones, such as internet usage, foreign travel, and maid services). If one models the Chinese government as concerned mostly with growth (and not with the static gains from opening up to consumers), one would expect much less openness in consumer goods than in producer goods, since only the latter type of openness has an impact on the production possibilities of a country. So why has China opened to consumer goods? I do not have any hard evidence on this. But even a cursory overview of the consumption goods that were available to common citizens in the early eighties would convince anyone that they were not sufficient to provide incentives to work hard. The extra income earned by opening a small firm was simply not very valuable because there were very few desirable goods to buy. It is not too big a stretch to imagine that the Chinese government understood this, and decided to open up to many imported consumption goods to spur entrepreneurs to work harder. The implicit message seemed to be: "create a firm, earn good profits, and you shall reap the results (in the guise of color TVs)."

2 Previous work and approach of this paper

The most compelling empirical studies on the impact of openness on productivity are those that provide plant- or firm-level evidence. Table 1, based on a much more comprehensive table by Erdem and Tybout (2003), is a selection of the evidence available. See Tybout (2003) for a thorough review of the relevant literature. To systematize this literature it is useful to use Tybout and Westbrook's (1995) productivity growth decomposition. They separate productivity growth in an industry into three terms, which Tybout (2003) calls: the scale effect (the contribution of increasing returns); the market share effect (the reallocation towards more productive firms); and the technical efficiency effect (within-firm total factor productivity). The last three columns in Table 1 list the different contributions to aggregate productivity, for those papers that explicitly attempt to disentangle them. Many papers do find within plant- or within-firm effects.

For example, Tybout and Westbrook (1995) use Mexican plant-level data to estimate the relative importance of the three effects, and correlate them with openness and foreign competition. They find that the scale effect was almost certainly not important, but find evidence for the market share and the technical efficiency effects.

In some (by no means all) cases they are able to significantly correlate the latter two effects with different measures of openness. Pavcnik (2002) uses Chilean data to construct a very careful estimate of plant-specific total factor productivity, which she then regresses on time dummies and trade orientation dummies. During the period immediately after the trade liberalization of the early 1980s, plants in the import-competing sector had productivity gains on average 3% to 10% higher than plants in the non-traded sector. Fernandes (2003) argues that her Colombian data set, unlike Pavcnik's, exhibits considerable variation in trade policy, both across industries within the same broadly defined import-competing sector, and over time. She uses this variation to identify specifically the impact of openness on plant productivity, and finds that trade protection has a negative impact on plant productivity.

One important tenet of this paper is that imports increase the competitive pressure that is placed on firms, in measurable ways. Specifically, I will show that the key driving mechanism is that σ, the elasticity of substitution among different varieties, increases with openness. The closest evidence of this mechanism that I know of is by Krishna and Mitra (1998), who study the dramatic trade liberalization episode that took place in India, circa 1991. This liberalization episode was arguably exogenous, since the trade reforms were imposed as a condition for a loan from the IMF. Their evidence suggests that there was a decrease in the price-cost mark-up, indicating an increase in competitive pressure in precisely the way I model here.

Taken together, the evidence presented above indicates that firms respond to an increase in the pressure of competition (and in particular import competition) with technological improvement. As mentioned in the introduction, such a response is antithetical to the spirit of Schumpeterian models. It has been modeled most successfully in the context of a single economy with an agency problem: see Scharfstein (1988) and Schmidt (1997), for example. As in my model, the latter paper considers what happens if managers can invest in cost reductions. Increased competition has two effects: first, it renders high-cost firms unprofitable, increasing the incentives to invest in cost reductions; second, it may also reduce the profits of existing firms, depressing managerial incentives. It is interesting that by introducing trade, openness may cause the opposite of Schmidt's second effect, thereby unambiguously raising firm owners' incentives to invest time in productivity enhancements. This paper contrasts with both Scharfstein (1988) and Schmidt (1997) by foregoing the formalism of the principal-agent problem, which may be a less important consideration for less developed countries, in which a large proportion of firms are one-plant establishments (90% in Pavcnik's data set).

In the international trade literature, Thoenig and Verdier (2003) also study the impact of openness on induced innovation. Their goal is to study the direction of innovation (neutral or skill-labor biased), with a view of explaining rising skill premiums both in the North and in the South. In Holmes and Schmitz (2001), firms face one basic trade-off: they can either engage in R&D, or they can block their rivals' R&D efforts. Both activities can be profit-increasing. Assume that the domestic country opens up to trade. Then, openness shifts the incentives towards R&D, with the extra assumption that firms are only able to block the R&D of their domestic rivals. As a consequence, openness leads to higher productivity. Ederington and McCalman (2004) also model firms' endogenous choice of productivity, a choice that is reserved to firm owners here. In their paper, fixed costs to export result in ex-ante identical firms sorting themselves into exporters and non-exporters. Firms that endogenously decide to export have larger market shares and therefore have an incentive to adopt technology earlier.

In addressing the theoretical question, I have attempted to bear in mind Tybout's (2003) observation that "a diverse body of theory suggests that the direction of change in the efficiency hinges critically upon model specifics." No model can escape making some assumptions, of course, and I justified at some length the inclusion of leisure in the utility function. Furthermore, particular care was taken in the following three ways.

First, I start from a well-known model that many trade economists believe is a correct depiction of some aspects of international trade. This is not the only reason to choose the monopolistic competitive model, however. The model is particularly suited to explain the two main pieces of the intuition. The first is the interaction between openness and product market competition: as countries open up, the number of varieties increases (Krugman 1980), which may be perceived as an increase in the elasticity of substitution by each producer (as in Devarajan and Rodrik 1991). The second important piece is that when countries open up, there are gains from trade that stem from the increased number of varieties available to consumers. The notion of the gains from trade through increased variety was an important part of Krugman's (1979) intuition. Surprisingly there is relatively little empirical work, with the two foremost exceptions being Feenstra (1994) and Broda and Weinstein (2003). The latter estimate elasticities of substitution among different varieties (defined to be goods in the same very disaggregated industry, but imported from different countries), for imports into the US between 1972 and 2001. They use those elasticities to calculate an import price index, and estimate that the index has fallen over the last thirty years by an additional 28% when the gains from increasing varieties are taken into account, compared to a conventionally calculated import index. Overall, the adjustment is important, and according to their estimates was responsible for a 3% increase in the US welfare.

Second, the model extends monopolistic competition in simple and reasonable directions. There are only two additional assumptions: firms are entities endogenously formed by workers who decide to become owners; and owners who wish to shift their firm towards the technological frontier face a trade-off about spending additional leisure in order to reap additional income.

Third, the model reproduces a number of empirical stylized facts. One prediction of the model is that firm owners will on average work more and have more income. This is indirectly confirmed by data reported in Ríos-Rull (1993) for skilled labor. Note that the secular decrease in hours worked is generally explained as the net effect of a substitution effect (which as wages increase makes people enjoy less leisure) and an income effect (which would have the same people increase both their income *and* their leisure), the latter presumably having won. In the present model, the conclusion that the income effect is larger falls naturally. The model also matches the result, reported in Fernandes (2003), that the impact of openness is larger for less competitive industries.

3 Model setup

The model is based on the well-known monopolistic competition models by Krugman (1979, 1980) and Helpman and Krugman (1985). It is augmented with a term for "leisure," which is broadly defined as any non-pecuniary disincentives for firm owners to "work harder." Thus, I assume that there is a trade-off between the rewards of hard work and the rewards of leisure, and extract consequences from that assumption (which is motivated by the anecdotal evidence described in the introduction). This simple and flexible model allows an investigation into the different effects that openness has on the incentives of firm owners. First, as we shall see, the model yields substitution effects between leisure and income, as the relative "price" of leisure changes. *Why* this relative price changes becomes then an important piece of the story. Second, consumers have a love for variety, represented by a finite elasticity of substitution between different varieties. This allows for a *second* route for openness to change incentives: openness increases variety and this increases the shadow value of income, shifting incentives away from leisure.

A. Consumption and Production

Assumption 1 (Consumers) *Consumers constitute a continuum of mass L. In any equilibrium, a continuum of goods with mass N is available. The utility of a consumer who consumes $q(\omega)$ of variety ω and who has leisure l is given by*

$$U = l\left(\int_0^N q(\omega)^\beta d\omega\right)^{1/\beta}. \tag{1}$$

β defines the elasticity of substitution between two different varieties as $\sigma = \frac{1}{1-\beta}$. I assume that $0 < \beta < 1$ (therefore $\sigma > 1$). Each consumer is endowed with one unit of labor and with $\bar{l}$ units of leisure*. Labor is the inelastically supplied numeraire good. In general, σ may be an increasing function of the number of varieties available, in which case it can be written as $\sigma(N)$.*[7]

The utility function defined above is identical to the standard monopolistically competitive function, except for the leisure term l, which enters multiplicatively. This form of the utility rationalizes the notion that many goods require time to be consumed. For example, it costs the same to purchase a home theater whether you are a busy executive or a retiree. But the amount of enjoyment derived from the purchase is likely to be much higher for the latter, who actually has the time to use it. The same would be true for cruises (which you may not enjoy if you use them to catch up with your email), books (which you may not have time to read), and so on. The key here is that consumers buying the same good may derive very different utility from it, not because their tastes are different, but because they do not have the same time to enjoy them.[8]

[7] Krugman (1980) argues intuitively that σ is likely to be an increasing function of N, in this way: "Increasing elasticity of demand when the variety of products grows seems plausible, since the more finely differentiated are the products, the better substitutes they are likely to be for one another." The main consequence of this assumption is that the elasticity of demand for each variety increases with the number of varieties. The appendix shows that this result can be made more rigorous in the context of a model with a finite number of varieties, even with constant σ.

[8] Becker (1965) posits final consumption goods "produced" by households that combine time with market goods. This is done with the production function $Z_i = f_i(x_i, T_i)$, where x_i is the quantity purchased of good i, T_i is the time spent consuming it, and Z_i is the final consumption good. I introduce two simplifications. First, I write $Z(\omega) = q(\omega)T(\omega)$, that is, I define the household's "production function" to be Cobb-Douglas with equal weights on time and consumption. Second, I assume the symmetric equilibrium in which consumption of all varieties is the same. Then, $T(\omega)$ is a constant that comes in front of equation (1). Simplifying the household's production function in this manner loses the notion of a changeable productivity of time, which is central to Becker's analysis, but it is sufficient for my purposes.

In this model, firm owners are simply those workers that have decided to start a firm, therefore they have the same preferences as the workers. Firm owners and workers differ in two aspects only: the former will generally have more income, from their profits; but they generally have less leisure, as they spend some time in order to increase the productivity of their firm.

The production structure is standard, with the labor required to produce quantity $q(\omega)$ of variety ω being initially defined as

$$L(\omega) = f + \overline{m}\; q(\omega)\ . \tag{2}$$

Here, f and $\overline{m}$ are the fixed and the marginal cost (in labor units), respectively.

B. Effort and Productivity

I assume that, initially, firms do not produce at their technological frontiers. In particular, a better technology is available, with marginal cost $\underline{m} < \overline{m}$, and it is the firm owners' task to try to acquire it. Note two characteristics of such an attempt. First, it must require some effort, and therefore cause a loss of utility. Here, this effort is modeled as a use of time, with consequent loss of leisure. In practice, one can imagine many examples in which the owner-CEO's time is required to increase productivity. This may occur, for example, if she needs to search among different varieties of the new technology, until she finds one that integrates well with the firm's production structure; or she may need to research better outlets for the firm's planned higher-quality products; alternatively, time may be required to adapt product characteristics to the tastes of a specific market; and so on.[9]

Second, the outcome of the owner's efforts may well be uncertain. The new technology (some of whose characteristics are likely to be tacit in nature) may only "reveal" itself after it is brought into the firm, and may not integrate with the existent facilities, or with workers' skills; the upgraded product may not match the tastes of the firm's customers, in spite of all marketing studies; or the owner may

[9] Some of these possibilities fall outside the purview of this model, and indeed of what normally is defined as "productivity." However, the model can be easily extended to include any of them. Take the example of a firm facing import competition that responds by upgrading its product quality. This can be analyzed by assuming that demand and prices are actually measured per unit of quality. Therefore, an owner that doubles her quality also doubles her revenue, at constant quality-adjusted prices. If she uses the same labor to produce the higher quality product, the model becomes formally equivalent to a reduction in marginal cost. Note that studies on productivity that use revenue - as opposed to quantity - in estimating the production function are not able to distinguish between an increase in productivity as normally defined (lower average costs to produce the *same* good), and gains in product quality.

simply waste her time in a search for better technology, stopping the search before a desirable fit is found. In all of these cases, the firm owner is not assured of the outcome beforehand. The assumption below captures these characteristics of owner effort.

Assumption 2 (Firm owner effort and productivity) *Firm owners may spend time in attempting to increase the productivity of their firms. They are successful with probability θ, in which case their marginal costs change from $\overline{m}$ to $\underline{m} < \overline{m}$. To get a probability of success θ, firm owners need to spend an amount of time $t(\theta)$. I assume that $t(0) = 0,\ t(1) = \infty$, $t'(\theta) > 0$, $t''(\theta) > 0$.*

The assumptions that $t(1) = \infty$ and $t(0) = 0$ mean that no finite amount of time guarantees success, while owners that spend no time at all have no possibility of success. The assumption that $t''(\theta) > 0$ is what one would expect if there are decreasing returns to the owners' time.

C. Timing

The last important assumption of the model deals with the timing of different agents' actions.

Assumption 3 (Timing of the model) *First, each worker decides independently whether to become a firm owner. Firm owners spend the fixed cost f, which is then sunk. Second, first owners decide how much time to invest in increasing productivity. Third, once they obtain their technology pick ($\underline{m}$ or $\overline{m}$), they decide independently how much to produce. Their role as owners ends, but they remain in the economy as consumers. All markets clear.*

4 Three-stage optimization

One consequence of assumption 3 is that the model can be analyzed in three stages. The first stage, in which workers decide whether to start up a firm, yields an equation for free entry, which in equilibrium determines the number of firms and therefore of varieties produced (as each firm produces a different variety). In the second stage, firm owners choose the optimal amount of time to spend searching for the better technology. Given the strict monotonicity of the time functions $t(\theta)$, they equivalently choose the optimal probability of success θ. This will give us one more equation. The third stage, in which all owners know their technologies and decide how much to produce, will yield the last two equations: one for the optimal production by owners with marginal cost $\underline{m}$ (which I will call "productive" owners), and one by owners with marginal cost $\overline{m}$ (the "unproductive" owners). The analysis proceeds by backward induction. We start with stage three, taking all actions in stages one and two as given.

A. *Third-stage consumer optimization*

In the third stage, the leisure that firm owners used up in stage two has been "sunk," and their total leisure is fixed at $(\bar{l} - t(\theta))$, where θ is the strategy that they picked in stage two. In stage three, then, firm owners only maximize the consumption portion of equation (1). The problem then becomes formally equivalent to a standard CES optimization, in which an individual with income I issues the following demand for variety ω:

$$d(\omega) = \frac{p(\omega)^{-\sigma}}{\int_0^N p(\omega)^{1-\sigma} d\omega} I, \tag{3}$$

where $p(\omega)$ is the price of variety ω. This is the demand function for regular workers as well, since their leisure is fixed at $\bar{l}$. Equation (3) can therefore also represent the aggregate demand for ω, if I is the aggregate income in the economy. Note that even though in general the elasticity of substitution increases with the number of varieties, we assume that no economic agent is large enough for his actions to have an impact on it. Moreover, I assume that N is large enough (alternatively, that each firm is a set of measure zero), so that no firm has an impact on the price integral in equation (3). Therefore, from the point of view of each firm, σ is also the constant elasticity of demand.

It is a straightforward exercise to insert the demand functions (3) into the utility function, yielding the following indirect utility:

$$V(I, P, l) = l\left(\frac{I}{P}\right), \tag{4}$$

for a consumer with income I and leisure l, where the "price index" P is defined as

$$P \equiv \left[\int_0^N p(\omega)^{1-\sigma} d\omega\right]^{\frac{1}{1-\sigma}}. \tag{5}$$

B. Third-stage owner optimization

Suppose that a mass $N < L$ of workers decide to start up a firm. No two owners will produce the same variety, as standard competition modes such as Bertrand would then erase the profits of at least one of them. Therefore, N also denotes the mass of varieties that are produced. Let us assume the symmetric result, in which all firm owners pick the same probability of success θ. Then, the economy has a mass θN of firms with marginal cost equal to $\underline{m}$ (the "productive" firms), and a mass $(1-\theta)N$ of firms with marginal cost equal to $\overline{m}$ (the "unproductive" firms). In what follows, I denote productive and unproductive firms' variable profits by $\underline{\pi}$ and $\overline{\pi}$, respectively.

The prices charged by productive and unproductive owners are $\underline{p}$ and $\overline{p}$, respectively. After substitution of these prices into the demand functions (3), we can calculate the quantity supplied by unproductive firms as follows:

$$\overline{q} = \frac{\overline{p}^{-\sigma}}{\theta \underline{p}^{1-\sigma} + (1-\theta)\overline{p}^{1-\sigma}} \frac{L-N+\Pi}{N},$$

with an analogous expression for the quantity supplied by productive firms. Here, Π is aggregate profits and $L-N$ is aggregate wages (recall that labor is the numeraire good), therefore $L-N+\Pi$ is the aggregate income in the economy.

Recall that each firm faces an elasticity of demand $\sigma(N)$, which from the point of view of the individual firm is a constant. An unproductive firm owner charges the usual mark-up: $\overline{p} = \overline{m}/(1-1/\sigma) = \overline{m}/\beta$. Analogously, a productive firm owner prices his variety at $\underline{p} = \underline{m}/\beta$. Substituting these prices in the equation above implies for the variable profits of unproductive firms:

$$\overline{\pi} = (\overline{p} - \overline{m})\overline{q} = \frac{(1-\beta)\, \underline{m}^{\sigma-1}}{\underline{m}^{\sigma-1} + \theta(\, \overline{m}^{\sigma-1} - \, \underline{m}^{\sigma-1})} \frac{L-N+\Pi}{N}. \qquad (6)$$

Note that $\overline{m}^{\sigma-1} - \underline{m}^{\sigma-1} > 0$, because $\overline{m} > \underline{m}$, and $\sigma > 1$. Productive firms' variable profits are analogously obtained, and are written as:

$$\underline{\pi} = \frac{(1-\beta)\overline{m}^{\sigma-1}}{\underline{m}^{\sigma-1} + \theta(\, \overline{m}^{\sigma-1} - \, \underline{m}^{\sigma-1})} \frac{L-N+\Pi}{N}. \qquad (7)$$

Both expressions above include the aggregate profit on the right-hand side, itself the sum of all of the individual profits on the left. We can aggregate all of the individual profits, which upon substitution from equations (6) and (7) yields:

$$\Pi = N\left[(1-\theta)\overline{\pi} + \theta\underline{\pi} - f\right] = (1-\beta)\left(L-N+\Pi\right) - Nf.$$

This equation can be solved for aggregate profits, $\Pi = (1/\beta - 1)(L-N) - Nf/\beta$, yielding the following result for aggregate income:

$$L - N + \Pi = \frac{L - N(1+f)}{\beta}. \tag{8}$$

That is, aggregate income in equilibrium is completely given by the (endogenously determined) mass of firm owners.

Finally, we can substitute aggregate income back into the equations for individual profits to obtain our first important equation:

$$\underline{\pi} = \frac{1/\beta - 1}{B + (1-B)\theta}\left(\frac{L}{N} - f - 1\right), \qquad \textbf{(Maximum Profit)} \tag{9}$$

where $B \equiv B(N) \equiv (\underline{m}/\overline{m})^{\sigma(N)-1} < 1$ is a "profit differential" parameter and it summarizes the incentives that firm owners face. The reason for this name is that B scales productive profits to obtain unproductive profits:

$$\overline{\pi} = \underline{\pi}B. \tag{10}$$

The smaller B is, the larger the gap between productive and unproductive profits, and thus all else equal the larger the incentives to innovate.[10] Note that B can become smaller in two ways: a decrease in $\underline{m}/\overline{m}$, or an increase in $\sigma(N)$. The first effect could happen if the technological leap available became more pronounced (exogenously to this model). The second effect, which implies an increase in the competitive pressure for each firm, can happen endogenously through an increase in the number of varieties, and it will play an important role in the paper.

C. Second-stage firm owner optimization

When firm owners optimize in the second stage they take third-stage indirect utility (equation 4), as a given function of income and leisure, and they also take the profits above (equations 9 and 10), as given. The second stage problem is then reduced to picking a probability of success θ (and therefore, given the profits, an expected income) that maximizes the expected indirect utility:

$$\underset{\theta}{Max}\ \frac{\left[\theta\underline{\pi} + (1-\theta)\overline{\pi} - f\right]\left[\overline{l} - t(\theta)\right]}{P} \qquad s.t.\ \ 0 \leq \theta \leq 1. \tag{11}$$

When an interior solution obtains, this maximization problem yields the following

[10] The notion that the incentives to innovate depend not on the absolute size of post-innovation rents but on the difference between pre- and post-innovation rents (precisely what is measured by this parameter B) is common with some later Schumpeterian literature (see for example Aghion et al. 2004).

first order condition, after the substitution from equation (10) is made:[11]

$$\underline{\pi} = \frac{f}{B + (1-B)\left[\theta - \frac{\bar{l} - t(\theta)}{t'(\theta)}\right]}. \qquad \textbf{(Optimal Effort)} \qquad (12)$$

The expression on the right yields, at constant $\underline{\pi}$, an inverse relationship between B and θ: more competition leads to more effort.

D. First-stage free entry

Finally, we can write down the equation for free entry. A worker who considers in the first stage whether to start a firm takes the subsequent equilibrium path as given. In particular, he takes the equilibrium choice θ as given. The marginal worker is indifferent about becoming a firm owner, and that can be written as:

$$\frac{\left[\underline{\pi}(B + (1-B)\theta) - f\right]\left[\bar{l} - t(\theta)\right]}{P} = \frac{\bar{l}}{P}.$$

The left hand side represents the expected utility of starting a firm, and takes as given the optimal value achieved by problem (11). Workers receive the utility on the right-hand side, with less income (equal to one, from their labor), but more leisure. The equation for free entry can equivalently be written as

$$\underline{\pi} = \frac{f + \frac{1}{1 - t(\theta)/\bar{l}}}{B + (1-B)\theta}. \qquad \textbf{(Free Entry)} \qquad (13)$$

5 Openness and the income-leisure trade-off

One of the most oft-cited advantages of increased international openness is that firms, when presented with the stark pressures of international competition, have added incentives to invest in their own productivity. A number of avenues have been proposed that articulate the fact they do so only after their country opens up, for instance those proposed by Holmes and Schmitz (2001), Thoenig and Verdier (2003) and Ederington and McCalman (2004). In this section I study how the incentives of *firm owners* change with openness, which in this paper is modeled as the integration of identical countries (formally, as an increase in L). I show that openness modeled in this way serves as an inducement mechanism for firm owners who value their leisure, if and only if openness brings about higher elasticities of substitution. Specifically, as we shall see, openness increases the "price" of leisure

[11] For emphasis, let us recall that owners are too small to act strategically, with consideration of their future role as consumers. In particular, they have a negligible impact on P.

relative to income. Firm owners respond by reducing their leisure time, thereby increasing expected productivity of their firms. The world as a whole gains, because the average higher productivity leads to lower prices, with gains to consumers. Note that firm owners are also better off, even though they are spending more time: first, because their higher efforts allow them to earn more; second, as all other consumers they reap the benefits of lower prices.

A. Intuitive properties of the equilibrium

The model reduces formally to three equations in three variables. Equation (9) comes from productive owners' profit maximization in the third stage. Equation (12) is the outcome of owners choosing the optimal time to invest in the second stage. Finally, equation (13) is for first stage free entry. The three endogenous variables are: N, θ, and $\underline{\pi}$.[12] At the end of this section I present a formal proof for the properties of the equilibrium, which relies on eliminating one of the variables ($\underline{\pi}$). However, it builds intuition for the properties of the model to study in this sub-section the properties of the equation for owner optimization. In the next sub-section I add free entry to system (although I will take free entry into account here), and finally in sub-section C, I add the last equation for a full general equilibrium result. As we shall see, something can be learned in each of these three steps.

To begin, note that the owners' optimization (equation 11) is essentially an unconstrained optimization problem (assuming that the restrictions on θ are non-binding). However, it can be transformed into a constrained choice that goes to the crux of the intuition. Define owners' expected income as $I = \underline{\pi}(B + (1 - B)\theta) - f$ and as before write their leisure as $l = \bar{l} - t(\theta)$. These two quantities are tied into a constraint through θ, and therefore an owner's optimization problem can be rewritten as

$$\underset{I,l}{Max}\ I\ l \quad s.t.\ l = \bar{l} - t\left(\frac{I + f - B(N)\underline{\pi}}{\underline{\pi} - B(N)\underline{\pi}}\right), \tag{14}$$

where both the endogenous $B(N)$ and $\underline{\pi}$ are constants from the point of view of the owner. This optimization problem is represented as the two solid lines in figure 1a. The level sets of the objective function $I\ l$ are convex to the origin. It does no harm to think of these as "indifference curves," as long as one remembers that they are

[12] These equations imply that the labor market clears. Total labor demand equals $N\left[f + \theta \underline{m}\underline{q} + (1 - \theta)\overline{m}\ \overline{q}\right] = Nf + \frac{(1-\theta)\ \beta\ \underline{m}^{\sigma-1} + \theta\ \beta\ \overline{m}^{\sigma-1}}{\underline{m}^{\sigma-1} + \theta(\overline{m}^{\sigma-1} - \underline{m}^{\sigma-1})} \frac{L - N(f+1)}{\beta} = Nf + L - N(f+1) = L - N$, which is total labor supply, since firm owners leave the labor force.

level sets of the *indirect* utility. Note that the constraint in problem (14) is downward sloping: the more leisure you have, the lower your effort in searching for new technology, and therefore the lower your expected income. Given our assumptions about the time function $t(.)$, the constraint is concave to the origin (this is one more reason to require that $t'' > 0$, besides being a consequence of decreasing returns to owners' time). Therefore, barring corner solutions, the owners' optimal point O is unique.

Seen in this way, the owners' optimization problem is very much the essential trade-off that is at the heart of this paper, between income and leisure. Note in particular that even though the constraint is non-linear, its slope close to the optimal point is the opportunity cost, or relative price, of income in terms of leisure. It is insofar as openness changes this relative price that it will change the incentives of firm owners as they maximize expected utility.

So far, this exercise was conducted at constant $\underline{\pi}$ and N, two endogenous variables. Suppose now that $\underline{\pi}$ increased, while still keeping N constant. It is straightforward to check that this relaxes the constraint in problem (14), which is represented by the dotted constraint in figure 1a. This naturally leads to owners choosing both more income and more leisure (that is, less time spent on technological improvement). Note that the increase in profits can be seen as increasing owners' endowment in income. As one might expect, owners use the extra endowment to increase not only their income, but also their leisure, decreasing the optimal probability of success θ.

Let us now analyze an increase in N. It is intuitive (and it will be shown rigorously below) that the increase in openness, modeled as an exogenous increase in L, will increase N. Therefore, here we are analyzing the consequences of openness for the owners' optimization problem. Since the profit differential parameter $B(N)$ decreases with N as the elasticity of substitution increases, and we know that $I+f < \underline{\pi}$, the argument inside the function $t(.)$ in equation (14) increases, causing the income-leisure constraint to go down. Intuitively, if $\overline{\pi} = B\underline{\pi}$ goes down, and if firm owners' keep the same level of effort, their expected income goes down. This shift in the constraint is represented as the dotted curve in figure 1b, which also retraces the original constraint through point O. If this were all that happened, of course, firm owners would lose. But since in this figure N is changing, we need to take the free entry condition (13) into account. Because firm owners are now at a lower indifference curve than regular workers (whose indifference curve is marked at $\bar{l}$), they are not indifferent about entry. With constant N, the only way to make them indifferent would be to increase $\underline{\pi}$, until firm owners get back on the same indifferent curve as before ($\bar{l}$). As already seen, as $\underline{\pi}$ increases, the constraint increases. It becomes the new constraint in figure 1b, through the optimal point O'. Lemma 1 shows that the new constraint must be flatter at all incomes than the old constraint, immediately leading to the conclusion that the new optimal point (O') is to the right of the original optimal point (O). Therefore, with increased openness, firm owners have more income but less leisure, exactly what you would expect under the pressures of globalization.

Lemma 1. *i) With a higher N, $\underline{\pi}$ increases until the owners' constraint in problem (14) is tangent to the "indifference curve" that has $I\ l = \bar{l}$. ii) The new constraint after the increases in N and $\underline{\pi}$ is everywhere flatter than the old constraint.*

Proof: i) Any endogenous changes in N and $\underline{\pi}$ must change the owners' constraint in such a way that it is tangent to the indifference curve where $I\ l = \bar{l}$, because only then are the owners both optimizing and indifferent about becoming a firm owner. ii) To show that the new constraint must be flatter, consider the derivative with respect to I of the constraint: $-t'\left(\frac{I+f-B(N)\underline{\pi}}{\underline{\pi}(1-B(N))}\right)\frac{1}{\underline{\pi}(1-B(N))}$. This evidently decreases in absolute value with both N and $\underline{\pi}$.

The lemma spells out the essential intuition of this paper, namely that the price of leisure after opening up increases. As already pointed out in a different context by Aghion et al (2004), the incentive to innovate is given by the difference between pre- and post-innovation rents, here $\underline{\pi} - \overline{\pi} = \underline{\pi}(1 - B(N))$. The increases in $\underline{\pi}$ and N both act in the same direction, that of enhancing this incentive. Higher profits are a consequence of free entry,[13] and they increase directly the incentives to innovate. Higher international competition, leading to higher σ and lower $B(N)$, has a positive effect on the profit *differential*, even as it decreases profits. Note that after the increases in N and $\underline{\pi}$, firm owners obtain the same (expected) utility as workers, just as they they did before the increases: the indirect utility of all agents is $\bar{l}/P$. But it is the *way* in which firm owners arrive at the same utility that matters. The increase in the relative price of leisure causes them to work harder in the search for better technology and to have more expected income. Finally, note that all economic agents gain, as the indirect utility is $\bar{l}/P$ increases through a lower

[13] With increased international competition, some firms will exit (that is, N/L will go down), which secludes remaining firms' profits.

price index P.

B. The role of the elasticity of substitution

It is widely argued that one consequence of globalization is higher elasticities of demand, which add to volatility in prices, decrease profits, and may intensify the insecurity felt by workers. In the context of this model, it is possible to show that the increase in the elasticity of substitution due to the increase in the number of varieties is essential for a *positive* impact of openness, namely the increased incentive to innovate. The easiest way to see this is to plot equation (12) for owners optimal effort, fully adding now a second building block: equation (13) for free entry. This is shown in figure 2, in which the solid lines are drawn at constant N. We already saw in the previous sub-section that with constant N, the owners' optimization leads to a decreasing relationship between $\underline{\pi}$ and θ (see figure 1a), and this is plotted as line O. Why should the free entry condition, represented as line FE, have a U shape? The free entry condition is a level set for the indirect utility function, the same function for which line O is the local maximum with respect to θ. Thus, the assumption that there is an interior solution θ for owner effort leads to the relationship between the two curves: as one "walks" along the direction θ, keeping $\underline{\pi}$ fixed, one first encounters the level $\bar{l}/P$ for the indirect utility, then the maximum indirect utility as one crosses line O, and then one comes "back down" to the level $\bar{l}/P$ again. For any given N, the equilibrium happens when firm owners are both optimizing and indifferent about remaining as workers: this is represented by point e.

The first observation that we can make from figure 2 and equations (12) and (13) is that the only way that L can change the equilibrium $\underline{\pi}$ and θ is through $B(N) = (\underline{m}/\overline{m})^{\sigma(N)-1}$. If the elasticity of substitution were a constant, figure 2 would determine a *unique* equilibrium $\underline{\pi}$ and θ. L would affect the model only through equation (9), in which case N just increases in proportion to L.

The second observation is that, when the elasticity of substitution increases with the number of varieties, the increase in L does change figure 2, as depicted by the dashed lines. Let us suppose that it is still true, even with a variable σ, that an increase in L leads to an increase in N (this will be made rigorous in the next sub-section). The increase in line O is simple to understand: at fixed $\underline{\pi}$, the higher elasticity of demand leads to a lower profit differential B, which raises the incentives to search for higher productivity.

In order to understand why FE increases with N, note that you can promise two things to entering firm owners: higher profits, or more leisure. At fixed θ, an increase in N lowers the profit differential B, depressing expected profits. The only way to make firm owners indifferent about founding a firm is to increase the profits of productive firms $\underline{\pi}$. Note that it would still be possible that the two curves go up but θ decreased. The following lemma states that the change in N unambiguously leads to a higher θ.

Lemma 2. *When N goes up, the following is true for figure 2. i) If σ is a constant, the figure remains unchanged. ii) If σ is an increasing function of N, both O and FE go up. iii) The increase in the two curves is such that the new equilibrium point has a higher $\underline{\pi}$ and a higher θ, as depicted.* Proof: see the appendix.

The main intuition to get from this sub-section is that with openness, and the accompanying larger number of varieties, two effects act against each other: first the incentives of firm owners are enhanced, causing them to innovate more. We already saw this in the previous sub-section, and here we see that the rise in curve O leads to higher θ. However, the increase in openness also deters entry, which by itself secludes firms and makes firm owners more comfortable about their profits and about using more of their leisure. In figure 2, a rise of FE leads to larger profits and lower effort θ.[14] The key point here is that it will always be the case that the former effect dominates the latter, and the incentive of firm owners to innovate always increases in the presence of openness, even if (and because) openness leads to import competition, and therefore to firm exit.

C. Formal proof

We can now close the model by bringing in the third equation (equation 9 for profit maximization), which so far was kept in the background. Let us first combine equations (9) and (13) to obtain:

$$\frac{1}{\sigma(N)-1}(\frac{L}{N}-f-1)=f+\frac{1}{1-t(\theta)/\bar{l}}. \tag{15}$$

Then, combine equations (12) and (13) to obtain:

[14] This "Schumpeterian" effect is what motivates some negative results on the impact of import competition on innovation. Thus, for example, the paper by Miyagiwa and Ohno (1995) studies firms incentives to delay adoption of new technologies, as the price of adoption decays with time (in this way, their set-up is similar to Ederington and McCalman 2004). With more liberal trade policies, a foreign firm encroaches on the turf of a domestic firm, decreasing the latter's incentive to innovate. It is therefore interesting to note that, once one takes owners' incentives into account, that result is overturned, as in the conclusion of this paragraph.

$$\frac{\bar{l} - t(\theta)}{t'(\theta)} \left[f \left(1 - \frac{t(\theta)}{\bar{l}} \right) + 1 \right] = \theta + \frac{1}{1/B(N) - 1}. \tag{16}$$

Note that we have eliminated $\underline{\pi}$ from the system, and therefore equations (15) and (16) constitute two equations in two variables, N and θ, and are depicted in figure 3. The following proposition establishes the main result of the paper.

Proposition 1. *Equation (15) defines a decreasing relationship, and equation (16) defines an increasing relationship between N and θ, as depicted in figure 3. When L increases, the curve corresponding to equation (16) does not shift. The curve of equation (15) shifts up, such that at each value of θ, N increases less than proportionally with respect to L. As a consequence, the impact of the increase in L on the three endogenous variables is as follows: i) θ increases. ii) N increases, but with a decrease in N/L. iii) $\underline{\pi}$ increases.* Proof: see the appendix.

That equation (16) defines an increasing relationship between N and θ should not be surprising. Indeed, that equation combines owner optimization with free entry, and we saw in the previous sub-section, as well as in figure 2, that combining those two conditions leads to the conclusion that an increasing N increases effort level. Furthermore, because equation (16) combines two decisions that have nothing to do with the market size, the equation itself does not change with the market size.[15]

The intuition for why equation (15) should define a decreasing relationship between N and θ is less direct. Recall that equation (15) combines the outcome of profit maximization with free entry. Suppose that N increased, at constant effort level θ. Even with constant elasticity of substitution, this decreases profits, since the higher number of firms incurs in more fixed costs, correspondingly decreasing income. But then the only way for free entry to hold is decrease the effort level θ. Finally, with a larger market, profits increase, causing the curve for equation (15) to go up (recall from figure 1a that an increase in $\underline{\pi}$ at constant N leads to a higher θ).

I end this section with a comparative statics exercise. It is motivated by the result in Fernandes (2003) that the impact of openness on productivity is larger the lesser the degree of competitiveness in an industry. I simulate that in figure 4, which depicts the changes in several variables, as the fixed cost f increases. A low fixed cost is the proxy in this model for a high level of competitiveness in an industry. Not

[15] While considering whether to become a firm owner, a worker takes profits, effort level, and fixed cost into account, but not the market size. The same is true for the firm owner considering the optimal effort level.

surprisingly, as f increases, the number of entrants decreases, and the effort level increases as rents increase (this is a Shumpeterian aspect). Of more interest is the third graph, which plots the ratio between the effort level with a large world size L (θ_{high}) and the effort level with a small world size (θ_{low}). As f increases, the change in θ also increases, even though θ was already large to begin with, confirming the excpectation of a larger effect for less competitive industries.

6 The role of the price index

When consumers have a love for variety, one further advantage of free trade is the increased number of varieties that are made available to them. This gain from trade has been highlighted by the work of Feenstra (1994) and most recently by Broda and Weinstein (2003), who calculate the decrease in the price index (P, in this paper) that results from trade openness. This section adapts the model of income-leisure trade-off to ask the following question: if the decrease in P increases the shadow value of income, can we rationalize that firm owners would as a consequence shift out of leisure? The current utility function, equation (1), is not adequate to look into this, because P does not alter the margin between income and leisure when leisure is just a (multiplicative) shift factor in the utility. This much is evident from the owners' problem, equation (11). Therefore, I depart more radically from Becker (1965) by introducing a different utility function, one in which leisure is valued as an additional consumption good. The easiest way to do so is to enter it additively:

$$U = \left(\int_0^N q(\omega)^{\beta} d\omega \right)^{1/\beta} + \nu(l). \tag{17}$$

Here, the function ν has the usual properties: $\nu' > 0$, $\nu'' < 0$. Contrary to the previous utility function, in which consumers need time to consume all other goods, but otherwise have no use for time, consumers with utility function (17) value the consumption of leisure time by itself. The argument of this paper is that both types of need are likely to be present, and therefore by separating them into two different utility functions, we are able to isolate the consequences for each of them. However, as I comment further in the last section of the paper, the implications of the two models are quite different.

The expression for the indirect utility now becomes:

$$V(I, P, l) = \frac{I}{P} + \nu(l), \tag{18}$$

and the basic mechanism at play in this section can be simply described: free trade as I shall prove decreases P, raising the shadow value of income. Firm owners that had been optimizing now value income more after the country opens up, and substitute out of some of their leisure. Thus, for example, in a society like China, where a large number of consumer goods and services were made available as the country opened up, people were suddenly motivated to become better entrepreneurs. Besides this modification, the rest of the model follows relatively unscathed, and a terse presentation of the additional results should suffice.

We again have three equations in the three endogenous variables: N, θ, and $\underline{\pi}$. Equation (9) for profit maximization remains unchanged, because that equation calculates the profits of the productive firm owners in the third stage of the problem, when all leisure decisions have been "sunk." Equation (12) changes to:[16]

$$v'\left(\bar{l}-t(\theta)\right)t'(\theta)=\frac{\underline{\pi}(1-B)}{P}. \qquad \textbf{(Optimal effort)} \qquad (19)$$

This equation matches the marginal cost of extra probability of success (less leisure, on the left) to the marginal benefit (extra profits, on the right).

Finally, equation (13) changes to

$$\frac{\underline{\pi}\,(\theta+(1-\theta)B)-f}{P}+v\left(\bar{l}-t(\theta)\right)=\frac{1}{P}+v\left(\bar{l}\right). \qquad \textbf{(Free Entry)} \qquad (20)$$

In words, firm owners' higher income and lower leisure gets them the same utility as workers.

As before, we can combine the equations two by two to get a rigorous solution to the model. Let us combine equations (9) and (20), with the result:

$$N\left\{f+\beta P\left[v\left(\bar{l}\right)-v\left(\bar{l}-t(\theta)\right)\right]\right\}=(L-N)(1-\beta). \qquad (21)$$

Note that P is a function of both N and θ (see the appendix for the properties of the price index). Lemma 3 finds simple sufficient conditions for equation (21) to define a decreasing relation $N(\theta)$.

Lemma 3. *If $\beta > 1/2$ (that is, if $\sigma > 2$), and if $t'(\theta)$ is sufficiently large (as defined in the proof), then the implicit function $N(\theta)$ defined by equation (21) is a decreasing function of θ.* Proof: see the appendix.

[16] I assume in this section that σ (and therefore B) is a constant, an important simplification since the algebra in this section is somewhat more involved. Note that the intuition of this section has to do with how P changes. Assuming that σ is a constant thus has the advantage of isolating that effect. Also note that I am again assuming an interior solution for θ.

Note that the sufficient condition that $\sigma > 2$ is reasonable. Broda and Weinstein (2003)'s elasticities of substitution lie around five and above. The sufficient condition that $t'(\theta)$ be sufficiently large means that the demands on owner time must be substantial, for the impact of leisure to matter.

To find a solution for the model, we need one more equation in N and θ, for which we make use of the conditions for owners' optimal effort level and for free entry, equations (19) and (20), obtaining:

$$v'\left(\bar{l} - t(\theta)\right) t'(\theta) \left(\frac{B}{1-B} + \theta\right) = \frac{f}{P} + v\left(\bar{l}\right) - v\left(\bar{l} - t(\theta)\right). \tag{22}$$

Note the dependence on N through P. Under the same general type of sufficient condition as in lemma 3, equation (22) defines an increasing relationship of N with respect to θ, as shown in the next lemma.

Lemma 4. *If $t'(\theta)$ is sufficiently large (as defined in the proof), then equation (22) implicitly defines a function $N(\theta)$ that is monotonically increasing.* Proof: see the appendix.

Since as just proven, equations (21) and (22) define a decreasing and an increasing relationship between N and θ, we can re-use figure 3 to show them. Figure 3 guarantees that if an equilibrium exists, then it is unique.

The next proposition establishes what happens when L increases.

Proposition 2. *When L increases, the curve for equation (22) does not shift. With the sufficient condition that $\sigma > 2$, as in lemma 3, the curve for equation (21) goes up. As a consequence, both N and θ increase.*

Proof: note that equation (22) does not depend explicitly on L. To see that N in equation (21) goes up with fixed θ, note that L increases the right side of the equation. Therefore, N must increase, in order for the left-hand side to increase and for the right-hand to decrease. Note that $\sigma > 2$ is sufficient to ensure that the left side of the equation increases with N.

Again, as in the previous section, world integration has a positive impact on productivity. As before, world integration is parametrized by an increase in L: as more countries integrate in the world economy, they reproduce the autarky equilibrium described above, except that the aggregate work force equals the sum of the integrated countries' work forces.

Note that L has no effect on equation (22). The reason is similar to the previous model. That equation combines two conditions: the optimal decisions of workers, when they are considering whether to establish a firm; the optimal effort level picked by firm owners. Profits enter these equations in exactly the same way, namely through the indirect utility of income, given by I/P. For the individual worker who is considering becoming a firm owner, the size of the economy does not play a role, only the individual profits ($\underline{\pi}$ and $\overline{\pi}$), the costs associated with the decision (f and the various $v(l)$), as well as the probability of success (θ). Of these, only the first group (profits) depends on the size of the economy. But this is precisely the group that enters the other condition, that of owner optimization. Therefore, it should be possible to eliminate profits once we combine the two conditions, and indeed this is what happens. Thus, the end result is unrelated to L.

By contrast, increasing L raises the curve for equation (21), which is shown in figure 3 as a dashed line. The reason for the shift is straightforward. Remember that equation (21) gives, for a fixed N, the optimal owner effort (combined with the condition for free entry). If L increases at constant N, aggregate income increases, driving up profits. This induces firm owners to spend more time in search for better technologies, therefore θ increases at constant N.

Since the average marginal cost can be written $\theta\underline{m} + (1-\theta)\overline{m}$, and $\underline{m} < \overline{m}$ by construction, world integration also leads unambiguously to lower average marginal costs, and therefore to higher average productivity, for the industry as a whole. Note that this result is by no means a foregone conclusion in this version of the model. Even though the size of the market naturally leads to higher expected profits, and therefore, to higher investment in effort time and thus to higher productivity when all else is equal, here all else is *not* equal. In particular, the general equilibrium consequence of the shift of equation (21) is mediated by equation (22). Had the latter been downward sloping, for instance, which is possible if the requirements on managerial time are not sufficiently large (if $t'(\theta)$ is too small), this could lead to *lower* owner effort.

7 Overview and differences of the two stories

Since we do not know exactly how leisure would enter utility, this paper takes the position that reality is likely to lie somewhere "in between" the two models, one in which utility is a multiplier that explains how much enjoyment consumers derive from their consumption goods, and the other in which it is a consumption good by itself. A contention of this paper is that both effects identified here are likely to be present.

However, it is important to note that the two effects will have quite different scopes of applicability. The first effect has to do most directly with import competition. In it, firm owners that see their incomes dwindling, decide "belatedly" to increase their productivity. They do so because in the presence of openness the relative price of leisure goes up, creating incentives for firm owners to shift out of leisure and into higher productivity. For this effect to appear, all that is needed is import competition in the sector in question. Of course, in this paper I only modeled one sector, but it is clear that if we had a model with many sectors, and if the country only opened in one specific sector, the effect would still be there, although limited to the sector that opened up. The main driving mechanism is an increasing elasticity of demand when countries open up, which reduces the profits of unproductive firm owners, and therefore increases their incentives to innovate.

I then took the general idea that there is a leisure-income trade-off to a different extreme, where leisure is a consumption good in itself. In this second model, in order to isolate the effect I assumed that the elasticity of substitution (the main driving force in the first model) was a constant. Here, what matters is the following direct mechanism for the relative price of leisure to go up when the country opens up: even at constant goods prices, openness drives down the real price of consumption goods, because people get more variety, increasing the value of income. Note that for *this* mechanism to work it does not suffice to open in the sector in question (and therefore the relationship with empirical studies that correlate within-firm productivity with each sector's trade barriers is weakened). Rather, it is necessary for the economy to open up in most, if not all, sectors. Here the importance of firm owners being at the same time consumers is heightened: with the increased variety of goods they will want to substitute some extra income for some leisure.

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APPENDICES

A Model with Finite Number of Varieties

For tractability, the main body of the text considers a model with a continuum of varieties, and assumes that producers of each variety face increasing elasticities of demand when the number of varieties increases. This appendix shows that such an assumption can be made more rigorous, by considering a model with a finite number of varieties. The utility function is written as:

$$U = l\left(\sum_{i=1}^{N} q_i^{\beta}\right)^{1/\beta},$$

with notation similar to the main text. A consumer with income I issues the following demand for variety i:

$$d_i = \frac{p_i^{-\sigma}}{\sum_{i=1}^{2n} p_i^{1-\sigma}} I.$$

The producer of variety i maximizes profits, which can be written as

$$\pi_i = p_i q_i - m q_i = \frac{(p_i - m)p_i^{-\sigma}}{p_i^{-\sigma} + P_{-i}} I,$$

with the notation $P_{-i} \equiv \sum_{i \neq 1}^{N} p_i^{1-\sigma}$. In the expression above, m is the producer's marginal cost, which is $\underline{m}$ or $\overline{m}$ for productive and unproductive producers, respectively. The first order conditions for profit maximization of variety i can be written:

$$\frac{m}{\beta} = p_i \left[1 - \frac{(p_i - m)p_i^{-\sigma}}{N\left(\theta \underline{p}^{1-\sigma} + (1-\theta)\overline{p}^{1-\sigma}\right)}\right], \tag{23}$$

where θ is the equilibrium proportion of productive producers and $\underline{p}$, $\overline{p}$ are the equilibrium prices of the two types of varieties available. By replacing p_i in the equation above by one of these prices we get an equation that is obeyed in equilibrium, for a total of two equations that could in principle be solved exactly in the two variables (the prices themselves). Note that such solutions will be functions of $1/N$. Taking into account that N is very large, we can Taylor-expand each of the two equations up to terms of order $1/N$:

$$p_i(1/n) = p_i(0) + \left(\frac{\partial p_i(1/N)}{\partial(1/N)}\right)_{1/N=0}\frac{1}{N} + O(\frac{1}{N^2}).$$

Substituting $1/N = 0$ in equation (23), we can solve for $p_i(0)$. Taking the derivative of the same equation with respect to $1/N$, substituting $1/N = 0$ allows us to solve for $\left(\frac{\partial p_i(1/N)}{\partial(1/N)}\right)_{1/N=0}$. Substituting everything into the expression above yields for one of the equations:

$$\frac{\overline{p}}{\overline{m}} = \frac{1}{\beta} + \frac{(1/\beta - 1)}{N(\theta + (1-\theta)B)},$$

with analogous expressions for the other price. The usual result of a constant mark-up is obtained in the limit when $1/N$ is very large: $\frac{\overline{p}}{\overline{m}} = \frac{1}{\beta}$. Here, we wish to retain one more term, that of $O(\frac{1}{N})$. We see that the mark-up is decreasing with N, which is consistent with an increasing elasticity of demand when N increases.

Proof of Lemma 2

The argument for parts i) and ii) can be found in the main text. To prove part iii), consider a small negative change in B, that is $dB < 0$. Starting from the initial equilibrium e, and at constant θ, the differential change in $\underline{\pi}$ in curves O and FE are calculated as follows:

$$(d\underline{\pi})^O = \frac{\underline{\pi}(-dB)(1-\widetilde{\theta})}{B + \widetilde{\theta}(1-B)},$$

$$(d\underline{\pi})^{FE} = \frac{\underline{\pi}(-dB)(1-\theta)}{B + \theta(1-B)},$$

respectively, where $\widetilde{\theta} \equiv \theta - \frac{\bar{l}-t(\theta)}{t'(\theta)}$. Since the expression $\frac{1-\theta}{B+\theta(1-B)} = \left(B + \frac{1}{\theta^{-1}-1}\right)^{-1}$ goes down with θ, and $\widetilde{\theta} < \theta$, then $(d\underline{\pi})^O > (d\underline{\pi})^{FE}$. This implies that the equilibrium point e moves upward and to the right. Therefore the new equilibrium values of θ and $\underline{\pi}$ verify: $\theta' > \theta$ and $\underline{\pi}' > \underline{\pi}$.

Proof of proposition 1

Note that the right-hand side of equation (15) increases with θ but does not vary with N, while the left-hand side decreases with N (recall that σ increases with N) and does not vary with θ. This establishes that equation (15) defines a decreasing relationship between N and θ.

Next, suppose that θ increases in equation (16). This increases the right-hand side and decreases the left-hand side, given the assumptions on $t(.)$. Therefore N must adjust to decrease the right-hand side, which it can do by increasing (recall that $B(N)$ decreases with N). This establishes that equation (16) defines an increasing relationship between N and θ.

Let us now see what happens when L changes. Obviously, equation (16) does not depend on L at all, and therefore it does not shift. As for equation (15), imagine for one instant that σ were a constant. Then, at fixed θ, N would just increase in proportion to the increase in L, such that L/N remained a constant. However, since σ actually increases as a consequence of the increase in N, the left side of the equation becomes smaller than the right side. To compensate, N has to decrease somewhat, starting from the proportional increase. As a conclusion, at a fixed θ, N increases, but N/L decreases.

This shift in the curve for equation (15) immediately leads to the conclusion that the equilibrium moves from e to e' in the figure, yielding a less than proportional increase in N, and a decrease in θ. Once we establish that N goes up, we can simply use Lemma 2 to imply that $\underline{\pi}$ must go up.

Properties of the "price index"

The price index is defined by equation (5), which is repeated here for convenience:

$$P \equiv \left[\int_0^N p(\omega)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}} .$$

Given the prices charged by the productive and the unproductive firm owners, and their respective proportions, this expression becomes

$$\frac{1}{P} = N^{\frac{1}{\sigma-1}} \beta \left(\frac{\theta}{\underline{m}^{\sigma-1}} + \frac{1-\theta}{\overline{m}^{\sigma-1}} \right)^{\frac{1}{\sigma-1}} . \tag{24}$$

Since $\sigma > 1$, $1/P$ is an increasing function of N. Furthermore, if the assumption that $\sigma > 2$ is made, as it is in section 6, then $1/P$ increases faster than N, as N itself increases. In particular, it will then prove useful to calculate $\frac{\partial P}{\partial N}$. Since P can be written as $P = N^{-\frac{1}{\sigma-1}} C$, where C does not depend on N, then $\frac{\partial P}{\partial N} = -\frac{1}{\sigma-1} \frac{P}{N}$.

It will also be useful to calculate $\frac{\partial P}{\partial \theta}$, which is done below:

$$\begin{aligned}&\frac{\partial P}{\partial \theta}\\&=-P\frac{1}{\sigma-1}\frac{\left[\frac{1}{m^{\sigma-1}}-\frac{1}{\overline{m}^{\sigma-1}}\right]}{\left[\frac{\theta}{m^{\sigma-1}}+\frac{1-\theta}{\overline{m}^{\sigma-1}}\right]}\\&=-P\frac{1}{\sigma-1}\frac{1-B}{B+(1-B)\theta}\end{aligned} \tag{25}$$

Note that this derivative is negative.

Proof of Lemma 3

We begin the proof by showing that the left hand side of equation (21) increases with N, at constant θ. Note that $V(\theta) \equiv v\left(\bar{l}\right) - v\left(\bar{l} - t(\theta)\right)$ is an increasing function of θ, but it is not a function of N. Therefore, $\frac{\partial}{\partial N}[N\left[f + \beta PV(\theta)\right] > 0 \iff f + \beta PV\left(\theta\right) + N\beta\frac{\partial P}{\partial N}V\left(\theta\right) > 0$. We can use the expression for $\frac{\partial P}{\partial N}$ calculated above, to get $f + \beta PV\left(\theta\right) + N\beta\frac{\partial P}{\partial N}V\left(\theta\right) = f + \beta PV\left(\theta\right) - \frac{1}{\sigma-1}\beta PV\left(\theta\right) = f + \beta PV\left(\theta\right)(2 - 1/\beta)$. Noting that both P and $V\left(\theta\right)$ are positive, the condition $\beta > 1/2$ is sufficient (but not necessary) to ensure that the last expression is positive.

Let us now show that the left hand side of 21 increases with θ, at constant N, which amounts to show that $\frac{\partial[PV(\theta)]}{\partial\theta} > 0$. Using the expression for $\frac{\partial P}{\partial \theta}$ obtained above, this is equivalent to:

$$P\left[v'\left(\bar{l} - t(\theta)\right)t'(\theta)\right] > VP\frac{1}{\sigma-1}\frac{1-B}{B+(1-B)\theta},$$

which can be simplified to

$$t'(\theta) > \frac{V(\theta)}{(\sigma-1)v'\left(\bar{l} - t(\theta)\right)\left[\frac{B}{1-B}+\theta\right]}.$$

For any given utility of leisure $v\left(l\right)$, the assumptions on its derivatives imply that $v'\left(\bar{l} - t(\theta)\right)$ and $V(\theta)$ are bounded, and so is $\theta < 1$. Therefore the right-hand side of inequality above is a positive bounded number, and the inequality becomes a condition on $t'(\theta)$ being sufficient large, as stated by the lemma.

Given that the left-hand side of equation (21) increases with both N and θ, and that the right-hand side decreases with N, the equation defines a decreasing relationship $N(\theta)$.

Proof of Lemma 4

Let us first assume that both θ is an interior solution, that is $0 < \theta < \theta_{\max}$, where $\theta_{\max}$ is defined as $t(\theta_{\max}) = \bar{l}$. Denote the left-hand side of equation (22) by $L(\theta)$, and its right-hand side by $R(N, \theta)$. Let us show that both $L(\theta)$ and $R(N, \theta)$ increase with θ. This is because: first, as was shown above, $\frac{\partial}{\partial \theta}(P) < 0$; second, $V'(\theta) > 0$, where $V(\theta)$ was defined in the proof of lemma 3; third, $\frac{\partial}{\partial \theta}\left(v'\left(\bar{l} - t(\theta)\right) t'(\theta)\right) = -v''\left(t'\right)^2 + v't'' > 0$, where to avoid clutter all arguments (such as θ or $\bar{l} - t(\theta)$) will be suppressed for the remainder of this proof.

It is also possible to show that if $t'(\theta)$ is sufficiently large, then $L'(\theta) > R'_\theta(N, \theta)$. This is equivalent to

$$[-v''\left(t'\right)^2 + v't''][\frac{B}{1-B} + \theta] + v't' > f\frac{\partial}{\partial \theta}\left(\frac{1}{P}\right) + v't'. \tag{26}$$

By substitution from equation (25), the inequality becomes $\left(-v''\left(t'\right)^2 + v't''\right)\left(\frac{B}{1-B} + \theta\right)^2 > \frac{f}{P}\frac{1}{\sigma - 1}$. Substituting from equation (22) for f/P, this is in turn equivalent to

$$\left(-v''\left(t'\right)^2 + v't''\right)(\sigma - 1)\left(\frac{B}{1-B} + \theta\right)^2 > v't'\left(\frac{B}{1-B} + \theta\right) - V(\theta).$$

Since $V(\theta)$ is strictly positive and $v't''$ is positive, a *sufficient* condition for the inequality above is that

$$t' > \frac{v'}{-v''(\sigma - 1)\left(\frac{B}{1-B} + \theta\right)}.$$

Now suppose that N increases, with fixed θ. Note that $L(\theta)$ does not depend on N, while since $\frac{1}{P}$ increases with N, $R(N, \theta)$ increases with N. Since, as we just proved, $L'(\theta) > R'_\theta(N, \theta)$, θ must increase to recover the equality of equation (22), which therefore defines an increasing relationship between θ and N, as we wanted to prove.

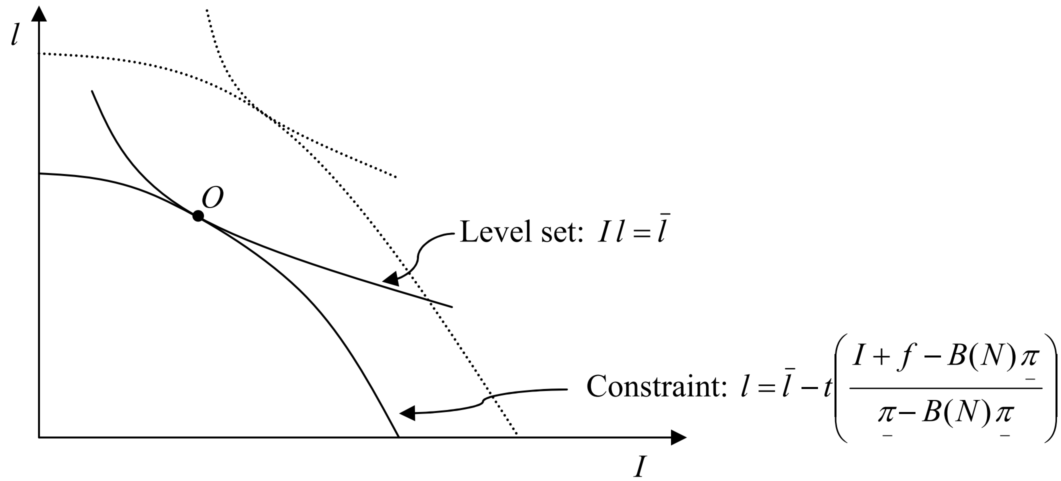

Figure 1a – Owner's constrained optimization, variable $\underline{\pi}$, constant *N*.

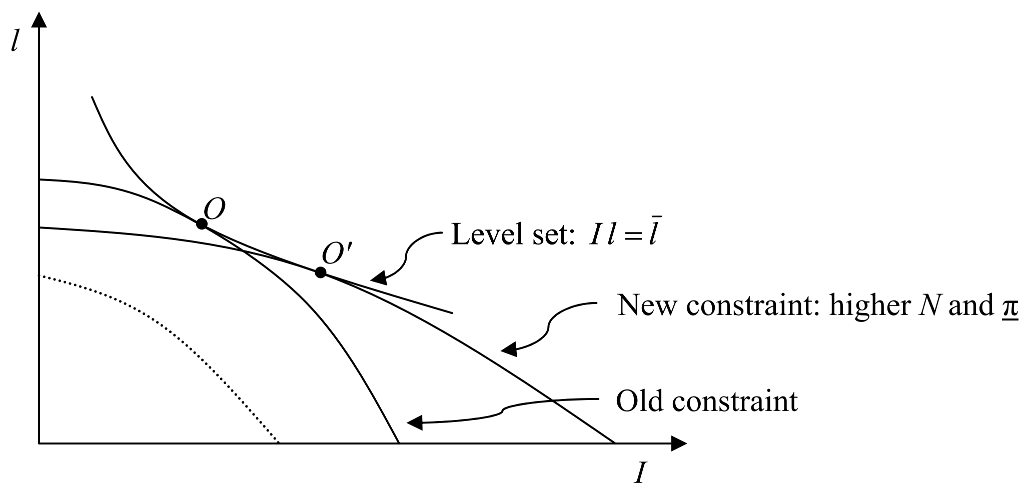

Figure 1b – Owner's constrained optimization, variable $\underline{\pi}$ and *N*.

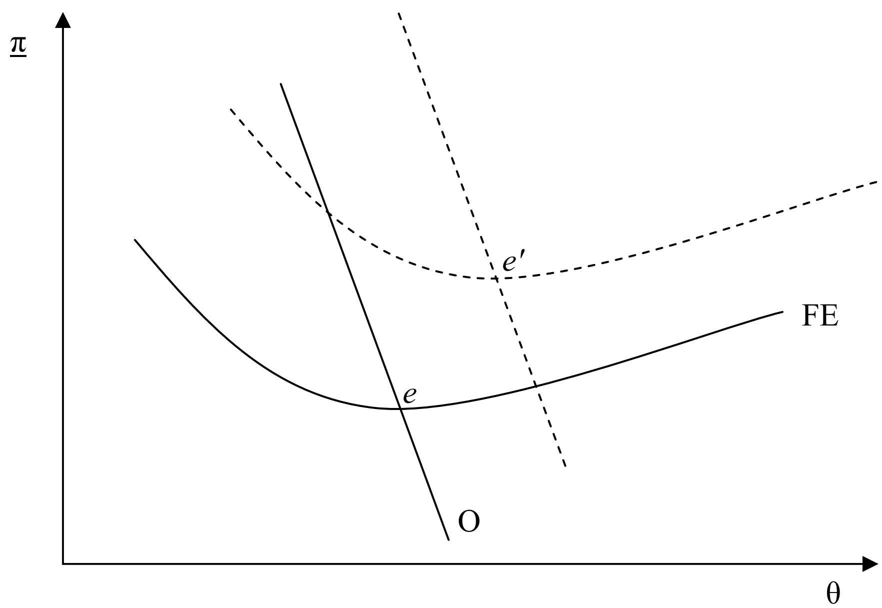

Figure 2 – Equations 12 (O – optimal effort) and 13 (FE – free entry), *N* constant.

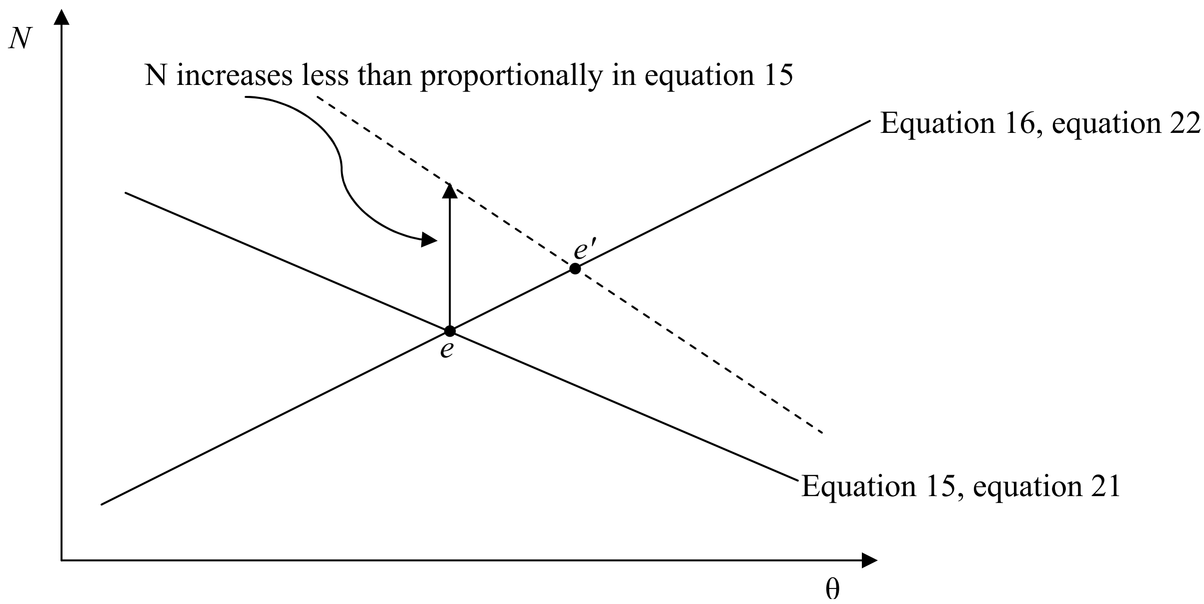

Figure 3 – Change in the full equilibrium with increasing *L*.

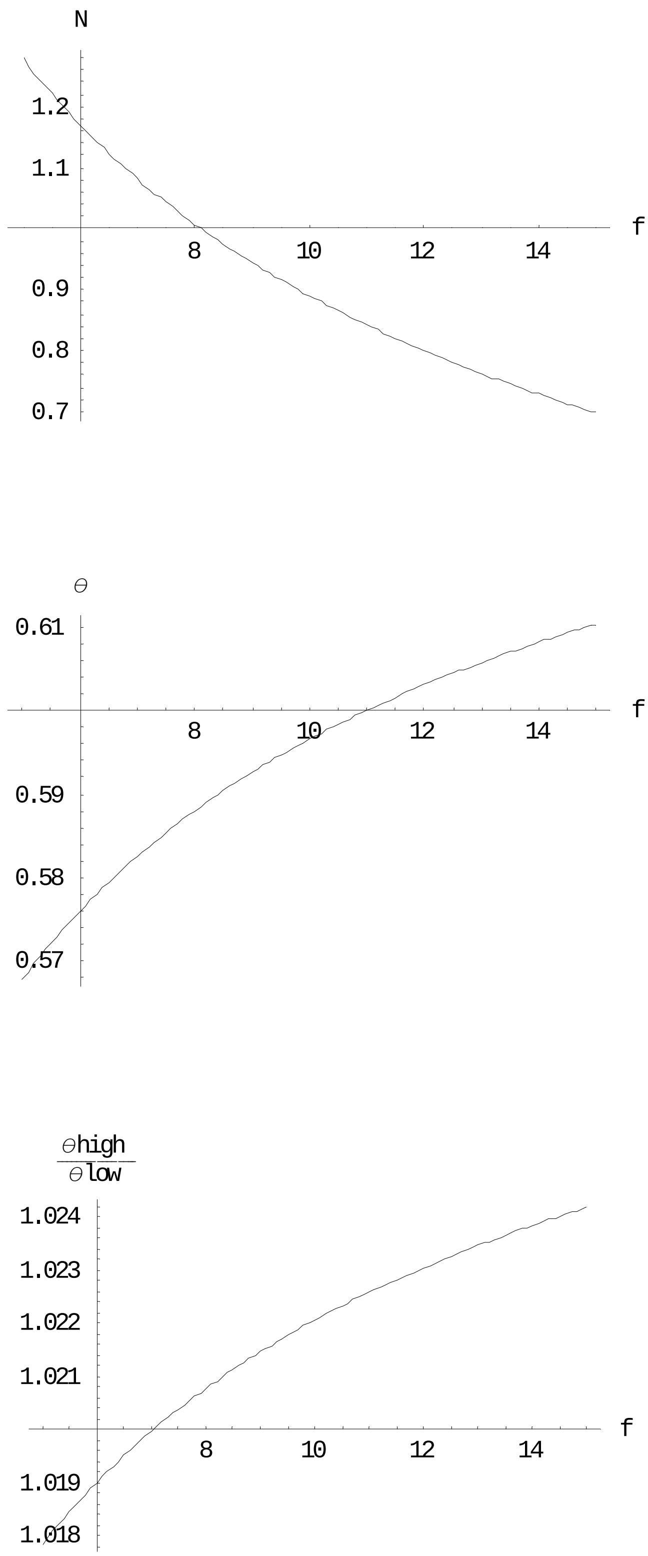

Figure 4 – Changes of endogenous variables with increasing *f*.

Table 1. A selection of firm- and plant-level studies on the impact of trade on productivity.

Paper	Country / years	Level	Estimation of technical efficiency effect	Identification of impact of trade (policy)	Firm (plant) level TFP gains	Market share effect?	Scale effect?
Harrison (1994)	Côte d'Ivoire	Firm	Hall (1988)-type estimates, to correct for market power and variable returns	1) "After trade reform" dummy 2) Tariffs 3) Import penetration	1) Yes 2) Yes 3) Mixed		
Tybout & Westbrook (1995)	Mexico 1984-1990	Plant	Solow residuals	1) Import license coverage 2) Nominal tariff rates 3) Effective protection 4) Import penetration	Some	Some	No
Pavcnik (2002)	Chile 1979-1986	Plant	Olley, Pakes (1996)-type estimates of TFP, using investment to control for simultaneity bias between variable inputs and productivity	Difference between export-oriented, import-competing, and nontraded-goods sectors.	Yes	Yes. Within-plant effect is 1/3 of total	
Fernandes (2003)	Colombia 1977-1991	Plant	Olley, Pakes, modified by Levinsohn and Petrin (2003)-type procedure: uses raw materials instead of investment to control for simultaneity bias	1) Lagged nominal tariffs 2) Eff. rate of protection 3) Import penetration	Yes	Yes. Within-plant effect is 68% of total	No
Muendler (2003)	Brazil 1986-1998	Firm	Olley, Pakes, plus: author's framework; Klette & Griliches (1996) correction for omitted price bias; IV to control for endogeneity of trade policy and volume	1) Tariffs 2) Import penetration	Yes (shorter time)	Yes (longer time, weaker)	