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Foreign Competition and Wage Inequality

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## **FOREIGN COMPETITION AND WAGE INEQUALITY\***

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### **Abstract**

I argue that increased foreign competition can affect technical choice and skill differentials even when actual imports do not rise significantly. I present a model of General Oligopolistic Equilibrium ("GOLE") in which a reduction in import barriers (whether technological or policy-imposed) encourages more strategic investment by incumbent firms. The predictions accord with many of the stylised facts: higher skill premia; higher ratios of skilled to unskilled workers employed in all sectors and throughout the economy; little change in import volumes or prices; and rapid technological progress with rather little change in total factor productivity.

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Keywords: General Oligopolistic Equilibrium ("GOLE"); skill-biased technical progress; skill premia; strategic investment; trade and wages.

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"With the life-cycle of products shrinking, and competition coming from unexpected corners of the globe, companies have to be more nimble than ever."  
– *The Economist*, January 29th, 2000, p. 98.

## **1. Introduction**

In this paper I reconsider the great debate on the causes of the apparent collapse in the demand for unskilled workers in OECD countries. In particular, I suggest that existing discussions of the effects of international trade on wage and employment differentials have focused unduly on competitive models. I propose an oligopolistic model in which changes in technology or trade policy expose domestic firms to greater foreign competition. The model integrates insights from the theory of industrial organisation with the kind of general equilibrium approach to goods and factor markets needed in trade applications. In addition, its predictions are more consistent with the stylised facts than those of existing models.

More than a decade of careful empirical work by both trade and labour economists has uncovered a number of stylised facts on which there seems to be general agreement. (Desjonqueres et al. (1999) and Haskel (1999) give recent summaries.) First, in recent decades the skill premium, the relative wage of skilled to unskilled workers, has risen in all sectors and in all countries, including less-developed and newly-industrialising countries as well as OECD countries. Second, the rise in the skill premium has been accompanied by increases in the ratio of skilled to unskilled employment in all sectors, both skilled- and unskilled-labour intensive. Third (though the evidence here is less clear-cut, especially for the U.S.), there has been no significant decline in the relative price of less skilled-labour-intensive goods. All three of these stylised facts conflict with the view (derived from the textbook Heckscher-Ohlin model) that the rise in the skill premium is mainly due to cheaper unskilled-labour-intensive imports.

Yet, as my opening quotation shows, popular discussion continues to give an independent role to "globalisation" as well as to technology shifts in explaining changes in

industrial structure and wage differentials. Moreover, the claim that skill-biased technological progress is the sole cause of the observed changes is itself open to question. I have noted in Neary (2001b) that, for this to hold in a multi-sector economy, the pattern of skill-biased technological progress must be fortuitously biased. It must be pervasive (to explain the rise in skilled to unskilled employment ratios in all sectors) yet concentrated in skill-intensive sectors (or else the aggregate demand for *unskilled* labour would rise). A different problem is the "productivity puzzle": if technological progress has been so important and all-pervasive as casual observation and patents data suggest, why have productivity growth rates not risen dramatically? Robert Solow's famous quip that "We see computers everywhere, except in the productivity statistics" has been only slightly qualified by Robert Gordon's evidence that productivity growth is illusory everywhere, except in the computer manufacturing sector. (See Gordon (2000).)

While the textbook Heckscher-Ohlin model is inconsistent with the observed changes, more sophisticated trade models have been proposed to explain the facts. Feenstra and Hanson (1996) and Jones (1997) have shown that out-sourcing of more unskilled-labour-intensive stages of production can raise skill premia and skill intensities in both exporting and importing countries. Acemoglu (1999), Dinopoulos and Segerstrom (1999) and Thoenig and Verdier (2000) show how trade liberalisation can induce skill-biased technological progress in models with endogenous innovation. Finally, Dinopoulos, Syropoulos and Xu (2000) and Ekholm and Midelfart Knarvik (2000) show how trade liberalisation in monopolistically competitive industries can induce rises in firm scale which raise skill intensity. However, these papers are vulnerable to the critique of Krugman (2000): observed levels and changes in trade volumes do not seem sufficiently large to explain the large changes in skill premia. Moreover, like almost all contributions to the trade and wages debate, these papers assume

that markets are competitive, either perfectly or monopolistically.<sup>1</sup> In this paper I hope to show that an approach based explicitly on strategic interaction by oligopolistic firms suggests some very different ways in which foreign competition can impinge on domestic factor markets.

The plan of the paper is as follows. Section 2 presents a model of oligopolistic competition in a single industry. Section 3 considers how the industry responds to trade liberalisation and technological change, while Section 4 looks at the implications for economy-wide factor markets in a model of general oligopolistic equilibrium. Section 5 explores the robustness of the results to alternative assumptions about the behaviour of firms. Finally, Section 6 concludes.

## 2. Strategic Investment and Industry Size

Consider an oligopolistic industry with  $n$  firms, each of which produces a symmetrically differentiated product. Assume (as in Vives (1985)) that demands are generated by a quadratic utility function:

$$u(x, n) = \sum_{i=1}^n a_i x_i - \frac{1}{2} b \left[ \sum_{i=1}^n x_i^2 + 2e \sum_{i=1}^n \sum_{j \neq i}^n x_i x_j \right] \quad (1)$$

where  $a_i > 0$ ;  $b > 0$ ; and  $e$  ( $0 \leq e \leq 1$ ) is an inverse measure of product differentiation. The inverse demand function for good  $i$  is therefore:

$$p_i = a_i - b \left[ x_i + e \sum_{j \neq i}^n x_j \right] \quad (2)$$

which is more conveniently written as:

$$p_i = a_i - b [(1-e)x_i + e\bar{x}] \quad (3)$$

where  $\bar{x} \equiv \sum_j x_j$  is the total output of all firms.

Assume that firms engage in two-stage competition, first choosing their levels of investment and then choosing outputs in a Cournot manner. Firm  $i$ 's investment, denoted by  $k_i$ , incurs up-front quadratic costs of  $\gamma k_i^2/2$ . The benefit comes in the form of linear reductions in marginal production costs:  $c_i = c_i^0 - \theta k_i$ . All firms have access to the same technology, so they have the same investment cost parameter  $\gamma$  and the same investment effectiveness parameter  $\theta$ . However, they may differ in their absolute efficiency levels, as measured by their marginal production costs in the absence of investment,  $c_i^0$ . With these assumptions, the profits of firm  $i$  (equal to operating profits  $(p_i - c_i)x_i$  less fixed costs) are:

$$\pi_i = (p_i - c_i)x_i - \gamma k_i^2/2 \quad (4)$$

The equilibrium is sub-game perfect, so firms take their investment decisions anticipating the effects on future product-market competition.

In the second stage, investment spending is sunk, so firms choose outputs taking the marginal costs  $c_i$  as given. The first-order condition for output is the standard Cournot mark-up formula:

$$p_i - c_i = b x_i \quad (5)$$

Using the demand function (3) to eliminate  $p_i$  gives firm  $i$ 's reaction function, expressed in terms of its own output and the output of all  $n$  firms:

$$b(2-e)x_i = A_i' - b e \bar{x} \quad (6)$$

where  $A_i' \equiv a_i - c_i$  is the maximum profit margin possible on good  $i$ , and so is a measure of the size of the market for that good. Summing over all  $n$  firms we can solve for industry output:

$$b\bar{x} = \frac{1}{2+(n-1)e} \bar{A}' \quad (7)$$

where  $\bar{A}' \equiv \sum_j A'_j$  can be interpreted as a measure of the size of the total market available to all firms. Substituting back into (6) gives the equilibrium output of firm  $i$ :

$$b(2-e)x_i = A'_i - \frac{e}{2+(n-1)e} \bar{A}' \quad (8)$$

Of course, the  $A'_i$  are endogenous: each  $A'_i$  is increasing in the corresponding  $k_i$ . Hence, from (8), firm  $i$ 's equilibrium output is increasing in its own investment and decreasing in the investment of all rival firms.

In the first stage, each firm chooses its profit-maximising level of investment, leading to the first-order condition:

$$\frac{d\pi_i}{dk_i} = \frac{\partial \pi_i}{\partial k_i} + \sum_{j \neq i} \frac{\partial \pi_i}{\partial x_j} \frac{dx_j}{dk_i} = 0 \quad (9)$$

The first term on the right-hand side represents the non-strategic motive for investment: it measures the direct benefits and costs of a unit increase in investment, equal to  $\theta x_i - \gamma k_i$ . The second term represents the strategic motive, as firm  $i$  anticipates the effects which a shift in its own period-2 reaction function will have on the outputs of other firms. From (8), higher investment by firm  $i$  reduces the equilibrium output of every other firm, which in turn from (4) raises firm  $i$ 's profits. So each firm has a positive strategic incentive to invest. To see this explicitly, substitute the appropriate derivatives from (4) and (8) into (9), to get the optimal relationship between investment and output:

$$\gamma k_i = \mu_n \theta x_i \quad \text{where:} \quad \mu_n \equiv 1 + \frac{e^2}{2-e} \frac{n-1}{2+(n-1)e} \quad (10)$$

The coefficient of  $x_i$  measures the marginal return to investment per unit output, of which  $\theta$

is the technological component and  $\mu_n$  is the strategic component. In the absence of strategic behaviour, investment is efficient (in the sense that it minimizes production costs) and  $\mu_n$  equals one. More generally, the right-hand expression in equation (10) gives:

Result 1: *For  $n > 1$  and  $e > 0$ , the strategic effect  $\mu_n$  is greater than one and is increasing in both  $n$  and  $e$ .*

The fact that  $\mu_n$  exceeds one, so that each firm engages in strategic over-investment, is well known. (See for example, Spencer and Brander (1983) and Fudenberg and Tirole (1984).) The key new finding is that the strategic effect  $\mu_n$  is *increasing* in  $n$ . As more firms enter the industry, each has a greater incentive to behave like a "top dog", raising its investment aggressively in order to improve its position in the output game.<sup>2</sup> The strategic effect also increases as goods become closer substitutes. Figure 1 illustrates.

Finally, we solve explicitly for equilibrium output and profits. Define  $A_i \equiv a_i - c_i^0$  as the maximum profit margin possible on good  $i$ , when firm  $i$  does not undertake any investment. It is helpful to interpret  $A_i$  as the *competitiveness* of firm  $i$ . Clearly,  $A_i = A'_i - \theta k_i$  and, in aggregate,  $\bar{A} = \bar{A}' - \theta \bar{k}$ . Substituting into (6) and using (10) yields, after some manipulations, the full expression for each firm's output:

$$b(2 - e - \mu_n \eta) x_i = A_i - \frac{e}{2 + (n-1)e - \mu_n \eta} \bar{A} \quad (11)$$

Following Leahy and Neary (1996, 1997), the parameter  $\eta$ , defined as  $\theta^2/b\gamma$ , can be interpreted as the relative efficiency of investment. Higher values of  $\eta$  raise the equilibrium size of each firm, but also make it less likely that an interior equilibrium exists for a given  $n$ , tending to encourage exit and an increase in concentration.<sup>3</sup> As for profits, substituting from the two first-order conditions (5) and (10) into (4) gives:



$$\pi_i = (1 - \mu_n^2 \eta / 2) b x_i^2 \quad (12)$$

For given  $\mu_n$  and  $\eta$ , this is increasing in  $x_i$ .<sup>4</sup>

### 3. Increased Competition, Blockaded Entry and Strategic Investment

We can now use the results of Section 2 to show how increased foreign competition affects the behaviour of domestic firms. It is helpful to begin with the simplest case of one home and one foreign firm, illustrated in Figure 2. Assume that the foreign firm's cost level  $c_i^0$  is initially too high to enable it serve the home market: its reaction function is shown as  $FF'$ . The home firm is thus a monopoly and has no need to engage in strategic investment. (From (10) with  $n$  equal to one, the strategic effect  $\mu_n$  is unity.) Its non-strategic reaction function is shown as  $HH'$ , and equilibrium monopoly output is given by point  $H'$ .

Now, suppose that either technological progress or a fall in trade barriers allows the foreign firm to compete at lower cost in the home market. Its reaction function shifts rightwards, as indicated by the horizontal arrow. If it shifts far enough that point  $F'$  lies to the right of point  $H'$ , then the incumbent firm has an incentive to invest strategically. Provided foreign costs do not fall far enough to shift the foreign firm's reaction function beyond the point  $H''$ , this strategic investment is sufficient to blockade entry.<sup>5</sup> The home firm invests just enough to ensure that the foreign firm's equilibrium investment and output are zero. Suppose, however, that foreign costs fall even further, so that the foreign reaction function lies outside  $HH''$ , the home firm's reaction function when it invests strategically in a duopoly. Now, the home firm no longer finds it profitable to blockade entry. Imports then occur, and the equilibrium is a duopoly with strategic investment by both firms, of the kind examined in the last section. The key point is that, for foreign cost levels which lead the

foreign firm's reaction function to meet the  $x$  axis in the range  $H'H''$ , entry is blockaded, and no imports occur, even though the *threat* of imports encourages the home firm to produce with a higher ratio of investment to output.<sup>6</sup>

To formalise this argument and extend it to many firms, we need to calculate the investment game explicitly (since investment and entry are equivalent in this model). Assume that firms differ only in their competitiveness,  $A_i$ , there are initially  $n-1$  firms in the industry, and the entrant is not competitive. The incumbent firms therefore play an  $(n-1)$ -firm game, in which the output of each is given by (11), with  $n$  replaced by  $n-1$ . Summing over all  $n-1$  active firms and using (10) gives total industry investment:

$$\theta \bar{k}_{-n} = \frac{\mu_{n-1}\eta}{2+(n-2)e^{-\mu_{n-1}\eta}} \bar{A}_{-n} \quad (13)$$

where the subscript " $-n$ " indicates that the summation is over the first  $n-1$  firms only.

Consider next the potential entrant, which I denote by a subscript " $*$ ". If it enters, it will participate in an  $n$ -firm game. However, it will only do so if its profits, and hence, from (12), its investment and output, are non-negative. From (8) and (10), with  $i$  replaced by  $*$ , the potential entrant's investment reaction function can be written as a function of the total investment of the other  $n-1$  firms,  $\bar{k}_{-n}$ :

$$\left[1 - \frac{\mu_n^2}{2}\right] \theta k_* = \frac{\mu_n^2}{2} \left[ A_* - \frac{e}{2+(n-2)e^{-\mu_n\eta}} (\bar{A}_{-n} + \theta \bar{k}_{-n}) \right] \quad (14)$$

The coefficient of  $k_*$  on the left-hand side is positive from the firm's second-order condition. Hence, for entry to be profitable, the right-hand side must be non-negative. Setting this equal to zero, with  $\bar{k}_{-n}$  given by (13), solves for the threshold level of the entrant's competitiveness  $A_*$  at which it would find it just profitable to enter when other firms' total investments are at the level attained in an  $(n-1)$ -firm game. Since entry will not actually occur at this level,

this is therefore the threshold for blockaded entry. It is convenient to express it in terms of the entrant's relative competitiveness, denoted by  $\phi$ : this equals the ratio of  $A_*$  to the *average* competitiveness of the incumbent  $n-1$  firms. The threshold level of  $\phi$  at which blockaded entry occurs is denoted  $\phi_B$ , defined as:

$$\left[ A_* \right]_B = \phi_B \frac{\bar{A}_{-n}}{n-1} \quad \text{where:} \quad \phi_B \equiv \frac{(n-1)e}{2 + (n-2)e - \mu_{n-1}\eta} \quad (15)$$

The equilibrium where the entrant's relative competitiveness equals  $\phi_B$  corresponds to point  $H'$  in Figure 2.

Actual entry will not occur until the entrant's competitiveness reaches a level at which it is just on the margin of entering an  $n$ -firm game. This can be calculated by setting (11) equal to zero (since investment is proportional to output from (10)), where now  $\bar{A}$  equals  $\bar{A}_{-n} + A_*$ . Solving for the threshold level of competitiveness and again expressing it relative to the average competitiveness of the incumbents, leads to  $\phi_E$ , defined as:

$$\left[ A_* \right]_E = \phi_E \frac{\bar{A}_{-n}}{n-1} \quad \text{where:} \quad \phi_E \equiv \frac{(n-1)e}{2 + (n-2)e - \mu_n\eta} \quad (16)$$

The equilibrium where the entrant's relative competitiveness equals  $\phi_E$  corresponds to point  $H''$  in Figure 2.

Comparing the expressions for  $\phi_B$  and  $\phi_E$  in (15) and (16), the only difference between them is in the strategic term  $\mu_n$ . Since, from Result 1,  $\mu_n$  exceeds  $\mu_{n-1}$ ,  $\phi_B$  must be less than  $\phi_E$ . Furthermore, stability conditions imply that both  $\phi_B$  and  $\phi_E$  are positive and less than one.<sup>7</sup> Hence there is a non-empty range of values of  $\phi$  on the unit interval, within which entry is blockaded. Summarising:

*Result 2: If the potential entrant's relative competitiveness lies in the non-empty range  $\{\phi_B, \phi_E\}$ , entry is blockaded, so no imports occur. However, incumbent*

*firms engage in more strategic investment than when the potential entrant is uncompetitive ( $\phi < \phi_B$ ).*

Having established the effects of increased foreign competition on a single sector, we are now ready to consider the implications for the economy as a whole.

#### **4. Foreign Competition and Income Distribution in General Oligopolistic Equilibrium**

To determine the impact of increased foreign competition on aggregate labour markets, the model of Sections 2 and 3 must be embedded in general equilibrium. In this paper, I am not concerned with the details of the resulting General Oligopolistic Equilibrium ("GOLE") model. Instead, as in Neary (2001b), where I first sketched this model, I will explain just enough of it to try and persuade readers of its logical consistency.

Consider first a single country, which we can think of as home. The key idea is that there is a continuum of sectors, each identical to the model of Section 2. Home demands are generated by an aggregate utility function, which is an additively separable aggregate of sub-utility functions defined over the consumption of the outputs of individual sectors. Each of these sub-utility functions is quadratic and is given by equation (1). All income (including profits and tariff revenue, if any) accrues to the aggregate household and is spent on current consumption.

Given the continuum assumption, firms are large in their own markets but insignificant in the overall economy. So it is reasonable to assume that they take factor prices, aggregate income, and the prices of goods produced in other sectors as given in making their decisions. Hence the model avoids the problem of sensitivity to the choice of numeraire which typically characterises general equilibrium models with oligopoly.<sup>8</sup> Since in this paper I am not interested in trade patterns or other compositional issues, I simply assume that all sectors are

identical.

The next issue to be addressed is the workings of factor markets. I assume just two factors, skilled and unskilled labour. On the demand side, I make the crucial assumption that *investment uses only skilled labour and production uses only unskilled labour*. This accords with many empirical studies, which measure the skill premium by the wage differential between non-production and production workers.<sup>9</sup> The results still go through under the more general assumption that both kinds of labour are used in both stages of production, and that investment uses skilled labour more intensively. However, the extreme case I consider is more convenient.

Given my assumption about factor intensities, it is natural to choose units such that each unit of investment requires a single skilled worker, and each unit of output requires a single unskilled worker. It is then straightforward to rewrite the firm's decision problem given by (4) in terms of the economy-wide returns to skilled and unskilled workers, which I denote by  $r$  and  $w$ , respectively. It can be shown that a rise in  $r/w$  lowers the demand for skilled labour, and raises that for unskilled labour, per unit output. Aggregating across all sectors, the economy-wide demand for skilled and unskilled labour is the integral of the demands from individual sectors.

Finally, on the supply side, I assume that aggregate factor supplies are variable, with the relative supply of skilled labour,  $S/L$ , an increasing function of its relative return,  $r/w$ . This can be rationalised, as in Dinopoulos and Segerstrom (1999), in terms of a model of human capital, where workers of differing abilities choose whether to remain unskilled or to invest in lifetime skill acquisition. If (as tractability requires) we confine attention to the steady states of such a model, the aggregate factor supply function is exactly as I assume here.

After these preliminaries, it is straightforward to examine the general-equilibrium effects

of changes in foreign competition, applying the partial-equilibrium results of Sections 2 and 3. Assume two countries, identical in all respects to the home country just outlined. The only additional assumption needed is that the two countries' markets are segmented, as in Brander (1981), that firms cannot relocate their production facilities (so no foreign direct investment takes place) and that all investments are market-specific. (Alternatively, I could assume that firms serve either the home or foreign markets, but not both.) In the initial equilibrium there are barriers to trade, for technological or policy reasons or both, which make it unprofitable for some potential foreign firms to compete in the home market. In the notation of Section 3,  $\phi$  is initially below  $\phi_B$ .

Now, assume an exogenous reduction in trade barriers, in both directions, such that  $\phi$  moves into the  $\{\phi_B, \phi_E\}$  interval. If the behaviour of home firms did not change, imports would now occur. However, as we have seen in the previous section, incumbent firms will engage in additional strategic investment which has the effect of blockading entry. This seems to capture the idea of "defensive innovation" proposed by Wood (1994). In the process, home firms increase their investment-output ratio,  $\mu_n$ , and therefore increase their relative demand for skilled labour. Since this happens throughout the economy, it feeds back onto factor markets. The higher relative demand for skilled labour leads to a rise in the economy-wide skill premium, which in turn encourages more skill acquisition and so induces an increase in the relative supply of skilled labour. This supply response dampens the increase in relative factor demands, but (assuming that factor markets are stable) cannot eliminate it. Finally, if the investment is interpreted as additional innovation, we can see that direct measures of innovation will increase, while total factor productivity (measured by the ratio of output to an appropriately weighted average of the two inputs) may not rise appreciably.<sup>10</sup> The temptation to note that all these predictions accord with the stylised facts

presented in the introduction is, of course, irresistible.

Naturally, the story can be enriched in a variety of ways. For example, I could allow for diversity between sectors, and in particular for the competitiveness of foreign firms to rise above  $\phi_E$  in some sectors. Then imports will rise in those sectors, while home production may rise or fall, depending on the initial value of  $\phi$ . In all cases, however,  $\mu_n$  rises both at home and abroad in all sectors, so the implications for factor intensity and skill premia are unchanged. A different direction in which the model could be extended would be to explore how the effects on the two countries would differ if they had different labour-market institutions, as in the competitive model of Davis (1998). These comments suggest only two among many promising directions for future research.

## 5. Entry and Technical Choice under Bertrand Competition

How are the results of Section 2 affected if firms compete on price, so the equilibrium is one of Bertrand competition, rather than of Cournot quantity competition? From (1), the direct demand functions are:

$$x_i = \alpha_i - \beta [(1+\epsilon)p_i - \epsilon\bar{p}] \quad (17)$$

where  $\bar{p} \equiv \sum_i p_i$  is the sum of all firms' prices.<sup>11</sup> The parameters in (17) are related in turn to the underlying preference parameters in (1) as follows:

$$\begin{aligned} \alpha_i &\equiv \frac{1}{b(1-e)} \left[ a_i - \frac{e}{1+(n-1)e} \bar{a} \right], \\ \beta &\equiv \frac{1}{b(1-e)} \frac{1+(n-2)e}{1+(n-1)e} \quad \text{and} \quad \epsilon \equiv \frac{e}{1+(n-2)e} \end{aligned} \quad (18)$$

Proceed now as in Section 2. In the second stage, optimal choice of price, given past investments which fix all the marginal costs  $c_j$ , leads to the first-order condition:<sup>12</sup>

$$x_i = \beta(p_i - c_i) \quad (19)$$

Substituting from the demand function (17) and eliminating  $\bar{p}$  gives the equilibrium price set by firm  $i$ :<sup>13</sup>

$$\beta(2+\epsilon)p_i = A_i' + \frac{\epsilon}{2-(n-1)\epsilon} \bar{A}' \quad (20)$$

where once again  $A_i' \equiv \alpha_i + \beta c_i$  is a measure of the size of the market for good  $i$ , and  $\bar{A}' \equiv \Sigma A_i'$ . Now each firm's equilibrium price is decreasing in both its own *and* its rivals' investment levels, reflecting the fact that second-stage actions are strategic complements rather than strategic substitutes.

In the first stage, firms take account of these strategic effects of investment, leading to the optimal relationship between investment and output:

$$\gamma k_i = \mu_n \theta x_i \quad \text{where:} \quad \mu_n \equiv 1 - \frac{\epsilon^2}{2+\epsilon} \frac{n-1}{2-(n-1)\epsilon} \quad (21)$$

For given  $\epsilon$ , the strategic effect  $\mu_n$  is decreasing in  $n$ . This seems to suggest that the model suffers from a familiar problem in oligopoly theory: results obtained under Cournot assumptions are often reversed under Bertrand assumptions. However, this overlooks the fact that when  $n$  is variable it does not make sense to treat  $\epsilon$  as fixed: from (17), this would imply that demands were unbounded. Instead, from (18), for a given value of the primitive substitutability parameter  $e$ , the value of  $\epsilon$  falls as  $n$  rises. Restating the strategic effect in terms of  $e$  rather than  $\epsilon$  gives:

$$\mu_n = 1 - \frac{(n-1)e^2}{[2+(n-3)e][2+(2n-3)e]} \quad (22)$$

We can now derive:



Result 3: For  $n > 1$  and  $e > 0$ , the strategic effect  $\mu_n$  is less than one and is decreasing in  $e$ . It is increasing in  $n$  if and only if  $e$  exceeds a threshold value  $\hat{e}$ , which is decreasing in  $n$ .<sup>14</sup>:

$$\hat{e} = \frac{-3 + \sqrt{9 + 8(n^2 - n - 1)}}{2(n^2 - n - 1)} \quad (23)$$

It is well-known that  $\mu_n$  is less than one in Bertrand competition. In the terminology of Fudenberg and Tirole (1984), each firm behaves like a "puppy dog", strategically *under*-investing in order to soften price competition in the second stage. The key new finding is that, except for low values of  $e$  or  $n$ , the strategic effect  $\mu_n$  is *increasing* in  $n$ . As more firms enter the industry, each firm's incentive to behave like a "puppy dog" is *reduced*, so the investment-output ratio drifts back towards its efficient level. Figure 3 illustrates how  $\mu_n$  varies with  $n$  for different values of the substitution parameter  $e$ .

To conclude this section, Bertrand competition yields results which, relative to the Cournot results of Section 2, are both less clear-cut and less favourable to the hypothesis that greater competition raises the ratio of fixed to variable costs. In particular, since  $\mu_2$  is always less than  $\mu_1$ , the entry of a second firm always leads an incumbent monopolist to strategically *under*-invest, so lowering the ratio of fixed to variable costs. However, for reasonable values of the substitution parameter  $e$ , further entry restores the *over*-investment result found under Cournot competition. From (23), this happens after the entry of a third firm provided  $e$  exceeds 0.562, after the entry of a fourth firm provided  $e$  exceeds 0.400, and so on (as Figure 3 shows). Hence, we can conclude that the hypothesis is reasonably robust to the assumption made about the nature of competition between firms.

## 6. Conclusion

In this paper I have presented a model of General Oligopolistic Equilibrium ("GOLE") in which increased foreign competition can affect technical choice and skill differentials even when actual imports do not rise significantly. A reduction in import barriers (whether as a result of technological change or trade liberalisation) encourages more strategic investment by incumbent firms, which raises the ratio of fixed to variable costs. Assuming only that fixed costs use skilled labour more intensively, the predictions accord with many of the stylised facts in the trade and wages debate: higher skill premia; higher ratios of skilled to unskilled workers employed in all sectors and throughout the economy; little change in import volumes or prices; and rapid technological progress with rather little change in total factor productivity.

The particular mechanism whereby increased foreign competition affects technological choice in this model is only one channel which may operate in oligopolistic markets. As I have shown in an earlier paper, Neary (2001b), similar predictions follow in a duopoly model when quantitative import barriers are replaced by their tariff equivalents. Taken together, the results of these papers suggest some general lessons for the ongoing debate on the role of trade in explaining labour-market outcomes. First, competition from other OECD countries may be even more important than competition from less-developed or newly-industrialising countries as a channel linking trade and domestic factor markets. In the model I have presented, trade liberalisation has the predicted effects even though the two countries are identical in all respects. (Empirical evidence that North-North trade has greater effects on employment than North-South trade is provided by Greenaway, Hine and Wright (1999).) Second, distinguishing between trade and technology as distinct influences on factor demands requires great care: in my model, increases in foreign competition can come about for either

technological or policy reasons. Finally, models which allow for oligopolistic interactions may be more satisfactory than those which rely on non-strategic competition, whether of the perfect or monopolistic varieties.<sup>15</sup> This is particularly true if we want to explain how foreign firms can pose a threat to domestic incumbents even when actual import volumes remain low.

Let me conclude with some more general remarks. A striking feature of the debate on technology, trade and wages is how open-ended it is.<sup>16</sup> No theoretical approach or empirical evidence can be considered irrelevant, since what we are attempting to do is to give a coherent explanation of the evolution of income distribution in both rich and poor countries over past decades. Trade theory has a central role to play in this task, but we trade theorists need all the help we can get. So we should welcome contributions from other fields, whether the theoretical insights from industrial organisation in the 1980s or the empirical insights from labour economics in the 1990s. Hopefully these can be integrated to give a fuller picture of "open-economy microeconomics", with trade theory at its core. Nothing less than that will be needed if we are to make solid progress in understanding the causes and consequences of the enormous changes which are occurring in the world economy.

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## Notes

1. An exception is a model of Vandebussche and Konings (1998), where entry by foreign firms reduces the bargaining power of domestic unions and so allows domestic firms to become more skill-intensive.
2. As  $n$  increases without bound, the value of  $\mu_n$  tends towards  $2/(2-e)$ . Because each firm has to incur endogenous sunk costs, the model does not converge towards a competitive limit as the number of firms rises, even when goods are homogeneous. Nocke (2000) derives a similar result.
3. To ensure a positive output, the left-hand side of (11) shows that it is necessary for  $\eta$  to be sufficiently low that:  $\eta < (2-e)/\mu_n$ . This is also the stability condition for the first-stage game, and it is more stringent than the second-order condition for choice of  $k_i$ :  $\eta < 2/\mu_n^2$ .
4. From the previous note, the coefficient of  $bx_i^2$  must be positive.
5. Strictly speaking, entry is "blockaded" rather than "prevented", since the firms make their investment decisions simultaneously, and there is no distinction between investment and entry). If the home firm moved first, the model would be similar to that of Dixit (1981).
6. Note the effects of successive falls in foreign costs on home output and investment. Initially, while the foreign firm is uncompetitive, such that its reaction function cuts the  $x$  axis to the left of  $H'$ , home output and investment remain at their monopoly levels. Next, for intermediate levels of foreign competitiveness, such that its reaction function cuts the  $x$  axis between  $H'$  and  $H''$ , home output and investment are *higher*. Finally, as the foreign firm becomes even more competitive, home output and investment fall, as the equilibrium moves upwards and to the left along the reaction function  $HH''$ .
7.  $\phi_B$  can be written as  $(n-1)e/[(n-1)e+(2-e-\mu_{n-1}\eta)]$ . But, from note 3, the stability condition for the game with  $n-1$  firms is that  $2-e-\mu_{n-1}\eta$  is positive. Hence  $\phi_B$  must be

positive and less than one. Similar reasoning, using the stability condition for the game with  $n$  firms, implies that  $\phi_E$  must be positive and less than one.

8. For the numeraire problem, see Gabszewicz and Vial (1972); for alternative attempts to circumvent it, see Cordella and Gabszewicz (1997) and Ruffin (2000). The sleight of hand I use here is identical to that used in models of monopolistic competition which adopt the specification of Dixit and Stiglitz (1977). The problems which arise with that model when the number of varieties is finite are discussed in d'Aspremont et al. (1996). Ironically, Dixit and Stiglitz used the continuum assumption in a working paper version of their paper, but dropped it from the published version. See Neary (2002) for further discussion.

9. This assumption is also made in other theoretical studies, such as Ekholm and Midelfart Knarvik (2000). By contrast, Dinopoulos et al. (2000) assume that higher output *raises* the relative demand for skilled labour. They cite some empirical evidence in support of this assumption, but all of it refers to cross-section studies of firms and plants of different sizes. This is less relevant to the issue considered here of increases in output by existing firms.

10. The productivity of unskilled labour is fixed by assumption in my model. By contrast, labour productivity (in the sense of the productivity of both skilled and unskilled workers) and total factor productivity are conceptually indistinguishable.

11. To derive this, sum the inverse demand functions (3) over all goods to get:  $\bar{p} = \bar{a} - b[1 + (n-1)e]\bar{x}$ . Using this to eliminate  $\bar{x}$  from (3), and collecting terms gives the required direct demand functions.

12. This implies that the price-cost margin per unit output is always less in Bertrand competition than in Cournot competition. From (19) and (5), these equal  $1/\beta$  and  $b$  respectively. But from (18),  $1/\beta$  is less than  $b$ .

13. The intermediate steps, which closely parallel equations (6) and (7) in the Cournot case,

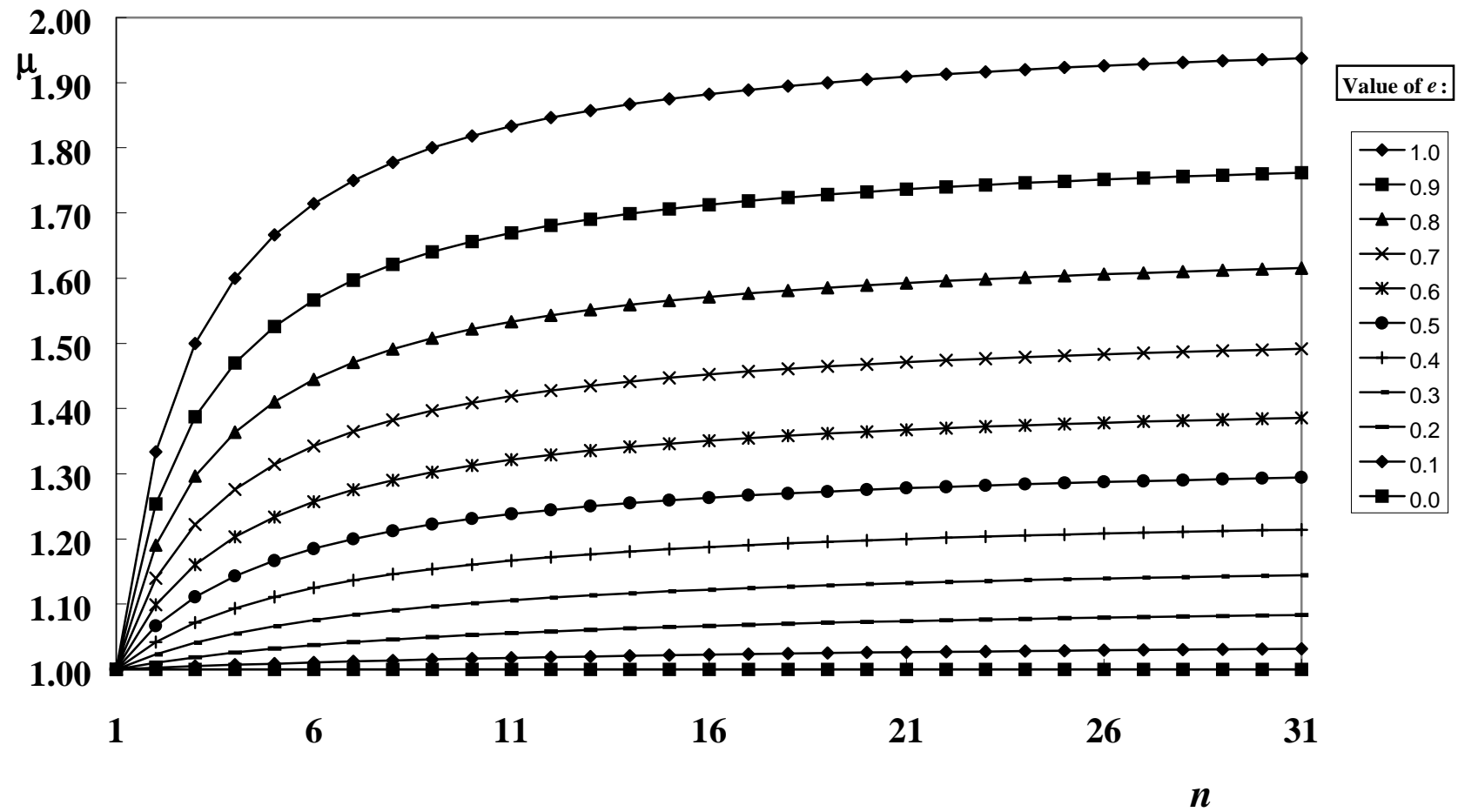


are:  $\beta(2+\varepsilon)p_i=A'_i+\beta\varepsilon\bar{p}$  and  $\beta\bar{p}=\bar{A}'/[2-(n-1)\varepsilon]$ .

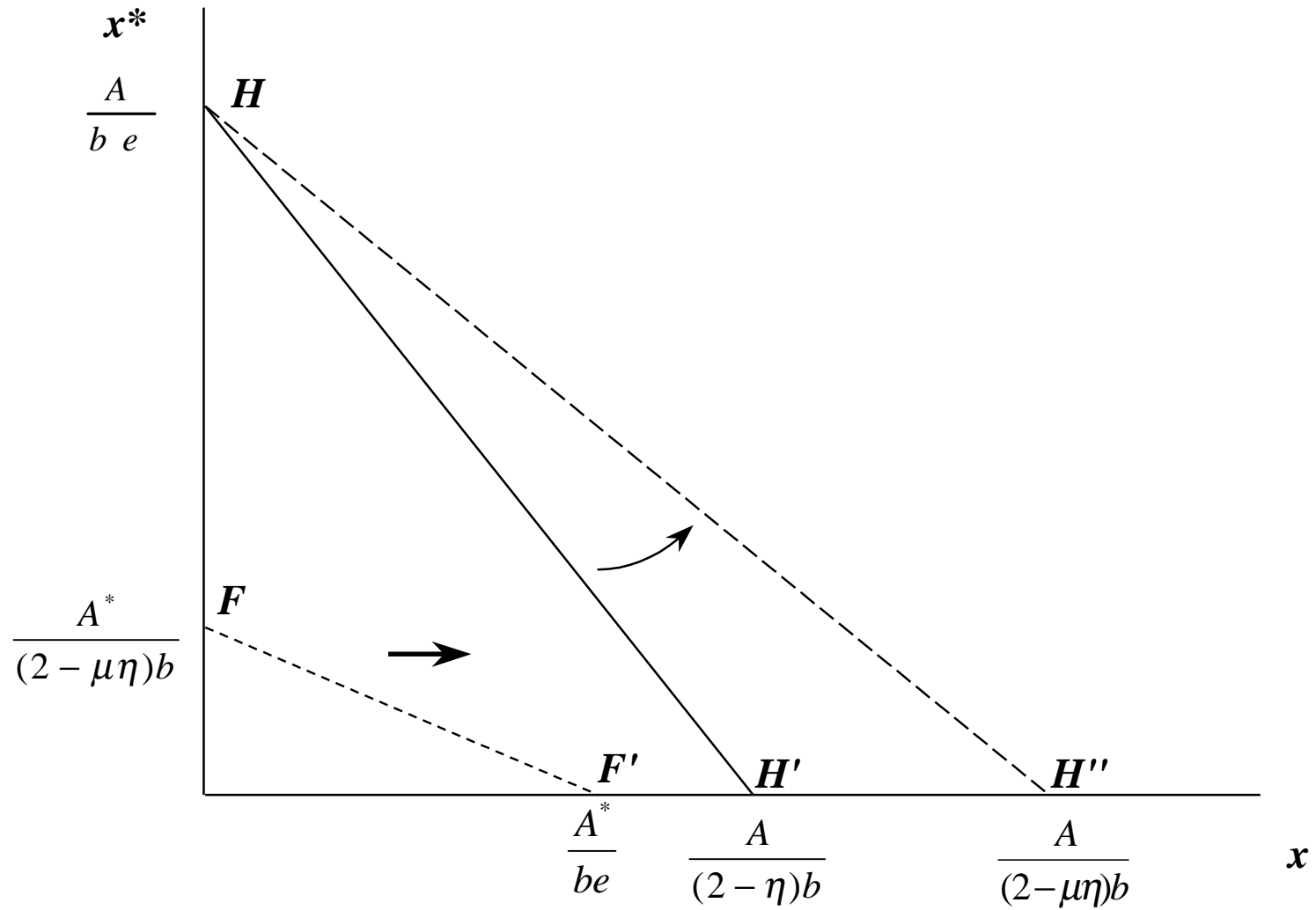
14. I elaborate further on this point in Neary (2001a).

15. Since  $n$  can take only integer values, we want to find out when the entry of an extra firm will raise  $\mu_n$ . Hence, we look for a positive value not of  $d\mu_n/dn$  but of  $\mu_{n+1}-\mu_n$ . The latter is proportional to  $(n^2-n-1)e^2+3e-2$ . Setting this equal to zero, and selecting the root in the  $\{0,1\}$  interval, gives the value of  $\hat{e}$  in Result 3.

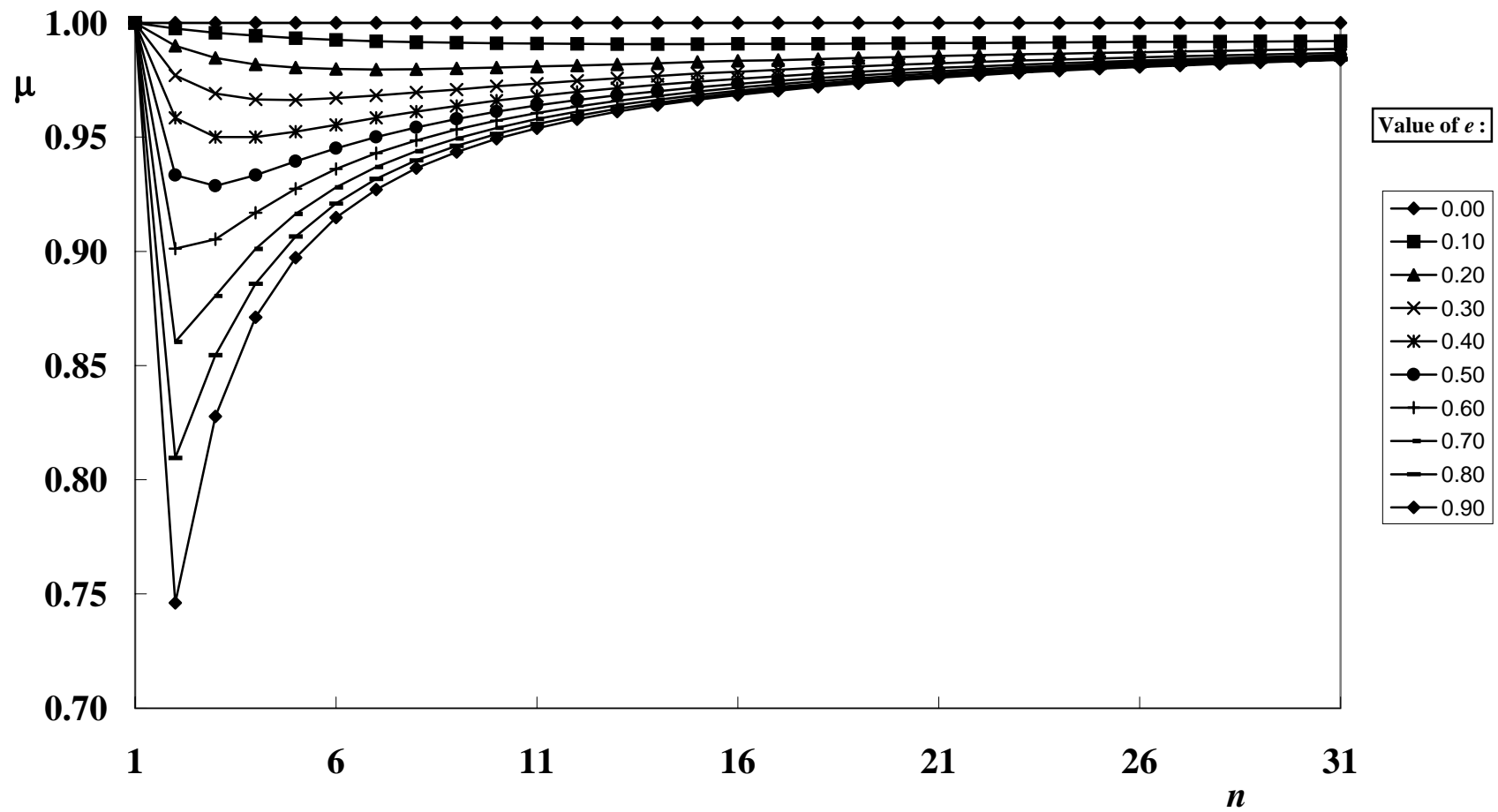
16. Some authors advocate broadening the debate even more widely. For example, Atkinson (2000) rejects what he calls the "Transatlantic Consensus" that changes in wage inequality have been caused by a fall in the relative demand for unskilled labour (whether due to trade or technology). Instead he suggests that social norms have shifted in the direction of greater tolerance of inequality.



**Figure 1. The Strategic Effect in Cournot Competition**



**Figure 2. Strategic Investment to Blockade Entry by an Incumbent Monopolist**



**Figure 3. The Strategic Effect in Bertrand Competition**