

Endogenous Pre-Trade Equilibria and Trade Liberalisation in Differentiated-Goods
Oligopoly Models

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Abstract

This paper provides a general model for the study of merger incentives and the effects of globalisation in oligopolistic markets. Employing a differentiated goods version of a standard Cournot model and allowing for the possibility of know-how transfer, we study a variety of mergers where the target firm has a continuing market presence post-merger. The paper explores the partners' choice between an independent division strategy (thus committing to capacity) and a joint-operation market-concentrating strategy and identifies which firms will have the greatest incentive to merge. We establish conditions for the initial equilibrium, identify trigger market-concentration levels and study the effect of unilateral and bilateral tariff changes on merger incentives.

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1. Introduction

With the progressive, multilateral removal of impediments to trade under the WTO, some policy makers and Non-Governmental Organisations (NGOs) in particular have raised concerns about the risks of agglomeration by large firms. Policy discussions have been particularly concerned about the risk of increases in market concentration in oligopolistic industries. International trade variants of the standard Cournot market-concentration model have tended to support these concerns, thus promoting the search for appropriate national or supra-national competition policies to counteract this possible downside of globalisation.¹ The idea that market concentration may be a problem also exists in the literature where governments choose trade policies to obtain the optimal level of market concentration from the national perspective, though typically this literature neglects the firms' incentives.²

However, whereas the bulk of the earlier homogeneous goods literature considered mergers which result in the target being closed down, this paper is concerned instead with mergers or strategic partnerships between firms producing differentiated goods, where the firm which is taken over continues to have an endogenous market presence, either as a (possibly revamped) plant producing its differentiated product or as an independent division, franchise or licensee.³ Examples of acquisitions which fit this model, where the firms differed considerably in size and degree of technical efficiency, are Volkswagen's purchase of Skoda and Seat and BMW's purchase of parts of Rover, while examples where the merging partners were seen to be closer in terms of size and efficiency would be the merger of Grand Met with Guinness (and latterly Seagram) to form Diageo, Coors and Molson breweries (each with

¹ For example, Long and Vousden (1995), Falvey (1998) and Falvey and Nathananan (2002) all employ variants of the Salant *et al.* (1983) model of mergers to show that liberalisation leads to undesirable increases in market concentration.

² In Ryman (2000), for example, governments pick the number of firms and then trade policy to maximise welfare in trade competition with a second country in a third market. Head and Ries (1997) study mergers between similar firms, which result in a single entity that reduces either fixed costs or (*ex ante* identical) marginal costs and then consider the appropriateness or otherwise of domestic or supranational regulation of the merger given the implications for domestic and world welfare. In Horn and Levinsohn (2001) governments use merger policy to choose the optimal level of market concentration and examine how this is influenced by trade policy. Horn and Levinsohn also provide an excellent and more extensive review of the literature and Ryan (2006) identifies a wider range of the salient antecedents to this paper.

³ Deneckere and Davidson, (1985) also study differentiated goods in the context of a Bertrand model.

independent management HQs), and most recently Arcelor and Mittal Steel. In addition, the sorts of partnership studied here characterise many of the 1980's mergers where corporate raiders and cash-rich tobacco and oil companies purchased a wide range of disparate firms, on the grounds that they were bringing superior management techniques to other industries.

This paper employs a simple variant of the Salant *et al.* (1983) model where firms of varying levels of efficiency produce a differentiated good and merging firms have the option of either setting output as one integrated firm or letting each entity act as an independent division. The partnership may also allow them access to better know-how (whether that be superior technological, process or management knowledge).⁴

This model is capable of generating a wide range of equilibria where firms may sequentially choose different organisational forms and/or partners depending on the cost and feasibility of the technology transfer and/or the degree of product differentiation. Our framework thus allows for a wider range of mergers than previous work and hence for a richer set of results. One important difference to the earlier literature is that the most efficient (largest) firm will no longer always merge with the least efficient (smallest) firm, but in some circumstances will find it more profitable to merge with the next most efficient. Additionally, we identify limits on market size and other variables which make firms switch from mergers where entities are operated as independent divisions to those where the firm operates as a single joint operation enterprise. These new results allow us to explain the various mergers discussed earlier in a single framework.

Having characterised the endogenous equilibrium, the paper moves on to consider some trade implications of the model and demonstrate that multilateral liberalisation is likely to reduce potentially less efficient tariff-jumping mergers and, at the margin, to promote more Independent-Division rather than Joint-Operation mergers, resulting in lower prices, and increased output, consumer surplus and aggregate producer welfare. Thus the number of cases properly of concern to competition authorities may

⁴ Research by McKinsey and the LSE (McKinsey and Co. (2005)) suggests that 70% of all efficiency gains are process rather than technology driven). For this reason we prefer the term 'Know-How' Transfer to Technology Transfer.

diminish rather than grow as a consequence of globalisation. Conversely this paper points to much greater merger-incentive problems in the presence of trade barriers.

Given the wide range of literature related to this topic we do not aim to provide an exhaustive survey here, but in addition to the Salant *et al.* (1983) tradition there are two further strands which are key to the model. The Joint-Operation option when technology is transferable is similar to Perry and Porter (1985), where a merged firm grows in size relative to its competitors by virtue of access to a larger capital stock and enjoys reduced production costs.⁵ However, while the Perry and Porter firm is larger, in the sense of having more physical capacity, overall market output falls relative to the initial state and there is market concentration. This is one, but not the only, possibility in this paper. The other important strand relevant to this paper is in the technology-transfer literature.⁶ Marjit *et al.* (2000) study the incentive for firms to license their superior technology in a multi-firm setting. The model we employ whereby firms purchase a target and operate it as an independent division employing the superior technology, is observationally equivalent. However, in addition we allow for the possibility of sequential mergers, employ an international setting, have differentiated goods and introduce the alternative joint-operation option.⁷

The remainder of the paper is set out as follows. Section 2 of the paper sets out the basic model, establishes a benchmark equilibrium, and sets out the merger and technology transfer processes. Section 3 considers indicative Independent-Division and Joint-Operation mergers and considers the sequential merger process in each case. Section 4 examines the interaction between the two cases and details a five-firm example. Section 5 considers the trade implications of the model, while Section 6 concludes.

⁵ Other papers in this tradition are Barros and Cabral (1994), Levinsohn (1996) and Head and Ries (1997).

⁶ Long and Vousden refer to cost transfers as the lower cost of producing output transferred to the low-cost firm following the closure of the target. Here technology transfer refers to the use by the target of the superior technological or management processes of the parent.

⁷ In addition Kabiraj and Marjit (2003) examine the incentive effect on technology transfers of tariff changes in a two-country, two-firm, homogeneous good model and the focus is on optimal tariffs and development. This paper studies the n -firm heterogeneous-goods case of mergers involving technology transfers in an international setting and considers the impact of changes in tariffs on the incentive of firms to merge. An alternative interpretation of this paper is that it is an international trade variant of

2. Preliminaries

2.1. The Model

The model is a partial-equilibrium Cournot oligopoly model with differentiated products and differing costs. The superior technology or management technique associated with the differences in costs may be transferable between firms via the merger process, albeit imperfectly. We assume that there is a small, initially fixed, number of firms, N , producing a differentiated product.⁸ We assume that firm i faces constant marginal cost, c_i , that marginal costs differ across firms, and firms are ranked such that $c_k > c_j$ if $k > j$. For simplicity we assume no fixed costs associated with production.⁹ Firms play a two-stage game as follows.

In stage one a firm decides whether it wishes to remain as it is, or to enter into a partnership with a rival. If it opts to engage in a strategic partnership or merger then it employs its superior management or technical ability if appropriate.¹⁰ In addition the partnership chooses whether to operate two independent divisions competing against each other (each maximising its own profits), or to operate the divisions together, taking a joint-output, profit-maximising, decision.¹¹ The profitability of each of these options will depend on how other players react to the firm's strategy. In stage two the

Baye *et al.* (1996) with differentiated goods and heterogeneous firm costs, however the general equilibrium formulation in that paper yields intractable results in this context.

⁸ In common with the literature in this area, we are taking the initial number of firms as fixed, although in equilibrium the number of surviving firms is determined endogenously. Thus, the initial N may be determined via a random allocation of marginal costs (and, depending on demand, a selection of N potential firms is able to produce profitably) but after that mergers are endogenous. Thus, taking the initial number of firms in the industry as given, we are focussing on the strategic and technological motives for a merger, franchise or licensing agreement.

⁹ It is typically possible to generate a wider range of results by employing fixed production costs, however, without minimising their significance, we want to focus on the underlying market concentration–divisionalisation issue in this paper. We do, however, allow later for a fixed cost arising from the merger process.

¹⁰ For expositional convenience, it is intuitively easier to discuss the paper in terms of a merger, however the analysis, particularly that of Independent Divisions, applies equally to a franchise or licensing arrangement. The only restriction is that one partnership does not preclude the possibility of another (that is we are not considering exclusive licences as in Marjit *et al.* (2000)).

¹¹ We could also include here the possibility of starting a new division (equivalent to developing a new brand. In the context of this model, this option will always be dominated by taking over an operating rival since taking over a competing rival reduces the number of players by one. Starting a new division

firms, including any independent divisions, decide their level of output in the market via Cournot competition.¹² The number of independent firms and divisions depends endogenously on decisions made in the previous stage of the game and the game is potentially repeated until an equilibrium is reached.

2.2. A Benchmark Equilibrium

Due to the complexity of the game, there is no simple function to describe payoffs in stage two of this game and it is thus necessary to solve the payoffs from each strategy separately and compare them in stage one. In order to aid the analysis, we initially derive a benchmark final-stage output rule associated with the case where there are N independent, single-plant, firms. We then consider how the various partnership options influence firm outputs and profits.

Focussing initially on demand, the representative consumer has a utility function of the form:

$$(1) \quad u(\mathbf{h}, \mathbf{h}^*) = AH - \frac{\gamma}{2} H^2 - \frac{1-\gamma}{2} \left[\sum_{i=1}^N h_i^2 \right]$$

where A is a positive constant, h_i is the sales of a firm, $H \equiv \sum_{i=1}^N h_i$ and γ is a substitution index between varieties of the good ranging from 0 (independent goods) to 1 (homogeneous goods).

From the above utility function, the inverse demand function facing firm i is given by:

$$(2) \quad p_i = A - (1-\gamma)h_i - \gamma \sum_{k=1}^N h_k \quad \forall h_i \in (1, N)$$

where p_i is the price. The profit maximisation problem for a representative firm is

is equivalent to taking over a non-operating rival (one whose costs are above the critical minimum level required for profitable participation in the market).

¹² In Section 5, we extend the model to the case where firms sell in two markets.

$$\text{Max } (p_i - c_i)h_i \text{ with respect to } h_i: \equiv \text{Max}_{h_i} \left[A - (1 + \gamma)h_i - \gamma \sum_{k=1}^N h_k - c_i \right] h_i$$

yielding first order conditions:

$$(3) \quad (p_i - c_i) = h_i.$$

By successive substitutions of h_k this yields

$$(4) \quad p_i = \frac{\Gamma(0)A + \gamma C - \Gamma(N)(1 - \Gamma(0))c_i}{\Gamma(0)\Gamma(N)}$$

where $C = \sum_{k=1}^n c_k$, and $\Gamma(z) = 2 + (z-1)\gamma$, for $z = 0, 1, 2, \dots, N$.

Output of plant i is therefore:

$$(5) \quad h_i = \frac{\Gamma(0)A + \gamma C - \Gamma(N)c_i}{\Gamma(0)\Gamma(N)}.$$

Firm (division) profit is given by

$$(6) \quad \pi_i = (p_i - c_i)h_i = h_i^2.$$

Given this single-plant firm benchmark we next need to consider the potential profitability of the various options a firm can pursue such as an independent-division or a joint-operation merger or a new division.

2.3. Mergers

We will consider the following merger (or partnership) process:¹³

1. Mergers are bilateral.
2. At any point in time all possible mergers are eligible for consideration, but only one will occur.
3. A merger between firms i and j involves a profit sharing pact between the two firms regarding the distribution of the change in profits, $\Delta\pi = \hat{\pi}_{ij} - \pi_i - \pi_j$, where $\hat{\pi}_{ij}$ are the profits that accrue to the merged firm.¹⁴

¹³ The merger process could be either a cooperative merger or a hostile takeover, the two being equivalent here as we are not concerned with the distribution of profits between the firms. However, for ease of exposition we will periodically refer to the higher-cost firm as the target. The actual identity of the instigator of any merger has no bearing on our analysis.

¹⁴ Alternatively, one firm can make a take-it or leave-it offer, or we could have a Nash bargaining game over the price and/or allow for outside offers, however, the distribution of merger profits is unimportant for the positive analysis.

4. The most profitable merger occurs at each juncture.
5. Steps 1-4 are repeated until equilibrium is established.

2.4. The Know-How Transfer Process

Following a merger, the low-cost firm may have the possibility of transferring its superior know-how as follows. The low-cost firm j can transfer its superior know-how to the target k according to the function, $\tilde{c}_k = c_j + \frac{\delta}{\gamma}(c_k - c_j)$ where \tilde{c}_k indicates the target's post-merger marginal cost, $\gamma \in (0, 1)$ is a measure of product differentiation, equivalent to the substitution index in production above (with $\gamma = 1$ indicating perfect substitutes and $\gamma = 0$ representing independent products), $\delta \in (0, \gamma)$ is a measure of the transferability of know-how (where $\delta = 0$ indicates perfect transferability and $\delta = \gamma$ indicates that know-how transfer is not possible).¹⁵

In evaluating the potential profitability of a merger the partners must consider the change in profit plus (possibly) a fixed cost, M . One interpretation of M is that it is the one-off cost (as opposed to the feasibility, δ) of implementing the know-how transfer, but it may also include legal fees and/or the cost of an anti-monopoly inquiry. It could be argued that this cost may vary according to the relative size of the merging firms, the difference in pre-merger processes, and/or the degree of concentration of the industry, but we will discuss these refinements in due course.

3. Independent Divisions versus Joint-Operations

We start this analysis of the various merger options by first examining an indicative merger of each type relative to the benchmark equilibrium, before exploring the consequence of a sequence of mergers of each type including the possibility of type-switching during the sequence.

¹⁵ This framework is more general than that used in most of the previous literature, whose assumptions about the transferability (or not) of cost advantages are encompassed by this approach. For example, when cost advantages are not transferable, as in the models of Long and Vousden (1995), Falvey (1998) and Falvey and Nathananan (2002), this is equivalent to $\gamma = 1$ and $\delta = 1$. Leahy (2002) looks at properties of the demand and cost function in a very general setting, and the Cournot version is equivalent to $\delta = \gamma \in (0, 1)$, while Ryan (2006), assuming costless technology transfer and homogeneous goods, is equivalent to $\gamma = 1$ and $\delta = 0$. This paper allows for $\gamma \in (0, 1)$ and $\delta \in (0, \gamma)$.

3.1. An indicative Independent-Division Merger

In this section we consider the strategy where the merged firm opts to run the newly acquired target k as a separate division and allows it to set its own output to maximise its divisional profits (on the assumption that all other firms or divisions are independent - other possibilities will be considered in due course). Thus each firm and division solves the same maximisation problem as in Section 2.1 with the modification that the marginal cost facing the target plant is now $\tilde{c}_k = c_j + \frac{\delta}{\gamma}(c_k - c_j)$,

where $\gamma \in (0, 1)$, $\delta \in (0, \gamma)$. This yields:

Lemma 1. *The price level falls for all goods (due to the increased competitiveness of the target) and output of the target's product rises as does the merged-firm's overall output.*

Proof: The post-merger price level of good j is:

$$(7) \quad \hat{p}_j = \frac{\Gamma(0)A + \gamma C + \Gamma(N)(\Gamma(0) - 1)c_j}{\Gamma(0)\Gamma(N)} - \frac{(\gamma - \delta)(c_k - c_j)}{\Gamma(0)\Gamma(N)} = p_j - (\gamma - \delta)R < p_j$$

where $R = \frac{(c_k - c_j)}{\Gamma(0)\Gamma(N)}$.

Similarly, the post-merger price of good k is now:

$$\hat{p}_k = \hat{p}_j = p_k - \left[\Gamma(N)(\Gamma(0) - 1) \left[1 - \frac{\delta}{\gamma} \right] + (\gamma - \delta) \right] R < p_k$$

$$(8) \quad \hat{h}_k = \left[h_k + (\Gamma(N) \left[1 - \frac{\delta}{\gamma} \right] - (\gamma - \delta) R \right] > h_k \text{ and the output of the merged firm is}$$

$$(9) \quad \begin{aligned} \hat{h}_j + \hat{h}_k &= \left[h_j - (\gamma - \delta)R \right] + \left[h_k + (\Gamma(N) \left[1 - \frac{\delta}{\gamma} \right] - (\gamma - \delta) R \right] \\ &= h_j + h_k + \left[\Gamma(N) \left\{ 1 - \frac{\delta}{\gamma} \right\} - 2(\gamma - \delta) \right] R > h_j + h_k \quad \blacksquare \end{aligned}$$

Proposition 1. *In the absence of any additional merger cost, an independent-division merger is always profitable for $N \geq 3$.*

Proof:

The change in profits from the Independent-Division merger is

$$\Delta \pi^{ID} = (\hat{p}_j - c_j) \hat{h}_j + \left(\hat{p}_k - \left\{ c_j + \frac{\delta}{\gamma} (c_k - c_j) \right\} \right) \hat{h}_k - (\hat{p}_j - c_j) h_j - (p_k - c_k) h_k$$

$$\Rightarrow \Delta \pi^{ID} = [\hat{h}_j^2 - h_j^2] + [\hat{h}_k^2 - h_k^2], \text{ which yields}$$

(10)

$$\Delta \pi^{ID} = \left[\Gamma(N) \left\{ 1 - \frac{\delta}{\gamma} \right\}^2 - 2\Gamma(N) \left\{ 2 - \frac{\delta}{\gamma} \right\} (\gamma - \delta) + 2(\gamma - \delta)^2 \right] R^2 + 2h_k \left[\Gamma(N) \left\{ 1 - \frac{\delta}{\gamma} \right\} - 2(\gamma - \delta) \right] R$$

For $N \geq 3$ this expression is positive. ■¹⁶

Corollary 1. *Profits are positively related to the pre-merger cost gap for $N \geq 3$ and, when know-how is perfectly transferable, negatively related to the degree of product differentiation for $N \geq 4$.*

Proof:

(11)

$$\frac{\partial \Delta \pi^{ID}}{\partial R} = 2 \left[\Gamma(N)^2 \left\{ 1 - \frac{\delta}{\gamma} \right\}^2 - 2\Gamma(N) \left\{ 2 - \frac{\delta}{\gamma} \right\} (\gamma - \delta) + 2(\gamma - \delta)^2 \right] R + 2h_k \left[\Gamma(N) \left\{ 1 - \frac{\delta}{\gamma} \right\} - 2(\gamma - \delta) \right] \geq 0$$

which is positive for $N \geq 3$.

Similarly for $\delta = 0$

¹⁶ The profit of a non-merging firm falls since $\hat{\pi}_r = \hat{h}_r^2$ where

$$\hat{h}_r = \frac{\Gamma(0)A + \gamma(C + C^*) + \gamma \left(c_j + \frac{\delta}{\gamma} (c_k - c_j) - c_k \right) - \Gamma(N)c_r}{\Gamma(0)\Gamma(N)} = h_r - (\gamma - \delta) \quad R < h_r.$$

The marginal non-merging firm may leave the market here (requiring a recalculation) and this is checked in all the simulations below.

$$(12) \frac{\partial \Delta \pi^{ID}}{\partial \gamma} = [2(N-3) + 2(N^2 - 6N + 7)\gamma]R^2 + 2h_k [N-3]R \geq 0, \text{ for } N \geq 4. \blacksquare$$

In the absence of the fixed merger cost M discussed earlier, the change in profits is always positive (for $N \geq 3$) and hence such a cost may be necessary to establish an internal equilibrium. In this scenario, for all values of γ and δ , the most profitable merger involves the most efficient firm taking over the least efficient, transferring its superior technology and running it as an independent division or franchise.

Perhaps surprisingly, Corollary 1 tells us that the change in profits is greater when the merger involves two firms selling similar goods. The intuition is that the increased output of the new (former high-cost) division, while reducing the original low-cost division's output, also has the effect of reducing the output of all the non-merging (outside) firms. This latter effect is greatest when γ is highest, yielding greater profits for the merger. This is equivalent to the merged firm squeezing competitors by making a commitment to capacity via the know-how transfer. From Lemma 1 and Proposition 1 we get:

Corollary 2. *As δ approaches γ , the change in profits goes to zero and thus some degree of know-how transfer is essential for an independent-division merger to be profitable.*

Proof: Follows immediately from equation 10. \blacksquare

This result is intuitive as an independent-division merger has no effect on market structure and hence can only be profitable if it leads to a cost reduction.

Corollary 3. *An independent-division merger is always welfare enhancing if technology is perfectly transferable.*

Proof: Since price falls, and both the output of the merged firm and aggregate output unambiguously rise, welfare rises.¹⁷

¹⁷ Note that the Herfindahl-Hirschman index has risen as a consequence of the merger despite the fact that it is welfare enhancing. This merely reinforces the point made by Farrell and Shapiro (1990) that

$$(13) \Delta CS = 2 \left[\frac{\delta (c_k - c_j)}{\gamma (N+1)} \right]^2 + H \left[\frac{\delta (c_k - c_j)}{\gamma (N+1)} \right] > 0$$

Where know-how is perfectly transferable, aggregate firm profits also rise, since the additional output displaces less efficient producers.

$$(14) \Delta \hat{\pi}_{jk} + \sum_{\substack{r=1 \\ (\neq j,k)}}^N \Delta \hat{\pi}_r = \left[\Gamma(N) \left\{ 1 - \frac{\delta}{\gamma} \right\}^2 - 2\Gamma(N) \left\{ 2 - \frac{\delta}{\gamma} \right\} (\gamma - \delta) + N(\gamma - \delta)^2 \right] R^2$$

■¹⁸

$$+ 2h_j \left[\Gamma(N) \left\{ 1 - \frac{\delta}{\gamma} \right\} - (\gamma - \delta) [H + 2 - h_j - h_k] \right] R > 0$$

3.2. Sequential Independent Division Mergers

The results in Proposition 1 and Corollary 1 are sufficient to allow us to use steps 1-4 as set out in Section 2.3 to identify the initial merger. The next question we must ask ourselves in this section is, given that the most profitable merger has occurred (between the most and least efficient firms 1 and N), how are subsequent merger incentives affected by this merger (that is, what is the sequence in step 5 of the merger process)?

It is important to note here that in the case of Independent Divisions the general form of the output equation is conveniently unaffected by the number of firms which have already merged, or the number of plants associated with each partner, or indeed outsiders. All that is required is a modification of the individual and aggregate cost component C in equation (5). It follows from this and the analysis above that:

the Herfindahl-Hirschman index may not always be an appropriate measure of the welfare effects of a merger.

¹⁸ There may be some cost to the know-how transfer but as long as its transfer is perfectly feasible ($\delta=0$) and there are positive profits this is sufficient to ensure a rise in overall welfare. This case differs from Lahiri and Ono (1988), in that we are not dealing with a marginal change in technology of the weakest firm. Rather, post-merger, the less efficient firm, j , assumes the technology of the most efficient firm, i , $\tilde{c}_j = c_i$. Thus, in this case we have a case of a (new) more efficient division

displacing less efficient producers (2, ..., $N-1$). Since overall output rises, aggregate costs are lower and the price falls, aggregate welfare unambiguously rises. In the more general case where $\delta > 0$, the merger with the less efficient target might result in only a marginal improvement in its costs and hence its increased output might merely displace more efficient producers and aggregate welfare may fall as in Lahiri and Ono.

Corollary 4. *For any given previous set of mergers by the most efficient firm, 1, with $N, N-1, \dots$ up to $k+1$, (denoted $[1, N, N-1, \dots, k+2]_{k+1}$), a subsequent independent-division merger between the most efficient firm and any other firm k (denoted $[1, N, N-1, \dots, k+1]_k$), is more profitable than any other independent-division merger involving the target k and any other firm m , given $k-1, k-2, \dots, 3, 2$, other independent competing firms. That is,*

$$\begin{aligned} \hat{\pi}_{[1, n-1, \dots, k+1]_k}^{ID}([1, n, n-1, \dots, k+1, k] | k-1 : \dots : 3 : 2) \\ > \hat{\pi}_{km}^{ID}([k, m] | [1, n, n-1, \dots, k+1] | k-1 : \dots : 3 : 2) \end{aligned}$$

$\forall k, m \in \{k-1, \dots, 3, 2\}$ where $([1, n, n-1, \dots, k+1, k] | k-1 : \dots : 3 : 2)$ and $([k, m] | [1, n, n-1, \dots, k+1] | k-1 : \dots : 3 : 2)$ indicate the respective new market structures.

Proof: Follows from Corollary 1 by induction. ■

Thus, in the absence of any other forces (in particular ignoring the possibility of Joint-Operation mergers), we would observe in equilibrium that the most efficient firm would operate several divisions which were formerly (relatively inefficient) independent firms. High-cost targets always have an incentive to join the coalition as they stand to lose if the low-cost firm engages in an alternative merger since Independent-Division mergers create a negative externality for non-participants (whose output and profits fall).¹⁹ The grand coalition (of the most efficient firm and its, sequentially, least-efficient targets) is therefore only limited by the size of the merger cost, M . There are no retaliatory Independent-Division mergers as the profits from such a merger are always less than those associated with any feasible merger for the most efficient firm.

If instead of a fixed merger cost M , we assumed that the merger cost was proportional to the production cost gap ($c_k - c_j$), then a richer merger pattern for independent-division mergers could be generated.²⁰ We will return to the issue of successive and multi-firm mergers when we discuss the full equilibrium.

¹⁹ See footnote 16. Note that the fact that outsiders lose avoids the first mover incentive problems in Horn and Persson (2001)

²⁰ However, as we will see in Section 5, even with a fixed M it is possible to generate a multiple multi-firm equilibrium simply by adding tariffs.

3.3. An Indicative Joint-Operation Merger

In this section a merging firm follows an alternative strategy. The two merging partners operate as a single firm, making a joint-production decision. Thus each plant produces its variant of the differentiated product, taking into account the effect of its sales decisions on the sales of the firm's other plant. We start by examining the simplest case first, where a single-plant low-cost firm is contemplating an arrangement with a single-plant higher-cost firm before moving on to the general case where the partners and non-merging competitors (outsiders) have multiple plants. The new maximisation problem involves choosing h_j and h_k to

$$(15) \quad \text{Max } (p_j - c_j)h_j + (p_k - c_k)h_k \text{ with respect to } h_j, \text{ and } h_k,$$

yielding first order conditions²¹

$$(16) \quad \begin{aligned} p_j - c_j &= h_j + \gamma h_k \\ p_k - c_k &= \gamma h_j + h_k \end{aligned}$$

This yields, for example, a new level of home market output (indicated by superscript \sim) by the lower-cost firm's original plant, j , of :

$$(17) \quad \tilde{h}_j = \frac{\Gamma(0)A + \gamma C - \Gamma(N)c_j - \gamma(c_k - c_j) + \delta \frac{\{(N-\gamma)\gamma + 1\}}{2(1-\gamma)}(c_k - c_j)}{2\{\Gamma(N) - \gamma^2\}}$$

The partners' post-merger outputs in terms of their pre-merger outputs (the benchmark established in Section 2.2) are:

$$(18) \quad \tilde{h}_j = \left[1 - \frac{2\gamma + (N-3)\gamma^2}{2\{\Gamma(N) - \gamma^2\}} \right] h_j - \frac{\gamma(c_k - c_j)}{2\{\Gamma(N) - \gamma^2\}} + \delta \frac{\{(N-\gamma)\gamma + 1\}}{4(1-\gamma)\{\Gamma(N) - \gamma^2\}}(c_k - c_j)$$

²¹ Subject to the new h_k being positive. If it is negative, we simply need to compute the effect of a takeover and close merger as in the standard market concentration literature.

(19)

$$\tilde{h}_k = \left[1 - \frac{2\gamma + (N-3)\gamma^2}{2\{\Gamma(N) - \gamma^2\}} \right] h_k + \frac{(\Gamma(N) - \gamma)(c_k - c_j)}{2\{\Gamma(N) - \gamma^2\}} - \delta \frac{\{4 + (2N-3)\gamma - (N+2)\gamma^2 + \gamma^3\}}{4\gamma(1-\gamma)\{\Gamma(N) - \gamma^2\}} (c_k - c_j)$$

The intuition behind equations (18) and (19) is as follows. Ignoring cost differences and know-how transfer, as long as products are not completely independent ($\gamma = 0$) a merged Joint-Operation firm will tend to reduce output in both plants so as to reduce competition and exploit market power. This reduction is captured by the first term in equations (18) and (19) above, which is a fraction less than one of the original level of output and depends on γ . It tells us the amount by which output would fall if costs were homogeneous across firms (and this term is the differentiated-good equivalent of the closure of the target firm in Salant *et al.* (1983)).²² The second term in (18) tells us the additional fall in the original low-cost firm's output, induced as a consequence of an increase in the target's output, where costs differ *ex ante*, ($c_k > c_j$), and technology is perfectly transferable. The third term in (18) corrects for the potential difficulty in technology transfer, and indicates a smaller reduction in the low-cost firm's output as the difficulty (δ) in transferring the superior know-how to the target increases. The corresponding second and third terms in (19), the output of the target plant, are of opposite sign and larger (since all other firms reduce their output in response to the technology transfer and thus the terms in (18) are only a fraction of those in (19)). Note that in the case where costs are different but technology is not transferable ($\gamma = \delta$), the final term in each equation dominates and the low-cost firm (while cutting overall output of the two plants) shifts production from the high cost firm's product towards its own good.²³

From equation (16) we can write the expression for the change in profit as a result of this two-firm (two-plant) merger as:

$$\Delta\pi^{JO} = (\tilde{h}_j + \gamma\tilde{h}_k)\tilde{h}_j + (\gamma\tilde{h}_j + \tilde{h}_k)\tilde{h}_k - h_j^2 - h_k^2 - M$$

$$\Delta\pi^{JO} = \tilde{h}_j^2 + 2\gamma\tilde{h}_k\tilde{h}_j + \tilde{h}_k^2 - h_j^2 - h_k^2 - M$$

²² With homogeneous goods the optimal strategy is for the more efficient plant to produce the entire output of the good, since in the absence of capacity constraints there will never be an incentive to produce an undifferentiated product at two locations with different constant marginal costs.

This equation does not readily simplify into a simple reduced form and unlike the independent-division mergers it cannot be unambiguously signed, even for $M = 0$, without recourse to parameterisation. The equation becomes even more complex when we introduce the possibility of sequential mergers. Thus in the rest of this section and later sections we rely on simulation analysis.²⁴

These Joint-Operation merger simulations highlight two key differences relative to the Independent-Division case. Table 1 reports simulations which demonstrate that profits are maximised at intermediate values of γ (dark squares) rather than when $\gamma=1$ as we saw in Section 3.1, while Table 2 reports an example where the most efficient firm, firm 1, would prefer to merge with the next most-efficient, firm 2, rather than the least-efficient firm (firm 4 in this example) as in the previous section.

The simulations in Table 1 report the results of a Joint-Operation merger between the most and least efficient firm for a market consisting of various numbers of firms from 20 down to 3 when know-how is perfectly transferable. With the exception of the $N = 20$ case, the reported output falls in each case but profits increase and depend positively on R (and hence on the cost difference between the firms), but in contrast to the Independent-Division case in equation (12) the greatest increase in profits (in percentage terms) occurs with internal values of γ .

Table 1: Simulation of Joint-Operation Merger between firm 1 and N for various values of N (with $\delta=0$, $A=10000$ and $c_i=50i$):

N	gamma	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
20	% fall in Output	-2.72	-2.93	-3.15	-3.36	-3.57	-3.79	-4.01	-4.25	-4.54
	% Change in profit	14.06	25.77	34.16	38.93	40.19	38.29	33.75	27.11	18.96
13	% fall in Output	23.03	20.04	17.10	14.21	11.35	8.52	5.71	2.90	0.02
	% Change in profit	-0.46	5.54	10.01	13.05	14.73	15.15	14.37	12.49	9.65
11	% fall in Output	27.83	24.33	20.90	17.53	14.20	10.92	7.67	4.40	1.06
	% Change in profit	-7.20	-1.48	3.08	6.52	8.84	10.06	10.19	9.30	7.50
9	% fall in Output	31.37	27.50	23.72	20.02	16.39	12.80	9.25	5.67	1.98

²³ This is the differentiated good equivalent of what Long and Vousden (1995), in the homogeneous goods context, refer to as the ‘cost-reducing effect’ of a merger (meaning the shifting of some production to the lower-cost producer following the closure of the less efficient target).

²⁴ An Excel file is available from the author.

7	% Change in profit	-13.06	-7.30	-2.49	1.34	4.16	5.97	6.77	6.60	5.58
	% fall in Output	33.43	29.37	25.43	21.59	17.83	14.12	10.43	6.69	2.79
5	% Change in profit	-16.68	-10.88	-5.98	-2.00	1.01	3.07	4.18	4.40	3.90
	% fall in Output	33.44	29.50	25.69	21.99	18.38	14.79	11.18	7.46	3.48
3	% Change in profit	-16.06	-10.70	-6.25	-2.74	-0.14	1.59	2.51	2.74	2.46
	% fall in Output	29.46	26.41	23.46	20.56	17.63	14.62	11.43	7.96	4.06
	% Change in profit	-5.48	-2.55	-0.44	0.96	1.76	2.06	1.98	1.65	1.25

The reason for this result is that the concentration effect is non-linear. The more substitutable the goods, the weaker is the benefit from reducing output due to the increase in output by outsider firms in response to the merger concentration. Conversely, for low values of γ the pre-merger equilibrium already reflects most of the desirable concentration and the additional concentration attributable to the merger is very small. These two effects give an internal equilibrium in this case. If we extend the analysis to allow for imperfect know-how transfer ($\delta > 0$) this reduces the potential profitability of all mergers and the threshold value of γ required for a profitable merger is reduced, although the maximum γ is unaffected, that is, the profit curve (as a function of γ) is shifted down. We include in this table the case where $N = 20$ as a merger between firms 1 and 20 results in the know-how transfer effect dominating the concentration effect and aggregate output rises, as in the Independent-Division case.²⁵

Table 2 reports the changes in profits relative to the initial Cournot equilibrium for the full set of possible Joint-Operation first-round mergers and illustrates the other feature of equation (20). Unlike in the homogeneous goods literature (see for example Ryan (2006), Neary (2003) or Falvey and Nathananan (2002)) the relationship between merger profitability and R is not strictly increasing in this model. In the homogeneous goods literature the most profitable merger always involves the most efficient and least efficient firms, and when know-how is fully transferable ($\delta = 0$) a similar result obtains here. However, in Table 2 we see that when δ is high and γ is low, the most efficient firm, firm 1, would prefer to merge with the next most efficient, firm 2, with 3 and 4 independent (merger $([1,2][3:4])$), rather than the least efficient firm 4

([1,4]|2:3). Thus when technology transfer is difficult and goods are not easily substitutable, the increase in market power is more important and the two closest firms have the most to gain.

Table:2 Example of profits being larger if firm 1 merges with nearest low cost firm, firm 2, (rather than high cost firms 3 or 4) when technology is NOT transferable									
$N = 4, A = 1000, c_i = 50i$ and $\delta = \gamma$	$\gamma=0.9$	$\gamma=0.8$	$\gamma=0.7$	$\gamma=0.6$	$\gamma=0.5$	$\gamma=0.4$	$\gamma=0.3$	$\gamma=0.2$	$\gamma=0.1$
Change in profits for 14 from [1,4] 2:3	-18.04	-13.16	-9.06	-5.81	-3.37	-1.70	-0.68	-0.2118	-0.0881
Change in profits for 13 from [1,3] 2:4	-17.43	-12.53	-8.49	-5.31	-2.96	-1.37	-0.44	-0.0532	-0.0103
Change in profits for 12 from [1,2] 3:4	-16.79	-11.90	-7.92	-4.82	-2.55	-1.04	-0.20	0.1045	0.0670
Change in profits for 23 from [2,3] 1:4	-16.80	-11.91	-7.93	-4.83	-2.56	-1.05	-0.20	0.1034	0.0665
Change in profits for 34 from [3,4] 2:4	-16.81	-11.92	-7.94	-4.84	-2.56	-1.05	-0.21	0.1022	0.0661
Change in profits for 24 from [2,4] 3:4	-17.46	-12.56	-8.51	-5.33	-2.97	-1.38	-0.45	-0.0555	-0.0113

3.4. Sequential Joint-Operation Mergers

The analysis above only involves a single-plant firm merging with another single-plant firm and all other firms are autonomous single-plant firms. However, more generally, we must allow for the possibility that there are F independent firms indexed $r \in (1, \dots, F)$ each with a different number S_r of plants, each indexed S_{rm} , with

$m \in (1, \dots, S_r)$ and $\sum_{r=1}^F S_r = N$. We wish to consider the case where two firms, i and j ,

which have already accumulated S_i and S_j plants, respectively, want to engage in a new strategic partnership or merger, with $S_{i+j} = S_i + S_j$ plants. In this general case,

the level of output for firm i 's most efficient plant \tilde{h}_{i1} satisfies:

²⁵ As one might expect, simulations confirm that whenever the technology transfer effect dominates (that is the aggregate merged firm's output rises) merger profits are positive. However, in this case a Joint-operation merger will always be dominated by an Independent-Division merger.

$$\begin{aligned}
(20) \quad & \left[(2 + 2\{S_{i+j} - 1\}\gamma) + \gamma \sum_{r=1(\neq S_{ij})}^F \frac{(2 + \{S_{i+j} - 2\}\gamma)}{(2 + \{S_r - 2\}\gamma)} \right] \tilde{h}_{i1} = \\
& (A - c_{i1}) + \sum_{r=1(\neq S_{ij})}^F \left\{ \frac{\gamma(c_r - c_{i1})}{(2 + \{S_r - 2\}\gamma)} \right\} \\
& + \frac{\delta}{2(1-\gamma)} \left\{ \begin{aligned} & 2 \sum_{m=2}^{S_{i+j}} (c_{im} - c_{i1}) + \sum_{r=1(\neq S_{ij})}^F \left\{ \sum_{m=2}^{S_r} (c_{rm} - c_{r1}) \right\} \\ & + \sum_{r=1(\neq S_{ij})}^I \left\{ \frac{1}{(2 + \{S_r - 2\}\gamma)} \left[\sum_{m=2}^{S_{i+j}} (c_{im} - c_{i1}) - \sum_{m=2}^{S_r} (c_{rm} - c_{r1}) \right] \right\} \end{aligned} \right\}
\end{aligned}$$

All outputs of other firms and plants, h_{rm} , can be readily derived from this and employed in the joint-operation, multi-plant firm simulations reported in Section 4 below. Profits must be similarly adjusted, increasing with the number of plants (due to increased market power) and, as before, decreasing in the degree to which know-how is transferable.

$$(21) \quad \pi_{i1} = (1 + (S_{i+j} - 1)\gamma)h_{i1}^2 - \left[\delta \sum_{m=2}^{S_{i+j}} \frac{(c_{im} - c_{i1})}{2(1-\gamma)} \right] h_{i1}$$

4. An Illustrative Sequential Equilibrium with Independent-Division and Joint-Operation Mergers:

In this section we use the analysis developed in Section 3 above to investigate the potential sequence of mergers required to determine the equilibrium market structure, that is we consider Step 5 of the merger process identified in Section 2.3.

In Section 3.1 we identified the merger sequence for a market where Independent-Division mergers are possible. We know that in such a market we will have, *ceteris paribus*, a sequence of mergers involving the most efficient firm and the least efficient remaining independent firm. We now wish to reconsider this sequence and offer the most efficient firm the option of choosing a Joint-Operation merger rather than an Independent-Division merger at each juncture. If the firm first chooses an Independent-Division merger, then subsequently it will compare a new Independent-Division merger with a joint operation involving its two existing independent plants and the target. Thus at each step, a firm with $S - 1$ existing divisionalised plants considers whether to engage in a joint-product merger and gain π^{JO} (converting all

its $S - 1$ existing plants plus the target into an S -plant/product Joint-Operation firm), or to engage in a further Independent-Division merger for a return of π^{ID} . For simplicity in this section we assume that know-how is perfectly transferable and consider the impact of imperfect know-how transfer (non-zero δ) in the discussion.

We are interested in finding the point in the merger sequence at which:

$$\pi^{JO} = S_j(1 + (S_j - 1)\gamma)\tilde{h}_j^2 > S_j\hat{h}_{ij}^2 = \pi^{ID}$$

Note that given the simplifying assumption on know-how transfer, the post-merger outputs of the merging partners are equalised, $\tilde{h}_i = \tilde{h}_k$ and $\hat{h}_{ij} = \hat{h}_{kj}$. Thus from (8) and (21) the respective condition we require is

(22)

$$\begin{aligned} \pi^{ID} = S_{i+j}\hat{h}_i^2 = S_{i+j} & \left[\frac{\Gamma(0)A + \gamma C - \gamma(c_j - c_i) - \Gamma(N)c_i - \sum_{m=1}^{S_{ij}}(c_{im} - c_{ii})}{\Gamma(0)\Gamma(N)} \right]^2 < \pi^{JO} = S_{i+j}(1 + (S_{i+j} - 1)\gamma)\tilde{h}_i^2 \\ = S_{i+j}(1 + (S_{i+j} - 1)\gamma) & \left[\frac{\Gamma(0)A + \gamma C - \gamma(c_j - c_i) - \Gamma(N)c_i - \sum_{m=1}^{S_{ij}}(c_{im} - c_{ii})}{\{(2 - \gamma)\{2 + (2S_{i+j} - 2)\gamma\} + \{2 + (S_{i+j} - 2)\gamma\}(N - S_{i+j})\gamma\}} \right]^2 \end{aligned}$$

which, when S_j , the number of plants owned by the target, equals 1, reduces to:

Proposition 2: *If $\delta = 0$, a firm will choose a Joint-Operations rather than an Independent Division merger iff*

$$\left[\{(2 - \gamma)\{2 + (2S_{i+j} - 2)\gamma\} + \{2 + (S_{i+j} - 2)\gamma\}(N - S_{i+j})\gamma\} \right]^2 < (1 + (S_{i+j} - 1)\gamma)\Gamma(0)^2\Gamma(N)^2$$

Proof: Follows from rearranging the above inequality. ■

Table 3 below identifies the first merger for which it pays for the merging multi-plant firm to switch from an Independent-Division strategy to a Joint-Operation merger,

depending on the number of firms in the market and γ . Thus this table tells us the point at which the Independent-Division merger sequence in Corollary 4 gives way to a Joint-Operation merger.

Table 3: With N firms in the industry the switch (involving all plants) from an Independent-Division to a Joint-Operation Merger to S-plant firm will occur on the (S-1) th Merger in the table below									
N	$\gamma = 0.1$	$\gamma = 0.2$	$\gamma = 0.3$	$\gamma = 0.4$	$\gamma = 0.5$	$\gamma = 0.6$	$\gamma = 0.7$	$\gamma = 0.8$	$\gamma = 0.9$
3	1 st	1 st	1 st	1 st	1 st	2 nd	2 nd	2 nd	2 nd
4	1 st	1 st	1 st	2 nd	2 nd	2 nd	2 nd	2 nd	3 rd
5	1 st	1 st	2 nd	2 nd	3 rd	3 rd	3 rd	3 rd	3 rd
6	1 st	2 nd	2 nd	3 rd	3 rd	3 rd	4 th	4 th	4 th
7	1 st	2 nd	3 rd	3 rd	4 th	4 th	4 th	5 th	5 th
8	1 st	2 nd	3 rd	4 th	4 th	5 th	5 th	5 th	6 th
9	2 nd	3 rd	4 th	5 th	5 th	6 th	6 th	6 th	7 th
10	2 nd	3 rd	4 th	5 th	6 th	6 th	7 th	7 th	7 th
11	2 nd	4 th	5 th	6 th	7 th	7 th	7 th	8 th	8 th
12	2 nd	4 th	6 th	6 th	7 th	8 th	8 th	9 th	9 th
15	3 rd	6 th	7 th	9 th	9 th	10 th	11 th	11 th	12 th
20	5 th	9 th	11 th	12 th	13 th	14 th	15 th	15 th	16 th
25	7 th	12 th	14 th	16 th	17 th	18 th	19 th	20 th	20 th

To interpret this table consider the case of $\gamma = 0.5$. If initially there were $N = 12$ firms in the industry then, subject to the merger increasing profits by more than M , a sequence of independent-division mergers will occur until on the seventh merger a seven-(independent-) division firm attempts to merge with the next firm in the sequence to create an eight division firm.

$$\text{Thus, } \pi^{ID}([1,12,11,10,9,8,7]|2:3:4:5:6) > \pi^{JO}([1,12,11,10,9,8,7]|2:3:4:5:6)$$

$$\text{but } \pi^{JO}([1,12,11,10,9,8,7,6]|2:3:4:5) > \pi^{ID}([1,12,11,10,9,8,7,6]|2:3:4:5).$$

Note that if a firm has already had seven independent-division mergers then all seven will be involved in the joint-operation merger with firm 8, since it follows from (22) that it is less profitable for only a subset of the divisions to be involved in the Joint-Operation decision. Intuitively, this makes sense since once a firm opts to exploit its market power (for a given γ) it makes sense to employ this strategy across all divisions simultaneously. Finally, the switch-over point, S^{JO} , is a positive function of γ and N. That is $\frac{\partial S^{JO}}{\partial N} > 0$ and $\frac{\partial S^{JO}}{\partial \gamma} > 0$ for $\gamma \in (0,1]$.

Once this switch takes place we have to examine a more complex range of potential Joint-Operation mergers to assess the next merger in the sequence. In the next section

we analyse a five-firm example, where we examine a range of subsequent possible joint-operation configurations (as well as the Independent-Division options in each case). These Joint-Operation scenarios for the five-firm case are represented by the shaded line in Table 3, which tells us that the switch from an Independent-Division merger strategy to a Joint-Operation merger strategy will occur on the third merger (to create a four-plant firm) for $\gamma = 0.7$, and on the second merger (to create a three-plant firm) for $\gamma = 0.4$, while the first merger (to create a two-plant firm) will be a Joint-Operation merger in the case of $\gamma = 0.2$. Finally, note that for $\gamma = 0$ the two types of merger yield equal profits (since there is no interaction between products anyway), while for $\gamma = 1$ an Independent-Division merger dominates for all $N > 2$.²⁶

4.1. An illustrative five-firm equilibrium:

We have now identified the pay-off associated with each expansion strategy, the conditions under which they may be profitable and the circumstances under which one form will dominate another. However, while the analysis above illustrates the pertinent issues, there clearly is no simple result in the absence of greater parameterisation of the problem. In this section, by way of illustration, we consider the payoffs associated with a five-firm version of the game, where $A = 10000$, $c_i = 50i$ and $\delta = 0$. We investigate all the possible merger (and de-merger) combinations at each stage, and report the most salient outcomes in Table 4.

[Table 4 about here – see end]

Again, when tracking merger history we invoke the key assumption that the most profitable merger occurs at each stage, although of course the complete set of payoffs allows us to see the result of an immediate jump to any configuration including the core-grand-coalition of [1:5:4:3:2]. We report the payoffs with M set to zero, however the actual observed equilibrium will depend on the value of M . The table is broken into three sections. Section 1 reports the change in profits for an Independent-Division [1,5] merger (line 1), the effect on all firms of a Joint-Operation [1,5] merger

²⁶ See Ryan (2006).

(lines 2-5) plus, by way of comparison, the results for a Joint-Operation [1,2] merger (line 6). The first point to note is that the payoffs behave as described in Table 3 above with an Independent-Division merger being preferred for γ greater than 0.2 and a Joint Operation for 0.2 or less.

As we can see, a Joint-Operation merger strategy causes the outsiders' profits to rise. So for example, for $\gamma = 0.4$ the change in profits for firm 2 from a [1,5] merger ($\Delta\pi^{jo} [2]([1:5],2,3,4) = 653368$) is greater than the profits for firms 1 and 5 from the same merger ($\Delta\pi^{jo} [1:5]([1:5],2,3,4) = 238711$). This outsider incentive effect is the key issue that leads to the difficulty in identifying the equilibrium in the homogeneous goods case such as in Horn and Persson (2001). However, in this example, for all the relevant mergers where $\Delta\pi^{jo} > \Delta\pi^{id}$ the profits for outsiders (while positive) are less than those for insiders, making such mergers less susceptible to incentive problems.²⁷

Section 2A reports the possible outcomes associated with a retaliatory [2,3] or [2,4] merger. Comparing these results with those in Section 2B, which reports the change in profits from the alternative [1,5,4] merger (relative to the relevant previous Independent-Division or Joint-Operation [1,5] merger), we see that the returns for the relevant [1,5,4] merger dominates the returns for either the [2,3] or [2,4] retaliation. Note in addition that, as reported in Table 3, if $\gamma = 0.4$ the move from [1,5] to [1,5,4] leads to a switch from an Independent-Division strategy, where the change in profits is $\Delta\pi^{id} [1,5,4] ([1,5,4]:2:3) = 339627$, to a Joint-Operation merger, where the profits (relative to the previous Independent-Division case (line 15)) are $\Delta\pi^{jo/id} = \pi^{jo} [1,5,4] ([1,5,4]:3:2) - \pi^{id} [1,5] ([1,5]:4:3:2) - \pi^{id} [4] ([1,5]:4:3:2) = 628256$. Line 16 gives the relevant change in the Joint Operation profits relative to the previous Joint Operation [1,5] which is the relevant comparison for $\gamma = 0.2$ or less.

Lines 18 and 19 compare the profits from the relevant [1,5,4] merger with the base profits of the individual firms when all firms were independent. Comparing these profits with the sum of those obtained via a step-wise merger process, we observe that the latter can yield different results to one where the multiple [154] merger can occur

²⁷ But note that $\delta < \gamma$ is crucial for this alternative Independent-Division effect.

simultaneously. For example, where the initial merger is an Independent Division merger, such as when $\gamma = 0.5$, the change in profits from the sequence of mergers $\Delta\pi^{ID}([1,5])([1,5]:2:3:4) = 488611$ and $\Delta\pi^{JO}([1,5,4])([1,5,4]:2:3) = 304531$ exceeds the change in profits from the same merger relative to the base (=712448 from line 18). This occurs because the initial Independent-Division merger reduces the profits of the outsider firm 4, which the subsequent [1,5,4] merger (whether Independent-Division or Joint-Operation) recovers. So the step-wise merger process biases acceptance of mergers that might not occur in a multilateral merger setting when the initial merger is an Independent-Division merger. By contrast, for $\gamma = 0.2$ the sum of the individual profits of the sequence of Joint-Operation mergers is lower than the base case because of the positive externality on outsiders, which is lost when a subsequent merger includes the outsider, thus biasing rejection relative to a base comparison in a multilateral merger.

Section 3 reports a selection of results for a retaliatory [2,3] merger, the next merger in the [1,5,4,3] sequence and an alternative [1,5,4,2] merger. Again the results behave as expected, with the Joint-Operation format replacing the previous Independent-Division mergers for γ in the 0.9-0.5 range.

What will the precise equilibrium be in this model? There are a number of possible contenders. In the absence of a merger cost M , either the process iterates to the grand Joint-Operation coalition of [1,5,4,3,2] or alternatively the merger process ends once the Independent-Divisions merger process exhausts itself (because of the Insider-Outside incentive conflicts with the Joint-Operation merger).²⁸ For all other possible equilibria, some substantial merger cost is essential. Thus, for example, with $\gamma = 0.5$, if we invoke a merger cost of $M = 400,000$, we will only observe the merger ([1,5]:2:3:4) and not ([1,5,4]:2:3), even though the subsequent Joint-Operation ([1,5,4,3]:2) would be highly profitable. By contrast, if $\gamma = 0.4$, both the [1,5] and [1,5,4] mergers would be feasible. However, if M is not a fixed number, and as we noted previously there are good reasons to think that it might not be, then the value of M associated with ([1,5,4]:2:3) might be significantly higher than that associated with

([1,5]:2:3:4) if the relevant regulatory body were to launch a long and expensive merger investigation. Similarly, it might be more costly to merge with a firm with a much lower level of know-how rather than with one with a similar level. Thus for $\gamma = 0.2$ the Joint-Operation merger ([1,5]:2:3:4) would not occur if $M_{15} = 650,000$, while the merger ([2,3]:[1,5]:4) with $M_{23}=190,000$ would happen. This is a different issue to the case where $\gamma = \delta$ reported in Table 2.

Hence this framework is potentially capable of generating equilibria with a wide variety of characteristics once we have the appropriate merger cost, M , plus product differentiation, marginal cost and know-how transfer parameters.

Observations from the five-firm equilibrium

Observation 1: *For high levels of substitutability, an Independent-Division merger is likely to dominate.*

Observation 2: *It is possible to identify conditions under which Joint-Operation mergers dominate Independent-Division mergers and for each level of substitutability γ , there is a critical merger such that an Independent-Division merger gives way to a Joint-Operation merger. Thus, a Joint-Operation merger becomes progressively more likely as γ falls and/or a sequence of Independent Division mergers has already occurred*

Observation 3: *There is thus a natural sequence of incentive-compatible Independent-Division mergers before we get to a Joint-Operation merger with its attendant problem of outsider incentives. The conclusion of this sequence of Independent-Division mergers may represent a natural benchmark equilibrium against which changes in policy such as the removal of tariffs (to be discussed below) may be measured.*

²⁸ Although, as we noted above, at all points where the Joint-Operation profits actually dominate Independent-Division profits, the returns to insiders dominate the returns to outsiders, so this may not be as problematic in this model.

Observation 4: We know that for $M = 0$, Independent-Division mergers are always profitable as long as $\delta < \gamma$ and $R > 0$, that is, there is some marginal cost gap between the firms and the superior technology or management processes are (at least imperfectly) transferable. Hence Joint-Operation mergers that dominate Independent Division mergers must always be profitable. Furthermore, it appears that such a Joint-Operation merger that actually occur yield higher profits to insiders than outsiders.²⁹

Observation 5: Where the initial merger is an Independent-Division merger, the sum of the change in profits associated with a merger sequence will be boosted relative to a comparison with the change in profits from the same simultaneous multilateral merger, since losses experienced by an outsider in as step-wise merger sequences will be recovered once absorbed into a merged firm. Hence a sequence of mergers which absorbs previous outsiders individually may involve more partners (and therefore be larger) than a simultaneous multi-firm merger.

Table 5: Case summary

	γ approaching 1	γ approaching 0
$\delta=0$	<u>Independent Division</u> mergers more likely between most and <u>LEAST</u> efficient	<u>Joint Operation</u> mergers more likely between most and <u>LEAST</u> efficient
$\delta=\gamma$	No merger, some degree of know-how transfer essential	Joint Operation mergers more likely between most and <u>NEXT MOST</u> efficient

5. Tariffs and Merger Activity

As well as allowing the new insights already explained into merger incentives in a closed economy, the model set out above also facilitates an analysis of the impact of

²⁹ Due to the complexity of the model, space constraints prevent us from exploring welfare effects of a Joint-Operation merger here. We know from Corollary 3 that an Independent-Division merger yields unambiguous benefits (under free trade as long as $\delta = 0$). We know from the homogeneous goods literature (see for example Falvey 1998) that Joint-Operation mergers are more complex as the increased concentration (and price) shifts surplus from producers to consumers and the conditions for a welfare gain are more restrictive than in the Independent-Division case.

increased globalisation on concentrated markets where evidence suggests that the target tends to have a market presence post-merger. Space constraints prevent a comprehensive analysis of all the possible cases, but the purpose of this section is to identify the main factors in the analysis from which the full range of possibilities can be deduced.³⁰ In this section we assume the world is composed of two countries, home and foreign (whose variables are denoted by an asterisk). Again we assume that each country has a small, initially fixed, number of firms (n and n^* respectively, and $n + n^* = N$), each producing a differentiated product, and the two markets are segmented with each firm selling in both markets. In the analysis below we take as given some initial equilibrium (as established via the process discussed in Section 4 above), given the existing set of tariffs or trading costs, and consider the effects of a change in the trade regime. In particular, we are interested in changes in the incentives for the two types of merger as a consequence of relaxing trade impediments.

For simplicity, we again take as our initial equilibrium the benchmark N -firm equilibrium where we impose a trading cost (such as a tariff or additional technical requirement) of t on imports into the home market from foreign firms. This modification is equivalent to an increase in the marginal cost faced by foreign firms, and hence this term rises in all the relevant equations in Section 3. We start by re-examining the benchmark output and price equations before detailing the effects on merger profits. The trading cost (tariff) inclusive price is:

$$p_{it} = p_i + \frac{\gamma n^* t}{\Gamma(0)\Gamma(N)} > p_i \text{ and a domestic firm's sales to the domestic market rise to}$$

$$h_{it} = h_i + \frac{\gamma n^* t}{\Gamma(0)\Gamma(N)}, \text{ while a foreign firm's sales to the domestic market fall to}$$

$$h_{it}^* = h_i^* - \frac{[\Gamma(0) + n\gamma]t}{\Gamma(0)\Gamma(N)}. \text{ That is, the output of all home firms rises by the same}$$

$$\text{absolute amount } \frac{\gamma n^* t}{\Gamma(0)\Gamma(N)}, \text{ while sales of each foreign firm to the domestic market}$$

³⁰ A slight modification to the equations, depending on which country is imposing the tariff and the location of each of the merger candidates, allows for other cases to be considered. See Ryan (2006) for some examples.

falls by an amount $\frac{[\Gamma(0) + n\gamma]t}{\Gamma(0)\Gamma(N)}$, which reflects the foreign firms' overall share of that

market. Sales in the foreign market by all firms are unaffected prior to a merger. Here we wish to focus on the impact of a tariff on merger incentives and equilibrium and, with one exception, we will not repeat the detailed merger analysis here save to say that it is very similar to that outlined in section 3.³¹ The exception is to note that a merger as a consequence of a protective tariff may in fact induce a price fall since

$$\tilde{p}_i = p_i - (\gamma - \delta) \frac{(c_k - c_j)}{\Gamma(0)\Gamma(N)} \quad \text{which may be less than the pre-tariff price,}$$

$$\tilde{p}_i = p_i - (\gamma - \delta) \frac{(c_k - c_j)}{\Gamma(0)\Gamma(N)} + \frac{\gamma n^* t}{\Gamma(0)\Gamma(N)} \quad \begin{matrix} > \\ < \end{matrix} p_i .$$

5.1. The effects of tariffs on merger incentives and possible equilibria

Having outlined the effect of a tariff above, we now wish to consider a variety of domestic and international merger possibilities and the effects of an exogenous tariff on their profitability. As with Section 3, it is relatively easy to analyse the outcomes in the case of Independent-Division mergers but rather more complex in the case of Joint-Operation mergers, where simulations are necessary.

Independent-Division merger.

For a domestic low-cost firm, a unilateral tariff, by raising the market share of a higher-cost domestic partner and hence the benefits of the know-how transfer, makes a merger more attractive and the change in profits is :

$$(23) \quad \Delta\pi_i^{ID} = 2[\Gamma(N)^2 - 4\Gamma(N)\gamma + 2\gamma^2]R^2 + 2[h_k + f_k][\Gamma(N) - 2\gamma]R \\ + 2[n^* \gamma t^h - \{\Gamma(0) + n^* \gamma\}t^f] \frac{[\Gamma(N) - 2\gamma]}{\Gamma(0)\Gamma(N)} R - M$$

where $R = c_k - c_j$ and t^h and t^f are the tariffs imposed by the domestic and foreign governments respectively. By comparison, the change in profits for a divisionalising merger for a foreign low-cost firm and higher-cost domestic partner is:

³¹ Full derivations are available in the Working Paper version of this paper.

$$(24) \quad \Delta\pi_i^D = 2 \left[\Gamma(N)^2 - 4\Gamma(N)\gamma + 2\gamma^2 \right] R^2 + 2(h_k + f_k) [\Gamma(N) - 2\gamma] R \\ + 2 \left\{ (\Gamma(0) + \gamma(n - n^*) + n^* \Gamma(N)) \gamma t^h \right. \\ \left. + ((\Gamma(0) - \gamma(n - n^*) - n^* \Gamma(N)) \gamma - (\Gamma(0)\Gamma(N)) t^f) \right\} \frac{R}{\Gamma(0)\Gamma(N)} - M.$$

5.2. Unilateral tariff/trading cost increases

We start by considering domestic mergers in a (unilaterally) restricting country.

Proposition 3: *A unilateral increase in the domestic tariff promotes takeovers of domestic targets by both domestic and foreign firms.*

Proof: In the divisionalising merger case in equation (23) above,

$$\frac{\partial \Delta\pi}{\partial t^h} = 2n^* \gamma \frac{[\Gamma(N) - 2\gamma]}{\Gamma(0)\Gamma(N)} R \geq 0$$

and similarly from (24) $\frac{\partial \Delta\pi}{\partial t^h} = 2\gamma \frac{[\Gamma(0) + \gamma(n - n^*) + n^* \Gamma(N)]}{\Gamma(0)\Gamma(N)} R \geq 0. \blacksquare$

The increase in price and domestic output as a consequence of a unilateral rise in the home economy's tariff raises the profits of all domestic firms (including firm n). In particular, because the tariff raises the potential market share that a target with improved technology can obtain, it becomes a more attractive target. However, a key question (particularly from the perspective of a policy maker contemplating a change in tariffs) is which firm has the most to gain from such a merger.

Proposition 4: *For an Independent-Division merger, if the domestic country raises its tariff unilaterally, for some range of costs $c_i < c_i^*$, less efficient foreign firms can outbid their more efficient domestic counterparts, and thus, ceteris paribus, comparatively less efficient 'low-cost' foreign firms merge with high-cost domestic partners at the expense of more efficient domestic firms.*

Proof:

If there were to be a bidding war between the leading domestic and foreign firm for firm n , and $c_i = c_{i^*}$, the foreign firm would be willing to pay more for the target firm since

$$(25) \quad \frac{\partial \Delta \pi_t^{D^*} - \Delta \pi_t^D}{\partial t^h} = \left[\frac{2\Gamma(0) + 2\gamma n + 2n^*(1-\gamma)}{\Gamma(0)\Gamma(N)} \right] \gamma R > 0.$$

As a corollary, it follows for some range of costs $c_i < c_{i^*}$ less efficient foreign firms can outbid their more efficient domestic counterparts. ■

Even if domestic policy makers were not concerned about domestic firms' share of the market, the fact a more efficient domestic firm could be outbid by a less efficient foreign rival is likely to be of concern to competition regulators.³² The intuition behind this result is that a foreign firm not only gets the benefits of the technology transfer to the target but, because the expansion in the target's output is (in part) at the expense of the low-cost foreign firm's tariff-ridden imports to the domestic economy, it has more to gain than a domestic low-cost firm as long as γ is strictly positive. That is, foreign firms are made more likely to engage in tariff-jumping mergers by increases in domestic tariffs. We also note:

Corollary 5: Starting from a world with free trade and only one multi-division firm, the imposition of a tariff can lead to an equilibrium with more than one multi-division firm.

Proof: Follows directly from Proposition 4. ■

Finally, takeovers of domestic firms are likely to be discouraged by any increase in foreign tariffs, $\frac{\partial \Delta \pi}{\partial t^f} \leq 0$, whereas takeovers of foreign firms are more likely. There is no dynamic aspect to technology acquisition in this paper, but clearly if there were, the fact that foreign targets, rather than weaker domestic firms, were experiencing efficiency gains (especially domestic know-how) would imply a different concern for policy makers.

³² If a comparatively less efficient foreign firm merges with the least efficient domestic firm, this raises the possibility of a welfare-reducing merger as discussed by Lahiri and Ono (1988).

5.3. Bilateral tariff reductions:

Of greater significance in the current climate is the alternative policy question of the effect of a bilateral reduction in tariffs under the WTO. In contrast to a unilateral tariff reduction, a bilateral reduction encourages mergers by both domestic and foreign firms.

Proposition 5: *When tariffs are originally equal, a bilateral tariff decrease will promote Independent Division mergers and remove the added incentive for foreign mergers.*

Proof: Assuming symmetric tariffs, from equations (23) and (24) the effect of the tariff on the change in profits from a takeover by a domestic or foreign low-cost firm is:

$$\frac{\partial \Delta \pi_i}{\partial t} = \frac{\partial \Delta \pi_i^*}{\partial t} = -\frac{2\Gamma(0)[\Gamma(N) - 2\gamma]R}{\Gamma(0)\Gamma(N)} < 0. \blacksquare$$

Mergers are made more profitable by bilateral reductions because the loss of the target's domestic market share as a result of the fall in the domestic tariff is outweighed by its potential gain in the overseas market due to the removal of the foreign tariff.

Joint-Operations Mergers and the integrated equilibrium

As long as the concentration effect dominates the know-how transfer effect in a merger, then in the case of a Joint-Operation merger a tariff (increase) makes mergers less likely at the margin. This occurs because the merged firm can only recover part of the increased profits in the market resulting from the tariff protection, as the remainder is captured by the outsider firms who react to the increased concentration by increasing their output.

The fall in merger profits as a result of the tariff can be seen by focussing on $\gamma = 0.49$ in Table 6 below, where with $M = 0$ a Joint-Operation merger without a tariff yields a marginal profit of 1 while with a tariff the merger yields a loss of 37. For γ less than

0.4, all Joint-Operation mergers record higher profits in the presence of a tariff, so this is only an issue for marginal mergers.³³

The fall in the profitability of marginal mergers is the key result when know-how is not readily transferable ($\delta = \gamma$) and is in line with the findings of Falvey and Nathananan (2001). However, when know-how is transferable, this marginal case is likely to be dominated and the equilibrium is likely to involve one or more Independent-Division and/or Joint-Operation mergers before arriving at an equilibrium for some positive M . In this case, the differing incentive effects of a change in trade costs or tariffs on Independent-Division and Joint-Operation mergers can also influence the organisational structure of the firm in equilibrium. The second half of Table 6 reports the change in profits for a range of values ($\gamma \in (0.211623-0.211620)$) where Independent-Division mergers are marginally more profitable in the absence of a tariff, while with a tariff the Joint-Operation strategy is preferred.³⁴ Thus, if at $\gamma = 0.211623$, $M = 657131.36$ such that a firm was indifferent to an Independent-Division merger in the absence of a tariff, a 10% tariff will induce a Joint-Operation merger.

Table 6: Effects of tariffs on merger profitability

Gamma	0.90	0.80	0.70	0.60	0.50	0.49	0.40	0.30
Change in ID profits $t=0, M=0$	425103	429898	441352	460364	488611	490773	528935	586113
Change in ID profits $t=10\%, n=0.9N, M=0$	425452	430148	441528	460485	488691	490851	528986	586143
Change in JO profits $t=0, n=0.9N, M=0$	-996426	-769039	-527403	-274730	-16401	1	238711	476641
Change in JO profits $t=10\%, n=0.9N, M=0$	-996907	-769359	-527600	-274835	-16443	-37	238709	476658
Gamma	0.211625	0.211624	0.211623	0.211622	0.211621	0.211620	0.20	0.10
Change in ID profits $t=0, M=0$	657169.47	657170.41	657171.36	657172.31	657173.25	657174.20	668430.34	791147.28
Change in ID profits $t=10\%, n=0.9N, M=0$	657185.79	657186.74	657187.69	657188.63	657189.58	657190.53	668445.27	791152.83
Change in JO profits, $M=0 t=0, n=0.9N$	657165.16	657166.99	657168.82	657170.65	657172.47	657174.30	678042.90	828215.65
Change in JO profits $t=10\%, n=0.9N$	657184.95	657186.78	657188.61	657190.44	657192.26	657194.09	678062.33	828227.21

³³ This mirrors the homogeneous goods case. See Long and Vousden (1995), Falvey (1998) and Falvey and Nathananan (2002).

The rationale for this result is that at the point where a firm might be indifferent between a Joint-Operation and Independent-Division merger under free trade, the restrictive effect of the tariff on foreign producers pushes the merged firm to adopt an even more aggressive market-concentration strategy. If we want to examine the effects of the WTO then, starting at a tariff-ridden equilibrium, a reduction in trading costs eliminates the distortion at this margin, and for multilateral reductions in trade costs or tariffs the result above is reversed so an Independent-Division merger becomes more profitable and dominates. Thus for $t = t^* = 10\%$, a firm will be indifferent to an Independent-Division merger at $M = 656894.5$ while a move to $t = t^* = 0$ generates the incentive for an Independent-Division merger since profits are now $657171.36 - M = 276.86$. We know from Corollary 3 that such mergers are welfare-enhancing.

6. Policy implications and Conclusions

The primary purpose of this paper was to look at an alternative model of merger incentives to the ‘merge and close’ paradigm in the homogeneous-goods, market-concentration literature, firstly to allow for a richer analysis of closed economy merger possibilities and then to consider its implications for current policy regarding merger activity in oligopolistic sectors as a result of trade liberalisation under the WTO. The model extends the market-concentration literature by considering three factors that allow firms to have an alternative presence after a merger: firstly by allowing differentiated goods, secondly by allowing merged firms to operate either jointly or as separate divisions and thirdly by allowing for the possibility of know-how transfer. In many mergers, such as those cited in the introduction, pre-merger entities have a continuing presence in the market post-merger and our formal analysis presented a model capable of explaining these mergers. It suggested that, at least in the context of the heterogeneous cost Cournot models frequently employed to analyse merger activity, firms’ incentives mean that they are more likely to opt for some form of Independent-Division merger such as the Volkswagen/Skoda/Seat example rather than a market concentrating Joint-Operation merger, except in the very restrictive circumstances of low substitutability between products and a small number of firms.

³⁴ The qualitative outcomes were robust to various levels of t and shares of n and n^* .

Our simulation results also suggested that we may initially see a stream of mergers involving independent divisions, followed by Joint-Operation mergers as the market becomes more concentrated. Furthermore, when cost differences are not significant and product differentiation is low, firms are more likely to enter partnerships with similar large firms. Thus in the case of the steel industry, where arguably much rationalisation and cost harmonisation has already taken place, we might expect that the next merger would involve two large firms whose product ranges were seen to have low degrees of substitutability. Without wishing to claim too much for this paper, this approximates to the Arcelor-Mittal Steel merger.

The trade analysis suggested that trade barriers are likely to be counterproductive on a number of levels including encouraging less favourable mergers, either by encouraging tariff-jumping by comparatively less-efficient foreign firms that are prepared to pay a premium for a target (frustrating the objective of a higher price for domestic producers), or by encouraging potentially welfare-reducing market-concentrating Joint-Operation mergers at the expense of Independent-Division mergers. Conversely, bilateral (multi-lateral) liberalisation, by removing these distortions, encourages beneficial know-how transfer through welfare-enhancing Independent-Division mergers. Thus, the need for competition regulation seems more pressing in the presence of trade restrictions than in a more liberalised world.

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Table: 4 Results of selected merger possibilities when technology is perfectly transferable:

		$N = 5, A = 1000, c_i = 50i$ and $\delta = 0$	$\gamma=0.95$	$\gamma=0.9$	$\gamma=0.8$	$\gamma=0.7$	$\gamma=0.6$	$\gamma=0.5$	$\gamma=0.4$	$\gamma=0.3$	$\gamma=0.2$	$\gamma=0.1$
1 2 3 4 5 6	Section 1	ID: Change in Profit for [1,5] from ([1,5]:2:3:4)	425088	425103	429898	441352	460364	488611	528935	586113	668430	791147
		JO Change in Profits for [1,5] from ([1,5]:2:3:4)	-1104141	-996426	-769039	-527403	-274730	-16401	238711	476641	678043	828216
		JO Change in Profits for 2 from ([1,5]:2:3:4)	1111214	1083227	1023077	954654	873920	775660	653368	499981	312064	107463
		JO Change in Profits for 3 from ([1,5]:2:3:4)	1083256	1057896	1002384	937957	860732	765605	646141	495308	309634	106780
		JO Change in Profits for 4 from ([1,5]:2:3:4)	1055298	1032564	981691	921260	847544	755549	638914	490636	307205	106096
		JO Change in Profits for 1& 2 from ([1,2]:3:4:5))	-1457397	-1343805	-1110242	-869706	-625726	-384668	-157308	39026	179043	236984
7 8 9 10 11 12 13	Section 2A	JO Change in Profits for [1,5] from ([1,5]:[2,3]:4)	4514657	4687703	5019220	5323184	5582191	5764274	5810938	5612896	495776	340886
		JO Change in Profits for [2,3] from ([1,5]:[2,3]:4)	-1468167	-1325399	-1050529	-789000	-541282	-310239	-102323	70680	190297	237230
		JO Change in Profits for 4 from ([1,5]:[2,3]:4)	1949436	1819215	1583816	1372620	1175957	984876	790537	584391	361203	133659
		JO Change in Profits for [1,5] from ([1,5]:[2,4]:3)	4453045	4627752	4962581	5269899	5532403	5718279	5769291	5576596	492864	339048
		JO Change in Profits for [2,4] from ([1,5]:[2,4]:3)	-1341189	-1201108	-929440	-668435	-418603	-182587	33714	219576	358493	434968
		JO Change in Profits for 3 from ([1,5]:[2,4]:3)	1937077	1806535	1570539	1358838	1161802	970540	776324	570826	349270	125377
14 15 16 17 18 19	Section 2B	ID: Change in profits for [1,5,4] from ([1,5,4]:2:3)	237334	239978	248243	260985	279202	304531	339627	388906	460069	567488
		JO Change in Profits for [1,5,4] from ([1,5,4]:2:3) rel. to previous $\pi^D[1,5] ([1,5]:2:3:4) + \pi^D 4 ([1,5]:2:3:4)$	-1700523	-1503045	-1085780	-645930	-196843	239652	628256	913857	101953	883855
		JO Change in Profits for [1,5,4] from ([1,5,4]:2:3)	-1328615	-1213364	-962880	-688287	-394741	-91579	204623	465564	647387	704939
		JO Change in Profits for [1,5,2] from ([1,5,2]:3:4)	-1579450	-1453945	-1188566	-906115	-611709	-315248	-34657	199194	337700	326497
		ID: Change in Prof. for [1,5,4] ([1,5,4]:2:3) rel. to base	560399	565797	583796	612486	654118	712448	793620	907890	107316	132288
		JO Change in Prof. for [1,5,4] ([1,5,4]:2:3) rel. to base	-1377458	-1177226	-750228	-294429	178073.2	647569	1082249	1432841	163263	163925
20 21 22 23 24 25	Section 3	JO Change in Profits for [1,5,4] from ([1,5,4]:[2,3])	7009544	7214980	7398114	7570536	7717532	7809322	7785907	7523047	674926	481967
		JO Change in Profits for [2,3] from ([1,5,4]:[2,3])	-1064500	-870596	-640210	-425483	-227783	-49991	102579	220730	289714	291674
		IND DIV: Change Profit [1,5,4,3] from ([1,5,4,3]:2)	106118	109388	117604	128544	143068	162500	188947	225900	279478	361207
		JO Change in Profits for [1,5,4] from ([1,5,4,3]:2) rel. to previous $\pi^D[1,5,4] ([1,5,4]:2:3) + \pi^D 3 ([1,5,4]:2:3)$	429591	973918	1603108	2192787	2710576	3106667	3304408	3189432	261157	148421
		JO Change in Profits for [1,5,4,3] from ([1,5,4,3]:2)	1409245	2062666	2934691	3812016	4678654	5501130	6209993	6659166	653001	508595
		JO Change in Profits for [1,5,4,2] from ([1,5,4,2]:3)	1284464	1725297	2613672	3504830	4383273	5215870	5933430	6390111	626760	483007

