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by
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Abstract

In this paper we consider the impact of vertical integration on a retailer's choices of product variety and specific, brand-supporting investment. In an incomplete contract environment, vertical merger encourages investment in integrated supply, and foreclosure of non-integrated manufacturers. Anti-competitive as opposed to efficiency interpretations depend delicately on a trade-off between the benefits of supplier-specific rather than generally applicable retailer investment, and the value of multi-product rather than single product retailing. Where retailers compete, it is shown that vertical integration implements competition reducing, product differentiating investment strategies.

Keywords: incomplete contracts, vertical integration, monopolization

JEL classification: L22, L12, L4

1. Introduction

Do vertical mergers enhance efficiency or promote market power? A vigorous debate has raged between proponents of the rival efficiency and anti-competitive viewpoints. Much of this attention has focused on the possibility of integration-induced market foreclosure. Indeed, such concerns have been prominent in motivating recent activity by competition authorities. For example, the UK Monopolies and Mergers Commission has, in the last few years, undertaken major investigations of the beer (1989), petrol (1990) and new motor car (1992) markets, each of which has involved a significant vertical component.

A strident attack on the anti-competitive case has been provided by Robert Bork. He argues strongly that "*the law against vertical merger is merely a law against the creation of efficiency*" [Bork (1978), p.234]. The view that vertical merger will lead to distortion in the supply and purchase prices faced by non-integrated rivals is dismissed. Integration is seen as an efficient response to transaction cost concerns. Oliver Williamson, too, takes this view that economising on transaction costs is "*the main purpose served*" by vertical integration [Williamson (1985), p.85-86].

In response to this challenge, a number of recent papers have attempted to set the anti-competitive perspective on a firmer theoretical foundation. A radical approach, was initiated in an important paper by Patrick Bolton and Michael Whinston [Bolton and Whinston (1993)]. Their argument strikes at the transaction cost basis that underlies much of the benign view of vertical merger. Building on the incomplete contract approach to integration formulated in Grossman and Hart (1986), they show that the very investment incentive effects that encourage efficient vertical integration in a bilateral context can lead to inefficiency in a multilateral environment. When a capacity-constrained monopoly supplier integrates with one of its buyers, over-investment in the internal relationship is encouraged. This distorts supply patterns, and may lead to inefficient foreclosure of non-integrated rivals.

In this paper we will adopt the Bolton-Whinston approach, emphasising the importance of investment *specificity* considerations in a multilateral context. Whereas Bolton and Whinston focus on supply assurance motives for integration, when essential input supplies may be limited, we consider the impact of vertical merger on a retailer's choices of product variety and brand-supporting investment.[1] Integration encourages single product as opposed to multi-product retailing, and product-specific rather than generally applicable investment. The interaction between efficiency and anti-competitive interpretations depends delicately on the trade-off of these effects. Unlike Bolton-Whinston (1993), the effects of vertical integration on

[1] Chandler (1959) contrasts the supply assurance motives for integration in extractive industries with those in consumer goods, and to a lesser extent finished producers' goods industries.

product market competition are also considered. In this context, our specificity emphasis is illuminating. We show that, by encouraging product-differentiating investment, vertical integration can effectively reduce inter-retailer competition. Such reductions in competition do not rely on foreclosure effects.

Though rarely involving full vertical integration into retailing, the UK motor car industry is characterised by long-term contractual relationships between manufacturers and independent dealers. These contracts generally impose some form of brand exclusivity on dealers, but often offer territorial protection from intra-brand competition in exchange. Manufacturers argue that such restrictions are essential in motivating brand-specific investment by retailers. They claim that managerial effort and capacity constraints generally limit the effectiveness of multi-brand dealerships. We model such investment effects explicitly in the paper.

In their 1992 report, the Monopolies and Mergers Commission recognises that exclusivity clauses do limit the ability of weaker brands to access dealer networks i.e. these brands suffer from market foreclosure. Anti-competitive effects on inter-brand competition are recognised.[2] The efficiency trade-off between motivating specific investment and foreclosure is at the heart of our analysis.

The car manufacturers claim vigorous inter-dealer, inter-brand competition. Furthermore, they argue that the specific investments induced by strong vertical ties, highlighted above, contribute positively to ensuring a healthy competitive environment. In contrast, we show in this paper that vertical integration may serve as an effective mechanism for implementing *competition-reducing* investment strategies.

We consider a simple setting where a retailer can be supplied by either one or two differentiated manufacturers. The retailer must make three sequential decisions: (i) whether to integrate with one of the suppliers, (ii) whether its technology should be largely specific to a single supplier or flexible, and (iii) whether to source product from one or both manufacturers. In turn, a number of key factors drive the outcome of this decision process: (a) the (exogenous) cost of merger, (b) the relative supply costs for specific and general technology, (c) the relative values of single versus multi-product retailing, and (d) the toughness of inter-retailer competition. We will focus on the interaction between these factors and the retailer's decisions.

A location framework is a natural setting for our analysis. With the suppliers fixed at opposite ends of a unit line, the retailer's once-and-for-all location decision represents its investment choice. A position at either end of the line constitutes investment that is highly specialised

[2] It is interesting to note that multi-brand dealerships do occur, but rarely involve brands that compete head-on.

towards a particular manufacturer, while a mid-point location indicates general purpose investment. Locating at one end of the line minimises the cost of transacting with the adjacent manufacturer, but maximises the transport costs of exercising the alternative supply option. A mid-point location ensures the widest range of supply options. Thus, we explicitly model the specificity dimension that is central to Williamson's approach to contracting [see e.g. Williamson (1985)].

Throughout our analysis we will adopt an extreme incomplete contracting framework, generating simple and clear-cut results. In such an environment, where enforceable contracts on future supply terms cannot be written, an independent retailer may be reluctant to locate at either end of the line. Once such location commitment is made, the retailer may effectively be locked-in to a particular supply relationship. Indeed, whenever single-product retailing is attractive, the independent retailer will always locate at the mid-point of the unit line, maximising supply options. Yet, in precisely these circumstances, an end-point location will be efficient, minimising transport costs. Vertical merger may then be attractive, overcoming lock-in concerns and encouraging adjacent retailer-supplier location. Of course, even then, integration will only take place if the resulting transport cost benefits outweigh the exogenous merger costs. However, in this case, when integration is individually attractive it will always increase overall welfare.

Costly integration will only occur if it leads to a *different* retailer location decision. This may, but need not, affect the retailer's product sourcing decision i.e. leading to single product rather than multi-product retailing. Where this change does occur, the supply market for the non-integrated manufacturer is foreclosed. Since the integrating parties take no account of such third party foreclosure effects in deciding to merge, a negative externality results. Clearly, inefficient foreclosure may therefore occur.

However, foreclosure need not always be inefficient. A move from double sourcing at the mid-point of the unit line to integrated single-product retailing at the end-point involves a saving on transport costs. This efficiency gain counteracts the loss of multi-product surplus. Any anti-competitive conclusion deduced from foreclosure therefore depends delicately on the resolution of the trade-off between these opposing forces. This trade-off is at the heart of the model.

In the context of our model, when multi-product retailing is optimal wherever the retailer locates, the lock-in threat will not materialise. Consequently, the retailer is indifferent to location in these circumstances. However, integration may still take place, if it results in a different retailer location decision. Efficiency implications then depend solely on the structure of transport costs. Privately attractive but inefficient integration may still occur.

Our results also hold for a simple re-interpretation of the model, where a monopoly manufacturer must decide to supply one or two retailers. The potential anti-competitive effects of integration can then be viewed as impacting on consumers. In this alternative context, upstream capacity constraints are important for our results to hold. The analogue of single product purchasing is then single retailer supply, creating a retailing monopoly. Again, vertical integration may bring about such an exclusive dealing arrangement, where standard contractual mechanisms fail.

The paper's primary focus is the impact of vertical integration on final market competition. A second downstream retailer is introduced into the model, allowing the endogenous relationship between vertical integration and the downstream competitive environment to be explored. We show that competition considerations may drive the integration process. Competitive interaction is seen to generate partially integrated equilibria, where integrated and non-integrated firms co-exist, and chains of integration, where the integration decisions of individual firms are driven by industry-wide merger activity.

A number of recent papers have also considered the effects of vertical merger on final market competition - for instance, Salinger (1988), Ordover, Saloner and Salop (1990) and Hart and Tirole (1990). However, they focus on the impact vertical merger has on supply pricing - both for the integrating buyer and for non-integrated rivals. In particular, the upstream division of an integrated firm will internalise the impact on the downstream division of any supply agreements undertaken. Essentially, in incomplete contract settings where commitment is difficult if not impossible to enforce, integration substitutes for contractual mechanisms in implementing bilateral profit maximising pricing behaviour. In contrast, our approach emphasises the investment implications of integration, and does not hinge on price effects or on the foreclosure of non-integrated rivals.

The new force driving vertical integration is a desire to alleviate the pressures of downstream competition. One obvious strategic response is product differentiation (see e.g. Porter (1980) for a detailed discussion). In the context of our model, a natural means of achieving this is for the retailers to locate apart, adjacent to suppliers, at opposite ends of the unit line. Making idiosyncratic, supplier specific investments enables retailers to enhance their "uniqueness".

In his seminal analysis of the emergence of *big business* in the United States, Alfred Chandler highlights the vertical dimension in the development of the modern corporation [see e.g. Chandler (1959) and (1977)]. He details growing benefits to integrated production and distribution, as manufacturers required increasingly specialised marketing services to support ever more sophisticated products in the last decades of the 19th century.[3] The scale effects of

[3] Examples cited by Chandler include sewing machines (Singer), agricultural machinery (McCormick) and amateur photography (Eastman Kodak) [see Chandler (1977), Part IV].

market expansion, brought about by urban growth and the emerging railway network, are emphasised as the driving force encouraging coordination within the firm. However, along with these expansion effects came new competitive pressures too, as the growing transport infrastructure connected previously distinct markets. Vertical integration into marketing and distribution, in effecting product differentiation and brand development, was increasingly recognised as a fruitful response to this tougher competitive environment in consumer goods industries [Chandler (1959), p.10-12].

Within our incomplete contract framework, non-integrated, independent retailers will be reluctant to invest in supplier-specific technology. Instead, they are likely to locate together, at the centre of the unit line - avoiding lock-in to either manufacturer, but intensifying downstream competition. Vertical integration of retailer and supplier, by eliminating lock-in concerns, provides a mechanism for competition-reducing differentiation. The potential anti-competitive effects of integration are then clear. Retailers can locate apart, at the ends of the line without fear of hold-up. Furthermore, close location ties between manufacturing and retailing stages are generated. As discussed already, such vertical linkages are often cited as a source of advantage in competitive environments. Of course, set against these benefits are the inevitable costs of integration.

We find that competition considerations may result in integration where it would not otherwise take place. Partial integration is the industry equilibrium response to moderate levels of competition. Integration by a subset of retailers is then sufficient to ease competitive pressures. Other firms can benefit, without incurring the additional costs of merger. However, as competition intensifies, a differentiation strategy may only succeed if *all* retailers participate, implicitly coordinating their actions. Individual integration decisions will then only be taken in response to (or in anticipation of) wider merger activity. A fully vertically integrated industry then results.

Our basic model framework is set out in the next section. Our formal analysis is presented in Section 3. In Section 4 we briefly outline two simple variations to the basic model. The basic framework is extended in Section 5 to consider the impact of final market competition on integration incentives.

2. The Basic Model

The basic model involves three interacting firms. A downstream retailer D can stock the products of two potential suppliers, U_1 and U_2. The upstream firms produce differentiated products, represented by their (fixed) locations at the ends of a unit line. U_1 is located at 0, U_2 at 1. D however can choose its location, ℓ. For simplicity we allow it to locate at ℓ=0 or

$\ell=1/2$. Model symmetry allows us to ignore the possibility of location at $\ell=1$. If D chooses $\ell=0$ its assets are tailored to U_1 supply while a mid-point location ($\ell=1/2$) indicates investment in general technology.

In purchasing product from upstream firms, D must decide whether to source from a single firm, or both firms. In making its decision the retailer will be influenced by the values of stocking a unique product line (m) relative to that of stocking product from both upstream firms (2d, or d per product line). We will assume that m > d. Note, however, that either multi-product or single product retailing may generate greater overall value.

Product must be transported from the upstream supplier to the retailer. The cost of transporting product from U_1 is denoted by t_1 while the transport cost for U_2's product is t_2. The magnitudes of these transport costs will depend on D's location. We will assume here that the total transport cost is *independent* of the volume stocked from a given supplier (but see Section 4(i)). This cost can therefore be thought of as the set-up cost of stocking a particular product line.

The cost of transporting supplies over half the unit line is given by $\underline{t}$, while the transportation cost from end to end is $\bar{t}$, where $\bar{t} > \underline{t}$. No transport cost is incurred if retailer and supplier locate together. For example, if D locates at 0 then no costs are incurred in purchasing product from U_1, but purchasing product from U_2 involves a transport cost $\bar{t}$. We will assume that $d > \bar{t}$, ensuring that both upstream firms will always be active in the supply market, irrespective of downstream firm location. Any additional downstream costs are embedded in the product values, m and d.

For simplicity, we will suppose that D buys product sequentially, in two batches. D receives sealed bids from both upstream firms to supply each batch. It must then make simple accept/reject decisions. Given a first batch sourcing decision, the retailer must then decide whether to stock a single product line, by purchasing the second batch from the same supplier, or to opt for double sourcing i.e. multi-product retailing, by purchasing the second product batch from a new supplier. Bidding for the second batch takes place after the first supply contract has been awarded.

Ours is a world of incomplete contracts in which supply prices and allocations, as well as location choice, cannot be enforceably specified at T = 0. The idea here is that supply requirements are uncertain at T=0 and location (quality) can never be verified by an outside arbiter. Profit sharing agreements between independent firms cannot be implemented either.[4] The only effective T=0 contracts are those conferring asset ownership rights. Such extensive

4 For a discussion of the profit sharing assumption, with and without integration, see Hart and Tirole (1990).

contracting restrictions are, of course, extreme but lead to a particularly clean and simple formulation of our problem. Note that, in the absence of enforceable price or profit agreements, exclusive dealing contracts are never attractive to the retailer and will be ignored in our analysis.

We will consider the effects of vertical integration between the downstream firm and one of the upstream firms. Model symmetry allows us to restrict attention to the possibility of D-U_1 integration only. Horizontal integration is not permitted, on anti-trust grounds. The integrated firm is assumed to maximise the joint profits of both its upstream and downstream divisions. A fixed cost E is incurred in undertaking a vertical merger. This is intended to broadly capture the legal, bureaucratic and incentive costs of integration. It is relatively simple to generate such a cost explicitly [see e.g. Williams (1996)], but for simplicity we do not do so here.

At T=1, uncertainty about supply needs is resolved and D decides on a location (to maximise profits). Supplies are then purchased (T=2). After transporting supplies, the final output is sold to consumers (T=3) and revenues are realised.

3. Analysis

As a benchmark for our analysis we will first consider efficiency. We assume that the monopoly downstream firm is able to extract all consumer surplus. In considering efficiency we can therefore restrict attention to the combined profits of the three firms. The efficiency of two decisions must be considered - the product sourcing decision and the downstream firm's location choice.

At each location there is a supply choice. Product can be sourced from U_1 alone, yielding value $m-t_1$. Alternatively, product can be sourced from both upstream firms, generating an overall profit of $2d-t_1-t_2$. Note that our assumptions (innocuously) rule out single sourcing from U_2 since $t_1 \leq t_2$.

For a given location, efficient sourcing implies combined profits of Π^*, where:

$$\Pi^* = \max[m-t_1, 2d-t_1-t_2].$$

The efficient choice of D's location, either at 0 or 1/2, must also be considered. We first derive the efficient supply allocation for a given location, and then determine the efficient location.[5]

[5] To ease notation we will drop the location argument, ℓ.

Proposition 1 [Efficiency]

(a) For a given location, efficiency implies:

U_1 supplies both batches if $t_2 > 2d\text{-}m$

U_1 and U_2 supply one batch each if $t_2 < 2d\text{-}m$

(b) The efficient location choice is given by:

$\ell=0$ if $2(d - \underline{t}) < \max[m, 2d\text{-}\bar{t}]$

$\ell=1/2$ if $2(d - \underline{t}) > \max[m, 2d\text{-}\bar{t}]$

Proof:

(a) Our assumption that $t_1 \leq t_2$ guarantees that it is always optimal to source at least one unit from U_1. If $t_2 > 2d - m$ the value of sourcing both units from U_1 $(m\text{-}t_1)$ exceeds that of double sourcing $(2d\text{-}t_1\text{-}t_2)$. Clearly if $t_2 < 2d - m$ the reverse is true.

(b) If $\ell=0$ the transport costs for U_1 supply are 0, and for U_2 supply are $\bar{t}$. Thus efficient profits are $\max[m, 2d\text{-}\bar{t}]$. Similarly when $\ell=1/2$ both Us have transport costs $\underline{t}$ so efficient profits are $\max[m\text{-}\underline{t}, 2(d\text{-}\underline{t})]$. The efficient location choice is then determined by which of these expressions is the larger. Since $m > m\text{-}\underline{t}$ locating at 1/2 is only efficient if $2(d\text{-}\underline{t}) > \max[m, 2d\text{-}\bar{t}]$. QED.

Stocking both products as opposed to one involves an additional transport cost (t_2). Double sourcing is optimal only if the added value of multi-product retailing exceeds this cost. If $2d\text{-}m < 0$, then stocking a single product is a fortiori optimal.

It is important to recognise that, because of changes in transport costs, the efficient sourcing decision may (but need not) depend on location choice. If $2d\text{-}m > \bar{t}$ both products will always be stocked, irrespective of D's location. Transport cost considerations alone then determine the optimal location - two costs of $\underline{t}$, for $\ell=1/2$, being compared with one cost of $\bar{t}$ for $\ell=0$. If $2\underline{t} > \bar{t}$ an end-of-line location is optimal, even if product is sourced from both upstream firms. Clearly, when single sourcing is optimal D should always locate at $\ell=0$. Location at $\ell=1/2$ is efficient only if multi-product sourcing is efficient.

Finally, note that if $\underline{t} < 2d\text{-}m < \bar{t}$ a change in D's location choice from $\ell=1/2$ to $\ell=0$ will result in an efficient switch from double to single sourcing. Choosing $\ell=0$ will then be efficient, if the transport cost savings $(2\underline{t})$ exceed the loss of the incremental value of multi-product retailing $(2d\text{-}m)$.

Integration incurs additional costs E and no benefits, *for a given location choice*. From a first best perspective, integration is therefore never desirable. However, where D's self-interest drives its location decision, integration alone may bring about efficient location choice - as we will see below.

The integration and location decisions made in equilibrium will depend on the overall magnitude of profits and their division among firms. Competition between suppliers clearly plays a critical role. The following result summarises the outcome of supply competition, for given retailer location.

Lemma 1 [Supplier Competition]

(a) Sourcing decisions are always efficient given location.

(b) U_1 always supplies the first unit, for a price $2d\text{-}m\text{-}t_1$

(c) The second unit is supplied by:

U_1 *if* $2d-m-t_2 \leq 0$

U_2 *if* $2d-m-t_2 > 0$

The price paid is $|2d-m-t_2|$

(d) In the non-integrated case profits are given by:

$\Pi_D = m-d + \min\{m-d,\ d-t_2\}$

$\Pi_{U1} = \max\{2d-m-t_1,\ t_2-t_1\}$

$\Pi_{U2} = \max\{2d-m-t_2,\ 0\}$

In the integrated case profits are given by:

$\Pi_{U1\text{-}D} = m-t_1-E$

$\Pi_{U2} = \max\{2d-m-t_2,\ 0\}$

Proof: See Appendix.

The basis for the above results is the fact that the upstream firm with the higher value supply can always undercut its rival, and will do so. The supply prices are determined by the value of D's best alternative i.e. by the second highest value supply option. If product is sourced from both Us, then D's outside option in negotiating with either supplier is a switch to single sourcing. The differential value added is then $m-(2d-t_2)$. In our basic model this is independent of transport costs. The supplier captures the residual value.

Where product is sourced from a single supplier (always U_1 in our model) then D's outside option, and hence its total share of trade value, is $m-t_2$. This is the value of exclusive sourcing from U_2. The result is driven by the perfect foresight of suppliers during the supply process. In dealing with U_1, D's threat point is U_2 supply. Such trade would yield D a payoff of $d-t_2$ for a single unit, and $m-t_2$ for two units. Clearly if one unit were to be bought from U_2 then U_1 could win the competition for the supply of the second unit by offering D a share m-d of trade, again yielding D an overall profit of $m-t_2$.

Given that an identical supply competition is used with integration, supply price and allocation are independent of this decision.[6] Thus, for a particular location, integration does not alter trade returns (though integration costs E are incurred). The impact of integration therefore arises from induced changes in D's location choice. It is to this that we now turn.

Lemma 2 [Location]

(a) Under non-integration D chooses location $\ell=1/2$ if $2d-m < \bar{t}$ and is indifferent about location otherwise.

(b) The integrated firm always locates at $\ell=0$.

Proof:

(a) Non-integration: D chooses location to maximise $\Pi_D = m-d + \min[m-d, d-t_2]$.

Clearly locating at $\ell=0$, thus maximising $d-t_2$ can never be strictly profitable. Indeed if $m-d > d-\underline{t} > d-\bar{t}$ or $d-\underline{t} > m-d > d-\bar{t}$ then D locates at $\ell=1/2$ in maximising $\min[m-d, d-t_2]$. However, if $m-d \leq d-\bar{t} < d-\underline{t}$ then $\min[m-d, d-t_2] = m-d$, and location is irrelevant.

(b) Integration: D's location is now chosen to maximise $\Pi_{D-U1} = m-t_1-E$.

Clearly this entails minimising t_1, i.e. choosing $\ell=0$. QED.

In the non-integrated case D chooses its location to maximise downstream profits only. When product is sourced from both upstream firms, D's share of the profit on each supply contract is determined by the incremental outside option value of single sourcing, m-d. Since this value is independent of transport costs, location choice is irrelevant in this case. Where D opts for single sourcing (always from U_1 given our assumptions) its share of profits is $m-t_2$ i.e. the value of the U_2 sourcing alternative. Clearly downstream profit maximisation then involves minimising the costs of U_2 supply. D_2 will therefore choose $\ell=1/2$.[7] Though $\ell=1$ is not permitted in our model, symmetry and the adverse consequences of lock-in to U_2 would render this option unattractive to D in any event.

In the integrated case, the effects of D's location choice on U_1's profits are internalised. D will locate at $\ell=0$. Lock-in to U_1 is no longer a concern, simply involving a transfer between divisions of the integrated enterprise. Internal transport costs are then minimised. Note that since additional transport costs are not incurred on incremental product volume, the location decision is never driven by attempts to raise D's share the value of trade with non-integrated U_2 (but see Section 4(i)).

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[6] We therefore concur with Bork that "the real cost of any transfer from the manufacturing unit to the retailing unit includes the return that could have been made on a sale to an outsider".

[7] Note that, in our formulation, the non-integrated D is concerned only with its outside option. It considers the efficiency consequences of its actions for the second best supply value, not the value of realised supply. This is, of course, an extreme formulation. In general bargaining between the buyer and supplier will result in a sharing of the efficiency gains. Some of the externality effect observed in our model would then be internalised.

Where the non-integrated D locates at $\ell=1/2$, integration always brings about a change in location choice. However, in the case where the non-integrated D is indifferent about location no such prediction can be made.

Proposition 2 [Integration]

(a) U_1 and D will integrate if this changes D's location choice and $E < \underline{t}$.

(b) If $E \geq \underline{t}$, D and U_1 will never integrate.

Proof:

If integration does not result in a change in location, then the sole effect is to reduce the combined D-U_1 profit by the merger cost, E.

If integration changes D's location choice (from $\ell=1/2$ to $\ell=0$) then D-U_1's gains are given by:

$\Pi_{U\text{-}D1}(\ell=0) - \Pi_{U1}(\ell=1/2) - \Pi_{D1}(\ell=1/2) = m\text{-}E - m\text{-}\underline{t} = \underline{t} - E$

Then D and U_1 have a strict incentive to integrate iff $E < \underline{t}$. QED.

Integration is attractive only if it will lead to a change in D's location decision, from $\ell=1/2$ to $\ell=0$. The cost of internal supply is then reduced by $\underline{t}$. For integration to be worthwhile this cost saving must exceed the merger cost, E. Clearly if no change in location, and therefore no transport cost gain, is forthcoming, then integration will never proceed.

In making the integration decision, U_1 and D consider their own future joint profits only. Integration may therefore impose a negative externality on the non-integrated upstream firm U_2. There are two mechanisms by which this can occur.

First, consider the case where U_2 always supplies one unit, irrespective of D's location. D's share of the gains from such trade, driven by its outside option, is then always m-d. The upstream firm collects the residual profit, 2d-m-t_2, and therefore bears the full increase in transport costs ($\bar{t} - \underline{t}$) if D changes its location decision from $\ell = 1/2$ to $\ell = 0$.

The transport costs induced by the integrated D's location decision can, in addition, affect supply patterns. In particular, D may utilise U_2 as a source of supply when located at 1/2, but rely exclusively on U_1 when $\ell=0$ is chosen. In this case, if integration induces a change in D's location decision, it will result in foreclosure of U_2's sales.

From a first best perspective, integration is never efficient since it involves a merger cost E. However, recognising that integration may be necessary to induce efficient location choice, merger may improve welfare *in equilibrium*. Clearly, when the non-integrated retailer makes an efficient location choice, integration can never be welfare-improving.

Proposition 3 [Welfare and Integration]

(a) If $2\underline{t}-E < 2d-m < \bar{t}$ then any vertical integration that occurs will reduce welfare.

(b) If $2\underline{t}-E < 2d-m$ and the retailer locates efficiently when indifferent, then any integration that takes place will reduce overall surplus

Proof:

(a) The integrated retailer always locates at $\ell=0$. From Proposition 1, integration only takes place if $E < \underline{t}$ and the non-integrated retailer locates at $\ell=1/2$.

$2\underline{t} - E < 2d-m \Rightarrow 2\underline{t} - (2d-m) < E < \underline{t} \Rightarrow m-d < d-\underline{t}$.

Consequently the non-integrated firm double sources at $\ell=1/2$.

Surplus from integration, and subsequent location at $\ell=0$ equals $\max\{m, 2d-\bar{t}\} - E$.

Surplus from non-integration and location at $\ell=1/2$ equals $2(d-\underline{t})$.

Now $2d-m < \bar{t}$ implies $m > 2d-\bar{t}$ therefore integration is inefficient if $2(d-\underline{t}) > m-E$, i.e. if $2d-m > 2\underline{t}-E$.

(b) Where double sourcing occurs irrespective of location then D is indifferent about location. If it then locates efficiently, integration (at cost E) must reduce surplus. From (a) we know that, if $2\underline{t}-E < 2d-m$ then double sourcing is optimal at $\ell 1/2$ and a switch to single sourcing at $\ell=0$ is welfare reducing. QED.

When single sourcing is optimal at $\ell=0$, the non-integrated retailer will locate at $\ell=1/2$. Where this takes place, integration, in shifting location from $\ell=1/2$ to 0, can only be inefficient if it affects U_2's profits (i.e. it has externality effects). This will only be the case if double sourcing occurs at $\ell=1/2$. A switch from double sourcing at $\ell=1/2$ to single sourcing at $\ell 0$ generates a clear transport cost saving ($2\underline{t}$). However, a merger cost E is incurred, and the benefits of multi-product retailing (2d-m) are lost. Merger is inefficient if the costs outweigh the benefits.

Suppose that single sourcing is everywhere optimal. A non-integrated retailer will then always locate at $\ell=1/2$, though location at $\ell=0$ is efficient. Nevertheless, vertical integration that brings about a change in downstream location decision would not always increase welfare. To be specific, if $E > \underline{t}$ merger costs exceed transport cost savings. Of course, where single sourcing is optimal irrespective of location, inefficient integration never takes place, since all welfare effects are internalised by D and U_1.

If double sourcing is optimal at every location the non-integrated retailer will be indifferent about location. The efficient location minimises overall transport costs. If $2\underline{t} > \bar{t}$ then location at $\ell=0$ is efficient, while location at $\ell=1/2$ is optimal if $\bar{t} > 2\underline{t}$. Of course, if the indifferent retailer always chooses the efficient location then integration can generate no benefit, and involves an added cost E.

Our analysis has suggested that integration may well cause a switch from double to single sourcing. The market for U_2's product is then effectively foreclosed. We will now address the question of whether such foreclosure is inefficient.

Proposition 4 [Foreclosure]

Conditional on integration:

(a) Foreclosure occurs if $\underline{t} < 2d\text{-}m < \bar{t}$.

(b) This foreclosure is inefficient if $2\underline{t} < 2d\text{-}m$.

Proof:

(a) Under non-integration D is supplied by both U's if $m\text{-}d < d\text{-}\underline{t}$.

When integrated D locates at ℓ=0 and is supplied by U1 only if $m\text{-}d > d\text{-}\bar{t}$.

Combining these conditions proves (a).

(b) Foreclosure yields overall profits m. Since the integrated firm locates at ℓ=0 there are no transport costs for D_1. Therefore from the efficiency results above, this is inefficient if $m < 2(d\text{-}\underline{t})$. Rearranging gives (b). QED.

Where it takes place, integration changes D's location decision from ℓ=1/2 to ℓ=0. Foreclosure results if supply patterns are sensitive to location choice. This will be the case if double sourcing occurs at ℓ=1/2 i.e. $m\text{-}d < d\text{-}\underline{t}$, while single sourcing is efficient for ℓ=0 i.e. $m\text{-}d > d\text{-}\bar{t}$. The benefits of multi-product retailing must therefore be sensitive to transport costs.

For a given location choice, the downstream firm's sourcing decision is always efficient. In considering the efficiency of foreclosure we therefore focus on the following question: Given that a change in location choice from ℓ=1/2 to ℓ=0 will result in foreclosure of U_2, does such a move maximise overall profits? Single sourcing at ℓ=0 involves no transport costs, while double sourcing at ℓ=1/2 incurs transport costs of $2\underline{t}$. For foreclosure to be efficient, these cost savings must exceed the lost value of multi-product retailing, 2d-m.

Comparing Propositions 3 and 4 it is worth noting that the efficiency of integration does not hinge on foreclosure effects. Suppose double sourcing is optimal at all locations and the non-integrated retailer locates at ℓ=1/2. Integration then brings about a change in location, but no foreclosure. Depending on the structure of transport costs, this may or may not bring about efficient location. Note also that foreclosure-inducing integration can be efficient.

4 Variations and Extensions to the Basic Model

i) *Unit transport costs*

An obvious variation on our basic model is to impose a transport cost *per batch* supplied by upstream firms. This contrasts with the basic setup, where a single transport cost is incurred *per product line*.

D's profits in this case can be obtained by simple adaption of the basic model results. Where double sourcing occurs, D's outside option is the single sourcing alternative. Of course this option now involves an additional cost, since a transport cost is incurred on both batches. D is thus able to extract $m\text{-}d\text{-}t_2$ from supplier U_1 and $m\text{-}d\text{-}t_1$ from supplier U_2 (cf. basic model results). Downstream profits are therefore given by $2(m\text{-}d)\text{-}(t_1+t_2)$. Where D opts for single sourcing (from U_1) the outside option of sourcing from U_2 now has value $m\text{-}2t_2$.

Now, when D finds double sourcing attractive at all locations, it is in general no longer indifferent about that location. To see this, note that D's profit is given by $2(m\text{-}d)\text{-}(t_1+t_2)$. The retailer therefore aims to minimise t_1+t_2. Where $\bar{t} < 2\underline{t}$ it is clear that D will prefer to choose $\ell=0$. Though such a location increases D's lock-in to U_1 (by reducing the value of the U_2 single sourcing option by $\bar{t} - \underline{t}$), this is offset by an increase of $\underline{t}$ in D's outside option when dealing with U_2. Conversely, when $\bar{t} > 2\underline{t}$, D prefers to locate at $\ell=1/2$. Only when $\bar{t} = 2\underline{t}$ will D now be indifferent to location choice.

Where a location choice of $\ell=0$ results from single sourcing, the non-integrated D will no longer always locate at $\ell=1/2$. In particular, this may not be so when single sourcing is optimal at $\ell=0$, but double sourcing is optimal at $\ell=1/2$. In the basic model, when such circumstances prevail, location at $\ell=1/2$ dominates. The key to this is to note that where single sourcing prevails a mid-point location is clearly optimal. However, when double sourcing occurs the value of the single sourcing option is independent of location. On introducing a per batch transport cost, the single sourcing option for the second batch is now transport cost dependent. Location at $\ell=1/2$ is no longer a dominant action for D.

When a per batch transport cost is incurred, this additional cost is always passed on to the downstream firm. Profits for the $U\text{-}D_1$ combination are therefore given by $\Pi_{D\text{-}U1} = m\text{-}2t_1$.

Where integration affects the location decision, it will therefore be optimal in a wider range of circumstances i.e. integration will now occur when a change in location is induced and $\mathbf{E} < 2\underline{t}$.

Note that this profit expression holds irrespective of which supplier D trades with. Where integrated D trades with U_2 there is an additional incentive to locate at $\ell=0$. The reduction in the transport costs of internal supply (by U_1) is of value not only when internal sourcing actually occurs, but also when supplies are sourced externally from U_2. In such cases, by raising the value of D's (internal) outside option, locating at ℓ=0 increases D's share of external trade profits.[8] Note that this effect is absent in our basic model above since there the value of a second unit of supply from a given supplier is not affected by additional transport costs, and hence by location choice.

ii) *Upstream monopoly*

A simple re-interpretation of the basic model allows us to consider a scenario where a monopoly upstream firm supplies competing downstream firms. The results derived above hold for this case too. However it is then vital that the single supplier is capacity constrained. A downstream firm, by securing all upstream output, can then be sure that it monopolises the downstream market. Of course, to achieve this a downstream firm must outbid its rival for all supply capacity. Thus a downstream firm may (inefficiently) purchase all upstream capacity to secure downstream monopoly, even though a single unit is sufficient for its production needs.

In the absence of such capacity constraints (and given the impossibility of exclusive dealing contracts) the upstream supplier cannot guarantee either downstream firm a monopoly position. Indeed the supplier would always have an incentive, having supplied one retailer on monopoly terms, to proceed to supply the other firm. Foreseeing this outcome, competition for supplies disappears, and with it so does supplier profit.

This effect is precisely that highlighted by Hart and Tirole (1990) in their first model. A non-integrated upstream firm, with unlimited capacity can never commit to supplying a single downstream firm. Monopoly profits are fully dissipated. Hart and Tirole show that, in this context, integration will eliminate upstream incentives to oversupply the downstream market. Where downstream monopoly is attractive, the integrated upstream supplier has every incentive to confer that monopoly power on its own downstream subsidiary.

In our model, by contrast, it is the downstream firm that is the monopolist. Since it is the residual claimant it will not purchase from both suppliers if single sourcing is optimal. The Hart-Tirole motive for integration is therefore absent in our basic model. Their effect would re-appear, however, if the retailer sold services to upstream manufacturers, but final sale revenues were earned directly by the upstream firms.

[8] This effect is the driving force behind some of the results in Bolton and Whinston (1990). See, for example, their Proposition 4.1.

5. Multiple Retailers

An important development of the basic model involves the introduction of an additional retailer. Only then can the possibility that both vertically integrated and non-integrated firms coexist in equilibrium be considered. We will show that such an industry structure can emerge, even though all downstream and all upstream firms are initially identical.

Secondly, we will be able to consider the endogenous relationship between downstream competition and vertical integration. A key concern in the anti-trust literature is whether vertical merger, that leaves horizontal concentration at both upstream and downstream levels unchanged, can adversely effect competition. In the context of a stylised model of such competition, we will show that downstream competition can indeed be weakened by integration. We will also explore the potential existence of chains of integration.

The two upstream firms, U_1 and U_2, are again located at the ends of the unit line. However, now two downstream firms, D_1 and D_2, can each locate at either end of the line or mid-way between the endpoints. We will permit vertical integration between U_1 and D_1, and between U_2 and D_2. U_2 and D_2's decision to integrate follows that by U_1 and D_1. Again a cost E is incurred in undertaking a merger. In evaluating the merits of integration, upstream-downstream pairs aim to maximise their combined profits.

Where a downstream firm is indifferent as to its supply source, we will assume that D_i purchases from U_i. To simplify matters considerably we will also assume that there is no value to either downstream firm in multi-product supply i.e. d=0. In the absence of competition, each downstream firm will therefore extract surplus m from consumers.

Our stylised model of competition will take the following form. We will suppose that if downstream firms locate strictly closer than Δ apart, then competition reduces each firm's revenues by θm.[9] Allowing Δ to vary will enable us to analyse the impact of increasing downstream competition on integration decisions.

[9] Note, in particular, that this competition effect is assumed independent of the levels of retailers' transport costs. This is natural in our setting, since transport costs are fixed not (per unit) variable costs. Our analysis of the competition effects of integration will therefore focus on location effects. In general, integration would also lead to changes in variable costs that will impact on competition. The costly merger process could then be seen (partly) as an investment in variable cost reduction. Numerous authors (e.g. Bonanno and Vickers (1988), Fershtman and Judd (1987)) have shown that the strategic effects of integration on rivals' behaviour may outweigh the direct cost benefits, rendering vertical integration unattractive. Vertical separation may then be the optimal response to tougher competition.

$\Delta = 0$

In this case there is no competition between downstream firms, irrespective of their location decisions. In such circumstances non-integrated downstream firms always locate at ℓ=1/2 (see Figure 1(i)). In doing so, they maximise their outside options and hence minimise lock-in to either upstream supplier. An integrated downstream firm will locate next to its upstream partner, at the appropriate end of the line (Figure 1(iii)). Integration removes lock-in worries and firms will then seek to eliminate inefficient transport costs. In the absence of competition, joint retailer-supplier profits are independent of industry-wide integration and location decisions. Partial Integration will therefore never be observed.

Profits for U-D pairs ($\Delta = 0$):

Non-Integration:	$\Pi_{U\text{-}D} = m - \underline{t}$
Full Integration:	$\Pi_{U\text{-}D} = m - E$

Clearly integration is attractive if and only if the transport cost savings outweigh the fixed cost of integration i.e. $E < \underline{t}$.

$0 < \Delta \leq 1/2$

With $\Delta > 0$ the possibility of downstream competition emerges. In this case, if downstream firms locate together then competition reduces their revenues by θm. On the other hand, if downstream firms locate at least a 1/2 unit apart, competition is avoided.

In the non-integrated case there are now two opposing forces at work. A desire to avoid lock-in to either upstream supplier drives both downstream firms towards location at ℓ=1/2. However, countering this, the prospect of competition encourages those downstream firms to locate apart. Below, we derive the condition for the lock-in effect to dominate.

Lemma 3 [Non-Integrated Location Choice]

If $\theta m < \bar{t} - \underline{t}$ then non-integrated downstream firms locate at ℓ=1/2.

Proof:

Locating at ℓ=1/2 is a dominant strategy for each non-integrated downstream firm.

Suppose first that D_j locates at ℓ=1.

D_i's ($i \neq j$) profits as a function of location are then given by:

$(1-\theta)m - \bar{t}$	at ℓ=1
$m - \bar{t}$	at ℓ=0
$m - \underline{t}$	at ℓ=1/2

Clearly locating at ℓ=1/2 maximises downstream profit.

Suppose now that D_j locates at $\ell=1/2$

D_i's ($i \neq j$) profits for each location are then:

$m - \bar{t}$	at $\ell=1$
$m - \bar{t}$	at $\ell=0$
$(1-\theta)m - \underline{t}$	at $\ell=1/2$

Profit is again maximised at $\ell=1/2$, if $(1-\theta)m - \underline{t} > m - \bar{t}$ i.e. if $\theta m < \bar{t} - \underline{t}$. QED.

Locating at one end of the unit line is bad for independent retailer profit, because it reduces the value of the second best sourcing option. Compared with a mid-point location, the transport cost incurred with this option increases from $\underline{t}$ to $\bar{t}$. Offsetting this is the potential value of creating distance between retailers. We will assume that the lock-in effect always dominates.

Condition A: $\theta m < \bar{t} - \underline{t}$.

Note that an integrated downstream firm will always locate next to its upstream subsidiary. Not only does this location decision minimise transport costs but in addition, by locating away from $\ell=1/2$, the integrated retailer will avoid competition with any non-integrated downstream firm. Given Condition A, vertical integration will therefore always lead to a separating of retailers.[10] With competition, the incentives to integrate are increased.

Profits for U-D pairs ($0 < \Delta \leq 1/2$) are given by:

Non-Integration:	$\Pi_{U\text{-}D} = (1-\theta)m - \underline{t}$
Partial Integration (D_j-U_j integrated):	$\Pi_{Uj\text{-}Dj} = m - E$
	$\Pi_{Ui\text{-}Di} = m - \underline{t}$
Full Integration:	$\Pi_{U\text{-}D} = m - E$

When $E > \theta m + \underline{t}$ both upstream-downstream pairs will remain unintegrated, since the costs of integration then outweigh any competition and transport cost benefits. Conversely when $E < \underline{t}$ both firms will integrate. However for intermediate E values, where $\underline{t} < E < \theta m + \underline{t}$, we will observe a partially integrated industry structure (see Figure 1(ii)). Note that both firms would prefer that their rival integrated (and located at an end-point) alone. In this way they would benefit from reduced competition without bearing the necessary costs of integration.

[10] Dixit (1983) develops a model where the structure of vertical relationships may result in greater spatial separation of retailers. However, in his model, this increased separation of downstream firms is driven by reduced entry into the retail industry. Furthermore, Dixit focuses on a traditional analysis of the value of contractual vertical restraints (franchise fees, royalties, etc.), in comparison with full integration, to a *monopoly* supplier. Transaction cost aspects of integration are ignored.

Since U_1 and D_1 have a first mover advantage they will remain unintegrated, forcing U_2 and D_2 to incur the costs of merger.

From an overall producer perspective, individual incentives to integrate are too weak. As stated above, for $E > \theta m + \underline{t}$ non-integration is the equilibrium industry structure. The costs of integration then exceed the competition and transport cost benefits of integration *for the individual firm*. However, in making their integration decision, a given manufacturer-retailer pair fail to internalise the competition benefits of merger to the rival retailer. Where $2\theta m + \underline{t} > E > \theta m + \underline{t}$, partial integration is optimal from an overall firm viewpoint, but will not be sustained in equilibrium.

The key observation from this section is the emergence of an asymmetric partially integrated industry structure for moderate competition, despite initially identical firms.

$1/2 < \Delta \leq 1$

Competitive pressures in the downstream market are now strong, and profit reducing interaction occurs unless Ds locate at opposite ends of the unit line.

A fear of lock-in still attracts non-integrated downstream firms towards the mid-point of the unit line. Countering this, the competition effect encourages these firms to locate at the end-points. Condition A again ensures that the lock-in threat dominates any competition effect encouraging firms to locate at the endpoints. Independent downstream firms will therefore always choose to locate at $\ell=1/2$.

Integrated downstream firms locate next to their upstream partners. Again, such location avoids inefficient transport costs, and may eliminate downstream competition. The role of this competition effect may be crucial, and depends delicately on integration patterns in the industry as a whole.

To be precise, if firms U_j and D_j do not integrate, no competition benefits will follow from integration of U_i and D_i. Even if D_i integrates with U_i and locates at $\ell=0$, competition between downstream firms will not be eliminated, since non-integrated D_j continues to locate at $\ell=1/2$ (and $\Delta > 1/2$!). However, if U_j and D_j are integrated, and D_j locates at $\ell=1$, then integration of U_i and D_i (in shifting D_i's location from $\ell=1/2$ to $\ell=0$) brings about the elimination of downstream competition. The delicacy of this competition effect prevents a partially integrated industry structure from emerging, as the following profit results make clear.

Profits for U-D pairs ($1/2 < \Delta \leq 1$) are given by:

Non-Integration:	$\Pi_{U\text{-}D} = (1-\theta)m - \underline{t}$
Partial Integration (by D_j-U_j):	$\Pi_{Uj\text{-}Dj} = (1-\theta)m - E$
	$\Pi_{Ui\text{-}Di} = (1-\theta)m - \underline{t}$
Full integration:	$\Pi_{U\text{-}D} = m - E$

It should be clear that with tough competition the partial integration structure will never emerge in equilibrium. Integration by one upstream-downstream pair alone cannot reduce competition. For $E < \theta m + \underline{t}$ both U-D pairs will integrate, while for $E > \theta m + \underline{t}$ both firms will remain unintegrated.

Note that for intermediate E, where $\underline{t} < E < \theta m + \underline{t}$, U_1 and D_1 only integrate in anticipation of merger by U_2 and D_2. Likewise, U_2 and D_2 will only integrate in response to D_1-U_1 merger. Chains of integration are therefore observed.

These competition results are summarised below.

Proposition 5 [Competition and Integration]
For $\underline{t} < E < \theta m + \underline{t}$, the competitive environment plays a critical role in determining industry structure:
(i) In the absence of competitive forces ($\Delta = 0$), both downstream firms will be non-integrated.
(ii) Moderate competitive pressure ($0 < \Delta \leq 1/2$) generates partially integrated outcomes i.e. vertically integrated and non-integrated firms co-exist.
(iii) A fully vertically integrated industry emerges when downstream competitive pressures are intense ($1/2 < \Delta < 1$). Furthermore, a chain of integration is observed.

In our analysis of the basic model (with monopoly D) it was assumed that the downstream firm was able to extract all consumer surplus generated by product sales. This allowed us to focus on (upstream and downstream) producer surplus alone in assessing efficiency. However, once competition between downstream firms is permitted, explicit consideration of consumers is illuminating. In particular, it seems reasonable to suppose that at least a fraction of the downstream profit dissipated through competition is passed on to consumers. Of course, it could be argued that this profit is in fact expended on (wasteful and unsuccessful) attempts to regain full market power. However, here we will assume that *all* revenues lost by firms as a result of the competitive process accrue to consumers.

Once competition between downstream firms is initiated, we have seen that for a range of merger costs E, integration takes place solely because this results in a reduction in that competition. When $\underline{t} < E < \theta m + \underline{t}$, integration occurs even though merger costs exceed the transport cost savings that result. In effect, the integrating firms in the industry are undertaking costly merger simply to avoid making transfers to consumers. Clearly, integration in such circumstances will be inefficient.

It should be pointed out that our analysis has been based on the assumption that consumers derive no added value from retailer separation. In general, consumers may benefit from the greater variety offered by integration-induced retailer differentiation. Such considerations would obviously affect our view of the efficiency implications of integration.

Finally, note that to simplify our analysis in this section, we have only considered single product firms. Given our basic assumptions, this rules out foreclosure effects. However, the changes in downstream location patterns induced by integration suggest that foreclosure effects would be restored in a richer model. Furthermore, in a multi-product setting, retailers' product portfolio choices may affect the intensity of inter-firm competition. This may further encourage additional integration-induced foreclosure.

6. Conclusions

In this paper we have modelled a retailer's choices between two rival suppliers and between single-product and multi-product retailing. An investment specificity decision must also be taken - in the form of a discrete location choice. Vertical integration may encourage supplier-specific location, where an independent retailer would choose general investment. Indeed, costly merger will only take place if a change in the retailer's location decision is induced.

When single product retailing dominates, an independent retailer will always choose a general location, thus minimising lock-in to a given supplier. However, in precisely these circumstances a supplier-specific location is efficient. Vertical merger may then be attractive, eliminating lock-in concerns and encouraging specific investment. Of course, such integration will occur only if the benefits of appropriate investment outweigh the (exogenously given) costs of merger. Whenever bilaterally attractive merger occurs, it will be efficient in this case.

Retailer supply patterns may be sensitive to the location decision. Integration can therefore result in foreclosure of the non-integrated supplier. Whether this foreclosure is efficient or not depends delicately on the inter-relationship between the relative merits of specific versus general investment, and single versus multiproduct retailing. In the context of this simple model we explore the interaction between efficiency and anti-competitive motives for vertical integration.

The basic model was extended to consider the impact of vertical integration on competition *between retailers*. Such competition may motivate otherwise unattractive merger. Integration, in encouraging supplier-specific investment, allows retailers to adopt competition-reducing product differentiation strategies. For moderate levels of competition, a partially integrated industry structure then results, as integration by a subset of firms is sufficient to reduce rivalrous interaction. With tougher competition, a coordinated integration process is essential. In this case, a fully vertically integrated industry results. The integration process then displays the characteristics of an integration chain.

Appendix (Proof of Lemma 1):

Here we derive the results of the supply competition process:

Non-integration

If unit 1 from U_1: value if both units from U_1 = m

value if unit 2 from U_2 = $2d-t_2$

winning supply price = $|2d-t_2-m|$.

If unit 1 from U_2: value of unit 2 from D_1 = $2d-t_1$

value of both units from D_2 = m

winning supply price = $|2d-t_1-m|$.

If U_1 offers unit 1 for p_1 and wins it gains: $p_1 + \max[0,m-2d+t_2]$.
If U_1 does not bid for the unit 1 contract it gains: $\max[0,2d-m-t_1]$.
Indifference implies $p_1^{max} = \max[0,m-2d+t_1] - \max[0,2d-m-t_2]$.

If U_2 supplies unit 1 at price p_2 it gains: $p_2 + \max[0,m-2d+t_1]$.
If U_2 loses the unit 1 contract it gains: $\max[0,2d-m-t_2]$.
Indifference implies $p_2^{max} = \max[0,m-2d+t_2] - \max[0,2d-m-t_1]$.

D will accept a bid that yields maximum two period gains. Here this implies D gains Π_D, where:

$$\Pi_D = \min\left[d-t_2-p_2^{max} + \min(d-t_1,m-d)\ ,\ d-t_1-p_1^{max} + \min(d-t_2,m-d)\right].$$

Let $M = [d-t_1-p_1^{max} + \min(d-t_2,m-d)] - [d-t_2-p_2^{max} + \min(d-t_1,m-d)]$.
Substituting in the expressions for p_1 and p_2 yields

$$M = (m-t_1) - \max[0,\ 2d-m-t_1] - (m-t_2) + \max[0,\ 2d-m-t_2]$$

If $M \geq 0$ U_1 wins the unit 1 supply contract. (Unit 1 from U_1 in case of tie, by assumption).
If $M<0$ U_2 supplies unit 1.

Now $M = [m-t_1 - \max(0,2d-m-t_1)] - [m-t_2 - \max(0,2d-m-t_2)]$.
Some simple algebra yields

$$M = [m-d + \min(m-d,d-t_1)] - [m-d + \min(m-d,d-t_2)].$$

By assumption $t_1 \leq t_2$, thus $M \geq 0$ and U_1 always supplies unit 1.

Since $M \geq 0$, $\Pi_D = m-d + \min(m-d,d-t_2)$.
Now, if D pays p^* for unit 1 from U_1 in equilibrium its profit is given by

$$\Pi_D = d-t_1-p^* + \min[m-d,\ d-t_2].$$

However, we know that $\Pi_D = m\text{-}d + \min[m\text{-}d, d\text{-}t_2\}$.

Consequently, unit 1 yields price $= 2d\text{-}m\text{-}t_1$, and

unit 2 yields price $= |2d\text{-}m\text{-}t_2|$.

U_1 supplies both units if $d\text{-}t_2 < m\text{-}d$.

One unit is supplied by each U if $d\text{-}t_2 > m\text{-}d$.

This is precisely the efficiency criterion, given location.

The payoffs are:

$\Pi_D \quad = m\text{-}d + \min[m\text{-}d, d\text{-}t_2\}$

$\Pi_{U1} \quad = \max[2d\text{-}m\text{-}t_1, t_2\text{-}t_1\}$

$\Pi_{U2} \quad = \max[0, 2d\text{-}m\text{-}t_2]$.

Vertical Integration (D-U_1)

If we assume the same auction process then again input allocation will be efficient, given location. The profit of U_2 remains the same, while the combined profits of U_1 and D are reduced by integration costs E.

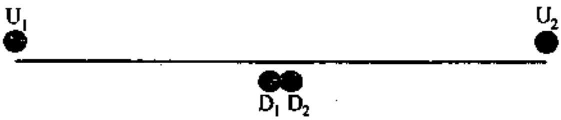
Payoffs:

$\Pi_{U1\text{-}D} = m\text{-}t_1\text{-}E$

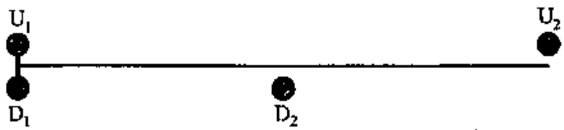
$\Pi_{U2} \quad = \max\{0, 2d\text{-}m\text{-}t_2\}$.

Figure 1

(i) Non-Integration



(ii) Partial Integration
(U_1-D_1 integrated)



(iii) Full Integration

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