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INTERNATIONAL OUTSOURCING IN
UNIONISED OLIGOPOLY

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STRATEGIC INVESTMENT AND INTERNATIONAL OUTSOURCING IN UNIONISED OLIGOPOLY

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Abstract:

We critically consider the conventional belief that the attractiveness of international outsourcing lies in cheaper labour costs overseas and that it offers a means to 'escape' the power of unions. We develop an oligopoly model in which firms facing unionised domestic labour market choose between producing an intermediate in-house or outsourcing it to a non-unionised foreign supplier that makes a relationship specific investment in developing the intermediate. We show that outsourcing typically results in higher wages and does not always reduce marginal costs. Trade liberalisation favours outsourcing particularly for the relatively less efficient firms.

(94 words)

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1. Introduction

The process of globalisation of goods and services markets and improvements in the technology of communication has been accompanied by a deepening in international specialisation and a tendency towards a vertical fragmentation of production across national borders. As a result, the 'make-or-buy' internalisation choice of firms (i.e. whether to produce an intermediate in-house or outsource it to an upstream supplier) is increasingly international in nature – as outsourcing is directed towards suppliers located abroad. In this context, the role of labour markets in influencing the mode-of-operation decision of firms has attracted increasing attention in public and policy debates. The conventional wisdom that appears to emerge from these debates suggests that international outsourcing may be used by firms as a way to 'escape' distorted domestic labour markets. Specifically, given the still significant role played by unionisation in many industrialised economies, it has been suggested that outsourcing is a means to weaken trade unions and that strong unions make outsourcing more attractive.[1] This view reflects the widespread notion that outsourcing is almost exclusively driven by the desire to reduce costs.[2] Indeed, cost reductions are the dominant arguments used by firms to justify their outsourcing decision.[3] However, a number of stylised facts are not consistent with this perspective. On the one hand, the evidence on outsourcing leading to a reduction in costs and/or to improvements in the quality of intermediates is not conclusive.[4] On the other hand, outsourcing does not appear to be more prevalent in countries with higher union coverage rates (see, e.g., Lommerud *et al*, 2009).

In this paper we argue that to gain a fuller understanding of the trade-offs involved in the mode-of-operation decision of firms requires broadening the focus of the analysis

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[1] For instance, machinist union leaders at Boeing see the company's refusal to allow them to bid for work against outside contractors as evidence that Boeing's outsourcing policy is not aimed at improving efficiency, but rather at weakening the union (*Seattle Times*, 10th Sept 2008).

[2] The common perception that the dominant motive for outsourcing is to reduce costs is exemplified by current predictions of an increase in outsourcing in response to the recession, as firms' incentives to cut costs increase in a downturn (e.g. *Outsourcers Outperform*, the Economist, July 2, 2009).

[3] The reduction of operating costs is the top (out of 10) reason for outsourcing in the Outsourcing Institute's annual survey of outsourcing current and potential end users (http://www.outsourcing.com/content.asp?page=01b/articles/intelligence/oi_top_ten_survey.html).

[4] For example, a study by management consultant Gartner and a survey by Direct Response, a provider of outsourced services, revealed that outsourced services may not results in any costs savings compared to services provided in-house, e.g. because of low quality and diluted brand values. Evidence that outsourcing of services may be negatively correlated with profits or productivity is also provided in some econometric analyses of firm level data; see, for example, Görg and Hanley (2004) for the electronics firms in Ireland, and Görzig and Stephan (2002) for manufacturing companies in Germany.

beyond cost considerations to encompass the strategic interaction between firms. An influential strand of the theoretical literature on outsourcing builds on the transaction cost approach pioneered by Coase (1937) and Williamson (1975, 1985). The transaction cost perspective – based on the role of incomplete contracts and asset specificity – places emphasis on the *economising* dimension (e.g. Williamson, 1991) of the make-or-buy decision of the firm, which is ultimately based on a total cost comparison of alternative organisational structures. Building on Leahy and Montagna (2007, 2009a, 2009b), we argue that – to the extent that firms have market power – *strategising*[5] considerations will interact with economising considerations in determining the mode-of-operation choice of firms.[6] These strategic considerations are also likely to interact with other institutional features of countries (such as for example labour market institutions) in affecting firms' incentives to outsource.[7] We develop an oligopoly model in which firms facing domestic unionised labour markets choose between vertical integration and outsourcing of part of the vertical production chain to suppliers located in non-unionised countries (possibly characterised by lower labour costs): final good production entails the use of a highly specialised firm-specific intermediate good that can either be produced in-house or outsourced. The intermediate input requires an investment in quality and customisation. The higher the investment, the more useful and valuable is this input to the final good firm in the sense that the latter will need to use fewer complementary inputs in the production of a unit of the good. The usefulness of the intermediate to the final good producer is thus endogenous. Under vertical integration, the investment in quality is done in-house, while under outsourcing it is made by the foreign supplier. Given that in this model the intermediate is not a generic

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[5] Williamson (1991) uses the term *strategising* to refer to behavioural responses of firms that possess market power.

[6] Williamson (1991) argues that *"most firms lack market power of the kind that is routinely assumed by the strategizing* [IO] *literature"*. However, empirical evidence suggests that the firms that operate in internationally (via export, outsourcing and foreign direct investment) tend to be larger than firms that operate only domestically (e.g. Tomiura, 2007). Hence, it is plausible to conjecture that such firms will tend to have higher degrees of market power – and that their mode-of-operation decision will therefore be more affected by considerations of a strategic nature.

[7] Although the literature on the effects of labour market institutions on the outsourcing decision is still fairly limited, there are notable exceptions to which this paper is related. Lommerud *et al* (2009) analyse how the incentive to outsource is influenced by unionisation within a partial equilibrium monopolistically competitive framework. Skaksen (2004) studies the implications of the potential of international outsourcing on union wages within a general equilibrium framework in which the decision to outsource occurs *after* union-firm wage negotiations. Koskela and Schöb (2008) analyse the effects of labour market reforms on the decision to outsource of unionised firms. A related, earlier, literature studies the effects of unionisation on the decision to do FDI: e.g. Zhao (1995), Bughin and Vannini (1995), Leahy and Montagna (2000), Naylor and Santoni (2003).

input that can be purchased from a spot market, the supplier will have to make a relationship-specific investment (RSI) which, in the presence of incomplete investment contracts, gives rise to a hold-up problem.[8] The downstream firm then bargains with the foreign supplier over the price of the intermediate. The make-or-buy decision of the firm therefore entails a trade-off between the higher corporate governance costs of vertical integration (i.e. the additional costs of coordinating a large vertically integrated organisation)[9] and the transaction costs associated with outsourcing (which involves entering a relationship with an upstream firm that is beset with problems of contractual incompleteness). Within this framework, we examine how the strategic interaction between firms and the relative strength of firms and unions determine unions' response to outsourcing and the incentive to outsource. Furthermore, we examine the effect of outsourcing on firms' investment and productivity, and the effect of changes in trade costs on the mode-of-operation equilibria.

The early transaction cost literature (e.g. the aforementioned work of Williamson) did not formalise the role of market interaction between competitors as it focussed on the bilateral relationship between a single producer and a potential supplier. An important breakthrough occurred when Grossman and Helpman (2002) contextualised this relationship within a theoretical framework that allows for an endogenous emergence of outsourcing with general equilibrium effects.[10] However, by relying on monopolistically competitive market structures that abstract from strategic interaction between firms, in these models the mode-of-operation choice of one firm does not affect that of its rivals. To examine the effects of strategic interaction between firms, an oligopoly setting is required. We are not the first to study outsourcing under oligopoly. In a two stage duopoly game, Nickerson and Vanden Bergh (1999) show how both governance costs and oligopolistic interaction can influence the organisation choice of firms. In their model, however, the buyer-supplier relationship is not modelled and no hold-up problem emerges. In Shy and Stenbacka (2003), the price of the input arises from the imperfectly competitive nature of the upstream sector and,

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[8] Grossman and Hart (1986) and Hart and Moore (1990) formalise the emergence of a hold-up problem from ex-ante investment distortions in a context in which negotiating advantages arise from asset ownership.

[9] Governance costs, which can also be thought of as managerial incentive costs of integration, have been extensively discussed in the literature. See for instance McLaren (2000) and references therein.

[10] This was further developed by Grossman and Helpman (2003 and 2005), and by Antràs and Helpman (2004). In most of these papers, outsourcing emerges in the presence of matching and is found to be more attractive the 'thicker' is the market for suppliers. The market thickness effect is also studied by McLaren (2000).

unlike our paper, is not influenced either by the level of investment made by the supplier or by buyer-supplier bargaining. In Chen *et al* (2004), within a model in which the upstream supplier competes with the downstream firm in the final good market, a strategic motive for outsourcing arises from a collusive effect resulting in a increase in the price of both intermediates and final goods. In general, in the existing literature on outsourcing in oligopoly, to our knowledge, issues related to incomplete contracts and relationship specific investment are not taken into account and their role in determining the nature of the trade-offs facing firms when making their mode-of-operation decisions are therefore disregarded.

Our analysis makes a number of contributions to the literature. A key feature of our paper is that we bring strategic considerations into a transaction cost framework in which the relationship specific investment a supplier needs to make in the quality of the intermediate is explicitly modelled. This enables us to offer an explanation as to why outsourcing can lead to an increase in the downstream firm's marginal cost of production – even when the foreign supplier has an underlying cost advantage in producing the intermediate. In the presence of contract incompleteness, the relationship specific investment generates a hold-up problem – which translates in this model into an under-investment in the quality of the intermediate that will work towards an increase in the marginal production cost of the downstream firm.[11] In addition, we show that upstream outsourcing paradoxically increases the aggressiveness of the domestic unions (which bid up the wage) in the downstream sector. The intuition is that the union knows that the wage it sets has a smaller effect on the labour demanded by the firm, as the impact of domestic wages on home marginal cost is relatively less important when the firm outsources part of its production abroad, because reliance on domestic labour is lower. Thus, while unions can capture part of the additional rents generated by the investment in quality (and hence under vertical integration reduce the incentive to invest), an attempt to escape from this problem by outsourcing may not lead to more investment (and hence to a lower marginal production cost). In this paper, therefore, not only do we endogenise the firms' mode-of-operation, but also (contrary to the existing oligopoly literature) the quality of the input which feeds back to the trade-off between outsourcing and vertical integration – by affecting marginal production costs.

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[11] As is standard in the literature, this contract incompleteness originates from the inability of third parties to verify the suitability of the inputs provided by the suppliers. See Spencer (2005) and Helpman (2006) for overviews.

In addition, we show that the existence of strategic effects allows for the emergence of asymmetric mode-of-operation equilibria, in which the firms choose different organisational forms even when they are ex-ante identical; this is in sharp contrast to the results obtained in the monopolistically competitive framework *à la* Grossman and Helpman in which asymmetric equilibria only arise in the presence of ex-ante efficiency differences. Consistent with Leahy and Montagna (2007, 2009a), we show that outsourcing – by *softening* the investment behaviour of rivals – can be viewed as a *defensive business strategy* that can be the best response to rivals' choice of vertical integration.

The plan of the remainder of the paper is as follows. Section 2 sets out the model. The game is solved in Section 3 and the equilibrium regimes are discussed in Section 4. Section 5 concludes the paper.

2.   The Model

We consider an industry in which there are two final goods firms that sell a homogenous good to an integrated market. This may be the home market of one or both of the firms or a third market. To economise on notation, we further assume that sales to the final good market do not involve a transport cost.[12] The inverse demand is given by:

$$p = a - \bar{y}, \tag{1}$$

with $\bar{y} = y_1 + y_2$, where p is the price of the good, a is a constant parameter, and y_1 and y_2 are the quantities produced by firms 1 and 2 respectively.

The production of the final good requires a specialised component, which is combined in fixed proportions with labour. One unit of this intermediate is required per unit of output. For firm i, let $l_i = \bar{l} - z_i > 0$ be the per-unit labour input requirement for the production of the final good, where $\bar{l}$ is constant and z_i captures the 'usefulness' of the intermediate: a high z_i reflects a better intermediate, one that requires to be combined with fewer units of labour in order to produce a unit of output; thus, a good quality intermediate leads to a lower labour requirement per unit of output and hence to a higher labour productivity. The 'usefulness' of the intermediate to the final producer

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[12] It is easy to show that adding a transport cost in selling would not change the results of the paper qualitatively.

depends on the level of the investment (K) in its quality and customisation for the final good production. We assume that $z = \sqrt{K}$, i.e. there are diminishing returns to investment. This is a plausible assumption and one that is needed to ensure an interior solution. We further assume that this investment does not require the use of labour.[13]

The firm can either produce the intermediate in-house (vertical integration) or outsource it to a foreign supplier. If produced in-house, the specialized component can be obtained at a marginal cost of $r_i = w_i \hat{r}_i$, where w_i is the wage paid by the firm and $\hat{r}_i$ is the per-unit labour requirement in its production. If it is outsourced to a foreign intermediate producer, the price of the intermediate input is q_i. To deliver this input to the home country where it is combined with labour, the outsourcing firm must pay a transport cost of t per unit of output.[14]

Labour markets in the domestic economy are unionised with firm-specific unions bargaining with firms over the wage, while they are perfectly competitive in the foreign country. The foreign country's wage is therefore exogenous and can be normalised at unity.

Using the superscripts V and O to denote vertical integration and outsourcing respectively, marginal production cost for firm i will thus be:

$$c_i^V = w_i(\hat{r}_i + \bar{l} - z_i) \tag{2a}$$

if the firm produces the intermediate in-house, and

$$c_i^O = q_i + w_i(\bar{l} - z_i) + t_i \tag{2b}$$

if the firm outsources its production to a foreign supplier.

If firm i is vertically integrated, its profit function is given by:

$$\pi_i^V = (p - c_i^V)y_i - K_i - G, \tag{3a}$$

where G represents the fixed governance cost[15] that a vertically integrated firm is assumed to incur. On the other hand, if the firm chooses to outsource, its profit function will instead be:

$$\pi_i^O = (p - c_i^O)y_i. \tag{3b}$$

When a firm chooses to outsource, it avoids both the investment costs and the governance cost of vertical integration. The investment costs are now borne by a foreign intermediate goods producer with whom the downstream firm has an outsourcing relationship and who has profits:

$$\mu_i = (q_i - r_i^m)m_i - K_i - E_i, \tag{4}$$

where r_i^m is the intermediate producer's marginal production cost – which can differ from r_i, the marginal production cost of producing the intermediate in-house. Output of the intermediate is given by m_i. Since one unit of the intermediate is needed in the production of each unit of final output, we can write $m_i = y_i$. The upstream firm must also incur a fixed entry cost E_i. Note that in equation (4) and thereafter we use the subscript i to refer to an upstream-downstream pair (i.e. i represents the upstream firm that has a bilateral outsourcing relationship with downstream firm i).

3. The Game

The model is a four-stage game. In stage one, firms decide whether to produce their intermediate in-house at home or outsource it to a firm in a non-unionised foreign location. If both firms outsource, then they each engage different foreign upstream firms to develop and supply the intermediate for them. In stage two, the firms invest in the development of the intermediate.[16] If they opt for vertical integration, firms undertake the investment in-house. If they outsource, then the specialised supplier firm

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[15] G captures the costs – *à la* Williamson (1975, 1985) – of running a larger and more complex organisation. See also footnote 9 above.

[16] The relationship between upstream and downstream firms is a bilateral one. As discussed above, the intermediates are highly specific to a downstream firm and we assumed that each downstream firm chooses to outsource to a different upstream firm. We can rule out the possibility that more than one upstream firm compete to supply a downstream firm. One could think of there being *ex ante* many identical potential intermediate suppliers. However, *only* one firm will enter to supply a particular downstream firm in equilibrium since with more than one upstream firm, as a result of Bertrand competition, the intermediate price would be driven to the marginal production cost and the firms will be unable to cover their investment and fixed entry cost. Anticipating this, only one firm will enter to invest in and supply the firm-specific intermediate of any particular downstream firm.

undertakes the investment. In stage three, the firms bargain with their firm-specific union over the wage and (if they outsource) they simultaneously bargain with the intermediate supplier over the price of the intermediate. We assume that the final good producer only has enough time to negotiate with a single supplier. As in Grossman and Helpman (2003), should bargaining breakdown, the producer will not have sufficient time to produce the intermediate itself, and so will exit the market – while the supplier will have wasted its investment. In stage four, firms produce and sell the final output.

We derive the subgame-perfect Nash equilibrium. As the game is solved by backward induction, we discuss the stages in reverse order starting with the final stage.

3.1   Stage 4

In the final stage of the game, the two firms engage in Cournot competition. Outputs are determined by maximising *operating* profits, defined as $\tilde{\pi}_i^h = (p - c_i^h) y_i$ (where $h=V,O$), since at this stage all fixed and investment costs have been sunk. The first-order condition is given by:

$$\frac{\partial \tilde{\pi}_i^h}{\partial y_i} = p - c_i^h - y_i = 0, \tag{5}$$

where ($h=V,O$) and ($i=1,2$). Combining the reaction functions implied by the first order condition in (5) with the inverse demand function in (1), we obtain the (final-stage) Nash equilibrium in quantities:

$$y_i = \frac{a - 2c_i^h + c_j^k}{3}, \tag{6}$$

where ($h,k=V,O$) and ($i,j=1,2$), with ($i\neq j$).

3.2   Stage 3

In stage three of the game, firms will bargain over the wage with their firm-level unions. If they outsource, they will also simultaneously bargain with their supplier firm over the price of the intermediate.[17] If the firm is vertically integrated, then all the labour used in

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[17] The purchase of intermediate components has sometimes been assumed to involve the combination of a fixed lump-sum payment and a price set at marginal cost. As highlighted by Spencer (2005), however, the transfer of rents through lump-sum payments is at odds with stylised facts about domestic and international transactions. Our paper recognizes that outsourcing contracts typically involve strictly positive prices that exceed marginal costs. The distribution of rents between intermediate supplier and

its production activities (assembly as well intermediate good production) is employed in-house. If it outsources, the firm's labour demand will only be made up of the workers employed in the production of the final good.

Firm i's firm-specific union's utility function is given by:

$$U_i^h = (w_i - \overline{w})L_i^h \qquad (h\text{=}V,O, i\text{=}1,2), \qquad (7)$$

where $\overline{w}$ is the reservation wage of the union and $L_i^h = y_i \xi_i^h$ is the total employment of the downstream firm – where $\xi_i^O = \overline{l} - z_i$ and $\xi_i^V = \hat{r}_i + \overline{l} - z_i$ are the firm level per-unit employment in the two regimes. The wage is determined via the maximisation of the following Nash bargain:

$$B_i^h = \left[(w_i - \overline{w})L_i^h \right]^{\beta} \left[(p - c_i^h)y_i^h \right]^{1-\beta} \qquad (h\text{=}V,O, i\text{=}1,2), \qquad (8)$$

where $\beta \in [0,1]$ is the bargaining power parameter. The larger is β, the greater is the bargaining power of the union. Recalling that all fixed and investment costs are sunk at this stage, firms and unions take the firm level per unit employment ξ_i^h as given. Therefore, regardless of the mode-of-operation chosen by the firm, bargaining between a union-firm pair will result in a wage w_i such that:

$$w_i = \overline{w} - \frac{\beta}{2-\beta}\frac{y_i}{\partial y_i / \partial w_i}. \qquad (9)$$

From (2) and (6) we can obtain $\partial y_i / \partial w_i = -(2/3)\xi_i^h$. Combining this with (9) yields:

$$w_i^h = \overline{w} + \frac{3}{2}\frac{\beta}{2-\beta}\frac{y_i}{\xi_i^h}. \qquad (10)$$

Other things equal, and independently of the mode-of-operation of the firm, the wage increases in the bargaining power of the union. Also, as can be seen from $\partial y_i / \partial w_i$, the greater is the per-unit input requirement of unionised labour ξ_i^h, the greater is the (negative) impact on the firm's output and operating profits of an increase in wage. The lower is ξ_i^h and the larger is the output of the firm, the more the wage will increase in the bargaining power of the union. Hence, unions will moderate their wage claims more the greater is the per-unit input requirement of unionised labour. Given that

final good producer – and hence the return for relationship specific investment – is determined through Nash bargaining over the price after investment is sunk.

outsourcing reduces the latter, this result goes against conventional wisdom – which contends that outsourcing weakens the rent extraction ability of unions. An explanation for this is that when the firm outsources, the union realises that increasing its wage has less of an impact on the labour demanded by the firm; this is because the effect of domestic wages on home marginal cost is relatively less important when the firm outsources part of its production abroad, since reliance on domestic labour is lower. As a result, the union becomes more aggressive in its wage setting and the per-unit rent for the workers still employed by the firm is higher (even though the *total labour rent* extracted from this firm may well be lower, since employment of unionised labour has declined). This result arises from a complementarity between foreign and domestic employment under outsourcing that is due to the complementarity between upstream and downstream activities.[18]

Now, substituting the wage equation in (10) into (2), the marginal costs can be written as:

$$c_i^O = q_i + \overline{w}(\overline{l} - z_i) + \frac{3}{2}\frac{\beta}{2-\beta}y_i + t_i, \tag{11a}$$

if the firm outsources its intermediate, and

$$c_i^V = \overline{w}(\hat{r}_i + \overline{l} - z_i) + \frac{3}{2}\frac{\beta}{2-\beta}y_i, \tag{11b}$$

if it is vertically integrated.

If firm i outsources, the price q_i of the intermediate is determined via the maximisation of the following Nash bargain:

$$N_i = [(q_i - r^m)y_i]^\delta[(p - c_i)y_i]^{1-\delta} \quad (i=1,2), \tag{12}$$

where $\delta \in [0,1]$ is the bargaining power parameter. The larger is δ the greater is the bargaining power of the upstream firm. Bargaining between firms occurs at the same time as bargaining with unions and takes the level of investment as given; this yields:

$$q_i = r_i^m - \frac{\delta}{2-\delta}\frac{y_i}{\partial y_i / \partial q_i} = r_i^m + \frac{3}{2}\frac{\delta}{2-\delta}y_i. \tag{13}$$

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[18] This result is akin to that obtained, in a different framework, by Skaksen and Sörensen (2001) and Lommerud *et al* (2009). The role of complementarities between workers' tasks in determining the benefits to workers from fragmentation of production was first highlighted by Horn and Wolinsky (1998).

Clearly, the price of the intermediate is ceteris paribus increasing in the bargaining power of the upstream firm and in the output of the downstream firm.

3.3 Stage 2

The firms choose their investment levels simultaneously in stage 2. If the intermediate is produced in-house, then K_i is chosen to maximise operating profits net of the investment cost, i.e. $\tilde{\pi}_i^V - K_i = y_i^2 - z_i^2$. Note that $(p - c_i^V)$ and K_i have been eliminated using (5) and $K_i = z_i^2$. We can model the firm as choosing the level of cost reduction (z_i), which simplifies the algebra somewhat. The resulting first-order condition is:

$$2\left(y_i \frac{dy_i}{dz_i} - z_i \right) = 0, \tag{14}$$

which implies: $z_i^V = \sqrt{K_i^V} = y_i(dy_i/dz_i)$. It will prove convenient to write this as:

$$z_i^V = \sqrt{K_i^V} = \theta^{Vk} y_i, \quad \text{where } k=(\text{V,O}). \tag{15}$$

The first superscript in θ^{Vk} refers to the mode-of-operation of firm i, while the second one refers to the mode-of-operation of its rival. The expression for θ^{Vk} differs depending on the mode-of-operation chosen by the rival firm. The expressions for θ^{Vk} in the different regimes are reported in Section I of the Appendix.

The θ parameters can be thought of as measures of investment-to-output ratios, with the 'aggressiveness' in investment increasing in θ. As shown in Section II of the Appendix, $\theta^{VV} > \theta^{VO}$ holds for any value of β and δ. This means that outsourcing by its rival tends to reduce firm i's investment-to-output ratio. Thus, outsourcing by one firm *softens* the behaviour of its rival, i.e. it reduces the latter's aggressiveness in investment. This results in a 'strategic motive' to outsource which is explored in more depth in Leahy and Montagna (2007).

If the intermediate is outsourced, then z_i is chosen to maximise the supplier's operating profit net of the investment cost; this is given by: $\mu_i = \frac{3}{2}\frac{\delta}{2-\delta} y_i^2 - z_i^2$, where we have made use of the fact that $(q_i - r_i^m) = \frac{3}{2}\frac{\delta}{2-\delta} y_i$ from (13) and we have eliminated K_i using $K_i = z_i^2$. At the optimum: $z_i^O = \frac{3}{2}\frac{\delta}{2-\delta} y_i(dy_i/dz_i)$. This expression for optimal investment is obviously similar to that in which firm i is vertically integrated. It differs

only in that the right-hand side is now multiplied by $(3/2)[\delta/(2-\delta)]$. We can write it in compact form as:

$$z_i^O = \sqrt{K_i^O} = \theta^{Ok} y_i, \quad \text{where } k=(V,O). \tag{16}$$

The expression for θ^{Ok} depends on the mode-of-operation chosen by the rival firm. As shown in Section II of the Appendix, $\theta^{OV} > \theta^{OO}$ holds for any value of β and δ. This means that outsourcing by a firm tends to reduce the other firm's investment-to-output ratio. So, as before, outsourcing by one firm 'softens' the behaviour of its rival, i.e. it reduces the latter's aggressiveness in investment.

Investment reduces the marginal costs of final good production – and these marginal cost reductions generate rents. For $\beta>0$ and $\delta<1$, under both modes-of-operation, the investing agent (i.e. the final good producer under vertical integration or the upstream supplier under outsourcing) will appropriate only a share of these rents. Under vertical integration, the investor shares rents with the unions while, in the outsourcing case, the investor shares rents with the downstream firm. These considerations have implications for the aggressiveness of investment, as reflected in the magnitude of the θ parameters. It will be the case for all but very high values of both β and δ that $\theta^{VV} > \theta^{OV}$ and $\theta^{VO} > \theta^{OO}$, i.e. the investment-to-output ratio is higher under vertical integration than under outsourcing (this is proved in Section III of the Appendix). The intuition for this rests on a key difference between the two modes-of-operation regimes, that is: under outsourcing the effectiveness of investment in reducing the marginal cost of producing the final good is lower than under vertical integration. This is because, as the marginal cost falls (and output increases), both the price of the intermediate (q) and the wage (w) rise endogenously under outsourcing, while only the wage rises under vertical integration. Note, however, that for sufficiently high bargaining powers of both the union and the supplier (as proved in Section III of the Appendix), the investment-to-output ratio is lower under vertical integration than under outsourcing (i.e. $\theta^{VV} < \theta^{OV}$ and $\theta^{VO} < \theta^{OO}$). The intuition for this reversal is that, in this instance, the vertically integrated firm must share the rents from investment with the unions to a greater extent, thus having a lower incentive to invest; however, at the same time, under outsourcing the upstream firm retains a greater share of the returns from investment. The fact that in this case the investment-to-output ratio is lower under vertical integration than under outsourcing would seem to suggest that by contracting

out the development of the intermediate a firm might obtain a lower marginal cost of producing the final good, due to the higher input quality resulting from the higher investment under outsourcing. However, this is not the end of the story, because under outsourcing the final good firm is now suffering from the effects of rent extracting behaviour of two parties rather than one: the unions (on the remaining level of employment) and the upstream supplier. Hence, even when unions are very strong, the marginal cost under outsourcing may still be higher than under vertical integration – despite a higher investment-to-output ratio.[19]

3.4 Stage 1

The firms simultaneously choose their mode-of-operation in stage 1 of the game. To establish whether a firm will outsource or choose to be vertically integrated, we must compare its profits under the two regimes for a given behaviour of its rival. To this end, it proves useful to obtain expression for the profits in terms of outputs and parameters only. Substituting from the first-order conditions for output in (5) and the expressions for optimal investment in (15) into (3a), we can rewrite the profit function under vertical integration as:

$$\pi_i^{Vk} = (y_i^{Vk})^2 \left[1 - (\theta^{Vk})^2 \right] - G, \text{ where } k=(V,O).\tag{17}$$

Using (5) in (3b), the profit function under outsourcing can be rewritten similarly as:

$$\pi_i^{Ok} = (y_i^{Ok})^2, \quad \text{where } k=(V,O).\tag{18}$$

It is immediately obvious from (17) and (18) that a sufficient condition for $\pi^{Ok} > \pi^{Vk}$ is that $y^{Ok} \geq y^{Vk}$. The term in square bracket is less than unity and so if outsourcing results in an increase in output then it dominates vertical integration.

3.5 Effects of the mode-of-operation on wages and union rents

Before proceeding to analyse the mode-of-operation equilibria in the following section, it is useful to expand on the implications of firms' mode-of-operation for wages and union rents.

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[19] Clearly, the difference between the marginal costs in the two regimes will also depend on the underlying differences between downstream and upstream firms' costs as determined by technology and/or factor prices.

It is straightforward to show that the greater is a firm's profitability, the higher is the total rent that its union can extract. Therefore, if a change in its mode-of-operation increases the downstream firm's operating profits, then this will lead to higher total union rents. To see this, note that equation (10) implies that $(w_i^h - \overline{w})\xi_i^h = \frac{3}{2}\frac{\beta}{2-\beta}y^i$, from which it follows that $(w_i^h - \overline{w})L_i^h = \frac{3}{2}\frac{\beta}{2-\beta}\tilde{\pi}_i^h$, since substitution from (5) into the operating profits yields $\tilde{\pi}_i^h = (y_i^h)^2$. Perhaps surprisingly, however, this does not mean that a switch in the mode-of-operation that raises the downstream firm's profitability also necessarily raises the union wage. This is because the union rents per unit of labour $(w_i^h - \overline{w})$ are proportional to $\dfrac{\tilde{\pi}_i^h}{L_i^h} = \dfrac{y_i^h}{\xi_i^h}$ which is the *operating profit per unit of labour employed*. Hence, *if* output (y_i^h) were constant, then a change in the mode-of-operation that reduced the per unit labour requirement (ξ_i^h) would raise the union wage. Outsourcing of the production of the intermediate would involve such a move and, as explained earlier, would lead to the union becoming more aggressive in its wage setting behaviour.

4. The Mode-of-operation Equilibria

We turn now to a discussion of the mode-of-operation equilibria. Clearly, there are four possible candidate equilibrium regimes: (**V**,**V**), (**V**,**O**), (**O**,**V**), and (**O**,**O**), where the first letter refers to mode-of-operation selected by firm 1 and the second letter refers to the mode-of-operation of firm 2.

We begin in subsection 4.1 with what we will call the "base case", in which the firms are ex-ante symmetric and furthermore there is no underlying cost advantage or disadvantage from outsourcing. The underlying cost advantage from outsourcing is captured by $\rho_i \equiv \overline{w}\hat{r}_i - r_i^m - t$ (i=1,2) which is a measure of the difference between the marginal production cost of the intermediate for the vertically integrated firm and that for the upstream supplier.[20] Hence in the base case, in the absences of an underlying cost advantage from outsourcing, $\rho_1 = \rho_2 = 0$. In subsection 4.2, we relax the assumption that $\rho_i = 0$, in particular to consider the effects of trade liberalisation

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[20] The *underlying* (ex-ante) cost advantage from outsourcing depends only on exogenous parameters. There will of course be an *ex-post* cost difference between firms which will depend on endogenous variables such as *w* and *q* among other things.

(captured by reductions in *t*). We also wish to analyse the effect of cost asymmetries between the firms. This is done in subsection 4.3 where we allow for changes in $\phi \equiv \overline{w}(\hat{r}_2 - \hat{r}_1)$, where the parameter ϕ can be thought of as the *pre-investment* cost advantage of firm 1 under vertical integration.[21]

4.1 The base case

When firms are ex-ante symmetric and there is no underlying cost advantage from outsourcing, it can be shown (see Section V of the Appendix) that the ex-post (i.e. equilibrium) marginal cost is higher under outsourcing than under vertical integration. This result is robust to different values of the bargaining power parameters β and δ, even when, for values of both β and δ close to one, the investment-to-output ratio is higher under outsourcing than under vertical integration – a situation which, as we explained in Section 3, arises from the countervailing effects of the *double* source of rent-extraction (from both the union and the upstream supplier) in the case of outsourcing, as against the *single* source of rent extraction (the union) under vertical integration.

In the base case, it can be shown that the pattern of equilibria depends on the level of governance cost, *G*. If *G* is sufficiently large, then both firms will choose to outsource (**O,O**). At *G*=0, both firms are vertically integrated and (**V,V**) is the unique subgame perfect equilibrium. At intermediate levels of *G*, there is multiple asymmetric equilibria (**V,O**) and (**O,V**). Further details are provided in Section VI of the Appendix.

The emergence of asymmetric equilibria can be explained by the existence of a negative interdependence between the firms' mode-of-operation decisions. As we showed, due to the greater aggressiveness of domestic unions in the presence of outsourcing as well as to the additional rent extracting activity of the upstream firm, outsourcing is a higher marginal cost (in exchange for lower fixed cost) – and hence a lower output – strategy. As a result, outsourcing can be seen as a less aggressive business strategy than vertical integration. The relative incentive to choose vertical integration is larger the larger is a firm's expected output – because the lower marginal production cost then applies to a larger output. Faced with lower marginal cost

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[21] Pre-investment cost differences between the firms could also result from asymmetries in the cost of serving the final good markets – e.g. in the instance in which one firm may be further away from the final good market than the other. Similarly, the effect of differential protectionist policies (should the firms be located in different countries) could also be incorporated into ϕ.

vertically integrated rivals, a firm will then have a lower anticipated market share and hence a lower incentive to vertically integrate than a firm that faces an outsourced rival. However, a firm facing an outsourcing (higher marginal cost) rival, will have a greater incentive to vertically integrate because it has a higher anticipated output (and hence will benefit more from a lower marginal production cost). Over a range of G, outsourcing is a best response to a rival's vertical integration but vertical integration is a best response to a rival's outsourcing. This result is analogous to that obtained in Leahy and Montagna (2009a,b) in a model without unions and with an endogenous choice of the mode of internationalisation. It is thus clear that the economizing and strategizing dimensions are entwined in determining the mode-of-operation decision of firms.[22]

It can be shown that whilst the order of equilibrium regions with respect to G is invariant to changes in the value of the bargaining power of unions (β) and of the upstream supplier (δ), the range of G over which outsourcing occurs in equilibrium increases in β and falls in δ. The effect of β is consistent with the conventional wisdom that strong union power may encourage outsourcing as a 'means-to-escape-unions' behaviour – even though this may result in higher wages for the workers who remain in domestic employment. As for the bargaining power of the supplier, a higher δ clearly reduces the share of rents available to the downstream firm under outsourcing and hence ceteris paribus increases incentives to vertically integrate.

4.2 Cost advantages of outsourcing and trade liberalisation

In this subsection, we again assume that the downstream firms are ex-ante symmetric and their prospective upstream partners are also ex-ante symmetric but we allow for the upstream and downstream firms to differ in their underlying costs, i.e. we allow for $\rho_i \equiv \overline{w}\hat{r}_i - r_i^m - t \neq 0$. This difference, which could arise from local differences in factor prices and/or technology, may also be affected by changes in trade costs t, with ρ increasing as t falls. Since we maintain the symmetry across firms at the same level in the production chain, $\rho = \rho_1 = \rho_2$. The ranking of equilibria with respect to the governance costs of vertical integration are the same regardless of ρ, the underlying cost advantage of the upstream producers. The resulting mode-of-operation regimes are illustrated in Figure 1 below. In the figure, the downward sloping curves are

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[22] This aspect is analysed in more detail in Leahy and Montagna (2009b).

indifference loci for the firm, giving combinations of G and ρ at which the firm is indifferent between vertical integration and outsourcing given the mode of operation of its rival. Above a locus, given the mode-of-operation of its rival, a firm would choose to outsource, and below the locus it would prefer vertical integration. Along the lower locus ($\pi_i^{VV} = \pi_i^{OV}$), firm i is indifferent between vertical integration and outsourcing when its rival is vertically integrated, while along the upper locus ($\pi_i^{VO} = \pi_i^{OO}$), the firm is indifferent between the modes-of-operation when its rival outsources.
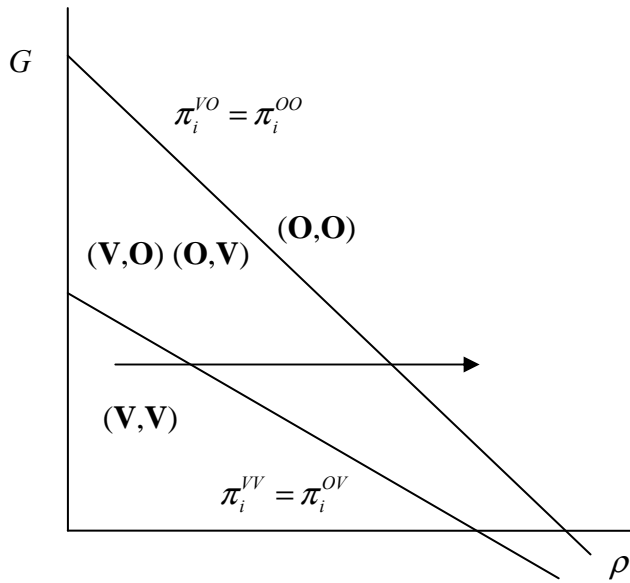

Figure 1: Cost advantages of outsourcing and trade liberalisation

It is clear from Figure 1 that trade liberalisation, by reducing the cost of importing the outsourced intermediate, increases the range of parameter values over which outsourcing is chosen. In the figure, trade liberalisation is captured by a rightwards movement at constant G (see the arrow representing the direction of increasing trade liberalisation). If G is sufficiently low, trade liberalisation moves us from (**V,V**) to the region of multiple equilibria (**V,O**) and (**O,V**), and then on to the region of (**O,O**).[23]

4.3   Cost asymmetries between downstream firms

So far we have assumed that the final goods firms are *ex ante* symmetric. However, since there is ample empirical evidence documenting the importance of intra-industry

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[23] Qualitatively, the effects of changes in β and δ on the equilibrium regions are the same as those discussed in sub-section 4.1 above.

cost and technology differences between firms,[24] it is interesting to examine the effects of underlying cost differences in firms for their propensity to outsource.

We find that, ceteris paribus, the higher cost firms are the ones that are more likely to choose to outsource. In Figure 2, where the first superscript in the labels of the indifference profit loci refers to firm 1 and the second refers to firm 2, we have set $\rho = \rho_1 = \rho_2 = 0$ (so that upstream firms have no cost advantage or disadvantage over downstream firms) and have allowed ϕ to increase: as this happens, the cost advantage of firm 1 over firm 2 gets larger.

G

$\pi_1^{VO} = \pi_1^{OO}$

$\pi_1^{VV} = \pi_1^{OV}$

(O,O)

(V,O)

(V,O)
(O,V)

(V,O)

(V,O)

$\pi_2^{OV} = \pi_2^{OO}$
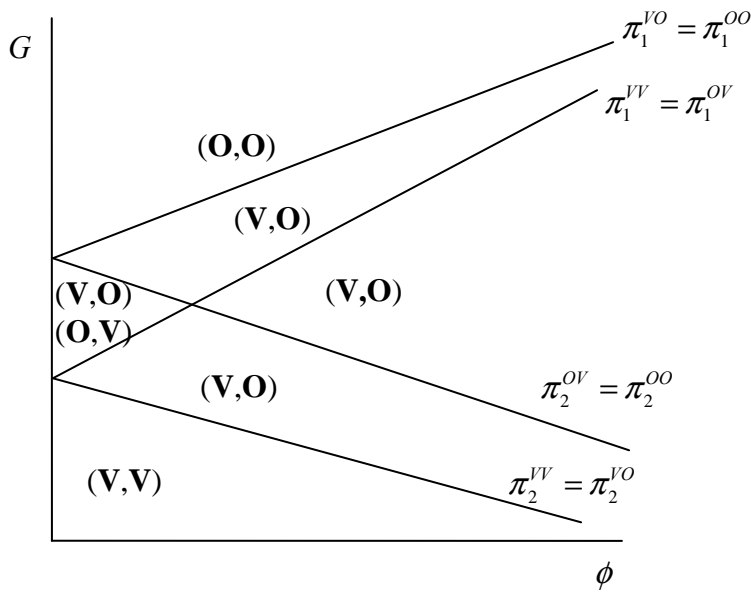
(V,V)

$\pi_2^{VV} = \pi_2^{VO}$

ϕ

Figure 2: Downstream cost asymmetries

As is clear from the figure, the region of (**V,O**) in which the first firm is vertically integrated while the, now higher cost, second firm outsources gets larger in ϕ. These results are consistent with the view emerging from our analysis that outsourcing represents a less aggressive business strategy than vertical integration.

5.   Concluding Remarks

We have used a unionised oligopoly model to examine how the strategic interaction between firms and between firms and unions determine the effects of unionisation on the incentive to outsource and the effect of outsourcing on investment and firms' efficiency.

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[24] See for instance Bartelsman and Doms (2000) for a survey of evidence.

We found that outsourcing can increase the aggressiveness of unions when not all unionised production tasks are outsourced. The reason for this is that the impact of domestic wages on a firm's marginal cost is relatively less important when the firm outsources part of its production abroad, because reliance on domestic labour is lower. Thus, while an increase in the bargaining power of unions will typically result in more outsourcing (and this is consistent with the view that foreign procurement of intermediate inputs may be used as a means to escape powerful unions), an increase in outsourcing will – other things equal – increase the wage that firms will pay on the (remaining) domestically employed labour. In addition to increasing the aggressiveness of domestic unions, outsourcing exposes the firm to a second hold-up problem due to its dependence on an upstream supplier. As a result, outsourcing is likely to lead to an increase in the marginal production cost of the downstream firm – even if there are substantial underlying cost advantages of the foreign supplier in producing the intermediate or when the investment-to-output ratios are higher under outsourcing than under vertical integration (as is the case for very high bargaining powers of unions and of the upstream supplier). Thus, if marginal costs are higher under outsourcing, firms' mode-of-operation choice involves a trade-off between this and the higher governance cost associated with vertical integration.

We also showed that by reducing the relative cost of procuring intermediates abroad, trade liberalisation increases the degree of outsourcing. Depending on the level of governance costs, it can change the equilibrium from one in which all firms vertically integrate, to an asymmetric one in which firms choose different modes-of-operation, to an equilibrium in which all firms outsource.

Finally, we showed that asymmetric equilibria (in which firms choose different modes-of-operation) emerge even when firms are ex-ante identical. In addition, in the presence of ex-ante cost asymmetries between firms, the relatively less productive firms are shown to be the ones that are more likely to choose to outsource and, in line with some of our earlier research, outsourcing could then be seen as a less aggressive business strategy than vertical integration.

Our model suggests that labour market deregulation policies aimed at reducing unions' power may result in less outsourcing and also in lower union wages. Our results provide a rationale for the stylised fact that, as highlighted in the introduction, outsourcing does not unambiguously lead to a reduction of a firm's marginal costs. They also help to explain why – even within the same industry – technologically similar

firms adopt different modes-of-operation (for instance, in the highly oligopolistic aerospace industry, outsourcing though increasing at Airbus still lags behind that of its rival Boeing).

Appendix

I.   The parameter θ in the different regimes

From (15) and (16), it is clear that the optimal z is proportional to output. So, it is possible to write the expression for investment in a general form as:

$$z_i^{hk} = \theta^{hk} y_i^{hk}, \qquad\qquad (A1)$$

where the first superscript refers to the mode-of-operation of firm i and the second refers to the mode-of-operation of its rival. The parameter θ takes on a different value depending on the mode-of-operation of the firm and that of its rival. When firm i is vertically integrated, we have $\theta^{Vk} = dy_i^{Vk} / dz_i$ for ($k=V,O$) and when firm i is outsourcing we get $\theta^{Ok} = (3/2)[\delta/(2-\delta)]dy_i^{Ok} / dz_i$ for ($k=V,O$).

To obtain an expression for dy_i / dz_i, differentiate (6) to get:

$$\frac{dy_i^{hk}}{dz_i} = \frac{1}{3}\left(-2\frac{dc_i^h}{dz_i} + \frac{dc_j^k}{dz_i}\right) \qquad (h=V,O \text{ and } k=V,O). \qquad (A2)$$

When firm i is vertically integrated, its marginal cost takes the form of (11b). Differentiation of (11b) with respect to z_i yields:

$$\frac{dc_i^V}{dz_i} = -\overline{w} + \frac{3}{2}F^V\frac{dy_i^{Vk}}{dz_i}, \qquad \text{where } F^V \equiv \frac{\beta}{2-\beta} \quad \text{and } (k=V,O). \qquad (A3)$$

When firm i is involved in outsourcing its marginal cost takes the form of (11a) with q_i eliminated using (13). Differentiation of this with respect to z_i yields:

$$\frac{dc_i^O}{dz_i} = -\overline{w} + \frac{3}{2}F^O\frac{dy_i^{Ok}}{dz_i} \quad \text{where } F^O \equiv \frac{\beta}{2-\beta} + \frac{\delta}{2-\delta} \quad \text{and } (k=V,O) \qquad (A4)$$

So, in general, we can write: $dc_i^h / dz_i = -\overline{w} + \frac{3}{2}F^h(dy_i^{hk} / dz_i)$ for ($h,k=V,O$). Similarly, the general expression for the effect of z_i on the rival firm's costs is: $dc_j^k / dz_i = \frac{3}{2}F^k(dy_j^{hk} / dz_i)$ for ($h,k=V,O$).

I.1   Firm i is vertically integrated

To find θ^{Vk}, we first need to find (dy_i^{Vk} / dz_i) for $k=(V,O)$. Substitution of (A3) and the general expression for dc_j^k / dz_i into (A2) yields:

$$\frac{dy_i^{Vk}}{dz_i} = \frac{1}{3}\left\{-2\left(-\overline{w} + \frac{3}{2}F^V \frac{dy_i^{Vk}}{dz_i}\right) + \frac{3}{2}F^k \frac{dy_j^{Vk}}{dz_i}\right\} = \frac{2}{3}\overline{w} - F^V \frac{dy_i^{Vk}}{dz_i} + \frac{1}{2}F^k \frac{dy_j^{Vk}}{dz_i}. \qquad \text{(A5)}$$

We also need an expression for dy_j^{Vk}/dz_i. Adopting an approach analogous to that we used to derive (A5), it is straightforward to show that:

$$\frac{dy_j^{Vk}}{dz_i} = -\frac{1}{3}\overline{w} - F^k \frac{dy_j^{Vk}}{dz_i} + \frac{1}{2}F^V \frac{dy_i^{Vk}}{dz_i} \qquad \text{(A6)}$$

Combining (A5) and (A6) yields:

$$\theta^{Vk} = \frac{dy_i^{Vk}}{dz_i} = \frac{\frac{2}{3} + \frac{1}{2}F^k}{1 + F^V + F^k + \frac{3}{4}F^V F^k}\overline{w} \qquad \text{for } k=(V,O) \qquad \text{(A7)}$$

I.2   Firm i is outsourcing

When firm i is outsourcing we need an expression for dy_i^{Ok}/dz_i. To obtain such an expression use (A4) and the general expression for dc_i^h/dz_i in (A2) to get:

$$\frac{dy_i^{Ok}}{dz_i} = \frac{2}{3}\overline{w} - F^O \frac{dy_i^{Ok}}{dz_i} + \frac{1}{2}F^k \frac{dy_j^{Ok}}{dz_i}. \qquad \text{(A8)}$$

This is clearly analogous to (A5) with O replacing V in the expression. So, following the same procedure as before, combine this with: $\dfrac{dy_j^{Ok}}{dz_i} = -\dfrac{1}{3}\overline{w} - F^k \dfrac{dy_j^{Ok}}{dz_i} + \dfrac{1}{2}F^O \dfrac{dy_i^{Ok}}{dz_i}$

and substitute into $\theta^{Ok} = (3/2)[\delta/(2-\delta)]dy_i^{Ok}/dz_i$ to get:

$$\theta^{Ok} = \frac{dy_i^{Ok}}{dz_i} = \frac{3}{2}\frac{\delta}{2-\delta}\left(\frac{\frac{2}{3} + \frac{1}{2}F^k}{1 + F^O + F^k + \frac{3}{4}F^O F^k}\right)\overline{w} \qquad \text{for } k=(V,O). \qquad \text{(A9)}$$

II.   Outsourcing by a firm lowers the investment-to-output ratios of its rival

Demonstrating that $\theta^{VV} > \theta^{VO}$ and $\theta^{OV} > \theta^{OO}$ hold for all values of β and δ is straightforward. Use (A7) to get an expression for $(\theta^{VV} - \theta^{VO})$. It is convenient to simplify the notation and write: $\frac{1}{\overline{w}}\theta^{VV} = R/S$ where $R = \frac{2}{3} + \frac{1}{2}F^V$ and $S = 1 + 2F^V + \frac{3}{4}(F^V)^2$. Similarly, using this notation, we can write:

$\frac{1}{w}\theta^{VO}=[R+\frac{1}{2}D]/[S+D(1+\frac{3}{4}F^{V})]$, where $D=\frac{\delta}{2-\delta}$. Then:

$$\frac{1}{w}\left(\theta^{VV}-\theta^{VO}\right)=D\frac{R(1+\frac{3}{4}F^{V})-\frac{1}{2}S}{S[S+D(1+\frac{3}{4}F^{V})]} \tag{A10}$$

The denominator of (A10) and the parameter D are clearly positive and the numerator reduces to $R(1+\frac{3}{4}F^{V})-\frac{1}{2}S=(\frac{2}{3}+\frac{1}{2}F^{V})(1+\frac{3}{4}F^{V})-(\frac{1}{2}+F^{V}+\frac{3}{8}(F^{V})^{2})=\frac{1}{6}>0$. From (A9), analogous calculations can be used to demonstrate that $\frac{1}{w}\left(\theta^{OV}-\theta^{OO}\right)>0$.

III. Investment-to-output ratios are lower under outsourcing except for high β and δ

We need to compare θ^{Vk} and θ^{Ok}. As above, it is helpful to simplify the notation and write: $\frac{1}{w}\theta^{Vk}=R'/S'$ where $R'=\frac{2}{3}+\frac{1}{2}F^{k}$ and $S'=1+F^{V}+F^{k}+\frac{3}{4}F^{V}F^{k}$. Similarly, we can write: $\frac{1}{w}\theta^{Ok}=\frac{3}{2}(DR')/[S'+D(1+\frac{3}{4}F^{k})]$ where $D=\frac{\delta}{2-\delta}$. Then:

$$\frac{1}{w}\left(\theta^{Vk}-\theta^{Ok}\right)=R'\frac{S'(1-\frac{3}{2}D)+D(1+\frac{3}{4}F^{k})}{S'[S'+D(1+\frac{3}{4}F^{k})]}. \tag{A11}$$

The denominator of (A11) and the parameter R' are clearly positive and the numerator is guaranteed to be positive for $D<\frac{2}{3}$ or, equivalently, $\delta<\frac{4}{5}$. Even if $\delta=1$, θ^{Vk} is still larger than θ^{Ok} unless β is also very high. To see this, let $\delta=1$. Then it follows that $D=1$, and the numerator becomes: $(\frac{1}{2}+\frac{1}{4}F^{k})-F^{V}(\frac{1}{2}+\frac{3}{8}F^{k})$ which is positive if and only if: $F^{V}<\frac{(1+\frac{1}{2}F^{k})}{(1+\frac{3}{4}F^{k})}$. Since F^{k} cannot exceed 2 by definition, a value of F^{V} close to unity – and thus a value of β close to unity – is required for θ^{Ok} to exceed θ^{Vk}. But note that if both β and δ are unity, then $F^{V}=1$ but $(1+\frac{1}{2}F^{k})/(1+\frac{3}{4}F^{k})<1$ and so in that interesting case: $\theta^{Ok}>\theta^{Vk}$.

IV. Reduced form equilibrium output expressions in the different regimes.

Combining (5) and (1), the first-order condition for output of a typical firm can be written in general form as:

$$a-c_{i}^{hk}-2y_{i}-y_{j}=0 \quad (i,j=1,2) \text{ and } (i\neq j) \quad h, k=(V,O) \tag{A12}$$

where c_{i}^{hk} is the marginal cost for firm i when it chooses mode-of-operation $h=(V,O)$ and its rival chooses mode-of-operation $k=(V,O)$. From the expression for the wage in

(10), the labour component of firm i's marginal cost is: $w_i^h \xi_i^h = \overline{w} \xi_i^h + \frac{3}{2} \frac{\beta}{2-\beta} y_i$ and from (13) the intermediate good's price it must pay under outsourcing is: $q_i = r_i^m + \frac{3}{2} \frac{\delta}{2-\delta} y_i$. Both of these depend on the firms' outputs. Making use of these relationships and the expression for investment in (A1), we can rewrite the first-order condition for firm i in general form as

$$A_i^h - 2y_i - y_j + \eta^{hk} y_i = 0 \qquad (i,j=1,2) \text{ and } (i \neq j) \quad h, k=(V,O) \qquad (A13)$$

where $\eta^{Vk} \equiv \overline{w} \theta^{Vk} - \frac{3}{2} F^V$ and $\eta^{Ok} \equiv \overline{w} \theta^{Ok} - \frac{3}{2} F^O$, with the first superscript referring to the mode-of-operation (V,O) of firm i and the second superscript to that of its rival. The parameters $A_i^V = a - \overline{w}(\hat{r}_i + \overline{l})$ and $A_i^O = a - (r_i^m + \overline{w}\overline{l} + t)$ only depend on the firm's own mode-of-operation. It is useful to use $\rho_i = \overline{w}\hat{r}_i - r_i^m - t$ $(i=1,2)$ and $\phi \equiv \overline{w}(\hat{r}_2 - \hat{r}_1)$ to write: $A_1^O = A_1^V + \rho_1$, $A_2^V = A_1^V - \phi$ and $A_2^O = A_1^V - \phi + \rho_2$.

From the equations for firm i an j in (A13), we can obtain the reduced form equilibrium output expressions for the two firms:

$$y_i^{hk} = \frac{(2-\eta^{kh})A_i^h - A_j^k}{3 - 2(\eta^{hk} + \eta^{kh}) + \eta^{hk}\eta^{kh}} \qquad (i,j=1,2) \text{ and } (i \neq j) \quad h, k=(V,O) \qquad (A14)$$

The reduced form expression for industry output is thus:

$$\overline{y}^{hk} = \frac{(1-\eta^{kh})A_i^h + (1-\eta^{hk})A_j^k}{3 - 2(\eta^{hk} + \eta^{kh}) + \eta^{hk}\eta^{kh}} \qquad (i,j=1,2) \text{ and } (i \neq j) \quad h, k=(V,O). \qquad (A15)$$

V. Demonstrating that in the base case that marginal costs are higher under outsourcing than vertical integration

In the base case, $A_i^h = A_j^k$ and hence industry output reduces to

$\overline{y}^{hk} = \frac{(2-\eta^{kh} - \eta^{hk})A_i^h}{3 - 2(\eta^{hk} + \eta^{kh}) + \eta^{hk}\eta^{kh}}$. It is straightforward to show that this is increasing in

η^{hk} and η^{kh} for all values of η consistent with stable interior solutions. Since $\eta^{VV} > \eta^{VO} > \eta^{OV} > \eta^{OO}$, it follows that $\overline{y}^{VV} > \overline{y}^{VO} = \overline{y}^{OV} > \overline{y}^{OO}$ regardless of the level of β and δ. Now, using (6) we find that: $\overline{y}^{hk} - \overline{y}^{rs} = \frac{1}{3}\{(c_1^{rs} - c_1^{hk}) + (c_2^{rs} - c_2^{hk})\}$ for $(h,k= V,O)$ and $(r,s=V,O)$. It is then easy to show that: $2c_1^{VV} = 2c_2^{VV} < (c_1^{VO} + c_2^{VO}) < 2c_1^{OO} = 2c_2^{OO}$ (here the first superscript refers to firm 1 and the second to firm 2). Combining this with the fact that $c_1^{VO} < c_2^{VO}$, it then follows that $c_i^{OO} > c_i^{VV}$, $c_i^{OO} > c_i^{VO}$, $c_i^{OV} > c_i^{VV}$ and $c_i^{OV} > c_i^{VO}$

(for $i=1,2$). Hence, ex-post equilibrium marginal costs in the base case are higher under outsourcing than under vertical integration.

VI. Equilibria in the fully symmetric base case

In the base case, the firms are *ex ante* symmetric and there is no underlying cost advantage from outsourcing. In that case, both firms choosing to vertically integrate is the unique subgame perfect Nash equilibrium at $G=0$. Using (17) and (18), it is clear that this requires that:

$$(y_i^{Vk})^2 \left[1 - (\theta^{Vk})^2\right] > (y_i^{Ok})^2 \quad (i,j=1,2) \text{ and } (i \neq j) \quad k=(V,O) \qquad (A16)$$

Taking the square root of both sides and making use of the reduced form expressions for output in (A14), this condition becomes:

$$\frac{\sqrt{1-(\theta^{Vk})^2}(1-\eta^{kV})A}{3-2(\eta^{Vk}+\eta^{kV})+\eta^{Vk}\eta^{kV}} - \frac{(1-\eta^{kO})A}{3-2(\eta^{Ok}+\eta^{kO})+\eta^{Ok}\eta^{kO}} > 0 \quad k=(V,O) \qquad (A17)$$

where $A_i^V = A_j^V = A_i^O = A_j^O = A$ as $\rho_i = \rho_j = \phi = 0$ in the base case. It can be shown that the condition in (A17) holds for all parameters consistent with stable interior solutions in all equilibria. It can also be shown that in the base case the difference in (A17) is strictly larger when the rival firm outsources. Hence, at any given G, the gain in profit from vertical integration relative to outsourcing is larger when the rival is outsourcing. Thus, there exists a non empty set of G such that:

$$(y_i^{VO})^2\left[1-(\theta^{VO})^2\right]-(y_i^{OO})^2 > G > (y_i^{VV})^2\left[1-(\theta^{VV})^2\right]-(y_i^{OV})^2 > 0 \quad (i,j=1,2) \qquad (A18)$$

For levels of G within this range, a firm will find it more profitable to be vertically integrated if its rival is outsourcing, but more profitable to be outsourcing if its rival is vertically integrated. Hence, for this region of G there are multiple asymmetric equilibria (**VO**) and (**OV**). Clearly, for $G > (y_i^{VO})^2\left[1-(\theta^{VO})^2\right]-(y_i^{OO})^2$, firms will always wish to outsource; hence (**OO**) is the unique equilibrium.

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