Integration or Outsourcing: Combining Ex Ante Distortions and Ex Post Inefficiencies

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Abstract

Final good production often requires a firm's headquarter services and a foreign supplier's manufacturing input. With incomplete contracts, firms that decide whether to source this input from an integrated or an outsourced supplier do not only have to consider the ex ante production incentives that influence the own and the supplier's underinvestment problem. Instead, firms also have to take into account the ex post risk that the supplier absorbs the producer's knowledge to become a competitor for the final good, both under outsourcing and integration. In line with the outcome of the knowledge protection approach, with an exogenous probability of such ex post inefficiencies associated with one particular organizational form, this organizational form becomes less likely. However, considering the supplier's incentives to become a competitor, integrated suppliers are more likely to become a competitor than outsourced suppliers such that outsourcing becomes per se more likely. As a competitor lowers the producer's profit, the producer might have an incentive to deter the supplier from becoming a competitor. More precisely, the producer has this incentive whenever the supplier's manufacturing input is not too important for the production.

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1 Introduction

To save production costs, firms often choose suppliers located in countries with weak protection of intellectual property rights in their production process. However, in those countries, production may be associated with high indirect ex post costs in the sense that firms there often face the risk that suppliers absorb the producer's knowledge and use it to defect and to become a competitor for the producer's final good. Ed Haddad, Vice President of *New Balance* stated the problem as following: "Once you teach them how to make it, anyone could do it. It could happen to any of our suppliers anywhere in the world."

And there are plenty of examples for firms whose knowledge has been absorbed and used by suppliers, as I will illustrate in detail in section 2. This risk concerns on the one hand firms that use suppliers for the production of the whole final good, as for example *New Balance* and *Schwinn/Giant*. On the other hand, this risk also emerges for firms whose suppliers are only responsible for the production of intermediate goods; consider the examples of *Apple* or *Palm*.

It is often assumed that such a risk of creating a competitor only emerges with an unaffiliated, outsourced supplier. For example, Blanas and Seric (2014) show in a study with 19 sub-Saharan-African countries that intra-firm trade is positively related to concerns over knowledge appropriation. However, there is evidence, as the examples of *Intel* and *SAP*, that knowledge leakage occurs also within the boundaries of the firm. In general, more than 70% of the firms that are in the "Inc 500", an index of young and fast-growing firms, were founded through replication or modification of an idea related to the founder's previous employment.

The effect of this risk of supplier defection on firms' organizational decisions is analyzed in the knowledge protection approach to the organization of firms. This approach builds on the nonexcludability of knowledge to explain a firm's ownership decision. According to Ethier (1986), "the basic consideration working against the outsourcing alternative is the fact that in order to sell its information for its full value, the firm must convincingly indicate what it has to sell, thereby losing, at least in part, its monopoly advantage." Hence the baseline trade-off is between the risk of knowledge absorption and of the supplier becoming a competitor associated with outsourcing and the lower costs of an outsourced supplier.[1] In other words, the trade-off in the knowledge protection approach considers the ex post inefficiencies of knowledge. However, since only suppliers of whole final goods are considered within this approach, it cannot be used to describe the cases - as for example the case of *Apple* - where suppliers of *intermediate inputs* become competitors.

Suppliers of intermediate inputs are included in the property rights approach to the organization on firms that, however, does not cover concerns of knowledge leakage. Instead, the approach relies on incomplete contracts à la Grossman and Hart (1986) and Hart and Moore (1990) where inputs are assumed to be noncontractible and relationship-specific such that underinvestment problems arise -

[1] This trade-off is analyzed and further extended in Ethier (1986), Ethier and Markusen (1996), Markusen (2001), Fosfuri, Motta and Rønde (2001) and Glass and Sagi (2002).

both under outsourcing and integration. Outsourced and integrated suppliers are only assumed to differ with regard to their property rights and, thus, their production incentives such that the degree of the underinvestment problems depends on the chosen organizational form. The central trade-off underlying the decision is between minimizing the own underinvestment problem vis-à-vis the supplier's underinvestment problem and concerns investment distortionts ex ante to production.[2]

To better understand firm's organizational decisions in the precense of concerns of knowledge absorption it is therefore straightforward to combine these two approaches such that both ex ante distortions and ex post inefficiencies are considered. The models by Chen, Horstmann and Markusen (2012) and by Markusen and Xie (2014) are the first steps in this direction. The trade-off underlying these two papers is between the ex post inefficiencies regarding the production incentives under outsourcing and integration and the ex post risk of defection associated with outsourcing only. These models can therefore also explain the organizational decisions of firms like *Apple* or *Palm* that employ outsourced suppliers for the production of intermediate inputs, however, they are still inappropriate to explain those cases as *Intel* or *SAP* where knowledge absorption takes place within the boundaries of the firm. To also explain those cases, I assume that the risk of knowledge absorption and supplier defection takes place both under outsourcing *and integration*. Hence, I combine the ex ante distortions of investment incentives of the property rights approach and the ex post risk of the knowledge protection approach under *both* organizational forms. In doing so, I analyze in how far the consideration of ex post inefficiencies changes a firm's organizational decision resulting from the ex ante distortions of production, i.e., the baseline outcome of the property rights approach.

For this analysis I consider a firm that produces a final good using headquarter services and a manufacturing input. Whereas the firm can produce the headquarter services on her own, the manufacturing input is provided by a supplier that can be either integrated or outsourced. Organizational decisions are made in the above described environment of incomplete contracts used in the property rights approach, however, over two periods. In the first period the producer is a monopolist for the final good. During this period, the supplier can observe the producer's headquarter services and may use this knowledge to defect in the next period and produce the final good on his own such that a duopoly arises. As a result, the producer takes in her organizational decision at the beginning of the first period both the ex ante production distortions and the ex post risk of a duopoly into account.

In the absence of aspects of ex ante inefficiencies, the baseline result of the property rights approach emerges and the respective more important supplier receives more production incentives. Since outsourcing implies a higher supplier revenue share than integration, outsourcing is chosen in manufacturing-intensive production processes. Vice versa, in headquarter-intensive production processes where the producer is more important for the production, integration is chosen as this gives higher production incentives to the producer than outsourcing.

[2] Important contributions to the property rights approach are made by Antràs and Chor (2013), Schwarz and Suedekum (2014), Antràs (2005, 2003), Antràs and Helpman (2004) and Grossman and Helpman (2004, 2002).

I then introduce the risk of knowledge absorption and a duopoly. In doing so, I first assume an exogenously given probability of a duopoly and analyze the effect on the headquarter-intensity that separates manufacturing-intensive from headquarter-intensive production processes. If the risk is only associated with either integration or outsourcing, only the expected profits of this organizational form are reduced and the respective organizational form becomes less likely. This is in line with the key result of the original knowledge protection approach that a higher probability associated with outsourcing makes outsourcing less likely. If both integration and outsourcing are associated with the knowledge risk, the profits of both organizational form are reduced and it depends on the level of the probabilities whether integration or outsourcing becomes less likely.

Since a supplier will only become a competitor if this implies having higher profits than as supplier, I then internalize the probability of ex post inefficiencies. As an integrated supplier receives a lower revenue share than an outsourced supplier, becoming a competitor implies a larger increase of the revenue share under integration than under outsourcing. As a result, an integrated supplier is more likely to become a competitor. Stated differently, integration is associated with a higher risk of a duopoly than outsourcing. Hence, contrary to the outcome of the knowledge protection approach, in my setup, the risk of a duopoly makes outsourcing *more* likely.

If the supplier has an incentive to become a competitor and a duopoly arises, the producer is worse off than in monopoly. I can then analyze for those possible duopoly cases whether the producer will pay a transfer to the supplier to avoid him from becoming a competitor. Interestingly, due to the incompleteness of contracts, this is only profitable if the supplier is not too important for the production.

The rest of this paper is organized as follows: Section 2 gives a more detailed illustration of the different examples. In section 3, I introduce the structure of my model. I then analyze the resulting organizational decisions under exogenously given probabilities in section 4. In section 5, I analyze a supplier's incentive to become a competitor and the effect on the producer's organizational decision. Section 6 provides an analysis whether the producer can prevent the duopoly through a transfer payment. Section 7 concludes and summarizes the main results of the analysis.

2 Examples of ex post inefficiencies

The risk of ex post inefficiencies, i.e., the risk that a supplier absorbs the producer's knowledge and uses it to become a competitor, is prevalent both for suppliers that produce the whole final good and suppliers that produce only intermediate inputs.

New Balance and *Schwinn/Giant* are examples for firms that made this experience when they sourced the complete production to suppliers. *New Balance*, an UK shoe manufacturer, had a taiwanese supplier to serve the taiwanese and chinese market. However, instead of only serving these markets, suddenly low-price *New Balance* shoes showed up in Japan, Western Europe and even in the U.S. In other words, the supplier tried to compete with *New Balance* on markets he

was not allowed to produce for. *Schwinn*, a US bicycle firm decided in the 1970s to outsource parts of it production as original equipment manufacturer to *Giant*. After a strike in its production facility, *Schwinn* moved all of its production to *Giant*. This enabled *Giant* to gain the knowledge necessary to build complete bicycles and to get to know the market. 1986, *Giant* then started its own production and became a competitor to *Schwinn*.

That a supplier can also become a competitor for the final good if he only produces an intermediate input show the examples of *Apple* and *Palm*. As *Apple* decided to be an "innovative design company", it outsourced many of its critical components. For example, among other inputs, *Apple* outsourced the production of screens for the iPad series to *Samsung*. *Samsung* used the knowledge about the critical components to become a competitor of *Apple*. For the production of its phones, *Palm* used *HTC* as original design manufacturer for the mechanical and electrical design. With this gained knowledge, *HTC* also became a phone producer and in the meantime has a much larger market share than *Palm*.

Importantly, this problem is not only relevant under outsourcing but also within the boundaries of the firm. Consider, for example, the case of the microprocessor manufacturer *Intel*. *Intel* was founded by two former workers of *Fairchield* - the general manager and the head of R&D. And it was founded shortly after one of the R&D workers at *Fairchild* has discovered the silicon-gate technique to produce semiconductor memory devices. At this crucial point in time, the two took not only the knowledge but also some workers with them. Whereas *Intel* is still very successful, *Fairchild* has only low relevance. Another example is the german software corporation *SAP* that has become popular for her software for the management of business operations and customer relations. *SAP* was founded by five former employees of the US consulting and IT corporation *IBM* who were developing a management software. When *IBM* received a comparable software from another firm, the employees decided to leave their employer and use the knowledge to develop their own competing management software.

3 The model

3.1 Technology and demand

I consider a firm that produces a final good y for which two inputs are required: Headquarter services h which are produced by the producer herself and a manufacturing component m which is provided by a foreign supplier. Headquarter services and the manufacturing component are combined to the final good y_H using a Cobb-Douglas production function:

$$y_H = \theta_H \left(\frac{h}{\eta_H}\right)^{\eta_H} \left(\frac{m}{(1-\eta_H)}\right)^{(1-\eta_H)} \tag{1}$$

where θ_H denotes the firm's productivity and $\eta_H \in (0,1)$ stands for the industry-specific headquarter-intensity of production, i.e., the importance of headquarter services in the production of the final

good. On the demand side, the firm faces an iso-elastic demand:

$$p = (A/Y)^{1-\alpha}\,. \tag{2}$$

Within this equation, p is the price of the final good. This price depends on a demand shifter $A > 1$, the elasiticity of demand $1/(1-\alpha)$ (with $\alpha \in (0,1)$) and the total production of the final good Y. As I will explain below, this level of total production, Y, depends on the market structure, i.e. on whether the producer is a monopolist for the final good or whether he has a competitor. Combining equations (1) and (2), the revenue of the firm is given by

$$R = p\, y_H = p\, \theta_H \left[\left(\frac{h}{\eta_H}\right)^{\eta_H} \left(\frac{m}{(1-\eta_H)}\right)^{(1-\eta_H)}\right]. \tag{3}$$

As the revenue depends on the price of the final good, a firm's revenue also depends on the market structure.

3.2 Structure of the game

The scope of the analysis in this paper is the organizational decision of the producer with regard to her supplier, i.e., whether she decides to source the manufacturing input from a supplier that is integrated within the boundaries of the firm or from an outsourced, unaffiliated supplier.

In line with the *property rights approach* to the organization of firms, this organizational decision is made in an environment of incomplete contracts as modeled by Grossman and Hart (1986) and Hart and Moore (1990). That is, I assume that the producer's and her supplier's investments are noncontractible in the sense that they can neither be specified ex ante in a contract nor verified by a third-party ex post. Due to this noncontractability, the parties bargain after the production over the distribution of the surplus. As the producer and her supplier anticipate this bargaining and provide relationship-specific inputs, both parties have an incentive to underinvest such that ex ante distortions of the production incentives arise. Importantly, the bargaining and, thus, the underinvestment are assumed to take place both under outsourcing *and* integration. However, the level of the underinvestment problem and, thus, of the ex ante distortions depends on the level of the production incentives and, thus, on the chosen organizational form of the supplier: Since an integrated supplier is basically an employer of the firm and has no property rights over his manufacturing input, he has a lower threat potential and lower production incentives than an outsourced supplier who has the property rights over his input. As a result, the producer has a higher threat potential and more production incentives if the supplier is integrated than if he is outsourced.

As the examples illustrated in the previous section show, employing a supplier also implies a risk of creating a competitor, i.e., of a duopoly. To include this risk of ex post inefficiencies inherent in the

knowledge protection approach, I consider a setup with two periods, "period 1" and "period 2",[3] where the producer chooses the organizational form that maximizes her profit over *both* periods. This two-periods-setup is depicted in figure 1: In period 1, the producer is a monopolist for the final good. However, in this period the supplier does not necessarily only produce his manufacturing input. Instead, he can also absorb the knowledge how to produce headquarter services. In period 2, he can use this knowledge to become a competitor to the producer such that a duopoly might arise. Contrary to the previous literature, I assume that this risk is not only prevalent if the producer employs an outsourced supplier, as in the examples of *Apple* or *Palm*. Instead, as the examples of *Intel* and *SAP* shows, a duopoly might also arise under integration.

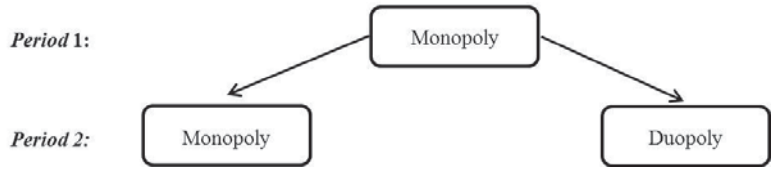

Figure 1: Overview over the market structure in the different periods.

Hence, in this setup, there are two differences between integration and outsourcing that the producer has to take into account in her organizational decision: On the one hand, as in the property rights approach, integration and outsourcing differ with regard to the ex ante production incentives of the producer and her supplier. In addition to this, both organizational forms are associated with an ex post risk of a duopoly, as proposed by the knowledge protection approach. The probability of this risk might differ among organizational forms.

The resulting production process can be modeled with the following timing of events:

Period 1: *Monopoly*

1. The producer chooses the organizational form Ξ of her supplier. $\Xi = O$ stands for outsourcing and $\Xi = V$ denotes (vertical) integration of the supplier. The producer then offers contracts to potential suppliers.
2. There is a huge mass of potential suppliers, each with an outside option equal to $w = 0$, that apply for the offered contract. The producer chooses one supplier out of the applicants.
3. The producer and her supplier choose independent from each other their level of input provision (h_{Mon} and m_{Mon}, respectively).
4. A bargaining over the surplus of production arises between the producer and the supplier. Revenue is realized and distributed according to the outcome of the bargaining process.

[3] There is a growing literature that embeds multiple periods in the Antràs and Helpman (2004) framework. Contributions are, for example, made by Defever et al. (2015), Kamal and Tang (2015), Kukharskyy (2016) and Kukharskyy and Pflueger (2016). However, these papers have a different focus and do not consider the risk of knowledge absorption through the supplier.

↙

Period 2: *Monopoly*

If the supplier does not become a competitor, the producer is still a monopolist in period 2. Then, she does not have to choose a new supplier. Instead, only the production and the bargaining are repeated:

3. The producer and her supplier choose again independent from each other their level of input provision, h_{Mon} and m_{Mon}.

4. The producer and her supplier bargain again over the distribution of the production surplus. The revenue is realized and distributed according to the bargaining outcome.

↘

Period 2: *Duopoly*

If the former supplier uses the absorbed knowledge on the production of headquarter services to become a competitor, the producer is a duopolist and has to find a new supplier before the production and the bargaining can take place.[4] In her search, she sticks to the organizational decision made at the beginning of the first period.

2. There are again several potential suppliers that apply for the contract; their outside option is given by $w = 0$. The producer picks one of these suppliers.
3. The producer and her supplier as well as the competitor and his supplier choose independent from each other their level of input provision. These levels are given by h_{Duo} and m_{Duo} for the producer and her supplier and $h_{Duo,C}$ and $m_{Duo,C}$ for the competitor and his supplier.
4. The producer and her supplier bargain again over the distribution of the production surplus. The revenue is realized and distributed according to the bargaining outcome.

3.3 Solution of the game

To determine the organizational decision of the producer, this setup is solved by backward induction over *both* periods. This organizational decision crucially depends on whether a monopoly or a duopoly arises in the second period such that the outcomes of these two market structures are analyzed separately in the following.

[4] I could also assume that the producer sticks to her period-1-supplier instead of searching for a new supplier: This supplier has already absorbed and used the knowledge such that a continuation of the relationship does not imply any additional risks for the producer. In contrast, using a new supplier bears the risk of creating again an additional competitor. However, with the continuation of the relationship the period-1-supplier would receive both profits as manufacturing input supplier for the producer and as competitor producing headquarter services. Hence, he would have very strong incentives to become a competitor, as long as his productivity as competitor is high enough to have positive duopoly profits.

3.3.1 Monopoly in period 2

If the producer is a monopolist, the level of total production, Y, is equal to the firm's own output, y_H, such that the price of the final good solely depends on this output:

$$p_{Mon} = (A/y_H)^{1-\alpha}. \tag{4}$$

The bargaining between the final good producer and her direct supplier over the distribution of the surplus value of the relationship in stage 4 is modeled as Nash bargaining. In this bargaining, the producer receives a revenue share β_H, whereas her supplier receives the remain $(1-\beta_H)$. These revenue shares depend on the bargaining power of the two parties: Due to the producer's higher threath potential under integration, the producer's revenue share is higher and the supplier's revenue share is lower under integration than under outsourcing. Hence, the revenue shares depend on the organizational form the producer chooses for her supplier in stage 1 of period 1 that will be analyzed below.

In stage 3 where the producer and her supplier decide on their input provisions, each of them anticipates this revenue share and chooses the input provision that maximizes the respective resulting own profit. Thus, the maximization problems are given by $h_{Mon} = \text{argmax}_h \{\beta_H R_{Mon} - c_H h\}$ for the producer and $m_{Mon} = \text{argmax}_m \{(1-\beta_H) R_{Mon} - c_M m\}$ for the supplier with c_H and c_M denoting the respective unit production costs of the producer and her supplier. The chosen input provisions reflect the well-known trade-off between revenue share and revenue level inherent of the property rights approach:

$$h^*_{Mon} = \frac{\alpha\beta_H\eta_H}{c_H} R^*_{Mon} \quad \text{and} \quad m^*_{Mon} = \frac{\alpha(1-\beta_H)(1-\eta_H)}{c_M} R^*_{Mon} \tag{5}$$

$$\text{with} \quad R^*_{Mon} = A\left(\alpha\theta_H \left(\frac{\beta_H}{c_H}\right)^{\eta_H} \left(\frac{1-\beta_H}{c_M}\right)^{1-\eta_H}\right)^{\frac{\alpha}{1-\alpha}}.$$

A higher revenue share of the producer increases her input provision and the revenue but decreases the supplier's input provision and, thus, the revenue. As this relation holds likewise for the supplier's revenue share, the producer has to properly allocate the production incentives through her organizational decision.

3.3.2 Duopoly in period 2

In a duopoly with the former supplier as competitor, the total production of the final good, Y, depends both on the output of the producer herself, y_H, and on the output of her competitor, y_C:

$$p_{Duo} = (A/(y_H + y_C))^{1-\alpha}, \tag{6}$$

where the output of the competitor is given by

$$y_C = \theta_C \left(\frac{h_{Duo,C}}{\eta_H}\right)^{\eta_H} \left(\frac{m_{Duo,C}}{(1-\eta_H)}\right)^{(1-\eta_H)} \quad \text{with} \;\; \alpha\theta_H < \theta_C < \theta_H. \tag{7}$$

Within this equation, θ_C denotes the productivity of the competitor. The competitor is assumed to use the absorbed knowledge to produce himself the headquarter services necessary for the production of the final good, $h_{Duo,C}$, and to employ a supplier that produces the manufacturing input, $m_{Duo,C}$, that the competitor formerly produced for the producer.[5] Since the competitor cannot one-to-one absorb the producer's knowledge on headquarter services, his productivity is strictly lower than the productivity of the producer herself.[6] The competitor's revenue is hence defined as

$$R_{Duo,C} = \left(A/\left(y_H + y_C\right)\right)^{1-\alpha} \;\; \theta_C \;\; \left[\left(\frac{h_{Duo,C}}{\eta_H}\right)^{\eta_H} \left(\frac{m_{Duo,C}}{(1-\eta_H)}\right)^{(1-\eta_H)}\right]. \tag{8}$$

Since the price depends both on the producer's own output and on the competitor's output, the revenue of the producer, as given by equation (3), also depends on both the producer's and the competitor's output:

$$R_{Duo} = \left(A/\left(y_H + y_C\right)\right)^{1-\alpha} \;\; \theta_H \;\; \left[\left(\frac{h_{Duo}}{\eta_H}\right)^{\eta_H} \left(\frac{m_{Duo}}{(1-\eta_H)}\right)^{(1-\eta_H)}\right]. \tag{9}$$

The bargaining of the producer and her supplier in stage 4 is analogeous to the bargaining in monopoly such that the producer receives a revenue share β_H and her supplier receives the residual, $1-\beta_H$. The competitor is assumed to make the same organizational decision as the producer such that the bargaining between the competitor and his supplier takes place likewise.

In the input provision decision in stage 3, the producer, the competitor and the respective suppliers maximize the respective own payoff, anticipating the bargained revenue shares. The maximization problems of the producer and her supplier are $h_{Duo} = \text{argmax}_h \left\{\beta_H R_{Duo} - c_H h\right\}$ and $m_{Duo} = \text{argmax}_m \left\{(1-\beta_H) R_{Duo} - c_M m\right\}$ for her supplier, those for the competitor and his supplier are given by $h_{Duo,C} = \text{argmax}_h \left\{\beta_H R_{Duo,C} - c_H h\right\}$ and $m_{Duo,C} = \text{argmax}_m \left\{(1-\beta_H) R_{Duo,C} - c_M m\right\}$. Contrary to the decision in monopoly, the price and, thus, the revenue of the producer and her competitor depend on all parties' investments such that the resulting input provisions depend not only on the respective own importance and the respective own revenue share but also on the

[5] I could also assume that the competitor is producing both components himself or always chooses an integrated supplier, since the machinery to produce the manufacturing input is already available. However, as the producer would still produce only headquarter services, he would still have to face the decision between integration and outsourcing. Thus, this assumption would create an (additional) asymmetry between the producer and her competitor that complicates the analysis and makes it difficult to disentangle different channels.

[6] Note that the competitor's productivity has to be higher than $\alpha\theta_H$ for the competitor to have positive duopoly profits. If the competitor has only a very low productivity, i.e., if $\theta_C < \alpha\theta_H$, he expects negative duopoly profits.

productivity of both the producer, θ_H, and her competitor, θ_C:

$$h^*_{Duo} = \frac{(1+\alpha)\,\beta_H\eta_H}{c_H}\frac{\theta_C}{\theta_C+\theta_H}R^*_{Duo}, \quad h^*_{Duo,C} = \frac{(1+\alpha)\,\beta_H\eta_H}{c_H}\frac{\theta_H}{\theta_C+\theta_H}R^*_{Duo,C},$$

$$m^*_{Duo} = \frac{(1+\alpha)\,(1-\beta_H)\,(1-\eta_H)}{c_M}\frac{\theta_C}{\theta_C+\theta_H}R^*_{Duo} \quad \text{and}$$

$$m^*_{Duo,C} = \frac{(1+\alpha)\,(1-\beta_H)\,(1-\eta_H)}{c_M}\frac{\theta_H}{\theta_C+\theta_H}R^*_{Duo,C} \tag{10}$$

$$\text{with} \quad R^*_{Duo} = \frac{A\,(\theta_H-\alpha\theta_C)}{(1-\alpha)\,(\theta_C+\theta_H)}\left(\frac{(1+\alpha)\,\theta_C\theta_H}{\theta_C+\theta_H}\left(\frac{\beta_H}{c_H}\right)^{\eta_H}\left(\frac{1-\beta_H}{c_M}\right)^{1-\eta_H}\right)^{\frac{\alpha}{1-\alpha}}$$

$$\text{and} \quad R^*_{Duo,C} = \frac{A\,(\theta_C-\alpha\theta_H)}{(1-\alpha)\,(\theta_C+\theta_H)}\left(\frac{(1+\alpha)\,\theta_C\theta_H}{\theta_C+\theta_H}\left(\frac{\beta_H}{c_H}\right)^{\eta_H}\left(\frac{1-\beta_H}{c_M}\right)^{1-\eta_H}\right)^{\frac{\alpha}{1-\alpha}}.$$

Anticipating these investments, in stage 2, the supplier will only accept a contract of the producer, if its value, $\pi^{\Xi}_{M,Duo}$, is at least equal to the outside option $w = 0$:

$$\pi^{\Xi}_{M,Duo} = \left(1-\frac{(1+\alpha)\,\theta_C\,(1-\eta_H)}{\theta_C+\theta_H}\right)(1-\beta_H)\,R^*_{Duo} \geq 0. \tag{11}$$

This leaves the producer with a profit of

$$\pi^{\Xi}_{H,Duo} = \left(1-\frac{(1+\alpha)\,\theta_C\eta_H}{\theta_C+\theta_H}\right)\beta_H R^*_{Duo}, \tag{12}$$

whereas the profit of her competitor,$\pi^{\Xi}_{H,Duo,C}$, and the competitor's supplier, $\pi^{\Xi}_{M,Duo,C}$, are

$$\pi^{\Xi}_{H,Duo,C} = \left(1-\frac{(1+\alpha)\,\theta_H\eta_H}{\theta_C+\theta_H}\right)\beta_H R^*_{Duo,C} \quad \text{and} \tag{13}$$

$$\pi^{\Xi}_{M,Duo,C} = \left(1-\frac{(1+\alpha)\,\theta_H\,(1-\eta_H)}{\theta_C+\theta_H}\right)(1-\beta_H)\,R^*_{Duo,C}. \tag{14}$$

3.3.3 Monopoly in period 1

Turning to period 1, where the market structure is always a monopoly, bargaining and production are analogeous to those in the monopoly in period 2. However, in period 1, the producer additionally chooses a supplier and decides on her supplier's organizational form for the two periods.

A supplier only applies for the producer's contract in stage 2 if the expected profit from participating in the production of the final good, $\pi^{\Xi}_{M,Mon}$, is at least equal to his outside option $w = 0$:

$$\pi^{\Xi}_{M,Mon} = (1-\alpha\,(1-\eta_H))\left(1-\beta^{\Xi}_H\right)R^*_{Mon} \geq 0. \tag{15}$$

In stage 1, where the producer chooses from which type of supplier she wants to source the manufacturing input, she chooses the organizational form that maximizes not only her monopoly profit of this period,

$$\pi_{H,Mon}^{\Xi} = (1 - \alpha\eta_H)\, \beta_H^{\Xi} R_{Mon}^{*}, \tag{16}$$

but her expected profit over *both* periods:

$$\pi_H^{\Xi} = \pi_{H,Mon}^{\Xi} + \left(\left(1 - pr^{\Xi}\right) \pi_{H,Mon}^{\Xi} + pr^{\Xi} \pi_{H,Duo}^{\Xi}\right) = \frac{\beta_H^{\Xi} R_{Mon}^{*}}{1-\alpha} \cdot \tag{17}$$

$$\left(\left(2 - pr^{\Xi}\right)(1-\alpha)(1-\alpha\eta_H) + pr^{\Xi}\left(\frac{\left((1+\alpha)\,\theta_C\right)^{\alpha}}{\alpha^{\alpha}\left(\theta_C + \theta_H\right)}\right)^{\frac{1}{1-\alpha}} (\theta_H - \alpha\theta_C)\, \delta_{help}\right).$$

with $\delta_{help} = \left(1 - \frac{(1+\alpha)\eta_H \theta_C}{\theta_C + \theta_H}\right)$. pr^{Ξ} denotes the probability that a duopoly arises under the organizational form $\Xi \in (O, V)$. The period-1-monopoly profit is always higher than the producer's profit in duopoly, as depicted in equation (12),

$$\frac{\pi_{H,Mon}^{\Xi}}{\pi_{H,Duo}^{\Xi}} = \frac{(1-\alpha)\left(\frac{\alpha}{1+\alpha}\right)^{\frac{\alpha}{1-\alpha}} (1-\alpha\eta_H)\left(\theta_C + \theta_H\right)^{\frac{1}{1-\alpha}}}{\theta_C^{\frac{\alpha}{1-\alpha}} (\theta_H - \alpha\theta_C)\left(\theta_H + (1 - \eta_H(1+\alpha))\right)} > 1, \tag{18}$$

such that the producer's expected profit over both periods is higher, the lower is the probability of a duopoly, pr^{Ξ}. As the expected profit, π_H^{Ξ}, depends both on the producer's (and her supplier's) revenue share and the probability of a duopoly, pr^{Ξ}, that may differ among organizational forms, the producer's organizational decision takes both the ex ante distortions and the ex post inefficiencies of production into account.

In the following analysis, in this crucial decision whether integration or outsourcing of the supplier is associated with higher producer profits π_H^{Ξ}, I first assume that the probability that the supplier uses the knowledge to become a competitor, pr^{Ξ}, is exogenously given. Then, in a second step I internalize this probability in the sense that I analyze when a supplier has an incentive to become a competitor and in how far the incentives differ among organizational forms.

4 Exogenous probability of defection

Assuming an exogenously given probability of ex post inefficiencies, i.e., of a competitor, I consider as a first benchmark case a situation without ex post inefficiencies, i.e., a situation where neither outsourced nor integrated suppliers use the producer's knowledge to become a competitor. In other words, in this benchmark case, there are only the ex ante investment distortions of the property rights approach at work such that integration and outsourcing differ only with regard to the producer's and her supplier's production incentives. Then, the profits in case of outsourcing,

π_H^O, and the profits in case of integration, π_H^V, are given by

$$\pi_H^O\left(pr^O=0\right)=\pi_{H,Mon}^O+\pi_{H,Mon}^O \text{ and } \pi_H^V\left(pr^V=0\right)=\pi_{H,Mon}^V+\pi_{H,Mon}^V \tag{19}$$

and the producer chooses outsourcing whenever

$$\pi_H^{rel}\left(pr^O=pr^V=0\right)=\frac{\pi_H^O\left(pr^O=0\right)}{\pi_H^V\left(pr^V=0\right)} \tag{20}$$

$$=\frac{\pi_{H,Mon}^O}{\pi_{H,Mon}^V}=\left(\left(\frac{1-\beta_H^O}{1-\beta_H^V}\right)^{\alpha(1-\eta_H)}\left(\frac{\beta_H^O}{\beta_H^V}\right)^{1-\alpha(1-\eta_H)}\right)^{\frac{1}{1-\alpha}}>1.$$

Solving for η_H, this relation can be used to derive the cutoff level of the headquarter-intensity, η_H^{crit}, at which the producer is indifferent between integration and outsourcing:

$$\eta_H^{crit}=1-\frac{Log\left[\beta_H^V\right]-Log\left[\beta_H^O\right]}{2\alpha\left(ArcTanh\left[1-2\beta_H^O\right]-ArcTanh\left[1-2\beta_H^V\right]\right)}. \tag{21}$$

If η_H is lower than this cutoff headquarter-intensity, the producer chooses outsourcing. Vice versa, if the headquarter-intensity is higher than the cutoff level, integration is chosen.[7] This reflects the baseline intuition of the property rights approach: For low values of the headquarter-intensity, i.e., in manufacturing-intensive sectors, the supplier is very important for the production. It is important to give him as much production incentives as possible and as the supplier receives a higher revenue share and has more production incentives under outsourcing, outsourcing is chosen. If the producer is more important for the production, her underinvestment problem is more severe and integration is chosen such that the producer has as much production incentives as possible.

Figure 2 illustrates this relation. It depicts the profits of integration and outsourcing subject to a variation of the headquarter-intensity as black, solid line or gray, solid line, respectively. For low values of the headquarter-intensity, the gray, solid line runs above the black, solid line such that outsourcing of the supplier leads to higher profits. Vice versa, for high values of the headquarter-intensity, integration is associated with higher profits.

With ex post inefficiencies, the producer's organizational decision is not only driven by the producer's and her supplier's production incentives. Instead, there is also a risk that the supplier absorbs and uses the producer's knowledge to become a competitor for the final good. The producer's profit is then given by the producer's (monopoly) profit without ex post inefficiencies, $\pi_H^{\Xi}\left(pr^{\Xi}=0\right)$, plus the change in profit induced by the risk of knowledge absorption, $\frac{\partial\pi_H^{\Xi}}{\partial pr^{\Xi}}\cdot\left(pr^{\Xi}-0\right)$, such that

[7] Since $\beta_H^V>\beta_H^O$ and both $Log[x]$ and $ArcTanh[x]$ are increasing in x, η_H^{crit} is strictly lower than 1. This implies that independent from the concrete level of the elasticity of demand and the revenue shares, there are always industries where producers decide to source the manufacturing input from an integrated supplier.

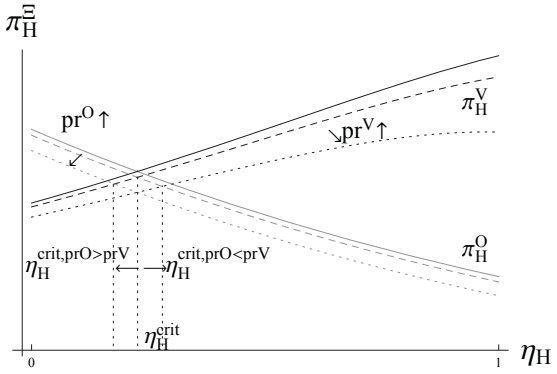

Figure 2: Profits under integration and outsourcing with ex post inefficiencies associated with outsourcing and integration.

the producer is indifferent between outsourcing and integration if

$$\pi_H^O\left(pr^O=0\right)+\frac{\partial\pi_H^O}{\partial pr^O}\cdot pr^O=\pi_H^V\left(pr^V=0\right)+\frac{\partial\pi_H^V}{\partial pr^V}\cdot pr^V \quad \text{with} \tag{22}$$

$$\frac{\partial\pi_H^\Xi}{\partial pr^\Xi}=-\frac{\beta_H^\Xi R_{Mon}^*}{1-\alpha}. \tag{23}$$

$$\left((1-\alpha)\left(1-\alpha\eta_H\right)-\left(\frac{\left((1+\alpha)\,\theta_C\right)^\alpha}{\alpha^\alpha\left(\theta_C+\theta_H\right)}\right)^{\frac{1}{1-\alpha}}\left(\theta_H-\alpha\theta_C\right)\left(1-\frac{\left(1+\alpha\right)\eta_H\theta_C}{\theta_C+\theta_H}\right)\right)<0.$$

As a higher probability pr^Ξ implies a higher risk of a duopoly and the producer's profit is higher in a monopoly than in a duopoly with knowledge absorption ((18)), the marginal change in profit induced by a risk of knowledge absorption, as described by (23), is smaller than 0. That is:

Proposition 1 *The producer's profit with ex post inefficiencies is lower than the profit without ex post inefficiencies. The higher is the risk of a competitor under either organizational form, the stronger is this effect.*

To illustrate proposition 1, compare the black, solid line and the gray, solid line without ex post inefficiencies with the black, dashed line and the gray, dashed line, respectively, in figure 2. The two dashed lines that represent a low risk of ex post inefficiencies run below the two solid lines.

The effect that the risk of ex post inefficiencies under either organizational form lowers this organizational form's profit is in line with the baseline result of the primary knowledge protection approach. There, only outsourcing is associated with the risk of a competitor and a higher risk of a competitor lowers the profits of outsourcing whereas the profits of integration are not affected. Hence, outsourcing becomes less likely.

However, remember that, to take cases as *Intel* or *SAP* into account, in my setup this risk also might be associated with integration. The higher is the risk under integration, the lower is the range of headquarter-intensity in which integration implies higher profits than outsourcing such

that outsourcing becomes more likely.

Which of these two opposing effects on the relative prevalence of outsourcing is dominating, depends on the relative risk level of ex post inefficiencies associated both with outsourcing and integration. In the interplay, assume first that the level of ex post inefficiencies is the same for outsourcing and integration, i.e., $pr^O = pr^V = pr$. Then the producer's relative profit $\pi^{rel}_{H,Duo}$ simplifies to

$$\pi^{rel}_{H,Duo} = \frac{\pi^O_{H,Duo}}{\pi^V_{H,Duo}} = \left(\left(\frac{1-\beta^O_H}{1-\beta^V_H} \right)^{\alpha(1-\eta_H)} \left(\frac{\beta^O_H}{\beta^V_H} \right)^{1-\alpha(1-\eta_H)} \right)^{\frac{1}{1-\alpha}} \tag{24}$$

such that the cutoff headquarter-intensity at which the producer is indifferent between integration and outsourcing is equal to the cutoff headquarter-intensity without ex post inefficiencies, η^{crit}_H, as defined in (21). This cutoff headquarter-intensity and the profits under integration or outsourcing for different risk levels are also depicted in figure 2. Whereas the solid lines illustrate the profits without the risk of ex post inefficiencies and the dashed lines show the profits for a low risk of ex post inefficiencies, the dotted lines depict the profits for a high risk of ex post inefficiencies. The intersection of the two solid, the two dashed and the two dotted lines always occurs at the same cutoff headquarter-intensity level, namely η^{crit}_H. Intuitively, the same risk of ex post inefficiencies for the two organizational forms decreases both profits to the same degree. Hence, when both organizational forms are associated with the same risk, there is no effect of ex post inefficiencies on the producer's organizational decision.

This pattern of a constant cutoff headquarter-intensity changes, however, once there are differences in the risk of ex post inefficiencies among the organizational forms. Consider the case where outsourcing is associated with a higher risk of ex post inefficiencies than integration. This is, for example, illustrated by the gray, dotted and the black, dashed line. In this case, the intersection is to the left of the intersection of the two solid lines ($\eta^{crit,prO>prV}_H < \eta^{crit}_H$). Vice versa, if integration is associated with a higher risk of ex post inefficiencies than outsourcing this can be depicted by the gray, dashed and the black, dotted line. Then, the intersection is to the right of the intersection of the two solid lines ($\eta^{crit,prO<prV}_H > \eta^{crit}_H$). Hence, the organizational form that is associated with a higher risk of ex post inefficiencies becomes less likely. This can be summarized as following:

Proposition 2 *With ex post inefficiencies associated with both organizational forms, it depends on the relative level whether outsourcing or integration becomes more likely.*

It is not possible to solve for the cutoff level of the headquarter-intensity at which the producer is indifferent between the two organizational forms analytically. However, some simple transformations show whether the cutoff level of headquarter-intensity is lower or higher than η^{crit}_H: As the cutoff headquarter-intensity η^{crit}_H is the same if there is no risk of ex post inefficiencies or if this risk is the same for both organizational forms, the indifference condition for the producer of (22)

can be rewritten as

$$\pi_H^O\left(pr^O = p\right) + \frac{\partial \pi_H^O}{\partial pr^O}\left(pr^O - p\right) = \pi_H^V\left(pr^V = p\right) + \frac{\partial \pi_H^V}{\partial pr^V}\left(pr^V - p\right) \tag{25}$$

and is fulfilled for η_H^{crit} if both organizational forms have the same risk $pr^O = pr^V = p$. Consider first that outsourcing is associated with a higher risk of ex post inefficiencies than integration, i.e., $pr^O > pr^V = p$. Then for $\eta_H = \eta_H^{crit}$, the profit under outsourcing is due to the higher probability of a duopoly defined as $\pi_H^O\left(pr^O = p\right)$ reduced by $\frac{\partial \pi_H^O}{\partial pr^O}\left(pr^O - p\right)$, whereas the profit under integration is given by $\pi_H^V\left(pr^V = p\right)$. In words, the profits under outsourcing are lower than the profits under integration such that η_H^{crit} cannot be the cutoff headquarter-intensity. Instead, as integration would lead to higher profits for this headquarter-intensity and integration is chosen for high values of the headquarter-intensity, the cutoff headquarter-intensity has to be lower than η_H^{crit}. Vice versa, if $pr^V > pr^O = p$, the outsourcing profits are higher than the integration profits. Hence, the cutoff intensity has to be higher than η_H^{crit}.

The previous results can be summarized as follows: It depends on the headquarter-intensity of production whether the manufacturing input is sourced from an integrated or from an outsourced supplier. The ex ante distortions determine that the manufacturing input in headquarter-intensive production processes will be sourced from an integrated supplier, whereas it will be sourced from an outsourced supplier in more manufacturing-intensive production processes. The introduction of ex post inefficiencies influences the level of the cutoff headquarter-intensity that separates headquarter-intensive from manufacturing-intensive production processes. More precisely, the higher is the risk of ex post inefficiencies under one particular organizational form, the less likely it becomes that the producer sources inputs from a supplier with this organizational form.

5 Supplier defection incentives

So far, to show the effect of both the ex ante distortions and the ex post inefficiencies on the producer's decision, I have assumed the probability that the supplier becomes a competitor to be exogenous. However, it is not a coincidence whether a supplier will become a competitor that can be described by such an exogenous probability. Instead, a supplier only will use the producer's knowledge to become a competitor if it pays off, i.e., if the expected profit as competitor, $\pi_{H,Duo,C}^*$, is higher than the profit as supplier of the monopolist, $\pi_{M,Mon}^*$, i.e., if

$$\frac{\pi_{H,Duo,C}^*}{\pi_{M,Mon}^*} = \frac{\left(\frac{1+\alpha}{\alpha}\,\theta_C\right)^{\frac{\alpha}{1-\alpha}} \beta_H^{\Xi}\left(\theta_C - \alpha\theta_H\right)\left(\theta_C + \left(1 - \eta_H\left(1+\alpha\right)\right)\theta_H\right)}{\left(1-\alpha\right)\left(1-\beta_H^{\Xi}\right)\left(1-\alpha\left(1-\eta_H\right)\right)\left(\theta_C + \theta_H\right)^{\frac{2-\alpha}{1-\alpha}}} > 1. \tag{26}$$

That is, a supplier has an incentive to become a competitor if the headquarter-intensity is lower than the competitor headquarter-intensity

$$\eta_H^{comp,\Xi} = \tag{27}$$

$$\frac{(\theta_C+\theta_H)\left(\beta_H^{\Xi}\left(\theta_C-\alpha\theta_H\right)\left(\left(1+\alpha\right)\theta_C\right)^{\frac{\alpha}{1-\alpha}}-\left(1-\beta_H^{\Xi}\right)\left(1-\alpha\right)^2\left(\alpha^{\alpha}\left(\theta_C+\theta_H\right)\right)^{\frac{1}{1-\alpha}}\right)}{\left(\beta_H^{\Xi}\theta_H\left(\theta_C-\alpha\theta_H\right)\left(\left(1+\alpha\right)\theta_C^{\alpha}\right)^{\frac{1}{1-\alpha}}+\left(1-\alpha\right)\left(1-\beta_H^{\Xi}\right)\left(\alpha\left(\theta_C+\theta_H\right)^{2-\alpha}\right)^{\frac{1}{1-\alpha}}\right)}.$$

This implies that the supplier only is better off as competitor than as supplier of the manufacturing input if headquarter services are not too important for the final good production. Intuitively, if the importance of the producer (and competitor) component for the final good is too high, i.e., if $\eta_H > \eta_H^{comp,\Xi}$, then it is too "expensive" for the supplier to become a competitor and $\pi^*_{H,Duo,C}/\pi^*_{M,Mon} < 1$ such that the profit as competitor in duopoly is lower than the profit as supplier in monopoly. Then, the supplier has no incentive to use the knowledge and the producer stays a monopolist.[8] This competitor headquarter-intensity $\eta_H^{comp,\Xi}$ is increasing in the supplier's relative productivity, θ_C/θ_H:[9]

$$\frac{\partial \eta_H^{comp,\Xi}}{\partial \frac{\theta_C}{\theta_H}} > 0. \tag{28}$$

Ceteris paribus, a higher productivity as competitor implies higher competitor profits, whereas the profits as supplier in monopoly do not change. As a result, a higher relative productivity makes a duopoly more profitable. In addition to this, $\eta_H^{comp,\Xi}$ crucially depends on the chosen organizational form - integration or outsourcing - and is higher, the higher is the revenue share as producer (or competitor):

$$\frac{\partial \eta_H^{comp,\Xi}}{\partial \beta_H^{\Xi}} > 0. \tag{29}$$

As the producer (as well as the competitor) has a higher revenue share under integration than under outsourcing, the critical competitor headquarter-intensity is higher under integration than under outsourcing, i.e., $\eta_H^{comp,V} > \eta_H^{comp,O}$. This is due to the fact that with integration the producer has the property rights over the manufacturing input. As a result, an integrated supplier receives a relatively small revenue share whereas the producer receives in this case a relatively high revenue share. Through the switch from "supplier" to "competitor", the formerly integrated supplier experiences a quite huge increase in his revenue share - instead of being the "little worker", he becomes the "big boss". In contrast, an outsourced supplier has the property rights over his input such that he already has a relatively high revenue share and the producer's revenue share under outsourcing is relatively small. Hence, becoming a competitor implies a stronger increase of the revenue share for the integrated supplier than for the outsourced supplier such that becoming

[8] As explained in detail in Appendix A.I, this can be mathematically justified by the relative level of the manufacturing input provision in monopoly and the headquarter services provision by the competitor in duopoly.

[9] In the main text only the sign of the derivatives is presented; the concrete derivations of the competitor headquarter-intensity are delegated to Appendix A.II.

a competitor and, thus, having a duopoly is much more attractive for an integrated supplier than for an outsourced supplier.

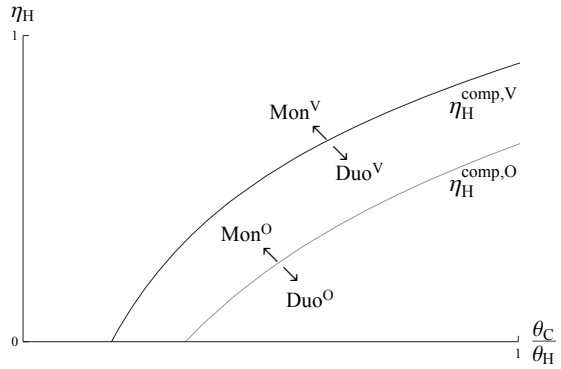

Figure 3: Critical competitor headquarter-intensity at which a supplier is indifferent between monopoly and duopoly.

The competitor headquarter-intensity, $\eta_H^{comp,\Xi}$, and the above shown properties are illustrated in figure 3 where the horizontal axis depicts the supplier's relative productivity, θ_C/θ_H, and the vertical axis depicts the headquarter-intensity, η_H. The critical competitor headquarter-intensity $\eta_H^{comp,\Xi}$ is illustrated as black line for integration and as gray line for outsourcing. First of all, for values below the respective line, a duopoly is chosen by the supplier whereas for values above the respective line he choses to stay a supplier to the monopolist. Thus, figure 3 depicts the negative relation between the headquarter-intensity and a supplier's incentive to become a competitor. In addition to this, as $\eta_H^{comp,\Xi}$ is positively related to the supplier's relative productivity, both the black and the gray line are upward sloping in the supplier's relative productivtiy. Finally, the black line that depicts the critical competitor headquarter-intensity under integration runs above the gray line that depicts this intensity under outsourcing. Summarizing these observations, figure 3 shows graphically that the range in which a supplier has an incentive to become a competitor is higher, the higher is his relative productivity and when he is integrated.

As a supplier either has an incentive to become a competitor or not, the probability that the supplier becomes a competitor takes either the value 0 or 1. The higher duopoly incentive under integration therefore cannot be transfered into a concrete probability. However, this higher incentive implies that the probability of ex post inefficiencies is per se higher under integration than under outsourcing. In terms of figure 2 above, a higher probability under integration induces a stronger decrease of the producer's profits under integration than of the producer's profits under outsourcing. As a result, the higher ex post inefficiencies under integration make integration less likely or, vice versa, outsourcing more likely. Hence holds:

Proposition 3 *Considering the supplier's incentives to become a competitor, the effect on the producer's organizational decision is contrary to the outcome of the knowledge protection approach: Since an integrated supplier has higher incentives to become a competitor than an outsourced sup-*

plier, a duopoly is more probable under integration such that outsourcing becomes relatively more likely.

More precisely, following Ethier (1986) and Markusen and Ethier (1996), in the primary knowledge protection approach where only outsourcing is associated with ex post inefficiencies, only outsourcing profits are reduced by these inefficiencies. As a result, outsourcing becomes *less* likely. This is contrary to the above explained effect that with ex post inefficiencies under outsourcing *and integration* integrated suppliers are more likely to become a competitor such that ex post inefficiencies make outsourcing *more* likely.

6 Prevention of a duopoly

If the supplier decides to become a competitor, the producer has lower profits than in monopoly ((18)). Hence, she might want to deter the supplier from becoming a competitor and therefore has an incentive to make an extra "deterrence" transfer payment to the supplier. This payment is profitable for the producer whenever it is lower than her loss through the transition from monopoly to duopoly that is given by

$$loss_H = \pi^*_{H,Mon} - \pi^*_{H,Duo}. \tag{30}$$

However, the supplier will only accept the payment if it is at least equal to his gain through the duopoly. In other words, the payment has to be equal or higher than the surplus of the competitor's profit in duopoly over the supplier's profit in monopoly,

$$gain_C = \pi^*_{H,Duo,C} - \pi^*_{M,Mon}. \tag{31}$$

That is, to be binding, the transfer payment has to be lower than the loss of the producer, given by (30), but higher than the gain of the supplier, defined in (31). Hence, the producer only has an incentive to pay a transfer if her loss is higher than the supplier's gain, i.e., if $loss_H > gain_C$. Stated differently, the producer will deter the supplier's entry if the importance of headquarter services for the production is higher than the critical headquarter-intensity $\eta_H^{prev,\Xi}$ with

$$\eta_H^{prev,\Xi} = \tag{32}$$

$$\frac{(1-\alpha)(\theta_C+\theta_H)^2\left(\left(1-\alpha\left(1-\beta_H^{\Xi}\right)\right)(\alpha(\theta_C+\theta_H))^{\frac{\alpha}{1-\alpha}}-((1+\alpha)\theta_C)^{\frac{\alpha}{1-\alpha}}\beta_H^{\Xi}\right)}{\left((1+\alpha)\theta_C^{\alpha}\right)^{\frac{1}{1-\alpha}}\beta_H^{\Xi}\left(\alpha\left(\theta_C^2+\theta_H^2\right)-2\theta_C\theta_H\right)-(1-\alpha)\left(\alpha(\theta_C+\theta_H)^{2-\alpha}\right)^{\frac{1}{1-\alpha}}\left(1-2\beta_H^{\Xi}\right)}.$$

Intuitively, a low η_H implies that headquarter services, about whose production the supplier has to absorb the producer's knowledge, are not so important for the production. Hence, as explained in the previous section, the supplier has strong monetary incentives to become a competitor such that his gain exceeds the producer's loss. Then it is too expensive for the producer to prevent the duopoly. The higher is the importance of headquarter services for the production, the lower is

the supplier's gain and the less expensive it becomes for the producer to deter the supplier from becoming a competitor. That is, only for sufficiently high values of the headquarter-intensity, the gain of the supplier is lower than the loss of the producer from the transition from monopoly to duopoly and the producer has an incentive to make the transfer payment to the supplier.

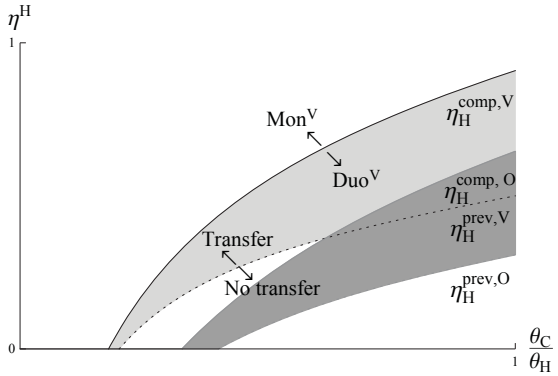

Figure 4: Critical prevention headquarter-intensity at which the producer is indifferent between paying a transfer or not.

Figure 4 illustrates this critical headquarter-intensity $\eta_H^{prev,\Xi}$ subject to a variation of the competitor's relative productivity θ_C/θ_H as black, dotted line or gray, dotted line, respectively. Above the respective line, it is profitable for the producer to make the transfer payment. Below the respective line, it is too expensive for the producer to intervene. Hence holds:

Proposition 4 *Contrary to a setup with complete contracts, the producer does not always have an incentive to prevent a duopoly. Instead, if the supplier is too important for the production, it becomes too expensive for the producer to deter him from becoming a competitor.*

More precisely, with complete contracts, monopoly profits are always higher than the sum of duopoly profits. As a result, a producer then always has an incentive to pay a transfer to her supplier to avoid a duopoly. That in my setup monopoly profits might also be lower than the sum of duopoly profits is due to the assumed contract incompleteness and the resulting ex ante investment distortions of the producer, her competitor and the suppliers.

Whether the producer has an incentive to pay a transfer or not, also depends on the competitor's relative productivity: A higher relative productivity of the competitor increases the competitor's profits and, thus, the supplier's gain. Hence, it becomes more expensive for the producer to deter the supplier's entry in the final good market and the critical headquarter-intensity $\eta_H^{prev,\Xi}$ increases:[10]

$$\frac{\partial \eta_H^{prev,\Xi}}{\partial \frac{\theta_C}{\theta_H}} > 0. \tag{33}$$

[10] As in the previous sections, the concrete derivations of the critical headquarter-intensity are delegated to the Appendix (A.III).

This is illustrated by the curvature of the black, dotted and the gray, dotted line in figure 4 that are both upwards sloping in θ_C/θ_H. As a higher revenue share of the producer / the competitor also implies higher expected competitor profits, it also increases the critical headquarter-intensity:

$$\frac{\partial \eta_H^{prev,\Xi}}{\partial \beta_H} > 0. \tag{34}$$

As the producer's (and the competitor's) revenue share is higher under integration than under outsourcing, this relation implies that the critical headquarter-intensity $\eta_H^{prev,\Xi}$ is also higher under integration than under outsourcing, i.e., $\eta_H^{prev,V} > \eta_H^{prev,O}$. The intuition is that an integrated supplier has more incentives to become a competitor than an outsourced supplier and, thus, also a higher gain. It is therefore, ceteris paribus, more expensive for the producer to deter an integrated supplier from market entry. In figure 4, the black, dotted line depicts the critical headquarter-intensity under integration and the gray, dotted depicts this critical headquarter-intensity under outsourcing. In line with the derivation, the black, dotted line runs for all values above the gray, dotted line.

However, even if the producer's has an incentive to make a transfer payment, this it not always necessary: The producer only actually pays a transfer to the supplier if the supplier has an incentive to become a competitor. Otherwise, the producer does not have to deter entry. Therefore it is important to compare this prevention headquarter-intensity $\eta_H^{prev,\Xi}$ with the competitor headquarter-intensity $\eta_H^{comp,\Xi}$ at which the supplier is indifferent between becoming a competitor or not. As the competitor headquarter-intensity is higher than the prevention headquarter-intensity, i.e.,

$$\frac{\eta_H^{comp,\Xi}}{\eta_H^{prev,\Xi}} > 1, \tag{35}$$

and a supplier only has an incentive to become a competitor if the headquarter-intensity is lower than the competitor headquarter-intensity $\eta_H^{comp,\Xi}$, the producer will only actually pay the transfer if the headquarter-intensity lies between the two critical headquarter-intensities, i.e., for $\eta_H^{prev,\Xi} < \eta_H < \eta_H^{comp,\Xi}$. The competitor headquarter-intensity is illustrated as solid line in figure 4. The black, solid illustrates this headquarter-intensity for integration, whereas the gray, solid line illustrates this headquarter-intensity for outsourcing. The gray dyed areas between the respective competitor and the respective prevention headquarter-intensity indicate the range under the respecitive organizational form where the producer actually pays the transfer to deter the supplier from becoming a competitor.

That is, only if headquarter services are neither too important nor too unimportant for the production of the final good, the producer will pay a tranfer to the supplier to prevent a duopoly.

7 Conclusion

Firms often use intermediate manufacturing inputs in their production process. They then have to decide for each input whether to source it from an integrated supplier or from an outsourced, unaffiliated supplier. I analyze the organizational decision of a firm with regard to her supplier in a setup where integrated and outsourced supplier are assumed to differ with regard to two aspects: First, in line with the property rights approach, integrated and outsourced suppliers differ with regard to their property rights and, thus, their ex ante distortions of the investment incentives. In addition, following the knowledge protection approach, using a supplier in the production process implies a risk that the supplier absorbs the producer's knowledge and uses it to become a competitor. Contrary to the knowledge protection approach, supported by evidence, this risk is assumed to be prevalent both under outsourcing and integration.

The ex ante investment distortions determine that the input is sourced from an outsourced supplier in manufacturing-intensive production processes, whereas the producer sources it from an integrated supplier in headquarter-intensive production processes. The concrete headquarter-intensity that separates manufacturing-intensive from headquarter-intensive production processes varies with the level of ex post inefficiencies associated with the two organizational forms. With an exogenously given probability of ex post inefficiencies, it depends on the level of this probability under outsourcing and integration whether outsourcing becomes more or less likely. More precisely, the higher is the risk of these inefficiencies under either organizational form, the less likely becomes this organizational form. This result is in line with the outcome of the knowledge protection approach where only outsourcing is associated with this risk and a higher risk of a competitor makes outsourcing *less* likely. However, if the supplier's incentives to become a competitor are considered, it becomes apparent that an integrated supplier is more likely to become a competitor than an outsourced supplier. Hence, integration is associated with a higher risk of ex post inefficiencies than outsourcing such that the existence of ex post inefficiencies under *both* organizational forms makes outsourcing *more* likely. Thus, assuming ex post inefficiencies to also arise under integration leads to a result that is completely contrary to the outcome of the knowledge protection approach.

As the producer is worse off in duopoly than in monopoly, the producer might have an incentive to pay a transfer to her supplier to prevent her from becoming a competitor. However, contrary to a setting of complete contracts, this is only profitable for the producer if the headquarter-intensity is neither too low nor too high.

There are several points left for future research. First of all, an important contribution to the existing literature would be to empirically test the predictions and compare them to the outcome of the knowledge protection approach. Thereby it is especially interesting to investigate in how far the results of this empirical analysis depend on how the risk of ex post inefficiencies of a country is measured. Furthermore, in this model, I only consider two periods. For future research, it would be interesting to incorporate more periods to see the long-run effects of a producer's decision. Finally, production of the producer and her competitor are assumed to only differ with regard

to the produced *quantity*. However, as in reality the goods of a producer and her competitor often also differ with regard to their *quality*, it would be straightforward to extend the model in this direction. More precisely, in line with the work of Ottaviano et al. (2002) and Picard (2015), it would be interesting to analyze the implications on a firm's organizational decision in this environment if consumers would have preferences for product quality and the firm and her competitor could determine the quality level of their final good through investions in R&D.

8 References

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9 Appendix

A.I Revenue and input provisions

The profit - both as supplier and competitor - is generally defined as revenue share times revenue level minus unit cost times the respective input provision. The revenue level is always lower in duopoly than in monopoly:

$$\frac{R^*_{Mon}}{R^*_{Duo,C}} = \frac{(1-\alpha)\left(\left(\frac{\alpha}{(1+\alpha)\theta_C}\right)^{\alpha}(\theta_H+\theta_C)\right)^{\frac{1}{1-\alpha}}}{\theta_C-\alpha\theta_H} > 1. \tag{A6.1}$$

This is easiest to see if assuming $\theta_C = l\theta_H$ with $\alpha < l < 1$:

$$\frac{(1-\alpha)\left(\left(\frac{\alpha}{(1+\alpha)l}\right)^{\alpha}(1+l)\right)^{\frac{1}{1-\alpha}}\theta_H}{(l-\alpha)\,\theta_H} > 1 \Leftrightarrow (1-\alpha)\left(\left(\frac{\alpha}{(1+\alpha)\,l}\right)^{\alpha}(1+l)\right)^{\frac{1}{1-\alpha}} > l-\alpha. \tag{A6.2}$$

Since $l > \alpha$, $1-\alpha > l-\alpha$ and $\left(\frac{\alpha}{(1+\alpha)l}\right)^{\alpha}(1+l) > 1$. In addition to this, in dependence on the level of the revenue share as supplier, a switch from "supplier" to "competitor" does not necessarily imply a higher revenue share. Hence, the decision to become a competitor might imply to receive a smaller share of a lower revenue level such that the supplier seems to be clearly worse off as competitor.

However, becoming a competitor might be associated with lower total costs. With similar unit costs, this is the case if the input provision as competitor, $h^*_{Duo,C}$, is lower than the input provision as supplier, m^*_{Mon}:

$$\frac{h^*_{Duo,C}}{m^*_{Mon}} = \frac{c_M\beta_H\eta_H\theta_H(\theta_C-\alpha\theta_H)}{c_H(1-\beta_H)(1-\eta_H)(\theta_C+\theta_H)(1-\alpha)}\left(\frac{1+\alpha}{\alpha}\frac{\theta_C+\theta_H}{{\theta_C}^{-\alpha}}\right)^{\frac{1}{1-\alpha}} > 0. \tag{A6.3}$$

From (A6.3) it is not clear whether the competitor's provision of headquarter services is lower or higher than the provision of the manufacturing input in monopoly. However, it is easy to see that the input provision as competitor in duopoly compared to the input provision as supplier in monopoly is higher, the higher is the headquarter-intensity :

$$\frac{\partial\frac{h^*_{Duo,C}}{m^*_{Mon}}}{\partial\eta_H} = \frac{\frac{h^*_{Duo,C}}{m^*_{Mon}}}{\eta_H\,(1-\eta_H)} > 0. \tag{A6.4}$$

That is, for low values of η_H, the input provision of headquarter services in duopoly is lower than the manufacturing input provision in monopoly. Then, the total costs are lower in duopoly than in monopoly. As a result, only for sufficiently low values of headquarter-intensity the lower total costs can offset the lower revenue as competitor such that the supplier has an incentive to become a competitor.

A.II Competitor headquarter-intensity

A.II.i Effect of a higher relative productivity

The effect of a higher relative productivity θ_C/θ_H on the competitor headquarter-intensity, $\eta_H^{comp,\Xi}$, is given by

$$\frac{\partial \eta_H^{comp,\Xi}}{\partial \frac{\theta_C}{\theta_H}} = \frac{\left(\kappa_{\theta_C/\theta_H} + \lambda_{\theta_C/\theta_H}\right) \alpha^{\frac{-\alpha}{1-\alpha}} \beta_H \theta_H^2 \left(\frac{\theta_C}{\theta_H}\right)^{\frac{1}{1-\alpha}-2} \left(\left(\frac{\theta_C}{\theta_H}\right)+1\right)^{\frac{1}{\alpha-1}}}{(1-\alpha)\,\mu_{\theta_C/\theta_H}} \quad \text{with} \tag{A6.5}$$

$$\mu_{\theta_C/\theta_H} = \left(\alpha^{\frac{-\alpha}{1-\alpha}} (1+\alpha)\,\beta_H \theta_H \left(\left(\frac{\theta_C}{\theta_H}\right)+1\right)^{\frac{-1}{1-\alpha}} \left(\left(\frac{\theta_C}{\theta_H}\right)-\alpha\right)\left(\frac{\theta_C}{\theta_H}\right)^{\frac{\alpha}{1-\alpha}}\right.$$

$$\left. + (1-\alpha)\,\alpha (1+\alpha)^{\frac{-\alpha}{1-\alpha}} (1-\beta_H)\,\theta_H \left(\left(\frac{\theta_C}{\theta_H}\right)+1\right)\right)^2 > 0,$$

$$\kappa_{\theta_C/\theta_H} = \left(1-\alpha^2\right) \alpha^{\frac{\alpha}{\alpha-1}} \beta_H \left(\frac{\theta_C}{\theta_H}\right)^{\frac{1}{1-\alpha}} \left(\left(\frac{\theta_C}{\theta_H}\right)+1\right)^{\frac{-1}{1-\alpha}} \left(\left(\frac{\theta_C}{\theta_H}\right)-\alpha\right)^2 > 0 \quad \text{and}$$

$$\lambda_{\theta_C/\theta_H} = (1-\alpha)\,(1+\alpha)^{\frac{-\alpha}{1-\alpha}} (1-\beta_H)$$

$$\left(\alpha^4 - \alpha^3 - \alpha^2 - (1 - 2\alpha\,((1-\alpha)\,\alpha+1)) \left(\frac{\theta_C}{\theta_H}\right)^2 + (\alpha\,(3 - 2\alpha\,((2-\alpha)\,\alpha+1))+1) \left(\frac{\theta_C}{\theta_H}\right)\right) \gtrless 0.$$

Although mathematical simulations show that $\lambda_{\theta_C/\theta_H} > 0$ and, thus, $\eta_H^{comp,\Xi} > 0$, the sign of $\lambda_{\theta_C/\theta_H}$ cannot be shown analytically. Hence, the sign of the whole derivation is mathematically not clear. However, I can prove in another way that the above derivation has to be positive: The competitor headquarter-intensity is determined by the supplier's profit in monopoly, $\pi_{M,Mon}$, and the competitor's profit in duopoly, $\pi_{H,Duo,C}$. As there is no competitor in a monopoly, the profit as supplier is not affected by the relative productivity of the competitor:

$$\frac{\partial \pi_{M,Mon}}{\partial \frac{\theta_C}{\theta_H}} = 0. \tag{A6.6}$$

In contrast, in duopoly, the competitor has higher profits, the higher is his relative productivity:

$$\frac{\partial \pi_{H,Duo,C}}{\partial \frac{\theta_C}{\theta_H}} = \frac{A\theta_H^{\frac{1+\alpha}{1-\alpha}} \left(\frac{\theta_C}{\theta_H}\right)^{\frac{1}{1-\alpha}-2} (1-\beta_H)^{\frac{\alpha(1-\eta_H)}{1-\alpha}} \beta_H^{\frac{\alpha\eta_H}{1-\alpha}+1} \mathrm{cH}^{\frac{-\alpha\eta_H}{1-\alpha}} \mathrm{cM}^{\frac{-\alpha(1-\eta_H)}{1-\alpha}} \nu_{\theta_C/\theta_H} \left(\theta_H \left(1+\left(\frac{\theta_C}{\theta_H}\right)\right)\right)^{\frac{-1}{1-\alpha}}}{(1-\alpha)^2 \left(1+\left(\frac{\theta_C}{\theta_H}\right)\right)^2}$$

$$> 0 \quad \text{with} \tag{A6.7}$$

$$\nu_{\theta_C/\theta_H} = (1+\alpha)^{\frac{\alpha}{1-\alpha}} \left(((1-\alpha)\,\alpha+1)\left(\frac{\theta_C}{\theta_H}\right) - \alpha^2\right)\left(1+\left(\frac{\theta_C}{\theta_H}\right) - (1+\alpha)\,\eta_H\right)$$

$$+ (1-\alpha)\,(1+\alpha)^{\frac{1}{1-\alpha}} \eta_H \left(\frac{\theta_C}{\theta_H}\right)\left(\left(\frac{\theta_C}{\theta_H}\right)-\alpha\right) > 0.$$

Hence, a higher relative productivity makes it more profitable for the supplier to become a competitor. As a result, the competitor headquarter-intensity increases.

A.II.ii Effect of a higher (producer) revenue share

A higher revenue share as producer (and competitor), β_H, clearly induces a higher competitor headquarter-intensity:

$$\frac{\partial \eta_H^{comp,\Xi}}{\partial \beta_H^{\Xi}} = \tag{A6.8}$$

$$\frac{\left(\alpha\left(1+\alpha\right)\left(\theta_C+\theta_H\right)\right)^{\frac{\alpha}{1-\alpha}}\theta_C^{\frac{\alpha}{1-\alpha}}\left(1-\alpha\right)\left(\theta_C-\alpha\theta_H\right)\left(\left(1+\left(1-\alpha\right)\alpha\right)\theta_H+\alpha\theta_C\right)}{\left(\left(1-\alpha\right)\alpha\left(1+\alpha\right)^{-\frac{\alpha}{1-\alpha}}\left(1-\beta_H^{\Xi}\right)\left(\theta_C+\theta_H\right)+\alpha^{-\frac{\alpha}{1-\alpha}}\left(1+\alpha\right)\beta_H^{\Xi}\theta_H\left(\theta_C+\theta_H\right)^{-\frac{1}{1-\alpha}}\theta_C^{\frac{\alpha}{1-\alpha}}\left(\theta_C-\alpha\theta_H\right)\right)^2} > 0.$$

As the producer has a higher revenue share under integration than under outsourcing, integration is associated with a higher competitor headquarter-intensity than outsourcing.

A.III Prevention headquarter-intensity

A.III.i Effect of a higher relative productivity

A higher relative productivity of the competitor, θ_C/θ_H, increases the prevention headquarter-intensity:

$$\frac{\partial \eta_H^{prev,\Xi}}{\partial \frac{\theta_C}{\theta_H}} = \frac{\alpha^{\frac{\alpha}{1-\alpha}}\left(1+\alpha\right)^{\frac{\alpha}{1-\alpha}}\beta_H\theta_H^2\left(\frac{\theta_C}{\theta_H}\right)^{\frac{2\alpha-1}{1-\alpha}}\left(1+\left(\frac{\theta_C}{\theta_H}\right)\right)^{\frac{-1}{1-\alpha}}\left(\left(1+\left(\frac{\theta_C}{\theta_H}\right)\right)^2\rho_{\theta_C/\theta_H}+\left(1+\alpha\right)\sigma_{\theta_C/\theta_H}\right)}{\tau_{\theta_C/\theta_H}} > 0$$

$$\text{with } \rho_{\theta_C/\theta_H} = \left(1-\alpha\right)\alpha^2\left(1-2\beta_H\left(\alpha^{\frac{2-\alpha}{\alpha-1}}\left(1+\alpha\right)^{\frac{2-\alpha}{1-\alpha}}\left(1-\left(\frac{\theta_C}{\theta_H}\right)\right)\left(1+\left(\frac{\theta_C}{\theta_H}\right)\right)^{\frac{2-\alpha}{\alpha-1}}\left(\frac{\theta_C}{\theta_H}\right)^{\frac{1}{1-\alpha}}+1\right)\right) > 0,$$

$$\sigma_{\theta_C/\theta_H} = \left(1-\alpha\left(1-\beta_H\right)\right)\left(2\alpha\left(\frac{\theta_C}{\theta_H}\right)+2\left(1-\left(\frac{\theta_C}{\theta_H}\right)\right)\left(\frac{\theta_C}{\theta_H}\right)-\alpha^2\left(\left(1+\left(2-\left(\frac{\theta_C}{\theta_H}\right)\right)\left(\frac{\theta_C}{\theta_H}\right)\right)\right)\right) > 0,$$

$$\text{and } \tau_{\theta_C/\theta_H} = \left(\left(1+\alpha\right)^{\frac{1}{1-\alpha}}\beta_H\theta_H\left(\frac{\theta_C}{\theta_H}\right)^{\frac{\alpha}{1-\alpha}}\left(1+\left(\frac{\theta_C}{\theta_H}\right)\right)^{\frac{-1}{1-\alpha}}\left(\alpha-\left(\frac{\theta_C}{\theta_H}\right)\left(2-\alpha\left(\frac{\theta_C}{\theta_H}\right)\right)\right)\right.$$

$$\left.-\left(1-\alpha\right)\alpha^{\frac{1}{1-\alpha}}\left(1-2\beta_H\right)\theta_H\left(1+\left(\frac{\theta_C}{\theta_H}\right)\right)\right)^2 > 0. \tag{A6.9}$$

A.III.ii Effect of a higher (producer) revenue share

A higher producer (and competitor) revenue share β_H increases the prevention headquarter-intensity:

$$\frac{\partial \eta_H^{prev,\Xi}}{\partial \beta_H} = \frac{\zeta_{\beta_H}\left(\left(2-\alpha\right)\alpha^{\frac{1}{1-\alpha}}\left(1+\alpha\right)^{\frac{-\alpha}{1-\alpha}}\left(1-\left(\frac{\theta_C}{\theta_H}\right)^{-\frac{\alpha}{1-\alpha}}\right)\left(1+\left(\frac{\theta_C}{\theta_H}\right)\right)^{\frac{2-\alpha}{1-\alpha}}-\alpha^2\left(1+\left(\frac{\theta_C}{\theta_H}\right)^2\right)+\left(2+4\alpha\right)\right)}{\epsilon_{\beta_H}}$$

$$> 0 \tag{A6.10}$$

$$\text{with } \zeta_{\beta_H} = \left(1-\alpha\right)^2\alpha^{\frac{\alpha}{1-\alpha}}\left(1+\alpha\right)^{\frac{\alpha}{1-\alpha}}\theta_H^2\left(\frac{\theta_C}{\theta_H}\right)^{\frac{\alpha}{1-\alpha}}\left(1+\left(\frac{\theta_C}{\theta_H}\right)\right)^{\frac{-\alpha}{1-\alpha}} > 0$$

$$\text{and } \epsilon_{\beta_H} = \left(\left(1+\alpha\right)^{\frac{1}{1-\alpha}}\beta_H\theta_H\left(\frac{\theta_C}{\theta_H}\right)^{\frac{\alpha}{1-\alpha}}\left(1+\left(\frac{\theta_C}{\theta_H}\right)\right)^{\frac{-1}{1-\alpha}}\left(\alpha-\left(\frac{\theta_C}{\theta_H}\right)\left(2-\alpha\left(\frac{\theta_C}{\theta_H}\right)\right)\right)\right.$$

$$\left.-\left(1-\alpha\right)\alpha^{\frac{1}{1-\alpha}}\left(1-2\beta_H\right)\theta_H\left(1+\left(\frac{\theta_C}{\theta_H}\right)\right)\right)^2 > 0.$$

As the producer's revenue share is higher under integration than under outsourcing, the prevention headquarter-intensity is higher under integration than under outsourcing.

A.III.iii Comparison with the competitor headquarter-intensity

If the supplier has an incentive to become a competitor, the competitor headquarter-intensity is higher than the "prevention" headquarter-intensity:

$$\frac{\eta_H^{comp,\Xi}}{\eta_H^{prev,\Xi}} = \tag{A6.11}$$

$$\frac{\theta_H^{\frac{1}{1-\alpha}}}{(1-\alpha)} \frac{\left(\alpha^{\frac{-\alpha}{1-\alpha}} \beta_H \theta_H^{\frac{-1}{1-\alpha}} \theta_C^{\frac{\alpha}{1-\alpha}} \left(\frac{\theta_C+\theta_H}{\theta_H}\right)^{\frac{-1}{1-\alpha}} (\theta_C - \alpha\theta_H) - (1-\alpha)^2 (1+\alpha)^{\frac{-\alpha}{1-\alpha}} (1-\beta_H)\right)}{\left(\alpha^{\frac{-\alpha}{1-\alpha}} (1+\alpha) \beta_H \theta_H^{\frac{-\alpha}{1-\alpha}} \theta_C^{\frac{\alpha}{1-\alpha}} \left(\frac{\theta_C+\theta_H}{\theta_H}\right)^{\frac{-1}{1-\alpha}} (\theta_C - \alpha\theta_H) + (1-\alpha)\alpha (1+\alpha)^{\frac{-\alpha}{1-\alpha}} (1-\beta_H)(\theta_C+\theta_H)\right)} \cdot$$

$$\frac{\left((1+\alpha)^{\frac{1}{1-\alpha}} \beta_H \theta_H^{\frac{-1}{1-\alpha}} \theta_C^{\frac{\alpha}{1-\alpha}} \left(\frac{\theta_C+\theta_H}{\theta_H}\right)^{\frac{-1}{1-\alpha}} \left(\alpha\left(\theta_H^2+\theta_C^2\right) - 2\theta_C\theta_H\right) - (1-\alpha)\alpha^{\frac{1}{1-\alpha}} (1-2\beta_H)(\theta_C+\theta_H)\right)}{\left(\alpha^{\frac{\alpha}{1-\alpha}} (1-\alpha(1-\beta_H)) \theta_H^{\frac{1}{1-\alpha}} - (1+\alpha)^{\frac{\alpha}{1-\alpha}} \beta_H \theta_C^{\frac{\alpha}{1-\alpha}} (\theta_C+\theta_H) \left(\frac{\theta_C+\theta_H}{\theta_H}\right)^{\frac{-1}{1-\alpha}}\right)} > 1.$$