Essays on the Organization of Multinational Firms

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von: Verena Nina Nowak, M.Sc.
geboren am 08.06.1987 in Duisburg

Erstgutachter: Prof. Dr. Jens Suedekum
Zweitgutachter: Prof. Dr. Hans-Theo Normann

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Chapter 1

Introduction

Firms often use intermediate inputs in the production of their final goods. For each of these inputs, the firm decides from which type of supplier to source it. More precisely, in this "make or buy"-decision, the firm chooses whether to source a specific input from a supplier that is integrated within the boundaries of the firm or from an outsourced, unaffiliated supplier. Integrated and outsourced suppliers may differ with regard to several aspects such that there are various theories to explain firms' organizational decisions.[1]

In this thesis, I contribute to this literature on the organizational decisions of multinational firms and extend it into various directions. In doing so, I mainly focus on the empirically highly relevant[2] property rights approach.[3] Within this approach it is assumed that firms' organizational decisions are made in an environment with relationship-specific inputs and incomplete contracts (à la Grossman and Hart, 1986 and Hart and Moore, 1990). As the producer and the suppliers anticipate that a bargaining will arise after the production of their inputs, they have an incentive to underinvest. Outsourced and integrated suppliers both underinvest; however, to a different degree: An outsourced supplier has the property rights over his input and therefore expects to receive a higher revenue share in the bargaining than an integrated supplier that is basically an employee of the firm. Outsourcing thus implies more production incentives, i.e., ceteris paribus a lower underinvestment, for the supplier than integration. However, stated differently, outsourcing is also associated with lower production incentives for the producer.

The seminal contributions of the property rights approach that consider this trade-off regarding the "make or buy"-decision are by Antràs (2003) and Antràs and Helpman (2004) and consider a producer that contracts with one single input supplier. As, according to the UNCTAD (2004) report on transnational corporations and foreign affiliates, firms have on average considerably more than one supplier,[4] these seminal contributions with one single supplier have been extended to settings with multiple suppliers. Following Baldwin and Venables' (2013) classification of production processes, the considered production processes with multiple suppliers can be separated in so called "spider" and "snake" production processes.

[1] For an overview see, for example, Spencer (2005).

[2] For example, Nunn and Trefler (2013) and Bernard, Jensen, Redding and Schott (2010) find the predicted positive relation between capital intensity (as proxy for headquarter intensity) and the prevalence of integration. Other studies whose results are in line with the predictions of the property rights approach are by Nunn and Trefler (2008), Federico (2010), Defever and Toubal (2011) or Corcos, Irac, Mion and Verdier (2013).

[3] Other major theoretical approaches to explain firms' organizational decisions are the transaction cost approach, the managerial incentives approach and the knowledge capital approach. They are discussed in a bit more detail in chapter 4 and 6.

[4] More details can be found here: http://unctad.org/en/Docs/gdscsir20041c3_en.pdf. This relation is also considered by Alfaro and Charlton (2009).

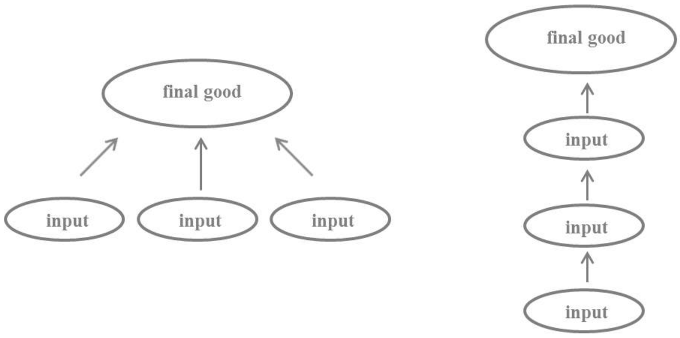

Figure 1.1: Classification of production processes.
Panel 1: “Spider” production process, Panel 2: “Snake” production process.

As depicted in the left panel of figure 1.1, “spiders” are production processes where a final good’s inputs enter in no particular order. Consider as an example the production of coffee capsules: Production of these capsules requires two inputs - the aluminium capsules and the coffee itself - that can be produced independent from each other. Contributions to explain firms’ organizational decisions in those “spiders” are made by Acemoglu, Antràs and Helpman (2007) and Schwarz and Suedekum (2014). Acemoglu, Antràs and Helpman (2007) consider a setup with multiple, completely symmetric suppliers - both with respect to the organizational forms and the input characteristics. In their model they hence determine endogenously the number of suppliers, however, either *all* suppliers are integrated or *all* suppliers are outsourced. Schwarz and Suedekum (2014) extend the analysis by headquarter services and the possibility to choose different organizational forms for different suppliers. They find the empirically relevant phenomenon of hybrid sourcing[5] where some suppliers are kept within the boundaries of the firm, whereas others are outsourced. However, as inputs are assumed to be symmetric with regard to their specific characteristics, their model cannot explain *which* suppliers are integrated and *which* suppliers are outsourced with hybrid sourcing.

In chapter 2, **Asymmetric spiders: Supplier heterogeneity and the organization of firms**, that is joint work with my supervisor Jens Suedekum and a former colleague, Christian Schwarz, and published in the Canadian Journal of Economics, we extend this work. We analyze organizational decisions in such a “spider” production process with possible asymmetries in the suppliers’ organizational forms *and* the suppliers’ input characteristics, as for example asymmetries in the suppliers’ technological importance for the final good. More precisely, we consider a property

[5]Empirical evidence for the relevance of hybrid sourcing is, for example, provided by Defever and Toubal (2013), Corcos, Irac, Mion and Verdier (2013), Kohler and Smolka (2012) and Tomiura (2007).

rights model of a firm with two heterogeneous suppliers and analyze *which* sourcing mode (outsourcing or vertical integration) is chosen for *which* of the two asymmetric inputs. We find that this decision crucially depends on the degree to which the two asymmetric components are substitutable: If they are close substitutes, the firm tends to outsource the technologically more important input while keeping the less important one inside the firm boundaries. This pattern can be reversed, however, if the two inputs are strongly complementary. The firm also tends to outsource low-cost inputs and components with low sophistication. We show that these theoretical predictions are consistent with numerous case studies and recent empirical evidence on the internal organization of firms.

The third chapter **Make or buy - on the organizational structure of firms with asymmetric suppliers** that is also co-authored by Jens Suedekum and Christian Schwarz and published in a collected volume of MIT Press, is kind of a "spin-off" product of the second chapter. In the same setup as before - a production process with one headquarter firm and two heterogeneous suppliers who contribute essential inputs of varying importance - we explain in detail the Shapley value approach used as the solution concept for the multilateral bargaining. In doing so, we gradually derive the firm's and the two suppliers' marginal contributions and revenue shares, explain how revenue is distributed between the producer and the two suppliers and show the impact of variations of different parameters on this distribution.

In the fourth chapter **The extra costs of outsourcing** that is joint work with Christian Schwarz, we still consider this "spider" setup with potential asymmetries in the characteristics of the suppliers' inputs, but take into account additional approaches to explain firms' organizational decisions. More precisely, whereas within the property rights approach, i.e., within the approach used so far, integrated and outsourced suppliers differ with regard to their investment incentives, it is argued in other contributions to the literature that integration might also be associated with economies of scope, i.e., that outsourcing induces costs. We give a detailed review of the literature and introduce extra costs of outsourcing into the previous setup. The organizational decision is then driven by two countervailing effects: The ownership rights effect favors outsourcing of a more important input, while the "indirect" effect via the suppliers' costs favors vertical integration. We derive sharp testable predictions in how far this indirect effect influences the producer's decision to keep the key inputs vertically integrated inside the firm's boundaries.

Chapter 5 differs from the last three chapters as it considers a "snake" production process, as illustrated in the right panel of figure 1.1. In contrast to "spiders", in "snake" production processes the inputs enter the production process in a particular order. The typical example for such a sequential production is Henry Ford's original Model T production assembly line. Antràs and Chor (2013) analyze a firm's organizational structure in such a sequential "snake" production process. They assume that the headquarter makes all organizational decisions along the value chain and find that these decisions depend on the respective input's position in the value chain and whether inputs are sequential complements or substitutes.

In this fifth - single-authored - chapter, **Organizational decisions in multistage production processes**, I argue that organizational decisions in multistage production processes are not always made by the downstream headquarter firm, but by the various intermediate inputs suppliers along the value chain themselves. To explain organizational decisions in those cases, I assume a production process with one headquarter (final good producer) and two suppliers at different positions within the chain. In this environment with incomplete contracts and relationship-specific investments, the firm decides only on the organizational form of her direct supplier, who in turn decides whether to outsource or to vertically integrate his own supplier. I find that the producer's and the supplier's organizational decisions are interrelated, particularly when production decisions occur sequentially. For instance, my model predicts that a higher technological importance of the downstream supplier raises the probability that the upstream supplier is vertically integrated. I also compare my model to the above "snake" framework by Antràs and Chor (2013). Then, I assume firms to be able to freely decide on their organizational decision structure and find for instance that firms with a higher overall productivity are more likely to choose a structure where the suppliers decide themselves on their suppliers' organizational forms.

To take into account the fear of firms to lose their knowledge to a competitor, I combine the property rights approach with the knowledge protection approach in the sixth - also single-authored - chapter, **The decision whether to integrate or to outsource - combining ex ante distortions and ex post inefficiencies**. To simplify the analysis, I return to the seminal contributions of Antràs (2003) and Antràs and Chor (2004) and consider a one-supplier-setup where final good production requires a firm's headquarter services and a foreign supplier's manufacturing input. Firms that decide whether to choose integration or outsourcing of the supplier for the provision of the input do not only have to consider the ex ante investment 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.

Chapter 7 summarizes the main new insights resulting from the analysis in this thesis.

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Chapter 2

Asymmetric spiders: Supplier heterogeneity and the organization of firms

Co-authored with Christian Schwarz and Jens Suedekum

2.1 Introduction

Most final goods require multiple intermediate inputs. Some of those intermediates are technologically more important than others and generate a higher value-added in the production process, some are inherently more sophisticated while others are easier to handle, some are cheaper to produce than others, and so on. For each of these asymmetric inputs, the headquarters in charge of the firm's organization have to decide on the crucial "make or buy" question. Should the component, given its specific characteristics, be manufactured by a subsidiary who is vertically integrated within the firm's boundaries, or should that input rather be subcontracted to an external supplier over which the firm has no direct control or ownership rights? Evidence suggests that the vast majority of firms answers this question differently for different inputs. That is, firms in reality do not typically outsource all of their intermediate inputs, or produce all of them in-house, but most choose an organizational structure with external and internal suppliers at the same time.[1] Yet, while economists have discussed the motives for such a "hybrid sourcing" choice per se, they have so far devoted little attention to the question which sourcing mode is chosen for which of the asymmetric intermediate inputs.

Case studies from the business literature point at interesting differences in that respect.[2] Consider, for example, the production of medical drugs. That final good consists, basically, of two components: the active ingredient that is crucial for the efficacy of the substance, and an appropriate vehicle (e.g., galantine capsules) as a carrier. Big pharmaceutical companies like *Novartis* tend to outsource the latter input, which is not generic but mostly customized to the respective product, to specialized external suppliers such as *West Pharma*. The essential pharmaceutical component, however, is produced in-house and is thus kept vertically integrated along with headquarter services like R&D and marketing. The international food giant *Nestle*, on the other hand, chooses a different organizational structure in the production process for its *Nespresso* cups. The essential component - the coffee - is sourced from external suppliers from various countries, while the other specific input - the aluminum capsules - comes from wholly owned Swiss subsidiaries.[3] Put differently, in some industries (like pharmaceuticals) firms seem to keep their most

[1] Kohler and Smolka (2015), Corcos, Irac, Mion and Verdier (2013), Defever and Toubal (2013), Costinot, Oldenski and Rauch (2011) and Tomiura (2007) provide evidence on the prevalence of hybrid sourcing for Spanish, French, US, and Japanese firms, respectively.

[2] See Bengtsson, von Haartman and Dabhilkar (2009), Chesbrough and Teece (1996), Lakemond, Berggren and van Weele (2006), Ulrich and Ellison (2005).

[3] For further information on the *West Pharma* and the *Nespresso* case, see the following websites (last accessed 21/08/2015): http://www.westpharma.com/en/Investors/Pages/AnnualReport.aspx and, respectively, here: http://www.nestle-nespresso.com/asset-libraries/Documents/Nespresso%20-%20Corporate%20Production%20Centres%20Factsheet.pdf.

important manufacturing inputs in-house and outsource only relatively less important components, while in other industries (like coffee) it seems to be the other way around.

In this paper, we provide a possible explanation for these different hybrid sourcing patterns across industries and derive testable empirical predictions. In particular, our theoretical model suggests that the first pattern (vertical integration of the most important inputs) is more likely to arise in industries where the degree of component substitutability is low and where the elasticity of final goods demand is high. The second pattern (outsourcing of the most important inputs), by contrast, is more widespread if inputs (or input qualities) are better substitutable and when demand elasticity is low.

We develop a property rights model of a firm that deals with two heterogeneous suppliers, each providing a unique manufacturing input. The property rights approach, which dates back to the pioneering work by Grossman and Hart (1986) and Hart and Moore (1990), has been used extensively to analyze the internal organization of firms, both from a theoretical and an empirical point of view. It relies on an environment with incomplete contracts and relationship-specific investments. Ownership structures matter in this context, because they shape the bargaining powers and, thus, the investment incentives of the involved parties who anticipate hold-up and renegotiation problems.

This literature mostly ignored issues of supplier heterogeneity in production processes with multiple inputs, however. In particular, following the seminal contributions by Antràs (2003) and Antràs and Helpman (2004), various models consider a setting where headquarter services are combined with one single manufacturing component. These frameworks investigate the industry- and firm-level determinants of the ownership decision whether to outsource or to integrate this unique supplier, but heterogeneity across inputs - by construction - plays no role in those models. Acemoglu, Antràs and Helpman (2007) consider a production process with a continuum of inputs, but all components are fully symmetric in that model, so that supplier heterogeneity also does feature in their approach.

The two models most closely related to ours are the recent frameworks by Antràs and Chor (2013) and by Schwarz and Suedekum (2014). The former consider a vertical value chain where inputs pass along various production stages and are refined in each stage. Inputs and their respective suppliers, thus, differ exogenously according to their level of "downstreamness", and the production process resembles a "snake" structure in the terminology of Baldwin and Venables (2013). Antràs and Chor (2013) show that an input's position on the value chain systematically affects the firm's respective ownership choice. In particular, if supplier investments are "sequential complements" and reinforce each other along the chain, the firm tends to outsource the upstream stages and to integrate the downstream ones. The opposite pattern emerges if inputs are relatively close substitutes so that supplier investments discourage each other ("sequential substitutes").

The model by Schwarz and Suedekum (2014) builds on the setup by Acemoglu, Antràs and Helpman (2007) with a continuum of suppliers. All components are simultaneously combined with headquarter services to assemble a final good, so that their production process resembles a "spider" structure in Baldwin/Venables-jargon. Schwarz and Suedekum (2014) show that firms might engage in hybrid sourcing, with some suppliers vertically integrated and others outsourced. That pattern, which cannot arise in the baseline frameworks with just a single supplier, emerges because it enables the headquarters to fine-tune the revenue distribution and the investment incentives inside the firm. However, since all inputs are symmetric along all exogenous dimensions in their model, they cannot address the main question of this paper, namely which sourcing mode the firm chooses for which input.

In this paper, we also consider a "spider" structure, yet we allow for exogenous asymmetries across inputs. Differently from existing models, we do not assume a continuum, but our framework features two discrete inputs/suppliers.[4] These two components can differ in three respects: i) their technological importance as measured by the input intensity in the production process (the respective Cobb-Douglas exponent), ii) their unit costs of production, and iii) their degree of sophistication as measured by the input fraction that is usable for the firm even when the respective supplier refuses to collaborate.

We first analyze technological asymmetries across components. If the two manufacturing inputs are relatively close substitutes, we find that hybrid sourcing always involves outsourcing of the "strong" supplier, who provides the technologically more important input, and vertical integration of the "weak" supplier. The reason is the incentivizing effect of property rights: if hybrid sourcing is optimal for the firm, it gives priority to transferring ownership rights to the supplier whose component input is relatively more intensively used in production. This pattern can change, however, once the elasticity of substitution across components is sufficiently low relatively to the elasticity of demand. Then, we also encounter an ownership pattern where the firm only outsources the weak supplier while keeping the strong supplier in-house. The intuition is that the weak supplier would have too little investment incentives as an integrated affiliate and this can backfire on the incentives of the strong supplier when investment choices are highly complementary. Put differently, in our "spider" setup, a similar complementarity effect is at work as in the "snake" model by Antràs and Chor (2013), even though production and investment choices are not

[4] The theoretical models by Du, Lu and Tao (2009) and by Van Biesebroeck and Zhang (2014) also study settings with incomplete contracts and multiple suppliers, but they focus on different mechanism than our framework.

sequential in our framework. In sum, our property rights model can rationalize both types of hybrid sourcing patterns observed in reality, and it makes testable empirical predictions under which conditions either of the two is more likely to emerge.

Turning to the other dimensions of heterogeneity, we show that if there are differences in unit costs across suppliers, the firm tends to outsource the low-cost, and to integrate the high-cost supplier. Supposing that the low-cost supplier comes from a foreign country, this implies a positive correlation between outsourcing and offshoring. Moreover, if components differ in their sophistication, we show that the firm tends to outsource the simpler input while keeping the complex one in-house. Both predictions are firmly in line with firm-level empirical evidence, as we discuss below.

The rest of this paper is organized as follows. Section 2.2 introduces the model structure, and section 2.3 analyzes the firm's ownership structure when components differ in their technological importance. Section 2.4 addresses heterogeneity in unit costs and sophistication across inputs. Section 2.5 concludes and discusses how the predictions of our model could be taken to the data.

2.2 The model

2.2.1 Technology and demand

We consider a firm that produces a final good q. Production of this good requires headquarter services and two different manufacturing components. The headquarter services are denoted by h and are provided by the final goods producer herself. The components are manufactured by suppliers. Specifically, we assume that there are two suppliers A and B who provide x_i units of their respective component, with $i = \{A, B\}$. The inputs are combined according to the following production function:[5]

$$q = \left(\frac{h}{\eta^H}\right)^{\eta^H} \left(\frac{X}{1-\eta^H}\right)^{1-\eta^H}, \tag{2.1}$$

[5] This technology is similar as in Acemoglu, Antràs and Helpman (2007) or Schwarz and Suedekum (2014), but assumes a discrete and fixed number of manufacturing components rather than a continuum of inputs. Notice that firm-level productivity differences as in Antràs and Helpman (2004) are not essential for our model. It would be straightforward, however, to include a productivity shifter into the production function (2.1).

$$\text{with} \quad X = \left[\eta_A \left(\frac{x_A}{\eta_A} \right)^{\alpha} + \eta_B \left(\frac{x_B}{\eta_B} \right)^{\alpha} \right]^{\frac{1}{\alpha}}. \tag{2.2}$$

The upper tier production function (2.1) is a standard Cobb-Douglas, where η^H denotes the headquarter-intensity and $\left(1-\eta^H\right)$ is the overall component-intensity of the production process. The aggregate component input X is given by a constant elasticity of substitution (CES) function as in (2.2), where η_i captures the input intensity of component i within the aggregate X (with $\eta_A + \eta_B = 1$), and where $\alpha \in (0,1)$ measures the substitutability of the two component inputs. On the demand side, the firm faces an iso-elastic demand function for the final product,

$$q = Yp^{-\frac{1}{1-\beta}}, \qquad \beta \in (0,1) \tag{2.3}$$

where p is the price, $Y > 1$ is a demand shifter, and $\frac{1}{1-\beta} > 1$ is the demand elasticity. Combining (2.1)-(2.3) yields the firm's revenue as a function of the input levels:

$$R = Y^{1-\beta} \left[\left(\frac{h}{\eta^H} \right)^{\eta^H} \left(\frac{\left[\eta_A \left(\frac{x_A}{\eta_A} \right)^{\alpha} + \eta_B \left(\frac{x_B}{\eta_B} \right)^{\alpha} \right]^{\frac{1}{\alpha}}}{1-\eta^H} \right)^{1-\eta^H} \right]^{\beta}. \tag{2.4}$$

For practical purposes, it is convenient to think of h, x_A and x_B as quality-adjusted inputs into the production process. Consider, as an illustration, the production of the coffee capsules mentioned in the introduction. In stylized terms, this final good requires two component inputs (the coffee, x_A, and the capsules, x_B) along with headquarter services h like general management. From a technological point of view, all three inputs are essential and at least on the component side require fixed proportions (a certain amount of coffee per capsule). Still, there is some substitutability in the sense that higher quality of one input can partly offset lower quality of the other. In this particular example, the parameter η_A thus describes how quality improvements of the coffee affect total output and revenue, ceteris paribus, and here we may expect $\eta_A > \eta_B$ since the coffee is more important than the capsules per se. Relatedly, more sophisticated design or better aluminum for the capsules might (at least to some extent) compensate for lower-quality coffee such that output and sales stay constant.[6] Hence, we may expect the parameter α to be higher in this context than in other production processes, for instance in the pharmaceutical

[6] Other examples for production processes where α is relatively high include the ICT industry, since the quality of code programming in software firms is better substitutable with the quality of, say, technical support.

industry, where quality defects of the active ingredient cannot be compensated at all by higher quality of the carrier.

2.2.2 Structure of the game

The producer's key decision in our model concerns the firm's organizational structure. That is, the producer decides for both components whether the respective supplier is an external subcontractor or a vertically integrated affiliate. The producer makes these organizational decisions in an environment with incomplete contracts à la Grossman and Hart (1986) and Hart and Moore (1990). All component and headquarter inputs are fully relationship-specific and noncontractible, as their characteristics cannot be precisely specified ex ante, nor be verified by a third party (e.g., a court) ex post.[7] Formally, we study the following five-stage game that we solve by backward induction:

1. The producer determines the organization of the firm by choosing the ownership structure of production. This decision is represented by a tuple $\Xi = \{\Xi_A, \Xi_B\}$, where $\Xi_i = O$ denotes outsourcing and $\Xi_i = V$ denotes vertical integration of the supplier of component $i = \{A, B\}$. Given this organizational decision, the firm offers contracts to potential suppliers. The contracts can include an upfront payment τ_i (positive or negative) to supplier i.
2. There is a huge mass of potential suppliers for both components. They apply for the contract, and the producer chooses one supplier for each component. Potential suppliers have an outside opportunity equal to w_i.
3. The headquarter and the two suppliers decide independently on their noncontractible input provision levels (h and, respectively, x_A and x_B). The unit costs of headquarter services are given by c_H. The unit costs of production for input i are given by c_i.
4. The three players bargain over the surplus value of the relationship.
5. Output is produced, revenue is realized and distributed according to the bargaining outcome.

Some comments about this setup are necessary. Most importantly, notice that a hold-up problem arises due to the assumed contract incompleteness. Agents cannot

[7] This contractual environment is surely an extreme one. It is assumed to stay as close as possible to the baseline model by Antràs and Helpman (2004). In an extension, Antràs and Helpman (2008) allow for partial contractibility of inputs and cross-country differences in contract enforcement. We could introduce these features into our model as well. This would make the exposition considerably more complicated, however.

commit on their input provision levels as stipulated in stage 1, so that the two suppliers and the producer end up in a bargaining over the surplus value of the relationship in stage 4, at a time where all input provision costs are already sunk. Anticipating this, all parties tend to underinvest into their input provisions in stage 3.

The producer's organizational decision in stage 1 matters, because it affects the bargaining powers of the involved parties in stage 4 and, hence, their investment incentives in stage 3. An outsourced supplier maintains the full property rights over his input, while a vertically integrated supplier is essentially an employee of the producer. As will become clear soon, an external supplier tends to be in a better bargaining position vis-à-vis the producer, as he threatens to withhold his entire input level in stage 4. Following the property rights approach of the firm, we assume that an integrated affiliate may also refuse to collaborate in the ultimate stage of the game. In such a case, owing to her residual control rights, it is then possible for the producer to confiscate the input and to use it at least partly.

2.2.3 Bargaining and Shapley values

Starting with stage 5, each player receives the payment agreed on in the bargaining. We solve the bargaining problem in stage 4 with the Shapley value approach (see Shapley, 1953) which is a standard solution concept in multilateral bargaining contexts. A player's Shapley value is "*the average of her contributions to all coalitions that consist of players ordered below her in all feasible permutations*" (Acemoglu, Antràs and Helpman, 2007). In the main text, we focus on the economic intuition while all formal derivations for the Shapley values are relegated to a supplementary appendix.[8]

In our model, coalitions can contain one, two or three players. Zero output is produced and no revenue is generated by coalitions consisting only of a single player, or by coalitions of the two suppliers. These coalitions are not feasible. Only coalitions with the producer and at least one input supplier are feasible. Within the set of feasible coalitions, the players can be ordered in different ways, and those orderings are called permutations. For each of those, the respective last player's marginal contribution is determined, i.e., the difference in revenue when the respective player is part of the coalition, and when the respective player is not part of it. These marginal contributions of the suppliers depend on the ownership structure of the

[8] In the supplementary appendix we furthermore show that our key results also hold with a different setup for the division of the overall surplus, namely multilateral asymmetric Nash bargaining where the producer and the suppliers receive predetermined revenue shares reflecting their (exogenously given) bargaining powers.

firm. During the bargaining, when supplier i refuses to collaborate, he threatens to withhold the fraction $\delta_i^{\Xi_i}$ of his input, while the producer can keep and effectively use the fraction $\left(1-\delta_i^{\Xi_i}\right)$. This parameter $\delta_i^{\Xi_i}$ captures both, property rights and the inherent degree of sophistication of the component. To see this, notice that in case of outsourcing, we have $\delta_i^O = 1$ irrespective of the input characteristics, because external suppliers maintain the full residual control rights. When supplier i is vertically integrated, however, the producer can use the fraction $0 < \delta_i^V < 1$ even without the supplier's cooperation, owing to her property rights. The parameter δ_i^V then becomes a natural measure for the component's sophistication. Intuitively, highly complex inputs like special purpose machines are characterized by a high δ_i^V, since they are hardly useable without the specific knowledge of the (internal) supplier. By contrast, simpler relationship-specific components such as uniquely tailored textiles are easier to use even if the supplier refuses to collaborate and are, thus, characterized by a lower sophistication δ_i^V.

Due to this difference in the residual control rights, an outsourced supplier causes a higher drop in revenue (has a higher marginal contribution) than an integrated supplier when leaving any coalition. Similarly, the marginal contribution of an integrated supplier is higher the more sophisticated his component is. The Shapley values of the two supplier, s_A^{Ξ} and s_B^{Ξ}, are then calculated as a weighted average of their marginal contributions to the different feasible coalitions, while the producer is the residual claimant and receives the total revenue minus the two Shapley values (see the supplementary appendix for details). Ultimately, the revenue share that supplier i realizes in the multilateral bargaining is denoted as s_i^{Ξ}/R, whereas the revenue share of the headquarter is s_H^{Ξ}/R.

2.2.4 Input investments

In stage 3, agents choose their input provision levels, taking into account the Shapley values that they anticipate to receive in the bargaining stage. Due to noncontractibility, each player chooses the investment so as to maximize the individual payoff, which equals the Shapley value minus the production costs. The input contributions of the suppliers and the producer can therefore be written as

$$\tilde{x}_i^{\Xi} = \text{argmax}_{x_i} \left\{ s_i^{\Xi} - c_i x_i \right\} \quad \text{and} \quad \tilde{h}^{\Xi} = \text{argmax}_{h} \left\{ s_H^{\Xi} - c_H h \right\}. \tag{2.5}$$

Notice that the payoff-maximizing input choices in (2.5) depend on the anticipated Shapley values, while those Shapley values depend in turn on the players' input provisions, which determine their marginal contributions to the different feasible coalitions. In this setup with two discrete and asymmetric suppliers, we can therefore not solve analytically for the input levels $\left\{\tilde{x}_A^{\Xi},\ \tilde{x}_B^{\Xi},\ \tilde{h}^{\Xi}\right\}$ and the Shapley values

$\{s_A^\Xi, s_B^\Xi, s_H^\Xi\}$ as functions of the firm's ownership structure Ξ. Instead, we have to rely on a numerical approach.[9] In the supplementary appendix, we illustrate this approach and discuss how the players' revenue shares and investment incentives are affected by technology and cost parameters for a given structure Ξ. To summarize some key insights, we find that:

i) Everything else equal, the higher is the headquarter-intensity η^H, the higher is the producer's realized revenue share and the lower are the revenue shares of both suppliers. A higher η^H also leads to a higher input contribution of the producer relative to the two suppliers.

ii) Everything else equal, if supplier A provides the technologically more important input (with higher input intensity $\eta_A > \eta_B$), he realizes the higher revenue share and provides a higher input contribution than the other supplier B ($\tilde{x}_A^\Xi > \tilde{x}_B^\Xi$).

iii) Everything else equal, if supplier A provides the more sophisticated input ($\delta_A > \delta_B$), he realizes a higher revenue share and makes a higher input contribution than supplier B.

iv) Everything else equal, if supplier A has lower unit costs ($c_A < c_B$), he realizes a larger revenue share and makes a higher input contribution than supplier B.

The intuition for i) is analogous to Antràs and Helpman (2004) or Schwarz and Suedekum (2014): If the headquarter provides a more important input, she has stronger bargaining power which in turn ameliorates her underinvestment problem. The logic behind ii), iii) and iv) is similar. With two asymmetric suppliers, the one who provides the technologically more important or more sophisticated input (or is able to produce his component at lower unit costs) also realizes a higher bargaining weight, which in turn incentivizes him to contribute more to the relationship.

While results i)-iv) refer to exogenous parameters of the model, the revenue distribution inside the firm and the investment incentives also depend on the firm's organizational structure Ξ, which is predetermined in the production and bargaining stages. In particular, we find that:

v) For given parameter values, the revenue share of supplier A is higher if he is outsourced than if he is vertically integrated. The supplier provides a higher

[9] In Schwarz and Suedekum (2014) it is possible to solve for these variables, because they assume a continuum of technologically symmetric suppliers, where each single supplier has a negligible impact on the average supplier contribution, and in turn, takes this average input level as given. This is different in our setup where suppliers are asymmetric and have a nonnegligible impact on each coalition.

input contribution under outsourcing than under vertical integration, ceteris paribus.

vi) For given parameter values, supplier A realizes a higher revenue share when the other supplier B is integrated than if supplier B is outsourced.

Result v) illustrates the well-known insight by Antràs (2003) that a transfer of property rights via outsourcing has an incentivizing effect for the respective supplier, because it raises his bargaining power as described before. In our model with two asymmetric components, there are also interesting interdependencies, as indicated by result vi): The revenue share of one supplier not only depends on his own organizational form, but also on the organization of the other supplier. Specifically, suppose supplier B is switched from vertical integration to outsourcing, so that he consequently realizes a higher revenue share (see result v). Ceteris paribus, this negatively affects A's realized revenue share, since B now takes out a larger piece of the pie. Whether this switch also has a negative effect on A's investment incentives is a priori not clear, however, because B subsequently contributes more to the relationship, so that the overall size of the pie increases. We return to this issue in the next section, where it will play an important role how closely complementary the two components are.

A direct implication of results v) and vi) is that the producer's residual revenue share is highest when both suppliers are integrated, and lowest when both are outsourced. For the intermediate cases with one integrated and one outsourced supplier (hybrid sourcing), her revenue share ranges in between as illustrated also in the supplementary appendix.

2.2.5 Contract offers

Finally, after having described the bargaining and the input provision stages, we move towards the producer's organizational decision. Before doing so, notice that in stage 2 suppliers only apply for a contract if the offered payoff at least equals their outside option w_i. Hence, the participation constraint of supplier i reads as $s_i^{\Xi} - c_i \tilde{x}_i^{\Xi} + \tau_i \geq w_i$. Since the producer can freely adjust the upfront payments in stage 1, those participation constraints are satisfied with equality, i.e., $\tau_i = w_i - s_i^{\Xi} + c_i \tilde{x}_i^{\Xi}$.

Then, in stage 1, the producer chooses the firm's organizational structure in order to maximize her own payoff, $s_H^{\Xi} - c_H \tilde{h}^{\Xi} - \tau_A - \tau_B$. Using the upfront participation fees, and bearing in mind that the sum of all Shapley values is equal to total revenue, this is equivalent to the following problem:

$$max_{\Xi}\ \pi = R\left(\tilde{h}^{\Xi}, \tilde{x}_A^{\Xi}, \tilde{x}_B^{\Xi}\right) - c^H \tilde{h}^{\Xi} - c_A \tilde{x}_A^{\Xi} - c_B \tilde{x}_B^{\Xi} - w_A - w_B. \tag{2.6}$$

In words, the producer chooses the tuple $\Xi = \{\Xi_A, \Xi_B\}$, with $\Xi_i \in \{O, V\}$, so as to maximize the joint payoff of the relationship, anticipating the implications of her organizational decision for the investment incentives of all agents (including herself) and the revenue distribution inside the firm.

2.3 The firm's organizational choice

The producer's final ownership choice is illustrated in figure 2.1.[10] We display headquarter-intensity η^H on the horizontal, and component A's input intensity η_A on the vertical axis. With $\eta_A = 1/2$ components are symmetric, and the technological asymmetry is larger the further away η_A is from 1/2. Panels 1 and 2 show two examples which assume identical parameter values, except for the component substitutability α. In the left (right) panel, α is relatively high (low), meaning that components are relatively good (bad) substitutes. The different colored areas specify which ownership structure is payoff-maximizing for the firm in different ranges of η^H and η_A.

In both panels, we observe that the producer decides to outsource both suppliers when the headquarter-intensity η^H is sufficiently low (blue color). Analogously, if η^H is sufficiently high, the producer chooses to keep both suppliers vertically integrated (red color). This pattern, with a positive correlation of vertical integration and headquarter-intensity, is well understood from property rights models à la Antràs (2003): Low headquarter-intensity implies that components are technologically very important in the production process. It is thus optimal to transfer ownership rights to them in order to tackle their underinvestment problems. Analogously, for high η^H, the producer provides the most important input herself. By choosing complete vertical integration, she can realize the highest possible residual revenue share to tackle her own underinvestment problem.

[10] Since we cannot solve explicitly for the input contributions and Shapley values, we also have to rely on a numerical approach to solve for the final ownership decision. We further illustrate this approach in the supplementary appendix. As a further supplement, we provide a customized MATHEMATICA 9.0 file to compute the final ownership decision, as well as input contributions and Shapley values for different parameter constellations. In the main text, we focus on the explanation of the underlying economic intuition.

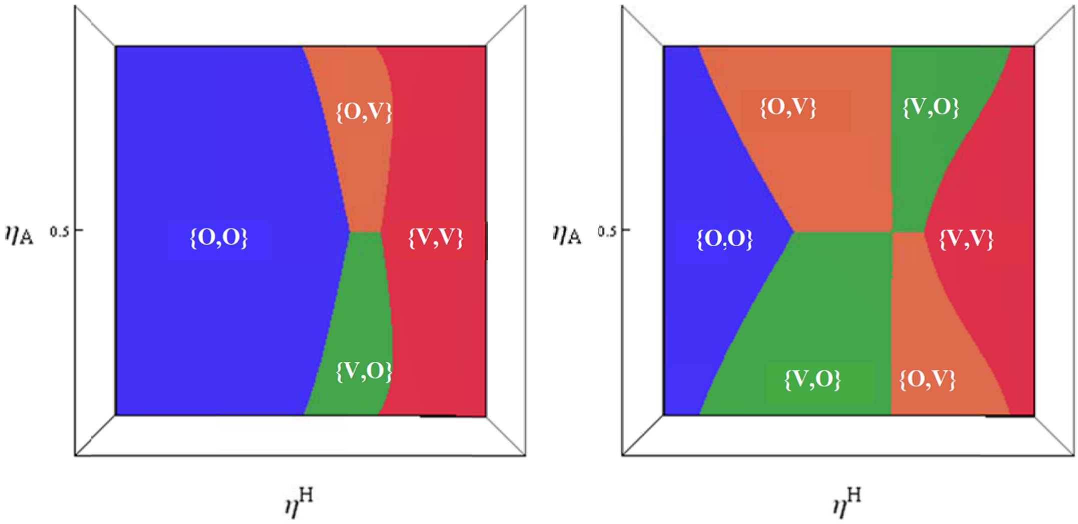

Figure 2.1: Ownership choice for varying headquarter-intensity and technological asymmetry.
Panel 1: High substitutability ($\alpha = 0.35$), Panel 2: Low substitutability ($\alpha = 0.1$). Common parameters: $c_A = c_B = 1$, $c^H = 1$, $\delta_A^O = \delta_B^O = 1$, $\delta_A^V = \delta_B^V = 0.85$, $\beta = 0.8$, $Y = 1$, $w_A = w_B = 0$.

2.3.1 Hybrid sourcing: Which sourcing mode for which input?

Importantly, for intermediate values of η^H we find that the producer chooses hybrid sourcing: one supplier is outsourced, while the other one is vertically integrated. The reason is that, for intermediate values of η^H, the uniform organizational structures $\{O, O\}$ and $\{V, V\}$ are not payoff-maximizing, as they exacerbate the underinvestment problem for the producer or, respectively, for the suppliers to an undue extent. Hybrid sourcing leads to a better balance of these underinvestment problems, and the producer uses her organizational decision to fine-tune the revenue distribution and the investment incentives inside the firm, similar as in Suedekum and Schwarz (2014). Figure 2.1 also shows that a stronger technological asymmetry across the two components makes the occurrence of hybrid sourcing more likely. This can be seen by noting that the parameter range of η^H, where hybrid sourcing is chosen, expands the further away η_A is from the symmetrical value of 1/2.

Turning to the main novel feature of our model, the key question for the hybrid sourcing constellations is then: Which organizational mode is chosen for which supplier? Here, the two examples in figure 2.1 make partly different predictions. Focus at first on panel 1 where the two components are relatively good substitutes (α is relatively high). Here we find that the producer always outsources the supplier of the technologically more important component. This can be seen by noting that only the organizational form $\{O, V\}$ (orange) exists if $\eta_A > 1/2$, but never the form $\{V, O\}$. Vice versa, for $\eta_A < 1/2$ we only observe $\{V, O\}$ (green) but never $\{O, V\}$. Now focus on panel 2, where we assume a lower degree of substitutability. For low-to-intermediate values of η^H, we first have a range of hybrid sourcing with the same properties as in panel 1. Then, at intermediate-to-high levels of η^H this pattern is reversed, and the producer now chooses $\{V, O\}$ for $\eta_A > 1/2$, and $\{O, V\}$ for $\eta_A < 1/2$. That is, she would now vertically integrate the strong supplier who provides the relatively more important component and outsource the weak supplier whose input is relatively less important for the final output.

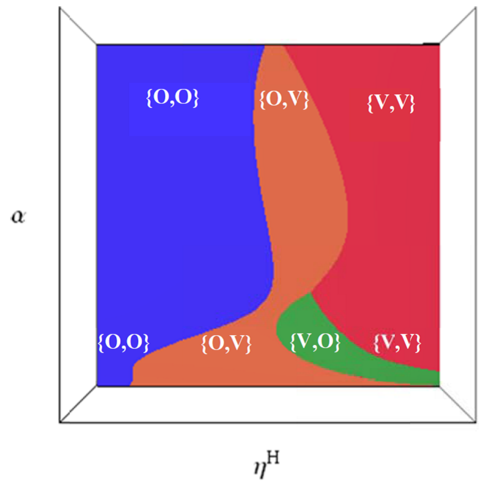

Figure 2.2: Ownership choice for varying headquarter-intensity and component substitutability.
Parameters: $\eta_A = 0.8$, $c_A = c_B = 1$, $c^H = 1$, $\delta_A^O = \delta_B^O = 1$, $\delta_A^V = \delta_B^V = 0.85$, $\beta = 0.8$, $Y = 1$, $w_A = w_B = 0$.

Figure 2.2 illustrates these two different hybrid sourcing patterns from a different angle. Here we impose that component A is technologically more important by setting $\eta_A = 0.8$, and we then depict the payoff-maximizing ownership structure for varying levels of headquarter-intensity (horizontal axis) and component substitutability (vertical axis) and for given values of the other parameters. This includes, in particular, the demand elasticity parameter β, which is still set to 0.8 in figure 2.2.

Consistent with figure 2.1, we find that the ownership structure changes over the range of η^H from $\{O, O\}$ to $\{O, V\}$ to $\{V, V\}$ if α is large. That is, when components are relatively close substitutes, the hybrid sourcing mode at intermediate levels of η^H is always such that the strong supplier A is outsourced and the weak supplier B is integrated. This corresponds to figure 2.1.1. Yet, when α is low enough, also the other hybrid sourcing pattern $\{V, O\}$ emerges at slightly higher levels of η^H, which corresponds to figure 2.1.2. In the following, we explain the intuition why this ownership pattern can be payoff-maximizing for the firm.

2.3.2 Why might the firm keep the important component inhouse?

The key results of our model so far can be summarized as follows: Given that hybrid sourcing is overall the preferred ownership structure (i.e., for nonextreme values of η^H), the firm will

- outsource the strong supplier and keep the weak supplier vertically integrated if the two components are relatively good substitutes (if α is high),
- vertically integrate the strong supplier and outsource the weak supplier if the two components are bad substitutes (if α is low), provided that headquarter-intensity η^H is also relatively high.

To understand the economic forces behind these results, it is important to realize how these ownership choices affect the Shapley values and the investment incentives of the two suppliers. With respect to the realized revenue shares (Shapley values), recall from results v) and vi) above that there is a clear ranking from the perspective of the strong supplier A. When it comes to his realized share s_A^{Ξ}/R, this is $\{O, V\} > \{O, O\} > \{V, V\} > \{V, O\}$ for the different organizational structures. Analogously, from the perspective of the weak supplier B, his ranking in terms of s_B^{Ξ}/R is $\{V, O\} > \{O, O\} > \{V, V\} > \{O, V\}$. However, the same rankings do not necessarily apply with respect to the suppliers' investment incentives. That is, an organizational structure that yields a higher revenue share to a particular supplier, does not always induce also a higher input contribution of that supplier. In fact, in the case of strong complementarity (low α) there is a discrepancy as we explain shortly.

Let us first deal with the simpler case where the two components are relatively good substitutes (high α), so that low effort by one supplier can be relatively easily offset by higher effort of the other one. For that case, it turns out that the above rankings then also apply when it comes to the optimal input investments $\tilde{x}_i^{\Xi}$ of the two suppliers. That is, the firm can unambiguously stimulate the investment of a supplier by providing him a higher bargaining power (Shapley value). The intuition for figure 2.1.1 and the high-α range in figure 2.2 are then straightforward to grasp: For intermediate levels of η^H, the producer finds it optimal to choose hybrid sourcing. It is more urgent for her to give good investment incentives to the supplier of the technologically more important input, i.e., to supplier A (recall that $\eta_A = 0.8$ in figure 2.2, so that A is technologically more important than B). This is achieved by the organizational structure $\{O, V\}$, which gives the strong supplier

A the ownership of his assets. That choice, of course, gives rather bad investment incentives to the weak supplier B, but low effort by him is not as harmful in this case, given the high degree of substitutability. In short, what governs the pattern in figure 2.1.1 is the logic of the standard incentive effect of the property rights approach.

Now consider the other case where α is low. Similarly as before, for low η^H the structure is still $\{O, O\}$ and for high η^H it is $\{V, V\}$. Moreover, for low-to-intermediate levels of η^H the producer still chooses $\{O, V\}$. Again this provides rather bad incentives for B, but since the producer takes out only a relatively small headquarter revenue share for herself, enough is left to induce a sufficiently high contribution x_B. As η^H rises further, however, the pattern eventually switches from $\{O, V\}$ to $\{V, O\}$.

The intuition for this shift is the following: Eventually, it is clear that the producer will revert to the $\{V, V\}$ structure if η^H is high enough. However, an immediate switch from $\{O, V\}$ to $\{V, V\}$ is not optimal, because this would lead to a stronger discouragement of both suppliers than the switch from $\{O, V\}$ to $\{V, O\}$. For the weak supplier B this is straightforward to see, but it also holds for the strong supplier A. In fact, it turns out that supplier A would contribute more under $\{V, O\}$ than under $\{V, V\}$ if α is low. The reason is that $\{V, O\}$ provides much better investment incentives to the weak supplier B than $\{V, V\}$. Since the two components are strongly complementary, this encouragement of B also encourages A to invest more in turn, provided a large enough piece of the cake is still left for the suppliers overall (η^H not too large). Stated differently, the producer first chooses $\{V, O\}$ rather than $\{V, V\}$ immediately, because the discouragement of B would backfire on the incentives of A given the strong complementarity of the two component inputs which urgently requires that both suppliers have good incentives. The transition towards the $\{V, V\}$ structure only occurs at higher levels of η^H, where an ever smaller piece of the pie is left for the suppliers anyway. In short, in figure 2.1.2 and in the low-α range of figure 2.2 a complementarity effect operates against the standard incentive effect.

Finally, we can also re-phrase our results on hybrid sourcing since it is ultimately the distance between α and β that matters for the results. In particular, rather than fixing β and letting α vary as in figure 2.2, we may as well fix a low value of α while letting β vary. Numerical simulations show that the pattern from figure 2.1.1 then arises for low values of β relatively close to α, while the pattern from figure 2.1.2 arises for high values of β relatively different from α (also see the supplementary appendix). In words, hybrid sourcing in sectors with low demand elasticity is such that the firm would always outsource the important input (input A). Vice versa, in sectors with high demand elasticity, the firm may also keep the more important input in-house when engaging in hybrid sourcing.

2.3.3 Relationship to Antràs and Chor (2013): Sequential substitutes versus complements

The magnitude of the substitution elasticity α (adjusted for headquarter-intensity) relative to demand elasticity β also plays a key role in the recent model by Antràs and Chor (2013). In their sequential ("snake") setup, suppliers are differentiated by their position on a vertical value chain. Supplier investments are sequential complements if $\alpha < \beta\left(1-\eta^H\right)$, and higher downstream investments raise the marginal investment return for upstream suppliers and thus encourage contributions. Vice versa, if $\alpha > \beta\left(1-\eta^H\right)$ supplier investments are sequential substitutes, and higher downstream investments discourage upstream suppliers since marginal revenue for the final product is decreasing rapidly.

Our model features a "spider" structure, where components are asymmetric in their technological importance but placed on the same stage of the value chain and, thus, enter the production process simultaneously. Still, there is a similar intuition how the suppliers' incentives are interrelated, which shows that this mechanism does not crucially hinge on the sequentiality of production per se.

In particular, if α is large relative to β and η^H, supplier investments are good substitutes and it is then generally more important to first shift bargaining power to the supplier of the technologically more important input. Yet, for low values of α supplier investments become more complementary and reinforce each other. This explains why the firm may find it optimal to choose a hybrid sourcing pattern, where property rights are only shifted to the weak supplier. Interestingly, although we cannot delineate the exact analytical conditions for the two cases as in Antràs and Chor (2013), we can conclude from our numerical results that the complementarity effect comes to dominate only if α is much smaller than β, i.e., if the elasticity of substitution across components is much lower than the elasticity of demand for the final product. Moreover, this effect eventually fades away if η^H becomes too large, because the producer then takes out too much of the overall surplus for herself and leaves too little room for the mutual cross-fertilization of the suppliers' investment incentives to play out.

2.4 Asymmetries in component sophistication and unit costs

2.4.1 Asymmetries in the suppliers' unit costs

In this section we analyze other domains of supplier heterogeneity (other differences in component characteristics), and how they shape the organizational decision of the firm. Specifically, first suppose that supplier A faces lower unit costs of input provision than supplier B, i.e., $c_A < c_B$. Figure 2.3 is analogous to figure 2.1 and depicts the resulting ownership decision. As before, we display η^H on the horizontal and η_A on the vertical axis. Moreover, the left panel assumes that the two inputs are relatively good substitutes, while substitutability α is lower in the right panel.

As before, the producer chooses outsourcing (vertical integration) of both suppliers for sufficiently low (high) values of the headquarter-intensity. Also similarly as before, for intermediate values of η^H the producer chooses hybrid sourcing, and the level of substitutability crucially affects which hybrid sourcing constellation is chosen.

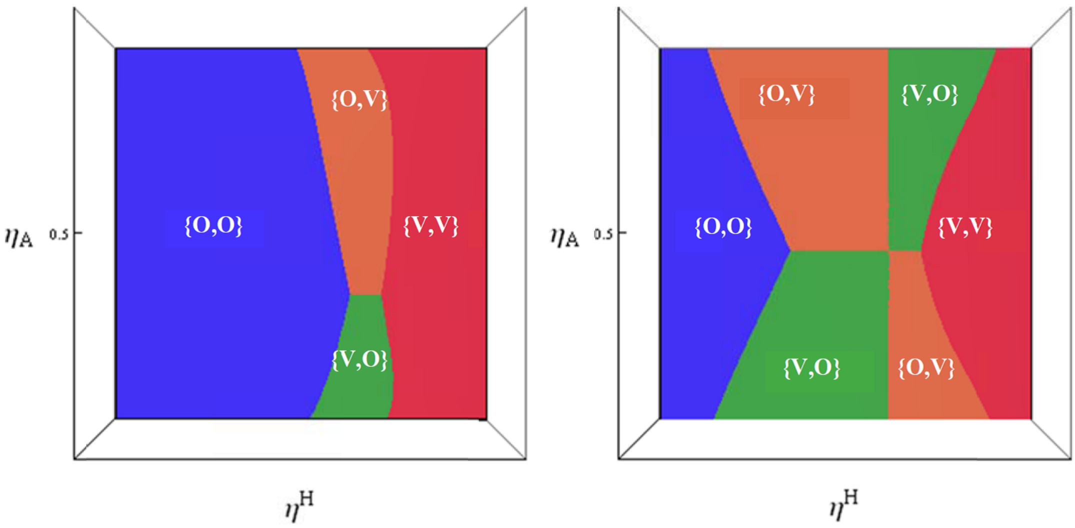

Figure 2.3: Asymmetries in the suppliers' unit costs.
Panel 1: High substitutability ($\alpha = 0.35$), Panel 2: Low substitutability ($\alpha = 0.1$).
Common parameters: $c_A = 1$, $c_B = 3$, $c^H = 1$, $\delta_A^O = \delta_B^O = 1$, $\delta_A^V = \delta_B^V = 0.85$, $\beta = 0.8$, $Y = 1$, $w_A = w_B = 0$.

Focus at first on figure 2.3.1 in the left panel, which depicts the case of high substitutability. Comparing it with figure 2.1.1, we see that the $\{O, V\}$ area now expands and the $\{V, O\}$ area shrinks. More specifically, the producer might now choose

$\{O, V\}$ even if $\eta_A < 1/2$. That is, she might vertically integrate supplier B even if his input is technologically more important, if that supplier also has relatively higher unit costs. Vice versa, the firm tends to outsource the low-cost supplier A, even if his input is technologically slightly less important. The intuition behind this choice is clear from result iv) described above: The lower unit costs c_A raise supplier A's input provision, and increase his Shapley value. Since supplier investments are well substitutable, it thus becomes more important for the firm to further boost A's incentives, hence the greater outsourcing tendency for that input. The producer only reverts to the ownership choice $\{V, O\}$ in the hybrid sourcing range if η_A becomes very small. This comes from the fact that the asymmetry in technological importance is then so strong relative to the difference in unit costs, that the firm finds it optimal to incentivize supplier B who produces a highly important input. The case of strong complementarity is depicted in the right panel of figure 2.3 and follows a similar logic. Comparing it to figure 2.1.2, we observe that the critical level of η_A where the hybrid sourcing constellations switch is no longer at $\eta_A = 1/2$, but now at a lower level of η_A. In other words, also in this case we observe the increased tendency to outsource the low-cost supplier A.

Some more discussion about the implications of these findings, and how they can be related to issues of global sourcing (with domestic versus foreign input suppliers), can be found in section 2.5.3.

2.4.2 Asymmetries in the components' degree of sophistication

Finally, suppose that the suppliers' components now also differ in their degree of sophistication while again assuming equal unit costs. More precisely, we assume $\delta_A^V > \delta_B^V$, which implies that supplier A provides a more sophisticated input than B, in the sense that A threatens to withhold a higher input fraction if he refuses to collaborate under vertical integration. The producer's ownership decision for this case is depicted in figure 2.4, which is again analogous to figure 2.1.

As can be seen, figure 2.4 shows that the firm tends to keep the more sophisticated input in-house. Focus at first on the left panel, where inputs are relatively good substitutes. Compared to figure 2.1.1, we observe that the area $\{O, V\}$ (orange) becomes smaller while the area $\{V, O\}$ (green) becomes larger. In particular, there are now constellations in the hybrid sourcing range where $\{V, O\}$ is chosen also for values of η_A larger than $1/2$. That is, given that input A is more sophisticated ($\delta_A^V > \delta_B^V$) and technologically mildly more important ($\eta_A > \eta_B$), the producer finds it profitable to integrate this input, and to outsource the less important, less

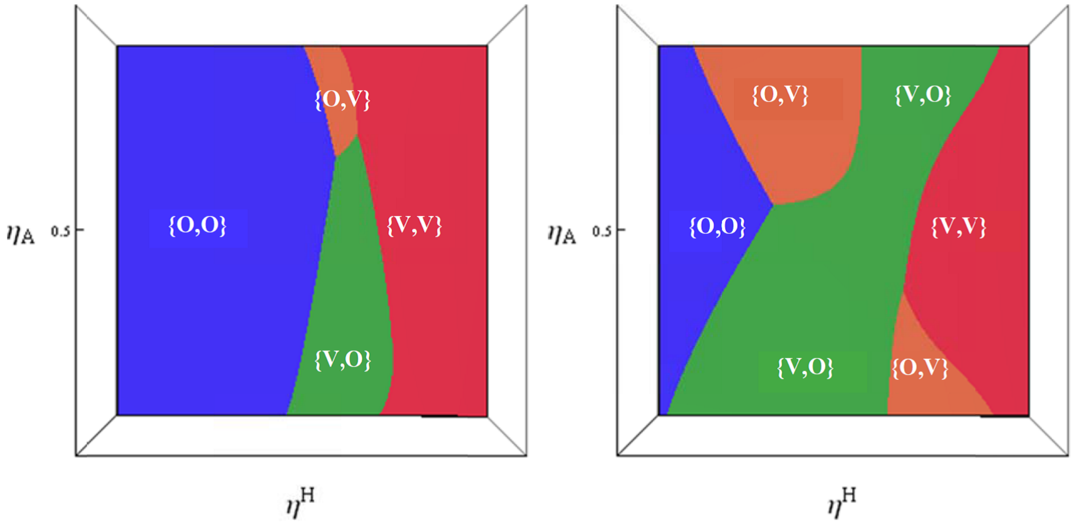

Figure 2.4: Asymmetries in the degree of sophistication.
Panel 1: High substitutability ($\alpha = 0.35$), Panel 2: Low substitutability ($\alpha = 0.1$).
Common parameters: $c_A = c_B = 1$, $c^H = 1$, $\delta_A^O = \delta_B^O = 1$, $\delta_A^V = 0.9$, $\delta_B^V = 0.85$, $\beta = 0.8$, $Y = 1$, $w_A = w_B = 0$.

sophisticated input B.[11] Only if the technological asymmetry becomes very strong, would the producer return to the ownership form $\{O, V\}$.

What is the intuition for this organizational decision? Recall from result iii) above that a higher sophistication implies, ceteris paribus, a higher revenue share and a higher input provision of the respective supplier, because he can exploit the fact that his physical input is hardly usable for the firm without his collaboration. In other words, due to the high sophistication of his component, supplier A has high bargaining power and good incentives even as an affiliate of the firm. For supplier B, by contrast, his bargaining power vis-à-vis the producer and his investment incentives under vertical integration are very bad, owing to the fact that his input is rather standard and easy to utilize even without his cooperation. The provision of ownership rights is therefore more effective as an incentivizing device for this supplier. In short, two forces drive the final ownership choice in figure 2.4.1: the standard incentive effect and a new sophistication effect, according to which simple inputs should be outsourced since the respective suppliers cannot be properly incentivized inside the firm.

[11] Recall that this would not happen with equal sophistication, where we only observe $\{O, V\}$ with $\eta_A > 1/2$.

Finally, in figure 2.4.2 the previously described complementarity effect is added to the picture. Even without the heterogeneous sophistication, the firm would now sometimes choose to integrate the technologically more important input (see figure 2.1.2). If, in addition, input A is also more sophisticated, this only reinforces that choice. To see this, note that the $\{V, O\}$ structure is much more pervasive in figure 2.4.2 than in figure 2.1.2. This pattern percolates especially for values of η_A mildly above 1/2, which is partly driven by the complementarity and partly by the sophistication effect.

2.5 Conclusion and discussion of testable empirical predictions

2.5.1 Summary

In this paper, we have introduced supplier heterogeneity into a property rights model. The firm operates a “spider” production process where two asymmetric inputs are simultaneously combined with headquarter services to a final product. Our model extends the seminal framework by Antràs (2003) and Antràs and Helpman (2004), and captures the empirically highly relevant scenario of hybrid sourcing where the firm chooses a different sourcing mode for some suppliers than for others. In particular, and in contrast to the recent model by Schwarz and Suedekum (2014), it allows us to analyze which sourcing mode the firm chooses for which of the asymmetric inputs.

The major shortcoming of our theoretical framework is that we have to rely on a numerical solution approach. This is due to the fact, that in our setup with multilateral bargaining among asymmetric agents, we cannot come up with closed-form solutions for the optimal input investments and the resulting revenue shares (Shapley values). To resolve this issue of analytical nontractability, we would have to impose symmetry at various point. This, however, would run exactly opposite to our main aim of studying the realistic scenario of a firm that contracts with multiple heterogeneous suppliers. Still, we believe that our model structure is useful as it allows us to separate the single forces that govern the firm's ultimate ownership decision, and to discuss their economic intuition.

2.5.2 Testable predictions for hybrid sourcing and their empirical relevance

What are the main novel results of our model and how can these predictions be confronted with data? Depending on the elasticity of substitution across components and the price elasticity of final goods demand, we show in section 2.3 that the firm may choose a different ownership structure when engaging in hybrid sourcing. In particular, when the two components are relatively good substitutes, the firm will always outsource the supplier of the technologically more important input while keeping the less important one in-house. This choice follows the standard logic of the property rights approach, according to which ownership rights should be shifted to important contributors in order to incentivize them to invest into the relationship. However, the hybrid sourcing pattern can change when the two component inputs are strongly complementary. In that case, and if headquarter-intensity is relatively large, we show that the firm might actually choose outsourcing of the relatively less and vertical integration of the more important component. At first glance, such a hybrid sourcing pattern appears to be at odds with the received logic of the property rights approach. Yet, our model can rationalize this firm decision within a property rights framework. In essence, it is because the incentives of the weak supplier would be very low as an integrated affiliate, and with strong complementarity, this would backfire too much on the strong supplier's incentives.

An empirical test of these predictions is hampered by two major difficulties. First, most production processes in reality do not consist of headquarter services and exactly two manufacturing components. Second, not all key parameters of our model are easy to measure in practice. It seems fair to say that the literature has found some consensus on appropriate empirical proxies for demand elasticity β and headquarter-intensity η^H, see the comprehensive discussion in Antràs (2015).[12] However, the technological asymmetry η_A and component substitutability α are more difficult to capture.

Fortunately, with respect to the first parameter, our results from section 2.3 could be tested empirically without a precise measure for η_A, as long as it is clear which input is the technologically more important one (corresponding to input A in the model). The reason is that figure 2.1 makes the same qualitative predictions for hybrid sourcing both for a mild technological asymmetry (η_A only slightly higher than 1/2) and for a strong one (η_A much higher than 1/2). We thus only need to know which component has the higher partial production elasticity, which could be

[12] Broda and Weinstein (2006) is the standard source for industry-specific proxies of demand elasticity, while sectoral headquarter-intensity is typically measured by industry-specific capital or R&D-intensity.

measured by the incremental increase in total output (or revenue) when raising the quality-adjusted input ceteris paribus.

As for the elasticity of substitution across components, to the best of our knowledge, a profound industry-specific proxy for α is unavailable in the current literature (also see the empirical part of Antràs and Chor, 2013). Still, our model may guide a more casual empirical approach or informed case studies. Intuitively, α should be low in sectors like the pharmaceutical industry, where quality upgrading of the vehicle carrier cannot make up by any means for any quality defects of the active ingredient, hence, substitutability is very low. Industries with a higher value of α, on the other hand, may include textiles and apparel where it is easier to trade-off wool quality with manufactured design applications, or the coffee cup example mentioned in the introduction. Our model suggests that in the first type of industries, we should see more vertical integration of the essential input, while in the second type this key component is more often outsourced.

An alternative empirical test, closer in spirit to the approach by Antràs and Chor (2013), would focus on the industry-specific demand elasticity. Recall that our model predicts that - for a given substitutability α - low demand elasticity (low β) tends to come with the hybrid sourcing pattern where the essential input is outsourced, whereas under high demand elasticity (high β) we may expect to see more vertical integration of the essential input.

The specific examples considered above seem to fit this pattern: Demand elasticity is relatively low in the coffee industry and relatively high in the pharmaceutical industry according to Broda and Weinstein (2006).[13] Moreover, component substitutability seems far easier in the coffee than in the pharmaceutical industry. These empirical anecdotes thus seem to be in line with the predictions of our model. We consider it an interesting avenue for future research to conduct such empirical tests in more detail.

2.5.3 Differences in unit costs (global sourcing) and sophistication

Our theoretical results from section 2.4 may also be addressed empirically. First, notice that supplier unit costs c_i should be interpreted broadly as including all sorts of transport and freight costs, taxes, tariffs and so on. One possible reason why a

[13] Demand elasticity ranges between 13.50 (NAICS code 325412 Pharmaceutical Preparation Manufacturing) and 15.07 (NAICS code 325411 Medicinal and Botanical Manufacturing) for the former industry, while in coffee and tea production (NAICS code 311920) it is only 8.82. The simple industry-average is 10.01.

component supplier could have lower unit costs than the other is then, obviously, location. Specifically, suppose the headquarters are located in a domestic high-wage country in Europe or North America, where indeed most multinational enterprises are based. Furthermore, suppose the high-cost supplier B also comes from this domestic country, while the low-cost supplier A is from some foreign low-wage country like China or India. One the one hand, supplier A then has a cost disadvantage due to transport costs and other trade barriers. However, we may assume that wages and production costs are generally much higher in the domestic country, so that our assumption $c_A < c_B$ holds even after taking these trade costs into account. With such a global sourcing scenario in mind, we may rephrase our results such that there is a positive correlation of outsourcing and offshoring: All else equal (i.e., for $\eta_A = 1/2$), and for medium headquarter-intensity, the firm would choose an external supplier organization for its foreign supplier, while the domestic supplier is integrated. This results is, thus, consistent with the empirical results by Kohler and Smolka (2015, 2012), who find that Spanish manufacturing firms tend to choose outsourcing more often when dealing with (low-cost) foreign than with (high-cost) domestic suppliers.

Finally, if components differ in their degree of sophistication, we have shown that the firm tends to outsource the relatively simpler input while the more sophisticated component is kept in-house. Although our precise measure for sophistication (δ_i^V) is surely difficult to observe empirically, we still note that this theoretical result is consistent with firm-level empirical findings by Corcos, Irac, Mion and Verdier (2013) and Costinot, Oldenski and Rauch (2011). They indeed find that French, respectively, US headquarter corporations rely more heavily on an internal supplier organization for nonroutine activities and complex inputs, while outsourcing is typically chosen for simpler tasks.

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2.7 Appendix

A.0 Outline of the appendix

This supplementary appendix consists of five parts.

In part I, we formally derive the Shapley values of the two suppliers and the producer that we provided economically intuitive in section 2.3.

In part II, we illustrate the results spelled out in section 2.4 of the main text. Those results refer to the payoff-maximizing input contributions of the three agents (the producer and the two suppliers A and B) and their realized revenue shares (Shapley value over total revenue) in the multilateral bargaining. For each result, we illustrate the respective realized revenue shares or input contributions (in either absolute or relative terms) for various parameter constellations reported next to each specific figure.

In part III, we illustrate the producer's ownership decision analogously as in figure 2.1-2.4 in the main text. We assume different parameter constellations as in the main text and thereby illustrate the robustness of our findings discussed there. For each figure in this supplementary appendix, we mention the analogous figure in the main text.

To the best of our knowledge there exists no profound industry-specific proxy for the elasticity of substitution across components α, however, there are empirical proxies for the demand elasticity β. Therefore, we "turn" our results to facilitate an empirical test. More precisely, contrary to the setup of the paper, we let β vary whereas we assume α to be fixed. In part IV, we provide the resulting organizational decisions for this variation of the demand elasticity.

In part V, we provide a robustness check for the Shapley value bargaining approach and consider an alternative bargaining concept. We derive the formal relations and show that most properties of the revenue shares and the input contributions and the resulting organizational decisions are similar to those under the assumed Shapley value approach.

We have produced all figures with the MATHEMATICA 9.0 files that are provided as a further supplement to this paper.

A.I Calculation of the Shapley values

In the computation of the Shapley values, at the bargaining stage both the firm's ownership structure $\Xi = \{\Xi_A, \Xi_B\}$ and the players' input contributions $\{x_A, x_B, h\}$ are given. Consider first the marginal contribution of a single supplier $i = \{A, B\}$ to a coalition of size two, i.e., with the producer. We denote this as $m(i,2)^{\Xi_i}$. If supplier i is outsourced, his marginal contribution corresponds to the total revenue of that coalition, since revenue drops to zero if he withholds his input. Formally, this is:

$$m(i,2)^O = \hat{H} x_i^{(1-\eta^H)} \eta_i^{\frac{(1-)(1-\eta^H)}{\alpha}} \tag{A2.1}$$

with $\hat{H} = Y^{1-\beta}h^{\beta\eta^H}(1-\eta^H)^{-\beta(1-\eta^H)}(\eta^H)^{-\beta\eta^H}$. If supplier i is integrated, revenue does not drop to zero if he withholds his input, but the firm earns $\hat{H}((1-\delta_i^V)x_i)^{\beta(1-\eta^H)}\eta_i^{\frac{\beta(1-\alpha)(1-\eta^H)}{\alpha}}$. Hence, the marginal contribution $m(i,2)^V$ is lower than $m(i,2)^O$ and is given by

$$m(i,2)^V = \hat{H}\left(x_i^{\beta(1-\eta^H)}\eta_i^{\frac{\beta(1-\alpha)(1-\eta^H)}{\alpha}} - \left((1-\delta_i^V)x_i\right)^{\beta(1-\eta^H)}\eta_i^{\frac{\beta(1-\alpha)(1-\eta^H)}{\alpha}}\right). \tag{A2.2}$$

Finally, a supplier's marginal contribution to the coalition of size three, $m(i,3)^\Xi$, can be written as

$$m(i,3)^\Xi = \hat{H}\left(\left(x_i^\alpha\eta_i^{(1-\alpha)} + x_j^\alpha\eta_j^{(1-\alpha)}\right)^{\frac{\beta\left(1-\eta^H\right)}{\alpha}} - \left(\left(\left(1-\delta_i^{\Xi_i}\right)x_i\right)^\alpha\eta_i^{(1-\alpha)} + x_j^\alpha\eta_j^{(1-\alpha)}\right)^{\frac{\beta\left(1-\eta^H\right)}{\alpha}}\right) \tag{A2.3}$$

with $i \neq j$ and $\delta_i^O = 1$, $0 < \delta_i^V < 1$ which depends on supplier i's own input investment, as well as on the contribution (and, hence, the ownership form) of the other supplier j. Using these marginal contributions, the suppliers' Shapley values are calculated according to

$$s_i^\Xi = \sum_{T\subseteq N}\frac{(t-1)!\,(n-t)!}{n!}m(i,t)^\Xi \quad \text{for } i\in\{A,B\}, \tag{A2.4}$$

where n is the total number of players, and t the number of players in a coalition ($t \leq n$). The term $(t-1)!\,(n-t)!\,/n!$ captures the probability that a player is in the last position of a feasible permutation. In our context, we have $n = 3$, so that this probability is equal to $1/3$ for the coalition with three players, and $1/6$ for a coalition of two players. Using ($A2.4$) and the marginal contributions (A2.1), (A2.2) and (A2.3), the Shapley value of supplier i is thus given by

$$s_i^\Xi = \frac{1}{6}m(i,2)^{\Xi_i} + \frac{1}{3}m(i,3)^\Xi, \tag{A2.5}$$

so that s_i^Ξ/R is the revenue share of supplier i. Last, since the headquarter is the only essential player in this setup, her Shapley value is given by the residual, $s_H^\Xi = 1 - s_A^\Xi - s_B^\Xi$, where s_A^Ξ and s_B^Ξ follow from ($A2.5$), and her revenue share is s_H^Ξ/R.[14]

[14] The sum of the marginal contributions of all suppliers must equal total revenue. However, the allocation of the marginal contributions is not necessarily efficient: The sum of the marginal contributions may deviate from the revenue of the coalition (see Hart and Mas-Colell, 1988). To assure that the total revenue is distributed among the three players, one player is the residual claimant, similar as in Hart and Moore (1990).

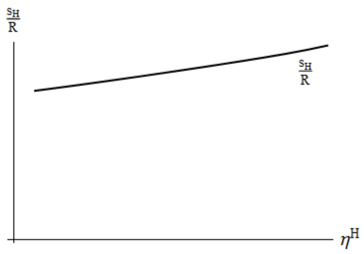
A.II Revenue shares and input contributions

A.II.i Higher headquarter-intensity η^H

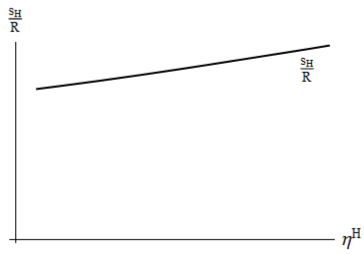
Common parameters: $c_A = c_B = 1$, $c^H = 1$, $\delta_A = \delta_B = 0.85$, $\eta_A = 0.5$, $Y = 1$, $w_A = w_B = 0$

The higher is the headquarter-intensity η^H, the higher is the producer's realized revenue share $\frac{s_H}{R}$.

$\alpha < \beta$, **low substitutability**

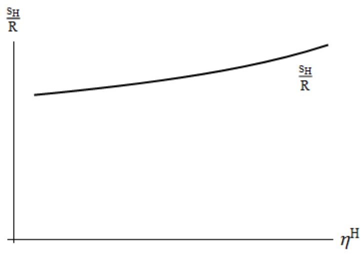


$\alpha = 0.1$, $\beta = 0.8$

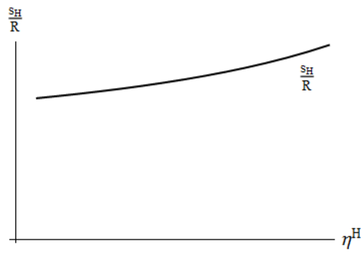


$\alpha = 0.05$, $\beta = 0.7$

$\alpha < \beta$, **high substitutability**

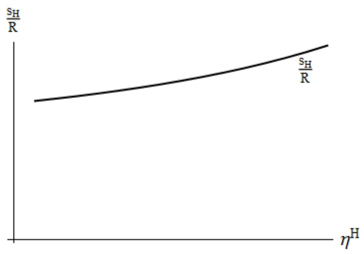


$\alpha = 0.35$, $\beta = 0.8$

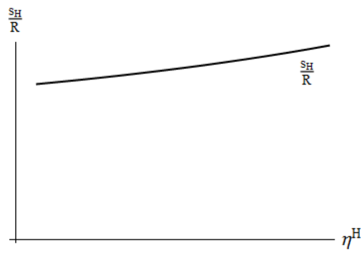


$\alpha = 0.5$, $\beta = 0.8$

$\alpha > \beta$, **very high substitutability**



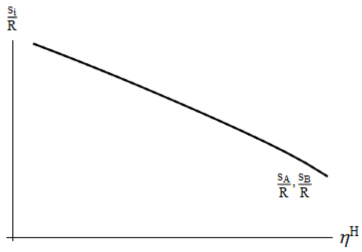
$\alpha = 0.9$, $\beta = 0.8$



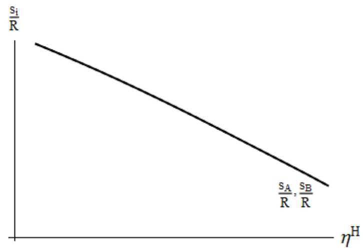
$\alpha = 0.7$, $\beta = 0.4$

The higher is the headquarter-intensity η^H, the lower are the revenue shares of the two suppliers ($\frac{s_A}{R}$,$\frac{s_B}{R}$).

$\alpha < \beta$, **low substitutability**

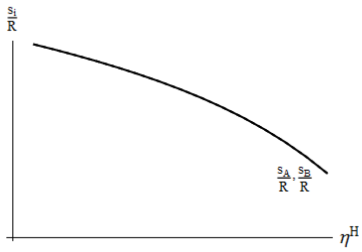


$\alpha = 0.1,\ \beta = 0.8$

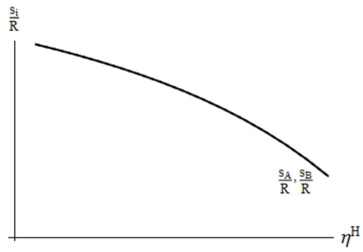


$\alpha = 0.05,\ \beta = 0.7$

$\alpha < \beta$, **high substitutability**

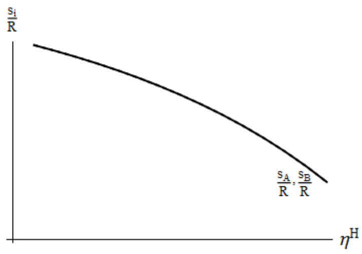


$\alpha = 0.35,\ \beta = 0.8$

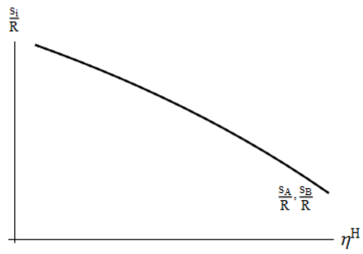


$\alpha = 0.5,\ \beta = 0.8$

$\alpha > \beta$, **very high substitutability**



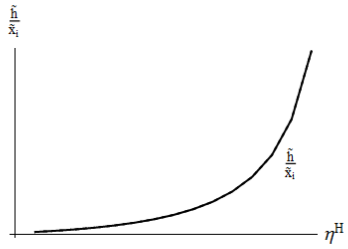
$\alpha = 0.9,\ \beta = 0.8$



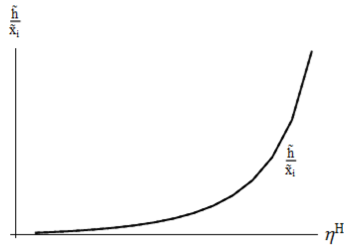
$\alpha = 0.7,\ \beta = 0.4$

The higher is the headquarter-intensity η^H, the higher is the input contribution of the producer relative to the two suppliers $\frac{\tilde{h}}{\tilde{x}_i}$.

$\alpha < \beta$, **low substitutability**

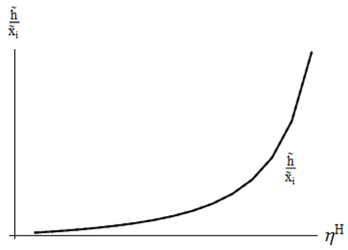


$\alpha = 0.1,\ \beta = 0.8$

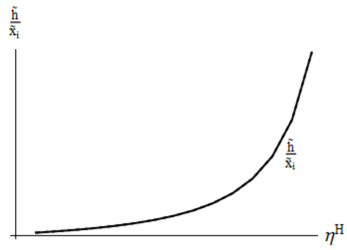


$\alpha = 0.05,\ \beta = 0.7$

$\alpha < \beta$, **high substitutability**

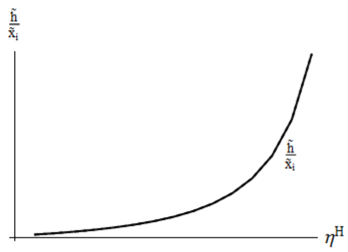


$\alpha = 0.35,\ \beta = 0.8$

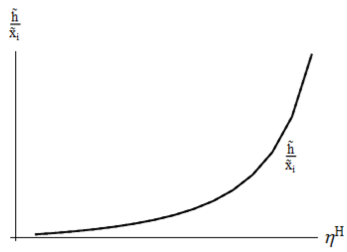


$\alpha = 0.5,\ \beta = 0.8$

$\alpha > \beta$, **very high substitutability**



$\alpha = 0.9,\ \beta = 0.8$



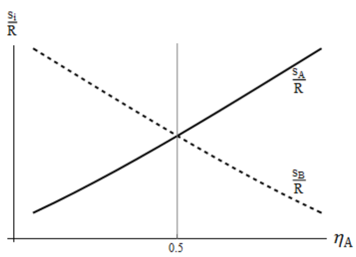
$\alpha = 0.7,\ \beta = 0.4$

A.II.ii Higher technological importance of supplier A's input ($\eta_A > \eta_B$)

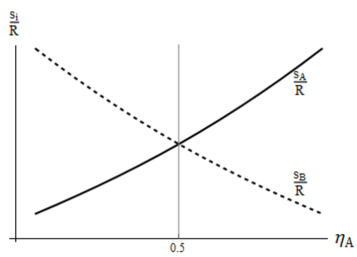
Common parameters: $c_A = c_B = 1$, $c^H = 1$, $\delta_A = \delta_B = 0.85$, $\eta^H = 0.8$, $Y = 1$, $w_A = w_B = 0$

If supplier A's input has a higher input intensity than supplier B's input, i.e. $\eta_A > \eta_B$, supplier A realizes a higher revenue share than supplier B, i.e. $\frac{s_A}{R} > \frac{s_B}{R}$. For the opposite case with $\eta_A < \eta_B$, results are analogous and we obtain $\frac{s_A}{R} < \frac{s_B}{R}$.

$\alpha < \beta$, **low substitutability**

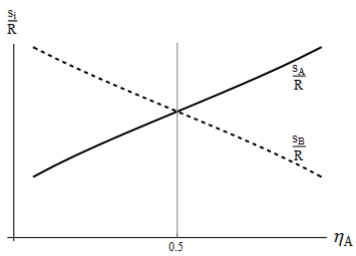


$\alpha = 0.1$, $\beta = 0.8$

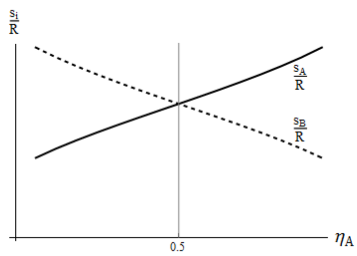


$\alpha = 0.05$, $\beta = 0.7$

$\alpha < \beta$, **high substitutability**

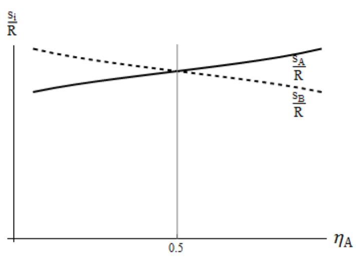


$\alpha = 0.35$, $\beta = 0.8$

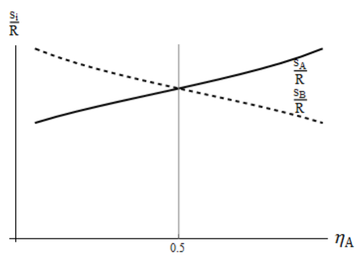


$\alpha = 0.5$, $\beta = 0.8$

$\alpha > \beta$, **very high substitutability**



$\alpha = 0.9$, $\beta = 0.8$

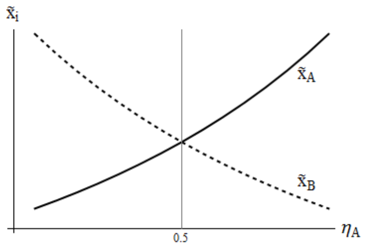


$\alpha = 0.7$, $\beta = 0.4$

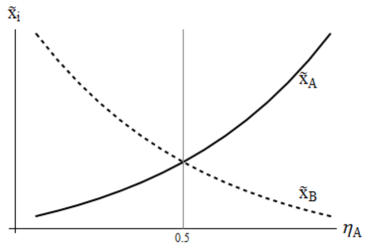
If supplier A's input has a higher input intensity than supplier B's input, i.e. $\eta_A > \eta_B$, supplier A makes a higher input contribution than supplier B, i.e. $\tilde{x}_A > \tilde{x}_B$. Vice versa, $\tilde{x}_A < \tilde{x}_B$ for $\eta_A < \eta_B$.

<u>Absolute input contributions</u>

$\alpha < \beta$, **low substitutability**

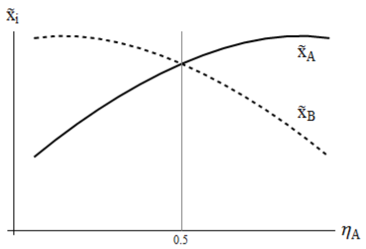


$\alpha = 0.1$, $\beta = 0.8$

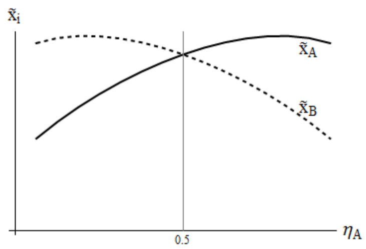


$\alpha = 0.05$, $\beta = 0.7$

$\alpha < \beta$, **high substitutability**

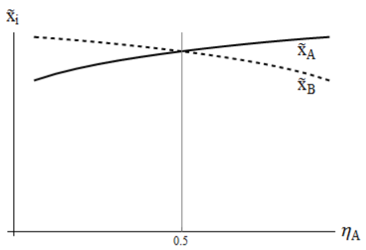


$\alpha = 0.35$, $\beta = 0.8$

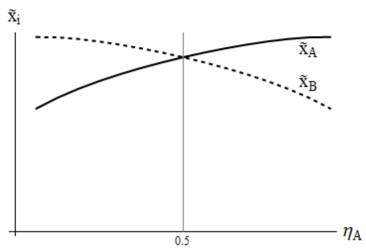


$\alpha = 0.5$, $\beta = 0.8$

$\alpha > \beta$, **very high substitutability**



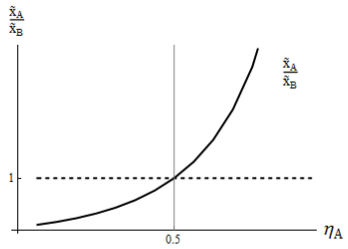
$\alpha = 0.9$, $\beta = 0.8$



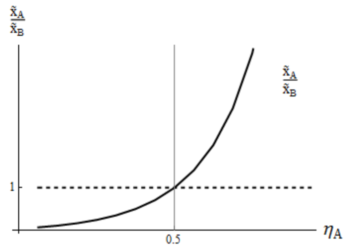
$\alpha = 0.7$, $\beta = 0.4$

Relative input contributions

$\alpha < \beta$, low substitutability

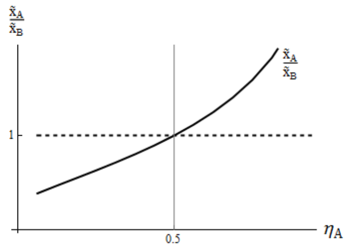


$\alpha = 0.1,\ \beta = 0.8$

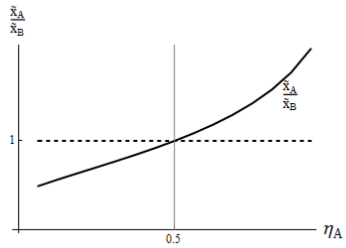


$\alpha = 0.05,\ \beta = 0.7$

$\alpha < \beta$, high substitutability

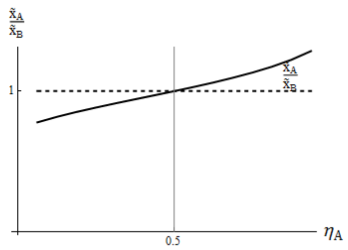


$\alpha = 0.35,\ \beta = 0.8$

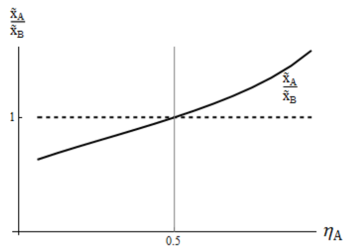


$\alpha = 0.5,\ \beta = 0.8$

$\alpha > \beta$, very high substitutability



$\alpha = 0.9,\ \beta = 0.8$



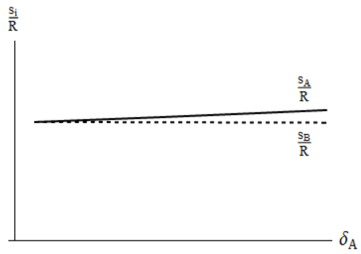
$\alpha = 0.7,\ \beta = 0.4$

A.II.iii Higher sophistication of supplier A's input ($\delta_A > \delta_B$)

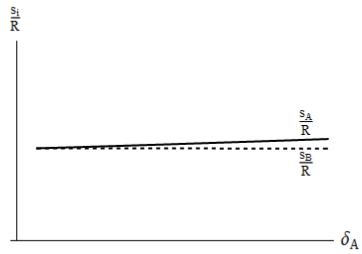
Common parameters: $c_A = c_B = 1$, $c^H = 1$, $\delta_A \geq 0.85$, $\delta_B = 0.85$, $\eta_A = 0.5$, $\eta^H = 0.8$, $Y = 1$, $w_A = w_B = 0$

If supplier A's input is more sophisticated than supplier B's input ($\delta_A > \delta_B$), supplier A realizes a higher revenue share than supplier B ($\frac{s_A}{R} > \frac{s_B}{R}$).

$\alpha < \beta$, **low substitutability**

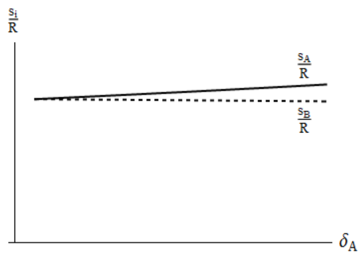


$\alpha = 0.1$, $\beta = 0.8$

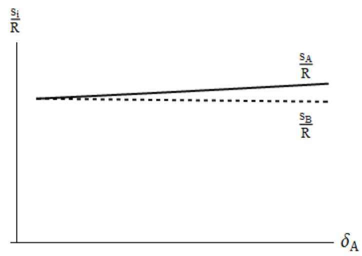


$\alpha = 0.05$, $\beta = 0.7$

$\alpha < \beta$, **high substitutability**

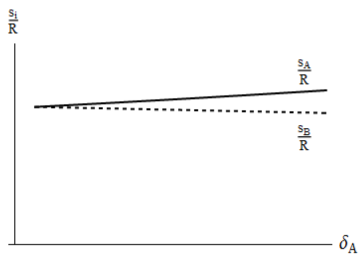


$\alpha = 0.35$, $\beta = 0.8$

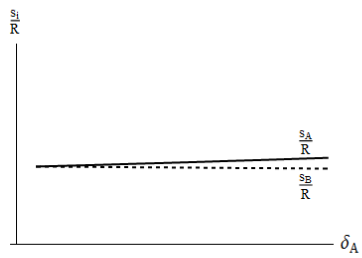


$\alpha = 0.5$, $\beta = 0.8$

$\alpha > \beta$, **very high substitutability**



$\alpha = 0.9$, $\beta = 0.8$

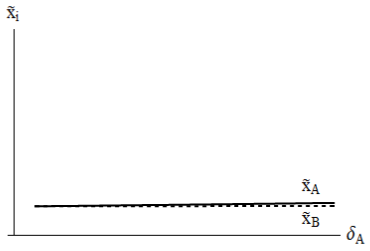


$\alpha = 0.7$, $\beta = 0.4$

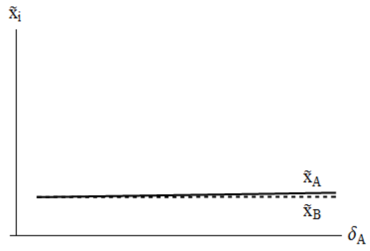
If supplier A's input has a higher sophistication than supplier B's input ($\delta_A > \delta_B$), supplier A makes a higher input contribution than supplier B ($\tilde{x}_A > \tilde{x}_B$).

Absolute input contributions

$\alpha < \beta$, low substitutability

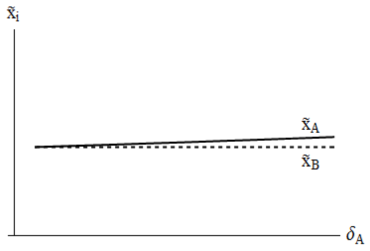


$\alpha = 0.1,\ \beta = 0.8$

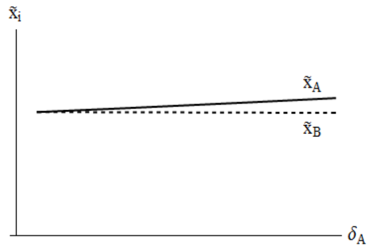


$\alpha = 0.05,\ \beta = 0.7$

$\alpha < \beta$, high substitutability

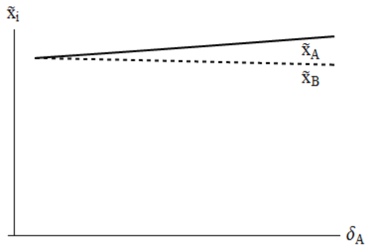


$\alpha = 0.35,\ \beta = 0.8$

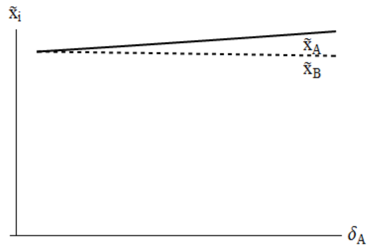


$\alpha = 0.5,\ \beta = 0.8$

$\alpha > \beta$, very high substitutability



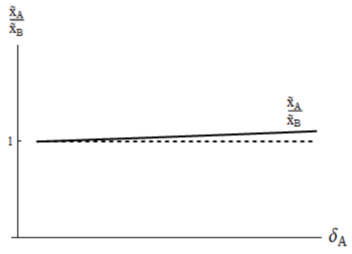
$\alpha = 0.9,\ \beta = 0.8$



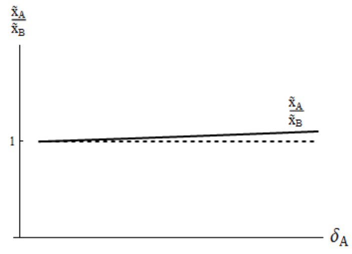
$\alpha = 0.7,\ \beta = 0.4$

Relative input contributions

$\alpha < \beta$, low substitutability

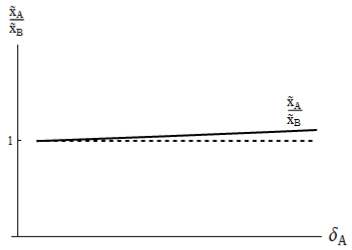


$\alpha = 0.1,\ \beta = 0.8$

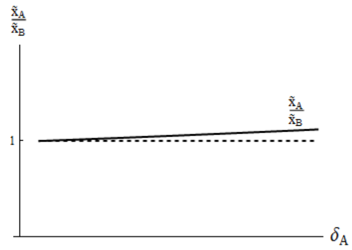


$\alpha = 0.05,\ \beta = 0.7$

$\alpha < \beta$, high substitutability

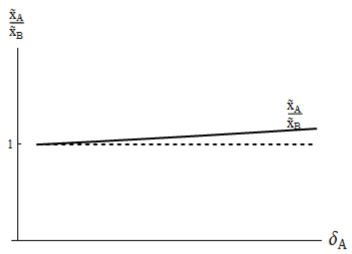


$\alpha = 0.35,\ \beta = 0.8$

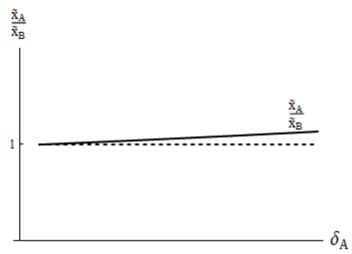


$\alpha = 0.5,\ \beta = 0.8$

$\alpha > \beta$, very high substitutability



$\alpha = 0.9,\ \beta = 0.8$



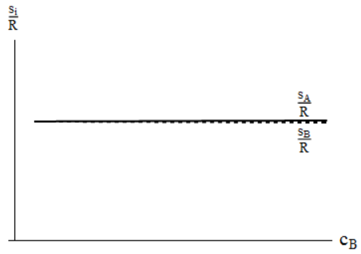
$\alpha = 0.7,\ \beta = 0.4$

A.II.iv Lower input costs of supplier A ($c_A < c_B$)

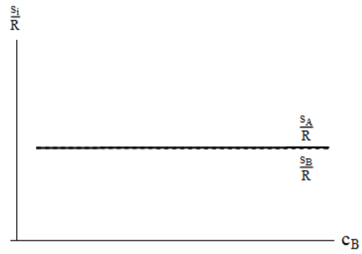
Common parameters: $c_A = 1$, $c_B \geq 1$, $c^H = 1$, $\delta_A = \delta_B = 0.85$, $\eta_A = 0.5$, $\eta^H = 0.8$, $Y = 1$, $w_A = w_B = 0$

If supplier A has lower unit costs than supplier B ($c_A > c_B$), supplier A realizes a higher revenue share than supplier B ($\frac{s_A}{R} > \frac{s_B}{R}$).

$\alpha < \beta$, low substitutability

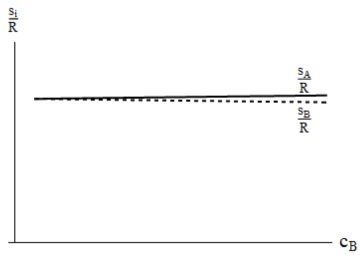


$\alpha = 0.1$, $\beta = 0.8$

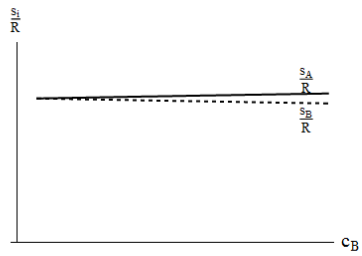


$\alpha = 0.05$, $\beta = 0.7$

$\alpha < \beta$, high substitutability

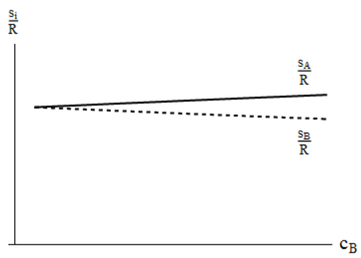


$\alpha = 0.35$, $\beta = 0.8$

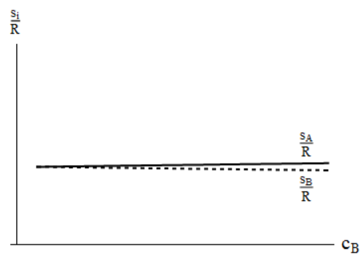


$\alpha = 0.5$, $\beta = 0.8$

$\alpha > \beta$, very high substitutability



$\alpha = 0.9$, $\beta = 0.8$

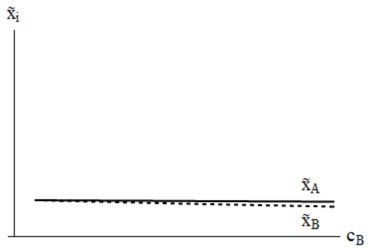


$\alpha = 0.7$, $\beta = 0.4$

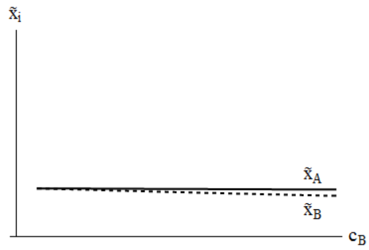
If supplier A has lower unit costs than supplier B ($c_A > c_B$), supplier A makes a higher input contribution than supplier B ($\tilde{x}_A > \tilde{x}_B$).

Absolute input contributions

$\alpha < \beta$, low substitutability

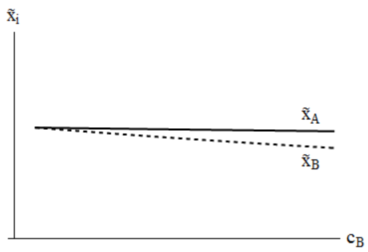


$\alpha = 0.1,\ \beta = 0.8$

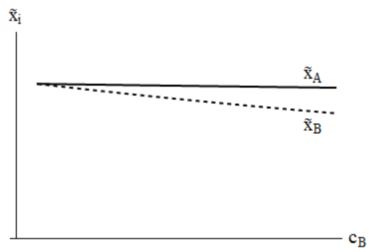


$\alpha = 0.05,\ \beta = 0.7$

$\alpha < \beta$, high substitutability

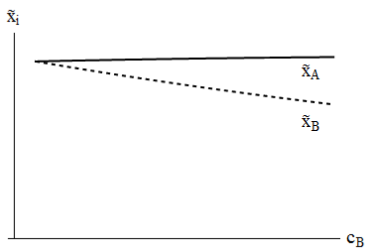


$\alpha = 0.35,\ \beta = 0.8$

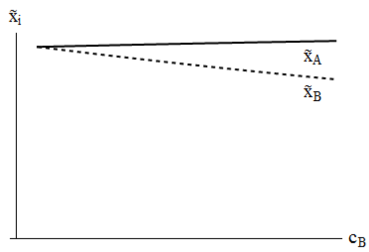


$\alpha = 0.5,\ \beta = 0.8$

$\alpha > \beta$, very high substitutability



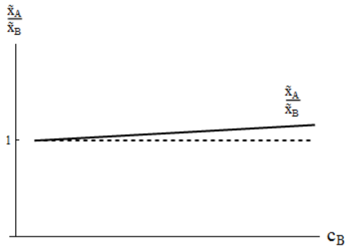
$\alpha = 0.9,\ \beta = 0.8$



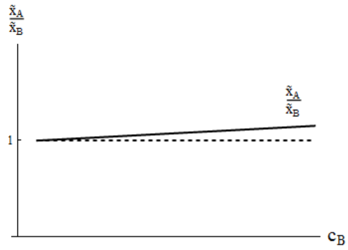
$\alpha = 0.7,\ \beta = 0.4$

Relative input contributions

$\alpha < \beta$, low substitutability

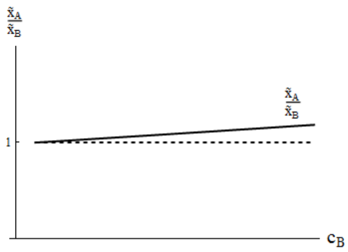


$\alpha = 0.1,\ \beta = 0.8$

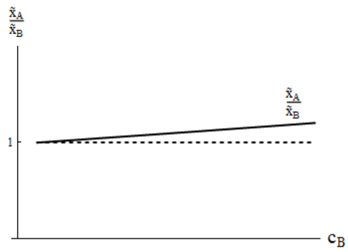


$\alpha = 0.05,\ \beta = 0.7$

$\alpha < \beta$, high substitutability

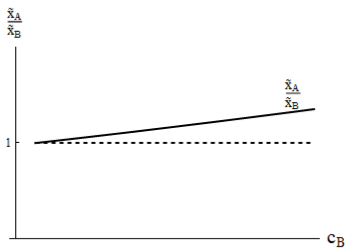


$\alpha = 0.35,\ \beta = 0.8$

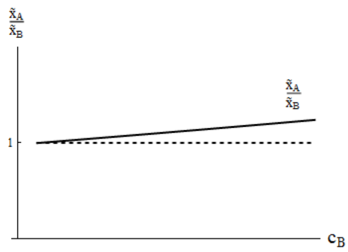


$\alpha = 0.5,\ \beta = 0.8$

$\alpha > \beta$, very high substitutability



$\alpha = 0.9,\ \beta = 0.8$



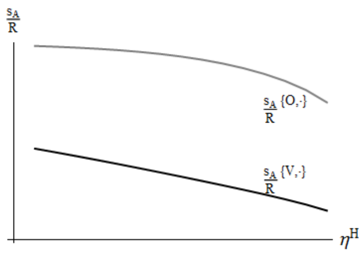
$\alpha = 0.7,\ \beta = 0.4$

A.II.v Outsourcing and integration: own organizational form

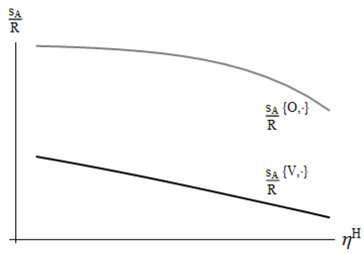
Common parameters: $c_A = c_B = 1$, $c^H = 1$, $\delta_A^O = \delta_B^O = 1$, $\delta_A^V = \delta_B^V = 0.85$, $\eta_A = 0.5$, $Y = 1$, $w_A = w_B = 0$

Supplier A's revenue share is higher if he is outsourced than if he is integrated, i.e. $\frac{s_A^{\{O,\cdot\}}}{R} > \frac{s_A^{\{V,\cdot\}}}{R}$.

$\alpha < \beta$, **low substitutability**

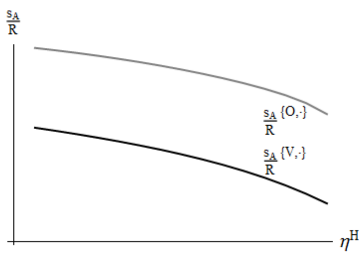


$\alpha = 0.1$, $\beta = 0.8$

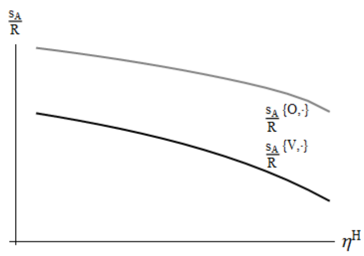


$\alpha = 0.05$, $\beta = 0.7$

$\alpha < \beta$, **high substitutability**

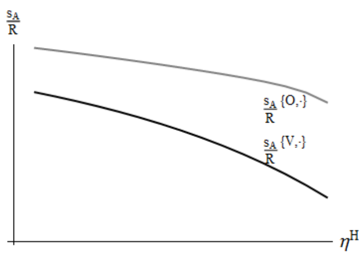


$\alpha = 0.35$, $\beta = 0.8$

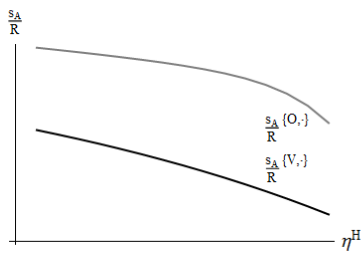


$\alpha = 0.5$, $\beta = 0.8$

$\alpha > \beta$, **very high substitutability**



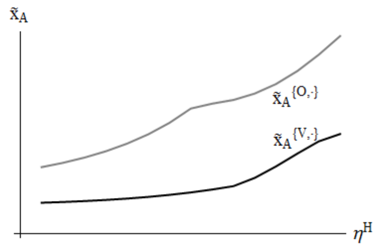
$\alpha = 0.9$, $\beta = 0.8$



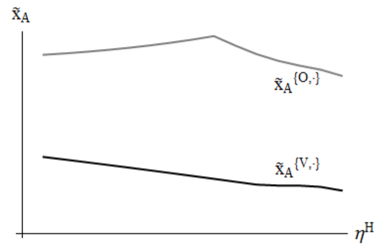
$\alpha = 0.7$, $\beta = 0.4$

Supplier A's input contribution is higher if he is outsourced than if he is integrated, i.e. $\tilde{x}_A^{\{O,\}} > \tilde{x}_A^{\{V,\}}$.

$\alpha < \beta$, **low substitutability**

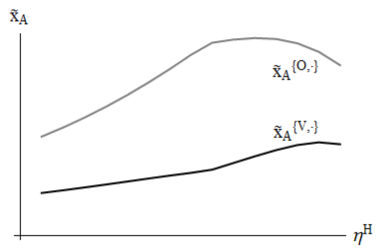


$\alpha = 0.1,\ \beta = 0.8$

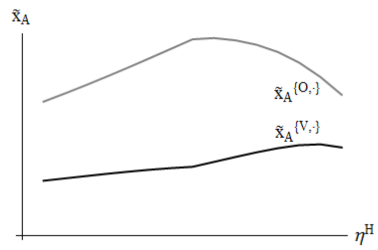


$\alpha = 0.05,\ \beta = 0.7$

$\alpha < \beta$, **high substitutability**

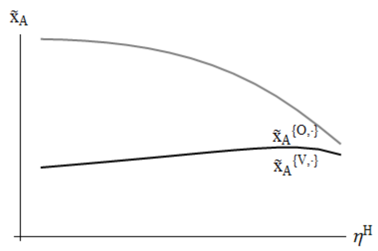


$\alpha = 0.35,\ \beta = 0.8$

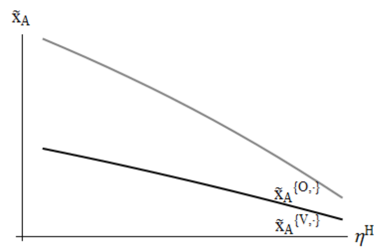


$\alpha = 0.5,\ \beta = 0.8$

$\alpha > \beta$, **very high substitutability**



$\alpha = 0.9,\ \beta = 0.8$



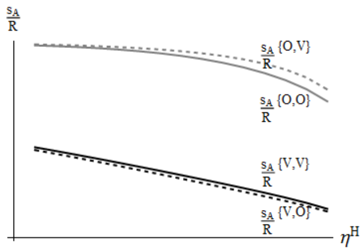
$\alpha = 0.7,\ \beta = 0.4$

A.II.vi Outsourcing and integration: organizational form of the other supplier

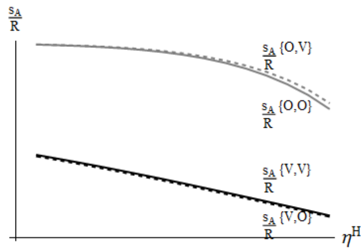
Common parameters: $c_A = c_B = 1$, $c^H = 1$, $\delta_A^O = \delta_B^O = 1$, $\delta_A^V = \delta_B^V = 0.85$, $\eta_A = 0.5$, $Y = 1$, $w_A = w_B = 0$

***Supplier** A**'s revenue share is higher if supplier** B **is integrated than if** B **is outsourced, i.e.,** $\frac{s_A^{\{O,V\}}}{R} > \frac{s_A^{\{O,O\}}}{R}$ **and** $\frac{s_A^{\{V,V\}}}{R} > \frac{s_A^{\{V,O\}}}{R}$.*

$\alpha < \beta$, **low substitutability**

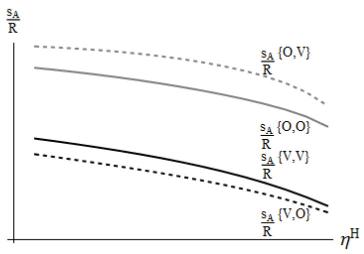


$\alpha = 0.1,\ \beta = 0.8$

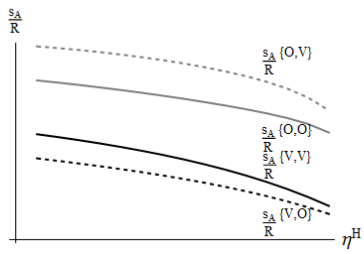


$\alpha = 0.05,\ \beta = 0.7$

$\alpha < \beta$, **high substitutability**

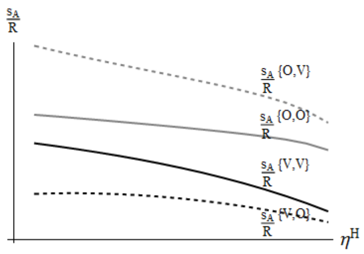


$\alpha = 0.35,\ \beta = 0.8$

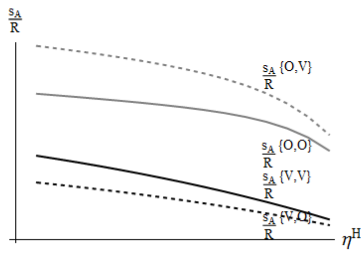


$\alpha = 0.5,\ \beta = 0.8$

$\alpha > \beta$, **very high substitutability**



$\alpha = 0.9,\ \beta = 0.8$



$\alpha = 0.7,\ \beta = 0.4$

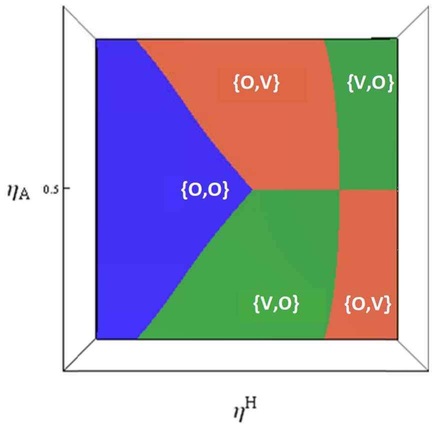
A.III The producer's ownership choice

A.III.i Ownership choice for varying headquarter-intensity and technological asymmetry

Common parameters: $c_A = c_B = 1$, $c^H = 1$, $\delta_A^O = \delta_B^O = 1$, $\delta_A^V = \delta_B^V = 0.85$, $Y = 1$, $w_A = w_B = 0$

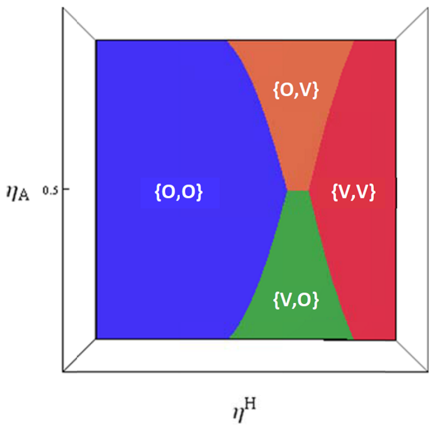
Figures are analogous to figure 2.1 in the main text, but for different parameter constellations.

$\alpha < \beta$, **low substitutability**



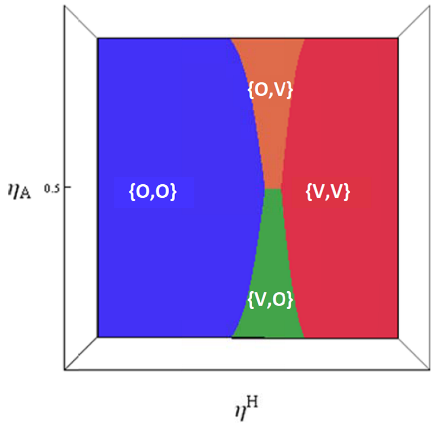
$\alpha = 0.05$, $\beta = 0.7$

$\alpha < \beta$, **high substitutability**

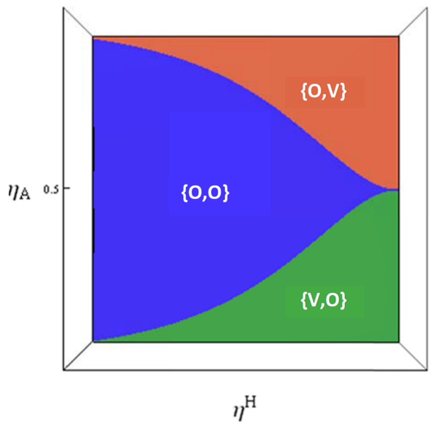


$\alpha = 0.5$, $\beta = 0.8$

$\alpha > \beta$, **very high substitutability**



$\alpha = 0.9,\ \beta = 0.8$

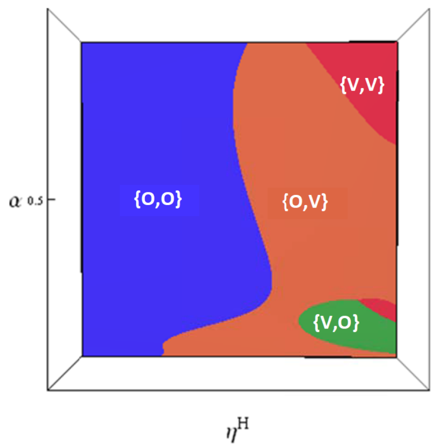


$\alpha = 0.7,\ \beta = 0.4$

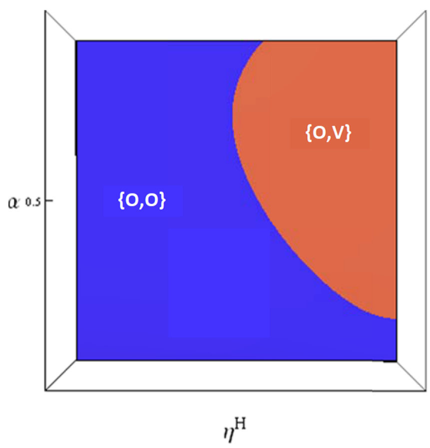
A.III.ii Ownership choice for varying headquarter-intensity and component substitutability

Common parameters: $c_A = c_B = 1$, $c^H = 1$, $\delta_A^O = \delta_B^O = 1$, $\delta_A^V = \delta_B^V = 0.85$, $\eta_A = 0.8$, $Y = 1$, $w_A = w_B = 0$

Figures are analogous to figure 2.2 in the main text, but for different parameter constellations.



$\beta = 0.7$



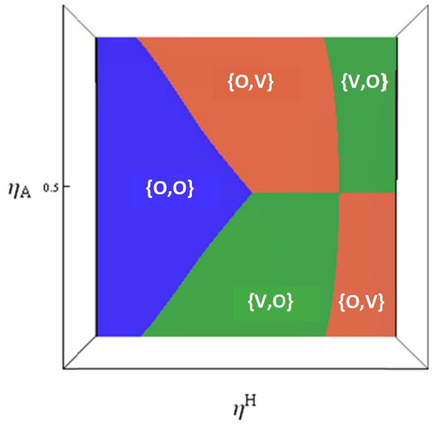
$\beta = 0.4$

A.III.iii Asymmetries in the suppliers' unit costs

Common parameters: $c_A = 1$, $c_B = 3$, $c^H = 1$, $\delta_A^O = \delta_B^O = 1$, $\delta_A^V = \delta_B^V = 0.85$, $Y = 1$, $w_A = w_B = 0$

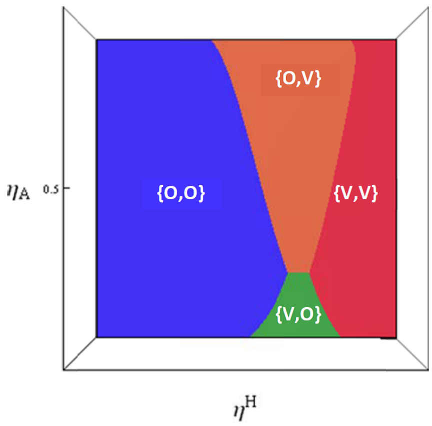
Figures are analogous to figure 2.3 in the main text, but for different parameter constellations.

$\alpha < \beta$, **low substitutability**



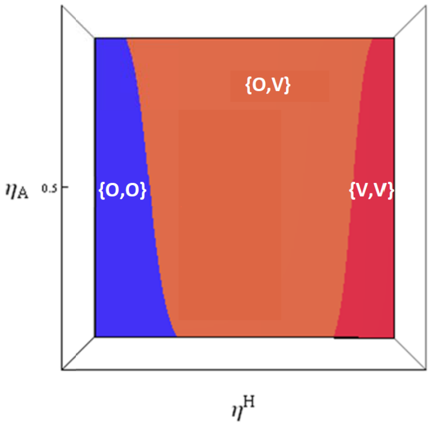
$\alpha = 0.05$, $\beta = 0.7$

$\alpha < \beta$, **high substitutability**

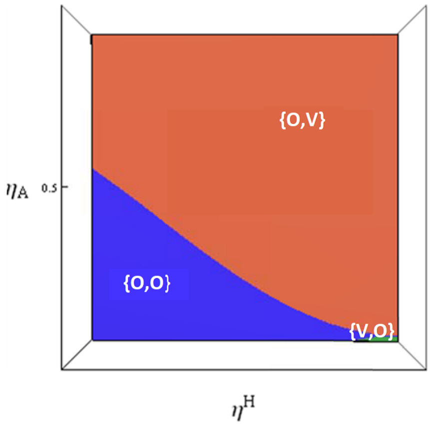


$\alpha = 0.5$, $\beta = 0.8$

$\alpha > \beta$, **very high substitutability**



$\alpha = 0.9,\ \beta = 0.8$



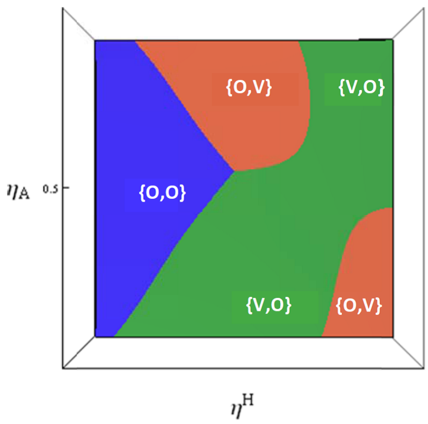
$\alpha = 0.7,\ \beta = 0.4$

A.III.iv Asymmetries in the degree of sophistication

Common parameters: $c_A = c_B = 1$, $c^H = 1$, $\delta_A^O = \delta_B^O = 1$, $\delta_A^V = 0.9$ $\delta_B^V = 0.85$, $Y = 1$, $w_A = w_B = 0$

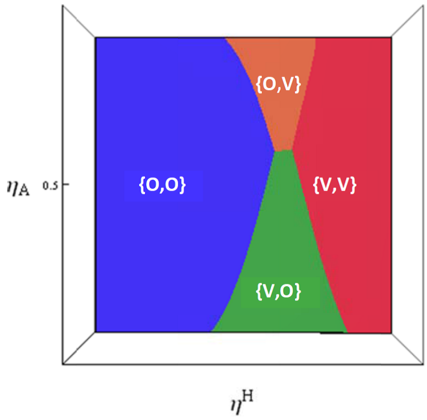
Figures are analogous to figure 2.4 in the main text, but for different parameter constellations.

$\alpha < \beta$, **low substitutability**



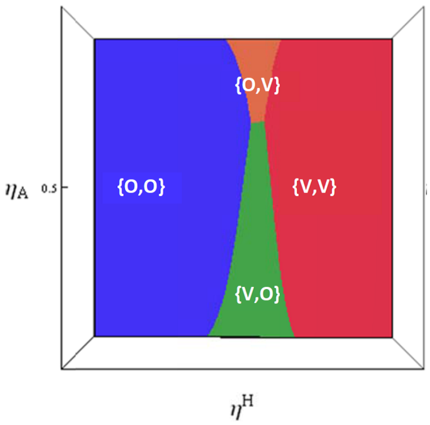
$\alpha = 0.05,\ \beta = 0.7$

$\alpha < \beta$, **high substitutability**

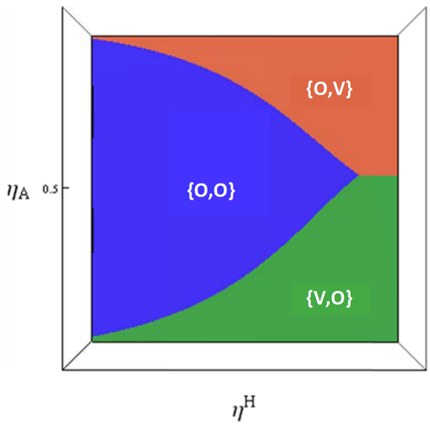


$\alpha = 0.5,\ \beta = 0.8$

$\alpha > \beta$, **very high substitutability**



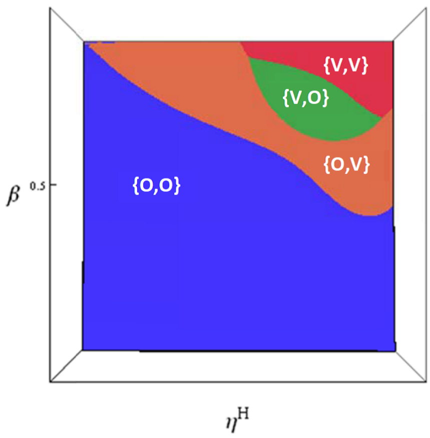
$\alpha = 0.9,\ \beta = 0.8$



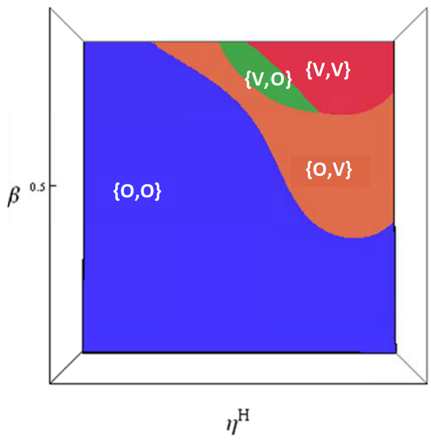
$\alpha = 0.7,\ \beta = 0.4$

A.IV Variation of demand elasticity

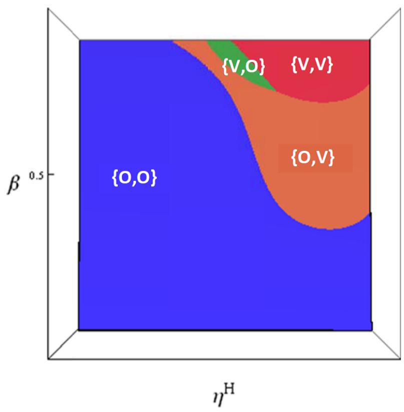
Common parameters: $c_A = c_B = 1$, $c^H = 1$, $\delta_A^O = \delta_B^O = 1$, $\delta_A^V = \delta_B^V = 0.85$, $\eta_A = 0.8$, $Y = 1$, $w_A = w_B = 0$



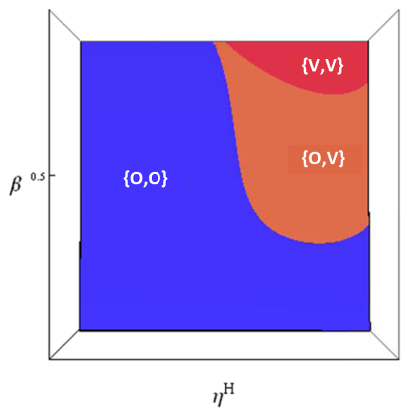
$\alpha = 0.1$



$\alpha = 0.2$



$\alpha = 0.24$



$\alpha = 0.35$

A.V Alternative bargaining concept

To test the robustness of our results, we also consider an alternative bargaining concept. For this test, we first assume the revenue to be distributed according to any alternative bargaining concept where the revenue SHARE does NOT depend on the suppliers' input contributions. As a result, we can derive closed-form solutions for the players' input provisions and the revenue level (in dependence on the respective revenue share rs). The input contributions and the revenue that solve $x_i^{\Xi} = \text{argmax}_{x_i} \left\{ rs_i^{\Xi} R - c_i x_i \right\}$ and $h^{\Xi} = \text{argmax}_h \left\{ (rs^H)^{\Xi} R - c^H h \right\}$ are given by

$$h = \frac{\beta \eta^H rs^H}{c^H} R \quad \text{and} \quad x_i = \beta(1-\eta^H)\eta_i \frac{\left(\frac{rs_i}{c_i}\right)^{\frac{1}{1-\alpha}}}{\eta_A \left(\frac{rs_A}{c_A}\right)^{\frac{\alpha}{1-\alpha}} + \eta_B \left(\frac{rs_B}{c_B}\right)^{\frac{\alpha}{1-\alpha}}} R \quad \text{with}$$

$$R = Y^{1-\beta} \left[\left(\frac{rs^H}{c^H}\right)^{\eta^H} \left(\eta_A \left(\frac{rs_A}{c_A}\right)^{\frac{\alpha}{1-\alpha}} + \eta_B \left(\frac{rs_B}{c_B}\right)^{\frac{\alpha}{1-\alpha}} \right)^{\frac{1-\alpha}{\alpha}(1-\eta^H)} \right]^{\frac{\beta}{1-\beta}}. \tag{A6}$$

Using these input contributions and the revenue, we then make a further assumption regarding the revenue shares to test the robustness of the Shapley-value-results. More precisely, we assume that the revenue share of a supplier depends on his technological importance η_i, his degree of sophistication δ_i and a term κ_i.[15] The revenue share of supplier A is then $rs_A = \eta_A \delta_A \kappa_A$ whereas supplier B's revenue share is $rs_B = (1-\eta_A)\delta_B \kappa_B$. In line with the Shapley value approach, the producer receives the residual as revenue share: $rs_H = 1 - \eta_A \delta_A \kappa_A - (1-\eta_A)\delta_B \kappa_B$.

As in the paper, we then discuss how the players' revenue shares and investment incentives are affected by technology and cost parameters for a given structure Ξ. In doing so, we test whether the relations of the Shapley value approach derived in the paper hold under the robustness check. Note that contrary to the Shapley value approach, we can derive these relations analytically.

A.V.i Higher headquarter-intensity η^H

- SV: The higher is the headquarter-intensity η^H, the higher is the producer's realized revenue share.
  $\rightarrow$ does not hold:
  $$\frac{\partial rs^H}{\partial \eta^H} = 0$$
- SV: The higher is the headquarter-intensity η^H, the lower are the revenue shares of the two suppliers.

[15] We could also assume that the revenue share additionally depends on the headquarter-intensity η^H. However, since the producer absorbs the suppliers' profits, we do not explicitly consider the headquarter-intensity. Note that η^H could be part of κ_i.

$\rightarrow$ does not hold:

$$\frac{\partial rs_A}{\partial \eta^H} = 0 \quad \text{and} \quad \frac{\partial rs_B}{\partial \eta^H} = 0$$

Contrary to the Shapley value approach, due to the assumptions regarding the revenue shares, the revenue shares do not depend on the level of the headquarter intensity.

- SV: The higher is the headquarter-intensity η^H, the higher is the input contribution of the producer relative to the two suppliers $\frac{\tilde{h}}{\tilde{x_i}}$.

  $\rightarrow$ holds:

$$\frac{\partial \frac{\tilde{h}}{\tilde{x}_A}}{\partial \eta^H} = \frac{c_A \delta_A^{-\frac{1}{1-\alpha}} \kappa_A^{-\frac{1}{1-\alpha}} \left(1 - \delta_A \eta_A \kappa_A - \delta_B \left(1-\eta_A\right) \kappa_B\right)}{c^H \eta_A \left(1-\eta^H\right)^2} \cdot$$

$$\left(\delta_A^{\frac{\alpha}{1-\alpha}} \kappa_A^{\frac{\alpha}{1-\alpha}} + c_A^{\frac{\alpha}{1-\alpha}} c_B^{-\frac{\alpha}{1-\alpha}} \delta_B^{\frac{\alpha}{1-\alpha}} \left(1-\eta_A\right)^{\frac{1}{1-\alpha}} \eta_A^{-\frac{1}{1-\alpha}} \kappa_B^{\frac{\alpha}{1-\alpha}}\right) > 0 \quad \text{and}$$

$$\frac{\partial \frac{\tilde{h}}{\tilde{x}_B}}{\partial \eta^H} = \frac{c_B \delta_B^{-\frac{1}{1-\alpha}} \kappa_B^{-\frac{1}{1-\alpha}} \left(1 - \delta_A \eta_A \kappa_A - \delta_B \left(1-\eta_A\right) \kappa_B\right)}{c^H \left(1-\eta_A\right) \left(1-\eta^H\right)^2} \cdot$$

$$\left(\delta_B^{\frac{\alpha}{1-\alpha}} \kappa_B^{\frac{\alpha}{1-\alpha}} + c_A^{-\frac{\alpha}{1-\alpha}} c_B^{\frac{\alpha}{1-\alpha}} \delta_A^{\frac{\alpha}{1-\alpha}} \left(1-\eta_A\right)^{-\frac{1}{1-\alpha}} \eta_A^{\frac{1}{1-\alpha}} \kappa_A^{\frac{\alpha}{1-\alpha}}\right) > 0$$

  As long as $0 < \kappa_A < 1$ and $0 < \kappa_B < 1$, a higher headquarter intensity raises the producer's input provisions relative to the two suppliers' input provisions.

A.V.ii Higher technological importance of supplier A's input ($\eta_A > \eta_B$)

- SV: If supplier A's input has a higher input intensity than supplier B's input, i.e. $\eta_A > \eta_B$, supplier A realizes a higher revenue share than supplier B. For the opposite case with $\eta_A < \eta_B$, results are analogous.

  $\rightarrow$holds:

$$\frac{\partial \frac{rs_A}{rs_B}}{\partial \eta_A} = \frac{\delta_A \kappa_A}{\delta_B \left(1-\eta_A\right)^2 \kappa_B} > 0$$

  The higher is η_A, i.e., the more important is supplier A relative to supplier B, the higher is supplier A's revenue share relative to supplier B's share.

- SV: If supplier A's input has a higher input intensity than supplier B's input, i.e. $\eta_A > \eta_B$, supplier A makes a higher input contribution than supplier B , i.e. $\tilde{x}_A > \tilde{x}_B$. Vice versa, $\tilde{x}_A < \tilde{x}_B$ for $\eta_A < \eta_B$.

  $\rightarrow$ holds:

$$\frac{\partial \frac{\tilde{x}_A}{\tilde{x}_B}}{\partial \eta_A} = \frac{\left(2-\alpha\right) c_A^{-\frac{1}{1-\alpha}} c_B^{\frac{1}{1-\alpha}} \delta_A^{\frac{1}{1-\alpha}} \delta_B^{-\frac{1}{1-\alpha}} \left(1-\eta_A\right)^{-2-\frac{1}{1-\alpha}} \eta_A^{\frac{1}{1-\alpha}} \kappa_A^{\frac{1}{1-\alpha}} \kappa_B^{-\frac{1}{1-\alpha}}}{1-\alpha} > 0$$

  The higher is η_A, the higher is supplier A's investment relative to supplier B's investment.

A.V.iii Higher sophistication of supplier A's input ($\delta_A > \delta_B$)

- SV: If supplier A's input is more sophisticated than supplier B's input ($\delta_A > \delta_B$), supplier A realizes a higher revenue share than supplier B.

  $\rightarrow$ holds:
$$\frac{\partial \frac{rs_A}{rs_B}}{\partial \delta_A} = \frac{\eta_A \kappa_A}{\delta_B \kappa_B (1-\eta_A)} > 0$$

  The better are the property rights of supplier A, the higher is supplier A's revenue share relative to supplier B's revenue share.

- SV: If supplier A's input has a higher sophistication than supplier B's input ($\delta_A > \delta_B$), supplier A makes a higher input contribution than supplier B ($\tilde{x}_A > \tilde{x}_B$).

  $\rightarrow$ holds:
$$\frac{\partial \frac{\tilde{x}_A}{\tilde{x}_B}}{\partial \delta_A} = \frac{c_A^{-\frac{1}{1-\alpha}} c_B^{\frac{1}{1-\alpha}} \delta_A^{\frac{\alpha}{1-\alpha}} \delta_B^{-\frac{\alpha}{1-\alpha}} (1-\eta_A)^{-1-\frac{1}{1-\alpha}} \eta_A^{1+\frac{1}{1-\alpha}} \kappa_A^{\frac{1}{1-\alpha}} \kappa_B^{-\frac{1}{1-\alpha}}}{1-\alpha} > 0$$

  The higher are supplier A's property rights, the higher is supplier A's input contribution relative to supplier B's input contribution.

A.V.iv Lower input costs of supplier A ($c_A < c_B$)

- SV: If supplier A has lower unit costs than supplier B ($c_A < c_B$), supplier A realizes a higher revenue share than supplier B.

  $\rightarrow$ does not hold:
$$\frac{\partial \frac{rs_A}{rs_B}}{\partial c_A} = 0$$

  Due to the assumptions regarding the revenue shares, the revenue shares do not depend on the level of the unit costs.

- SV: If supplier A has lower unit costs than supplier B ($c_A < c_B$), supplier A makes a higher input contribution than supplier B ($\tilde{x}_A > \tilde{x}_B$).

  $\rightarrow$ holds:
$$\frac{\partial \frac{\tilde{x}_A}{\tilde{x}_B}}{\partial c_A} = -\frac{c_A^{-1-\frac{1}{1-\alpha}} c_B^{\frac{1}{1-\alpha}} \delta_A^{\frac{1}{1-\alpha}} \delta_B^{-\frac{1}{1-\alpha}} (1-\eta_A)^{-1-\frac{1}{1-\alpha}} \eta_A^{1+\frac{1}{1-\alpha}} \kappa_A^{\frac{1}{1-\alpha}} \kappa_B^{-\frac{1}{1-\alpha}}}{1-\alpha} < 0$$

  The lower are supplier A's marginal costs, the higher is supplier A's investment relative to supplier B's investment.

A.V.v outsourcing and integration: own organizational form

- SV: Supplier A's revenue share is higher if he is outsourced than if he is integrated.
  $\rightarrow$ holds:
  $$\frac{rs_A\{O,\cdot\}}{rs_A\{V,\cdot\}} = \frac{\delta_{AO}}{\delta_{AV}} > 1$$
  Since a supplier's property rights are higher with outsourcing than with integration, i.e. $\delta_A^O > \delta_A^V$, supplier A's revenue share is higher with outsourcing than with integration.
- SV: Supplier A's input contribution is higher if he is outsourced than if he is integrated, i.e. $\tilde{x}_A^{\{O,\}} > \tilde{x}_A^{\{V,\}}$.
  $\rightarrow$ unclear whether it holds:
  $$\frac{\tilde{x}_A^{\{O,\}}}{\tilde{x}_A^{\{V,\}}} = \delta_{AO}^{\frac{1}{1-\alpha}} \delta_{AV}^{\frac{1}{1-\alpha}} \left(\frac{1 - \delta_{AO}\eta_A\kappa_A - \delta_B (1-\eta_A)\kappa_B}{1 - \delta_{AV}\eta_A\kappa_A - \delta_B (1-\eta_A)\kappa_B} \right)^{\frac{\beta\eta^H}{1-\beta}} \cdot$$
  $$\left(\frac{c_A^{-\frac{\alpha}{1-\alpha}} \delta_{AO}^{\frac{\alpha}{1-\alpha}} \eta_A^{\frac{1}{1-\alpha}} \kappa_A^{\frac{\alpha}{1-\alpha}} + c_B^{-\frac{\alpha}{1-\alpha}} \delta_B^{\frac{\alpha}{1-\alpha}} (1-\eta_A)^{\frac{1}{1-\alpha}} \kappa_B^{\frac{\alpha}{1-\alpha}}}{c_A^{-\frac{\alpha}{1-\alpha}} \delta_{AV}^{\frac{\alpha}{1-\alpha}} \eta_A^{\frac{1}{1-\alpha}} \kappa_A^{\frac{\alpha}{1-\alpha}} + c_B^{-\frac{\alpha}{1-\alpha}} \delta_B^{\frac{\alpha}{1-\alpha}} (1-\eta_A)^{\frac{1}{1-\alpha}} \kappa_B^{\frac{\alpha}{1-\alpha}}} \right)^{-\frac{\alpha+\beta\left((1-\alpha)\eta^H-1\right)}{\alpha(1-\beta)}}$$
  Without making further assumptions, it is not clear if this relation holds.

A.V.vi outsourcing and integration: organizational form of the other supplier

- SV: Supplier A's revenue share is higher if supplier B is integrated than if B is outsourced.
  $\rightarrow$ does not hold:
  $$\frac{rs_A\{O,V\}}{rs_A\{O,O\}} = \frac{rs_A\{V,O\}}{rs_A\{V,V\}} = 1$$
  Since we assume the suppliers' revenue shares to solely depend on the own property rights, supplier A's revenue share is not affected by supplier B's organizational form.

Finally, we numerically analyze the resulting organizational decisions. The results are in line with our previous results. Most importantly, we find - in dependence on the level of substitutability - both the property rights incentive effect and the complementary effect such that we can observe both outsourcing and integration of the more important suppliers:

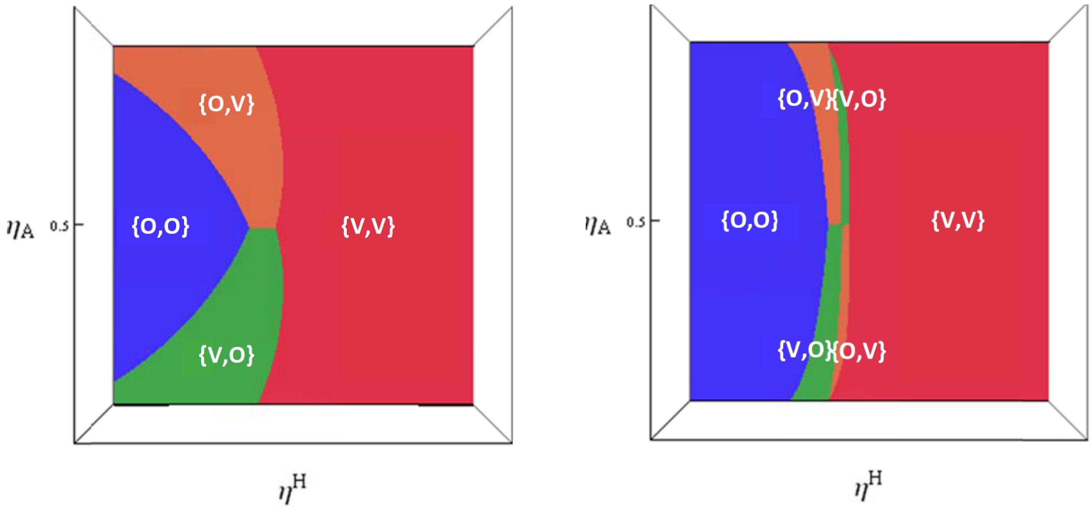


Figure analogous to figure 2.1: Ownership choice for varying headquarter-intensity and technological asymmetry.
Panel 1: High substitutability ($\alpha = 0.35$), Panel 2: Low substitutability ($\alpha = 0.1$)
Common parameters: $c_A = c_B = 1$, $c^H = 1$, $\delta_A^O = \delta_B^O = 1$, $\delta_A^V = \delta_B^V = 0.85$, $\beta = 0.8$, $Y = 1$, $\kappa_A = \kappa_B = 0.6$, $w_A = w_B = 0$

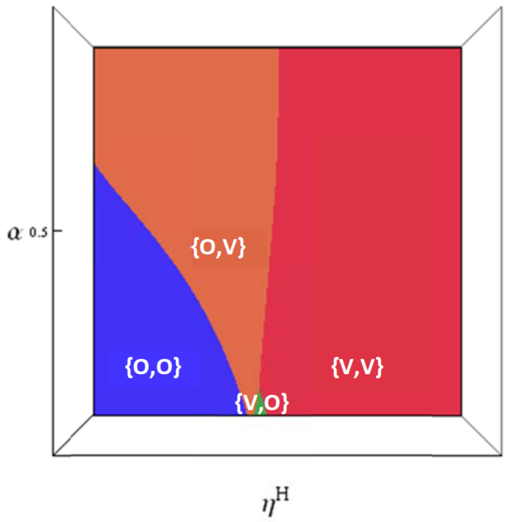


Figure analogous to figure 2.2: Ownership choice for varying headquarter-intensity and component substitutability.
Parameters: $c_A = c_B = 1$, $c^H = 1$, $\delta_A^O = \delta_B^O = 1$, $\delta_A^V = \delta_B^V = 0.85$, $\eta_A = 0.8$, $\beta = 0.8$, $Y = 1$, $\kappa_A = \kappa_B = 0.6$, $w_A = w_B = 0$.

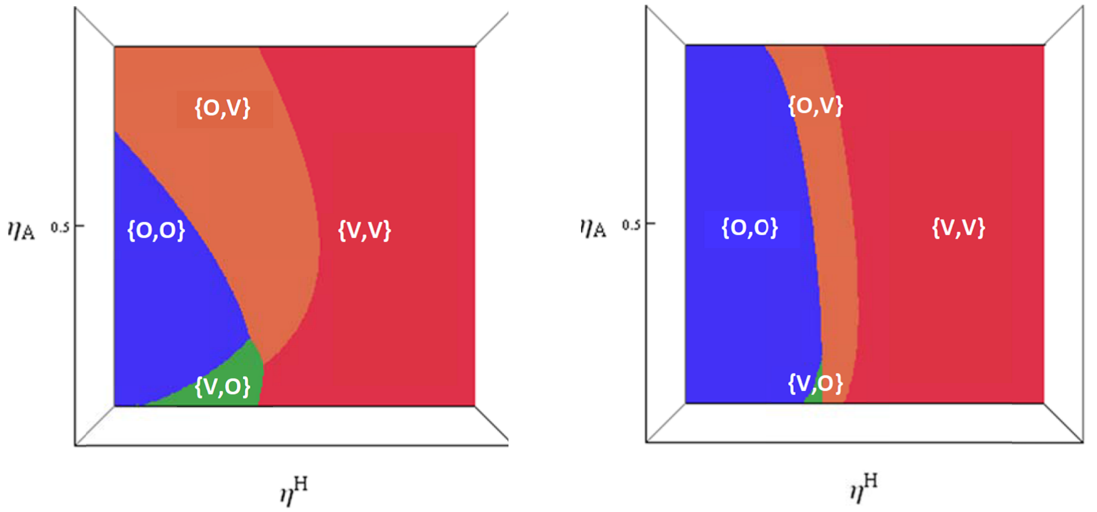


Figure analogous to figure 2.3: Asymmetries in the suppliers' unit costs. Panel 1: High substitutability ($\alpha = 0.35$), Panel 2: Low substitutability ($\alpha = 0.1$). Common parameters: $c_A = 1$, $c_B = 3$, $c^H = 1$, $\delta_A^O = \delta_B^O = 1$, $\delta_A^V = \delta_B^V = 0.85$, $\beta = 0.8$, $Y = 1$, $\kappa_A = \kappa_B = 0.6$, $w_A = w_B = 0$.

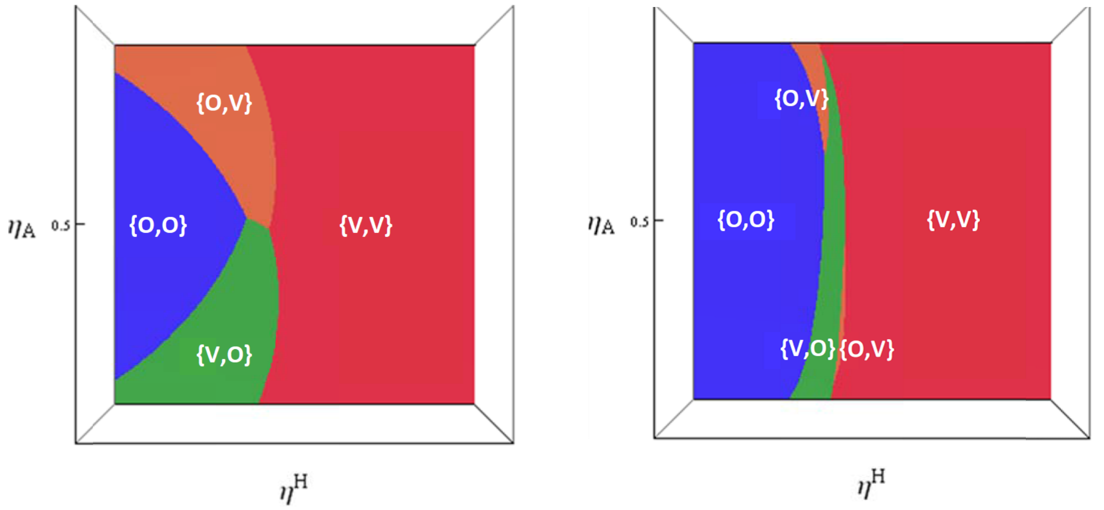


Figure analogous to figure 2.4: Asymmetries in the degree of sophistication. Panel 1: High substitutability ($\alpha = 0.35$), Panel 2: Low substitutability ($\alpha = 0.1$). Common parameters: $c_A = c_B = 1$, $c^H = 1$, $\delta_A^O = \delta_B^O = 1$, $\delta_A^V = 0.9$, $\delta_B^V = 0.85$, $\beta = 0.8$, $Y = 1$, $\kappa_A = \kappa_B = 0.6$, $w_A = w_B = 0$.

Chapter 3

Make or buy - on the organizational structure of firms with asymmetric suppliers

Co-authored with Christian Schwarz and Jens Suedekum

3.1 Introduction

Final goods producers differ widely in their sourcing strategies for intermediate inputs. For example, *Nike* mostly collaborates with external subcontractors, while *Intel* keeps the vast majority of components within the boundaries of the firm and thus relies heavily on vertically integrated suppliers that are directly owned and controlled by the mother company.[1] Most firms, however, actually pursue a "hybrid sourcing" strategy and choose different organizational modes for different suppliers.[2] In the production of the S40, for example, Volvo outsources such parts as the side mirror, the fuel tank, and the headlights, whereas other components (such as the main engine) are produced by vertically integrated subsidiaries.

This empirically pervasive phenomenon of hybrid sourcing is hard to understand with the seminal model of the multinational enterprise (MNE) that Antràs and Helpman (2004) have introduced into the international trade literature. In that framework, which assumes an environment with incomplete contracts, a producer provides headquarter services and interacts with one supplier that provides an essential manufacturing component for the final product. The producer chooses whether to outsource or vertically integrate that supplier, taking into account that this ownership decision ("make or buy") matters for the supplier's incentives to contribute to the relationship.[3] However, because there is just one single supplier, by construction the firm cannot be characterized by a coexistence of different organizational modes, even though this seems to be the most common organizational structure of MNEs in the data.

In this chapter, we provide an extension of the baseline model by Antràs and Helpman (2004) and consider a production process with headquarter services and two manufacturing components. These two components are imperfect substitutes and may be asymmetric in terms of their technological importance for the final good, in terms of their unit costs of production, and in terms of their inherent degree of sophistication. As in the baseline model, we assume an incomplete contracts environ-

[1] See Antràs and Rossi-Hansberg (2009) for a detailed discussion of several examples of MNEs.

[2] See Tomiura (2007), Jabbour (2008), Kohler and Smolka (2012), and Jabbour and Kneller (2010) for systematic evidence on the importance of hybrid sourcing strategies in multinational firms.

[3] As will become clearer below, this model structure with incomplete contracts is characterized by hold-up and underinvestment problems, since inputs are relationship-specific and investment costs are sunk. An outsourced supplier then tends to have higher bargaining power vis-à-vis the producer, as he can threaten to withhold his entire input level. A vertically integrated supplier is basically an employee of the producer, and hence has no ownership rights over his inputs. However, following the property rights approach to the firm (see Grossman and Hart, 1986; Hart and Moore, 1990), we assume that the producer cannot fully make use of that input if the vertically integrated supplier refuses to collaborate, which in turn gives some bargaining power to those subsidiaries.

ment that eventually leads to a bargaining over the surplus of the relationship. Yet, in contrast to Antràs and Helpman (2004) who assume a bilateral Nash bargaining between the producer and the single supplier, we encounter a more complex bargaining among three parties, the producer and the two asymmetric suppliers. Our solution approach relies on the Shapley value, similar as in Nowak, Schwarz and Suedekum (2016) and in Schwarz and Suedekum (2014), which has proven to be a useful tool in the analysis of such multilateral bargaining scenarios (see Shapley, 1953; Acemoglu, Antràs and Helpman, 2007). In this chapter we illustrate in detail how asymmetries across components affect the bargaining powers of the two suppliers (i.e., their Shapley values), the revenue distribution within the firm and, ultimately, the producer's decision about the firm's organizational structure.

The main advantage of our model is the possible emergence of hybrid sourcing, that is, a firm structure in which one supplier is integrated and the other one is outsourced. We can thus analyze under which circumstances this realistic outcome of hybrid sourcing is likely to emerge, and if it emerges, which organizational mode is chosen for which component. Our model leads to a rich set of theoretical predictions about these issues, which we then contrast with insights from a recent empirical literature that has unraveled several new facts about the internal structure of MNEs. In particular, Alfaro and Charlton (2009) and Corcos, Irac, Mion and Verdier (2013) find that MNEs tend to keep high-skill inputs and components with a higher degree of asset specificity within their boundaries, whereas they tend to outsource simpler inputs from the early stages of the production process. It has been difficult so far to rationalize those empirical findings with the baseline model by Antràs and Helpman (2004), chiefly because that framework does not deal with multiple suppliers or inputs. Our extension with two suppliers/components is broadly consistent with these empirical patterns.

More specifically, our model suggests that hybrid sourcing occurs if the overall production process is neither too headquarter- nor too component-intensive. Given that the producer actually chooses hybrid sourcing, our model then predicts that the producer tends to keep the more "sophisticated" input, which requires more special expertise to be usable, within the boundaries of the firm. The simpler and more standard component is, in contrast, more likely to be outsourced. These theoretical results are in line with the empirical findings of Alfaro and Charlton (2009) and Corcos, Irac, Mion and Verdier (2013).

Recently, there have been notable developments in the theoretical literature on the organization of multinational firms based on the seminal approach by Antràs and Helpman (2004). More specifically, Antràs and Helpman (2008) have extended that framework to realistically allow for partial contractibility of the input investments. Antràs and Chor (2013) provide a framework to study the organization of global value chains in which intermediate inputs are refined by multiple vertically related suppliers until production eventually reaches its final stage. Our framework differs from that model because we consider two inputs on the same stage of the value chain that are both simultaneously combined with headquarter services to produce a final good. Other extensions are due to Du, Lu and Tao (2009) and Van Biesebroeck and Zhang (2014). In the former model, the same input can be provided by two suppliers, and "bi-sourcing" (one supplier integrated and the other outsourced) can arise out of a strategic motive because it systematically improves the headquarter's outside option and thus the bargaining power. In our model, hybrid sourcing can emerge because of an entirely different motive. Van Biesebroeck and Zhang (2014) also study an incomplete contracts model with multiple suppliers. However, they do not focus on the organizational decision of outsourcing versus integration. Finally, in Nowak and Schwarz (2016) we extend the present framework.[4]

The rest of this chapter is organized as follows. In section 3.2 we introduce our basic model framework. Section 3.3 analyzes the multilateral bargaining and introduces the solution concept of the Shapley value. In section 3.4, we illustrate how the producer's organizational decision affects the bargaining powers of the different agents and the revenue distribution inside the firm. Section 3.5 then deals with the question which organizational structure the producer ultimately chooses. Finally, section 3.6 provides a summary and a discussion of our main results.

3.2 The model

3.2.1 Technology and demand

We consider a firm that produces a final good y. Production of this final good requires headquarter services and two different manufacturing components. The headquarter services are denoted by h and are provided by the firm (the "producer") itself. The components are produced by suppliers. Specifically, we assume that there are two suppliers a and b who provide m_i ($i \in \{a, b\}$) units of their respective component.

The inputs are combined according to the following production function:

$$y = \theta \left(\frac{h}{\eta^H}\right)^{\eta^H} \left(\frac{M}{1-\eta^H}\right)^{1-\eta^H}, \tag{3.1}$$

$$\text{where} \quad M = \left[\eta_a \left(\frac{m_a}{\eta_a}\right)^{\epsilon} + \eta_b \left(\frac{m_b}{\eta_b}\right)^{\epsilon}\right]^{\frac{1}{\epsilon}}. \tag{3.2}$$

[4] For a recent review of the literature, see Antràs (2014).

The upper tier production function, equation (3.1), is a standard Cobb-Douglas, where θ denotes the firm's overall productivity level, η^H is the headquarter-intensity, and $\eta^M = 1 - \eta^H$ is the overall component intensity of the production process. The aggregate component input M is given by a constant elasticity of substitution (CES) function as in equation (3.2), where η_i denotes the input intensity of component i within the aggregate M (with $\eta_a + \eta_b = 1$). Finally, the parameter $\epsilon \in (0, 1)$ measures how well the two components can be substituted.

These parameters capture firms' technological differences within and across industries. To give an example, one may expect the headquarter-intensity η^H to be high in pharmaceutical or software firms and low, say, in firms from the automotive industry. The parameter η_a (with $\eta_b = 1 - \eta_a$) captures the degree of asymmetry of the two components in terms of their technological importance. As an example, consider the production of perfume. This final good requires two component inputs: alcohol as the base material and the highly specific aroma compounds that differentiate the fragrances. Here, the substitutability across those components is low, and the aroma oil has a much higher input intensity than the alcohol. In sales agencies, on the other hand, inputs like technical support and customer services are more symmetric (η_a and η_b are more similar) and better substitutable (higher ϵ).

On the demand side, the firm faces an iso-elastic demand function for the final product

$$y = Yp^{-\frac{1}{(1-\alpha)}} \tag{3.3}$$

where p is the price of the good, $Y > 1$ is a demand shifter, and $1/(1 - \alpha) > 1$ is the demand elasticity, with $\alpha \in (0, 1)$. Combining equations (3.1), (3.2) and (3.3) yields the firm's revenue level which depends endogenously on the input provision levels h, m_a and m_b:

$$R = \theta^{\alpha} Y^{1-\alpha} \left[\left(\frac{h}{\eta^H} \right)^{\eta^H} \left(\frac{\left[\eta_a \left(\frac{m_a}{\eta_a} \right)^{\epsilon} + \eta_b \left(\frac{m_b}{\eta_b} \right)^{\epsilon} \right]^{\frac{1}{\epsilon}}}{1 - \eta^H} \right)^{1-\eta^H} \right]^{\alpha} . \tag{3.4}$$

3.2.2 The firm's organizational choice

The producer's key decision in our model concerns the firm's organizational structure. For both components $i \in \{a, b\}$ the producer decides whether the respective supplier is an external ("outsourced") subcontractor or a subsidiary that is vertically integrated within the boundaries of the firm. This "make or buy" decision is made in an environment with incomplete contracts in which the provision levels of the relationship-specific inputs are not contractible, similar to Antràs and Helpman

(2004) or Schwarz and Suedekum (2014). A hold-up problem thus arises and the producer and the two suppliers end up in a bargaining over the surplus value of the production; consequently, all parties tend to underinvest into their input provisions. The producer's ownership decisions matter for the bargaining powers of the three parties because an outsourced supplier maintains the full ownership and property rights over his input, whereas a vertically integrated supplier does not. The organizational structure thus ultimately affects both the total revenue level and its distribution.

We consider the following five-stage game that we solve by backward induction:

1. The producer chooses the firm's organizational structure. This decision is represented by a tuple $\Xi = \{\Xi_a, \Xi_b\}$, where $\Xi_i = O$ denotes outsourcing and $\Xi_i = V$ denotes vertical integration of the supplier of component $i \in \{a, b\}$. The tuple Ξ can thus take four possible realizations: $\{O, O\}$, $\{O, V\}$, $\{V, O\}$ or $\{V, V\}$.

2. Given the organizational decision, the firm offers contracts to potential suppliers. Contract may include a participation fee τ_i (positive or negative) from supplier $i \in \{a, b\}$.

3. There is a large number of potential suppliers for both components. Each potential supplier has an outside opportunity equal to w^M. Potential suppliers apply for the contract, and the producer chooses one supplier for each component $i \in \{a, b\}$.

4. The headquarter and the suppliers a and b decide independently on their noncontractible input provision levels (h and, respectively, m_a and m_b).

5. After the input investments are sunk, the three players bargain over the surplus value of the production of the final good. Output is produced and revenue is realized and distributed according to the outcome of the bargaining process.

Starting with stage 5, the surplus value over which the producer and the two suppliers bargain is the realized revenue level as given in equation (3.4). We denote the headquarter's revenue share by β^H, and the suppliers' revenue shares by β_a and β_b. Revenue is distributed among the three players such that $\beta^H + \beta_a + \beta_b = 1$. For the modeling of the bargaining process, we use the Shapley value as the solution concept. This is a standard solution concept in multilateral bargaining contexts (see Shapley, 1953; Acemoglu, Antràs and Helpman, 2007). The details of this bargaining game are analyzed in the next section.

In stage 4, both the producer and the suppliers choose their input provision levels, given the revenue shares that they anticipate to receive in the bargaining stage. The producer chooses h so as to maximize $\beta^H R - c^H h$, where c^H denotes the unit costs of headquarter services. Analogously, the supplier $i \in \{a, b\}$ maximizes

$\beta_i R - c_i^M m_i$, where c_i^M denotes the unit cost level of the supplier who signed the contract. We show in the appendix to this chapter that the following input provision levels maximize the payoff of the producer and the suppliers, respectively:

$$h = \frac{\eta^H \beta^H}{c^H} R \quad \text{and} \quad m_i = \left(1 - \eta^H\right) \eta_i \frac{\left(\frac{\beta_i}{c_i^M}\right)^{\frac{1}{1-\epsilon}}}{\eta_a \left(\frac{\beta_a}{c_a^M}\right)^{\frac{\epsilon}{1-\epsilon}} + \eta_b \left(\frac{\beta_b}{c_b^M}\right)^{\frac{\epsilon}{1-\epsilon}}} R \quad \text{with} \tag{3.5}$$

$$R = \Theta \left[\left(\frac{\beta^H}{c^H}\right)^{\eta^H} \left(\eta_a \left(\frac{\beta_a}{c_a^M}\right)^{\frac{\epsilon}{1-\epsilon}} + \eta_b \left(\frac{\beta_b}{c_b^M}\right)^{\frac{\epsilon}{1-\epsilon}} \right)^{\frac{1-\epsilon}{\epsilon}\left(1-\eta^H\right)} \right]^{\frac{\alpha}{1-\alpha}}$$

where $\Theta = Y\left(\alpha\theta\right)^{\frac{\alpha}{1-\alpha}}$ is an alternative measure of productivity. As can be seen from equation (3.5), both the revenue share and level affect the two parties' investment incentives: Ceteris paribus, a higher revenue share β^H raises the headquarter's input provision h and, hence, the revenue level. However, a higher β^H lowers the remaining share $1 - \beta^H = \beta_a + \beta_b$ for the suppliers, and thereby their input provisions, which in turn reduces the revenue level. This relationship illustrates that the producer needs to properly incentivize the suppliers in order to tackle the underinvestment problem that is inherent in this game structure.

In stage 3, suppliers only apply for a contract when the overall payoff offered in stage 2 exceeds or at least equals the outside option w^M. A supplier's overall payoff is the anticipated revenue share and the participation fee, minus the costs of production. Thus, the participation constraint reads as:

$$\beta_i R - c_i^M m_i + \tau_i \geq w^M. \tag{3.6}$$

Because the producer can freely adjust the upfront payments in stage 2, those participation constraints will be satisfied with equality, that is,

$$\beta_i R - c_i^M m_i + \tau_i = w^M \quad \Leftrightarrow \quad \tau_i = w^M - \beta_i R + c_i^M m_i. \tag{3.7}$$

Finally, in the first stage the producer chooses the firm's organizational structure in order to maximize her own payoff. Using equation (3.7), this implies that the producer's problem is equivalent to maximizing the joint payoff of all players:

$$\pi = R - c^H h - c_a^M m_a - c_b^M m_b - 2w^M \tag{3.8}$$

which can be rewritten as follows by using the expressions from equation (3.5):

$$\pi = \left[1 - \alpha \left(\eta^H \beta^H + \eta^M \frac{\eta_a \left(\frac{\beta_a}{c_a^M}\right)^{\frac{1}{1-\epsilon}} + \eta_b \left(\frac{\beta_b}{c_b^M}\right)^{\frac{1}{1-\epsilon}}}{\eta_a \left(\frac{\beta_a}{c_a^M}\right)^{\frac{\epsilon}{1-\epsilon}} + \eta_b \left(\frac{\beta_b}{c_b^M}\right)^{\frac{\epsilon}{1-\epsilon}}} \right) \right]$$

$$\left[\left(\frac{\beta^H}{c^H}\right)^{\eta^H}\left(\eta_a\left(\frac{\beta_a}{c_a^M}\right)^{\frac{\epsilon}{1-\epsilon}}+\eta_b\left(\frac{\beta_b}{c_b^M}\right)^{\frac{\epsilon}{1-\epsilon}}\right)^{\frac{1-\epsilon}{\epsilon}\left(1-\eta^H\right)}\right]^{\frac{\alpha}{1-\alpha}}-2w^M. \tag{3.9}$$

The producer cannot freely set the revenue shares subject to $\beta^H + \beta_a + \beta_b = 1$, but those shares are determined in the multilateral bargaining in the ultimate stage of the game. The revenue distribution thus hinges on the bargaining powers of the three agents, which are in turn crucially affected by two sets of factors: i) technology parameters such as the input intensities η^H and η_i, unit costs c_i^M, and the degree of component substitutability ϵ, and ii) the organizational structure of the firm. Whereas the former set of factors is exogenous, the latter is endogenously chosen by the producer.

In other words, the producer maximizes equation (3.9) with respect to the tuple $\Xi = \{\Xi_a, \Xi_b\}$ subject to the technology parameters. This organizational decision pins down the bargaining powers and hence the revenue distribution, as it determines the ownership rights of the suppliers.

3.3 The bargaining process and the Shapley value

We now turn to the formal description of the bargaining process and the solution concept of the Shapley value. Ultimately, our aim is to analyze which organizational structure the producer chooses depending on the firm's technology. For this purpose, it is useful to proceed in three steps. The first step is to introduce some basics of the multilateral bargaining process and the Shapley value and to illustrate the impact of technological asymmetries across the two components on the revenue distribution within the firm. In this section, we still neglect the ownership dimension, however, and implicitly assume that both suppliers maintain the full property rights over their assets. Second, in section 3.4 we show how the Shapley values and the revenue distribution depend on the producer's organizational decision, and we discuss how this dependence interacts with the impacts of the exogenous technological factors. Finally, in section 3.5 we pull all pieces together and analyze the payoff-maximizing organizational choice.

3.3.1 Shapley value: The basics

The Shapley value (Shapley, 1953) is the most widely used solution concept for multilateral bargaining contexts, satisfying the five fundamental conditions "individual fairness", "efficiency", "symmetry", "additivity", and the "null player". This bargaining furthermore assumes that potential outcomes are known by all agents. Recall, however, that it occurs after the investment decisions have been made, so the input productions (and thus the potential bargaining outcomes) are observable ex post to all participants.

According to Acemoglu, Antràs and Helpman (2007, 923) a "player's Shapley value is the average of her contributions to all coalitions that consist of players ordered below her in all feasible permutations". Thus, to determine the Shapley values of the three players in our model, several steps are necessary:

1. Derivation of the set of feasible permutations
2. Calculation of the marginal contributions
3. Forming the average
4. Derivation of the Shapley value and the revenue distribution.

Derivation of the set of feasible permutations A coalition is a collaboration of players that comprises at least a nonempty subset of the players. With three players (the producer and the two suppliers) the coalition size can be theoretically one, two or three. It can be seen from (3.1) and (3.2) that the production of the final good requires headquarter services and at least one component. Hence, coalitions of size one earn zero revenue. The same applies for coalitions of two players that do not contain the producer. Such coalitions earn zero revenue as well.[5]

Within the coalitions, the players can be ordered in different ways and these different orderings are called *permutations*. In figure 3.1, we illustrate the set of all theoretically possible permutations and the relevant ("feasible") permutations that earn nonzero revenue. The position of a single player within a permutation indicates the entry sequence. For example, in the permutation $\{H, b, a\}$, supplier a was the last player to enter. When calculating marginal contributions, this entry sequence is crucial as we consider the player in this last position to be the one who leaves an existing coalition.

Calculation of the marginal contributions The marginal contribution of a player is the difference between the revenue of the coalition when the respective player is part of it and the coalition's revenue when the respective player is not part of it. A player's marginal contribution to a coalition is determined only if the other players in this coalition "are ordered below her in all feasible permutations". In

[5] A key difference of our model compared to Antràs and Helpman (2004) is that not all inputs are essential in our framework. Namely, a coalition of the producer with one supplier earns positive revenue as long as $\epsilon > 0$ in the CES function (3.2). Antràs and Helpman (2004) consider a setup with a producer and one manufacturing component, where the two inputs are combined in a Cobb-Douglas fashion. They assume a bilateral Nash bargaining.

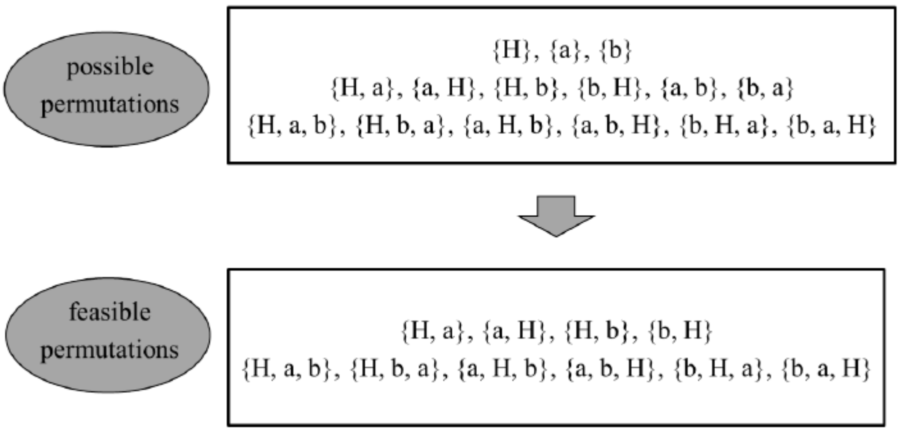


Figure 3.1: Possible and feasible permutations.

terms of figure 3.1, this means that we have to focus on those feasible permutations in which the respective player is in the last position. Consider, for example, supplier a: In a coalition with the producer, there are two possible permutations: $\{H, a\}$ and $\{a, H\}$. Supplier a is in the last position only with $\{H, a\}$, and we have to calculate only the marginal contribution for this permutation. For a coalition of size 3, there are two relevant permutations for the calculation of supplier a's marginal contribution, namely $\{H, b, a\}$ and $\{b, H, a\}$.

Let us first consider coalitions of size 2, that is, among the producer and one supplier i. When supplier i leaves this coalition, the producer becomes the sole player and the remaining total revenue is 0. Thus, the marginal contribution of the supplier in a coalition of size 2 (denoted by MC_i^2) equals the total revenue of this coalition:

$$MC_i^2 = \hat{H} m_i^{\alpha(1-\eta_H)} \eta_i^{\frac{\alpha(1-\epsilon)(1-\eta_H)}{\epsilon}} \quad \text{with}$$
$$\hat{H} = \theta^{\alpha} Y^{1-\alpha} h^{\alpha\eta^H} \left(1-\eta^H\right)^{-\alpha\left(1-\eta^H\right)} \left(\eta^H\right)^{-\alpha\eta^H}. \tag{3.10}$$

The same reasoning applies to the producer, whose marginal contribution to a coalition of size 2 also equals the total revenue of this coalition:

$$MC_{Hi}^2 = \hat{H} m_i^{\alpha(1-\eta_H)} \eta_i^{\frac{\alpha(1-\epsilon)(1-\eta_H)}{\epsilon}} \tag{3.11}$$

where $i \in \{a, b\}$ indexes the supplier with whom the producer has formed the coalition.

Next, we consider coalitions of size 3. When supplier i leaves this coalition, the producer and the remaining supplier j can realize a revenue equal to $\hat{H}\left(m_j^{\epsilon}\eta_j^{1-\epsilon}\right)^{\alpha\left(1-\eta^H\right)/\epsilon}$, so the marginal contribution of supplier i is

$$MC_i^3 = \hat{H}\left(\left(m_i^\epsilon \eta_i^{1-\epsilon} + m_j^\epsilon \eta_j^{1-\epsilon}\right)^{\alpha\left(1-\eta^H\right)/\epsilon} - \left(m_j^\epsilon \eta_j^{1-\epsilon}\right)^{\alpha\left(1-\eta^H\right)/\epsilon}\right) \quad \text{with} \quad i \neq j. \tag{3.12}$$

Yet if the headquarter leaves a coalition of three players, the revenue of the remaining two suppliers is again equal to 0. Hence, the marginal contribution of the producer is

$$MC_H^3 = \hat{H}\left(m_i^\epsilon \eta_i^{1-\epsilon} + m_j^\epsilon \eta_j^{1-\epsilon}\right)^{\alpha\left(1-\eta^H\right)/\epsilon}. \tag{3.13}$$

Forming the average Starting from these marginal contributions, the Shapley value is calculated with the help of

$$SV_k = \sum_{S \subseteq N} \frac{(s-1)!\,(n-s)!}{n!} MC_k^s \quad \text{with} \quad k = \{H, a, b\}. \tag{3.14}$$

Here, $n = 3$ is the number of all players, and s is the number of players in a coalition ($s \leq n$). The term $\frac{(s-1)!(n-s)!}{n!}$ captures the weights when forming the average across all feasible permutations, and it equals the probability that a specific player k is in the last position of such a feasible permutation.

In coalitions of two players ($s = 2$) , this probability equals $\frac{(2-1)!(3-2)!}{3!} = 1/6$ for both suppliers a and b. As can be seen from figure 3.1, in total there are six theoretically possible coalitions of size 2, yet each supplier is in the last position only in one case. The producer, in turn, has a probability of 1/3 of being in the last position in a feasible permutation of size two, namely $\{a, H\}$ and $\{b, H\}$, which both have an individual probability equal to 1/6. For a coalition size of 3, the weight is $\frac{(3-1)!(3-3)!}{3!} = 1/3$ for all players, because there are six feasible permutations for this coalition size, and each player is in the last position twice.

Derivation of the Shapley value and the revenue distribution Using these probabilities and the marginal contributions calculated previously, we can now derive the Shapley values of the three players and the revenue shares that result in the multilateral bargaining. For supplier i, the Shapley value is given as follows:

$$SV_i = \frac{1}{6} MC_i^2 + \frac{1}{3} MC_i^3 \tag{3.15}$$

which is the weighted average of his marginal contribution to all feasible permutations where the other players are ordered below. Analogously, the Shapley value of the producer is

$$SV_H = \frac{1}{6}MC^2_{Hi} + \frac{1}{6}MC^2_{Hj} + \frac{2}{6}MC^3_H \quad \text{with} \quad i \neq j. \tag{3.16}$$

Notice that because $MC^2_{Hi} = MC^2_i$ and $MC^3_H > MC^3_i$, the Shapley value of the producer exceeds that of a single supplier.

These Shapley values given in equations (3.15) and (3.16) form the basis for the determination of the revenue distribution. Namely, the revenue share of supplier $i \in \{a, b\}$ is given by the supplier's Shapley value divided by the firm's total revenue:

$$\beta_i = \frac{SV_i}{R} \tag{3.17}$$

$$= \frac{m_i^{\alpha\left(1-\eta^H\right)}\eta_j^{\alpha(1-\epsilon)\left(1-\eta^H\right)/\epsilon} + 2\left(\left(m_i^\epsilon \eta_i^{1-\epsilon} + m_j^\epsilon \eta_j^{1-\epsilon}\right)^{\alpha\left(1-\eta^H\right)/\epsilon} + \left(m_j^\epsilon \eta_j^{1-\epsilon}\right)^{\alpha\left(1-\eta^H\right)/\epsilon}\right)}{6\left(m_a^\epsilon \eta_a^{1-\epsilon} + m_b^\epsilon \eta_b^{1-\epsilon}\right)^{\alpha(1-\eta^H)/\epsilon}}$$

These revenue shares are dependent on the input provision levels m_a and m_b, which in turn depend on the revenue shares. As a result, we cannot solve explicitly for the revenue shares of the suppliers. However, it is possible to display the underlying system of equations (see the appendix to this chapter) that we later on solve numerically.

For the determination of the producer's revenue share, one must take into account the efficiency, additivity, and null player axioms of the Shapley value approach. The sum of the marginal contributions must equal the total revenue. However, the allocation of the marginal contributions is not necessarily efficient, as the sum of the marginal contributions may deviate from the revenue of the coalition (see Hart, 1990; Hart and Mas-Colell, 1988). To assure that the total revenue is distributed among the three players, the revenue shares are thus only calculated for two players, namely the two suppliers. One player receives the residual revenue share, as in Hart and Moore (1990) and Acemoglu, Antràs and Helpman (2007). We assume that the producer is this residual claimant because that is the only essential player (the "null player") in this bargaining game. Hence, the headquarter revenue share is given by $\beta^H = 1 - \beta_a - \beta_b$, where β_a and β_b follow from equation (3.17).

3.3.2 Illustration: The revenue distribution with asymmetric inputs

We now illustrate how the Shapley values and the revenue shares are affected by the exogenous technological factors. Specifically, we use numerical analysis to study the impact of variations in the following parameters:

1. The headquarter-intensity of final goods production (η_H)
2. The input intensities of the suppliers (η_i)
3. The suppliers' unit costs (c_i^M)
4. The degree of component substitutability (ϵ)

Recall that throughout this section, we assume that both suppliers maintain full ownership of their assets. That is, in the multilateral bargaining they threaten to take away their entire input provision levels, respectively.

Headquarter-intensity η^H The headquarter-intensity measures the technological importance of the producer's contribution to the final good. This is the key parameter to pin down the revenue distribution in the baseline model by Antràs and Helpman (2004), where η^H immediately implies the residual input intensity of the single manufacturing component. In Schwarz and Suedekum (2014), in which they consider multiple but symmetric components, η^H also pins down the input intensity of each of those single manufacturing inputs. In our model, there can be asymmetries across the two components that crucially affect the players' bargaining powers and the revenue distribution, as we will show shortly. However, to isolate the impact of η^H, it is useful to first consider the benchmark scenario in which the two components a and b are symmetric in terms of their input intensities ($\eta_a = \eta_b = 1/2$) and unit costs ($c_a^M = c_b^M = c^M$).

Figure 3.2 illustrates how the revenue distribution changes upon variation of η^H, keeping the other parameters fixed. The left panel refers to the revenue share (Shapley value over total revenue) of supplier a, which is identical to supplier b's revenue share because the two components are symmetric. The right panel depicts the residual share β^H as a function of η^H.

As can be seen, the higher is the headquarter-intensity of final goods production, the lower is the revenue share of both suppliers and the higher is the producer's residual revenue share that follows from the multilateral bargaining process. The reason is simple: The higher is η^H, the lower is the overall importance of the manufacturing components for the production process. Both suppliers thus make lower marginal contributions to all relevant coalitions and thus have lower Shapley values as they threaten to take away fewer inputs. This lower bargaining power, in turn, implies a higher residual revenue share for the producer.

This outcome of the bargaining process is therefore qualitatively consistent with efficiency considerations from contract theory (Hart and Moore, 1990). All parties underinvest into the relationship due to the presence of the hold-up problem. The higher (lower) is η^H, the slacker (fiercer) are the suppliers' underinvestment problems for the overall relationship. Hence, to ensure ex ante efficiency, it becomes

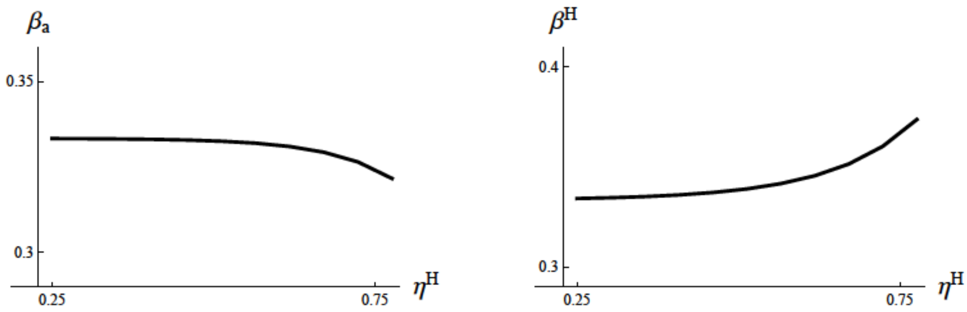


Figure 3.2: Variation of the headquarter-intensity η^H.
($\eta_a = \eta_b = 0.5$, $c_a^M = c_b^M = 1$, $c^H = 1$, $\epsilon = 0.06$, and $\alpha = 0.92$)

less (more) important to incentivize the suppliers, and hence they should receive a smaller (larger) share of the surplus.

Technological asymmetries across components η_i We now study technological asymmetries across the two components. In the left panel of figure 3.3, we depict the revenue shares of suppliers a and b (β_a and β_b) as a function of η_a for given values of η^H, $c_a^M = c - b^M = c^M$, c^H, ϵ, and α. In the right panel, we illustrate the corresponding residual share for the producer.

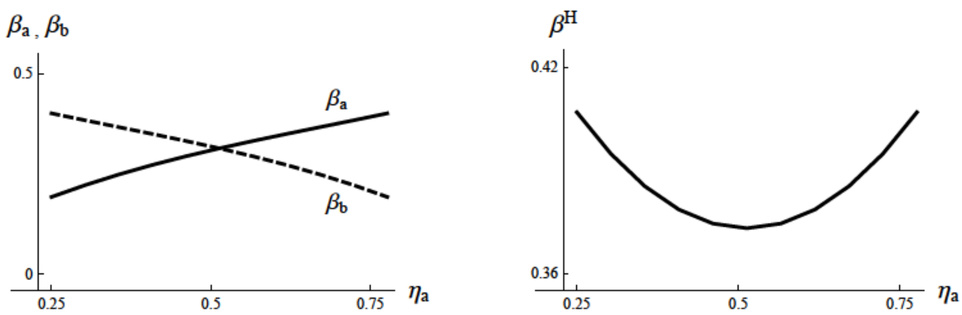


Figure 3.3: Technological asymmetries across components.
($\eta^H = 0.8$, $c_a^M = c_b^M = 1$, $c^H = 1$, $\epsilon = 0.06$, and $\alpha = 0.92$)

The left graph shows that the supplier who provides the technologically more important input realizes the higher revenue share in the bargaining stage. In particular, the share β_a is increasing in η_a, whereas β_b is decreasing in η_a as $\eta_b = 1-\eta_a$. Clearly, with $\eta_a > 1/2$ supplier a has a higher Shapley value than supplier b, because supplier a makes higher marginal contributions owing to the greater technological importance of his input. Put differently, supplier a has a higher bargaining power because he can threaten to take away the more important component.

Interestingly, the right panel of figure 3.3 shows that the producer's revenue share β^H is also affected by the degree of asymmetry of the two components, despite the fact that the headquarter-intensity η^H is kept fixed in that figure. In particular, β^H is the lowest when the two components are symmetric (with $\eta_a = \eta_b = 1/2$), while β^H is increasing in the degree of asymmetry across components, that is, when η_a becomes larger or smaller than 1/2.

The intuition for this result can be grasped from the curvatures in the left panel of the figure. Consider a constellation in which component a has a low input intensity η_a. Hence, it follows from the bargaining setup that β_a is low and β_b is high. Now suppose that η_a increases in this scenario. This change leads to a more than proportional increase of β_a, while the reduction of β_b is small relative to the decrease of $\eta_b = 1 - \eta_a$. Overall, the increase of β_a is stronger than the decline of β_b, so that β^H must decrease. In contrast, increasing η_a in a constellation where η_a is already high leads to a relatively small increase of β_a and to a relatively strong reduction of β_b. Hence, β^H must increase. In other words, the β_a schedule is first concave and then convex in η_a, which in turn drives the U-shaped curve in the right panel of figure 3.3.

Economically, this means that unimportant suppliers have a higher marginal gain in bargaining power when becoming technologically more important, whereas the marginal gain in bargaining power is lower for important suppliers who already receive a large revenue share. It also means that the producer realizes the lowest bargaining power when the two suppliers are equally strong. Once the two suppliers become asymmetric in terms of the technological importance of their inputs, this also materializes in a higher bargaining strength of the producer.

Suppliers' unit costs c_i^M Next, we consider the impact of asymmetries in the suppliers' unit costs. Figure 3.4 is analogous to figure 3.2 and depicts β_a (left panel) and β^H (right panel) as a function of the headquarter-intensity η^H. The solid lines in both panels refer to the benchmark case with symmetrical components (both in terms of input intensities and unit costs), whereas the dashed lines refer to the case in which input intensities are the same but unit costs c_a^M are lower than c_b^M.

As the left graph of figure 3.4 shows, the lower unit costs c_a^M raise supplier a's revenue share β_a. The intuition is that that lower unit costs lead to an increase in the input provision level of supplier a. Hence, supplier a's marginal contribution to all coalitions and his Shapley value go up.

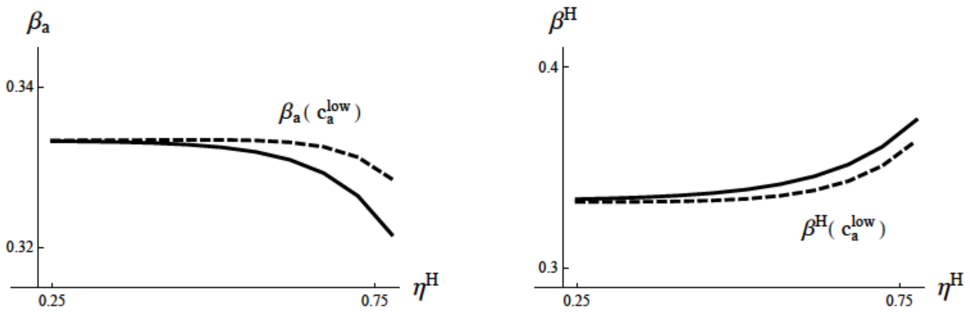


Figure 3.4: Asymmetries in the suppliers' unit costs.
Solid lines: $c_a^M = c_b^M = 1$; dashed lines: $c_a^M = 0.2$, $c_b^M = 1$.
($\eta_a = \eta_b = 0.5$, $c^H = 1$, $\epsilon = 0.06$, and $\alpha = 0.92$)

The producer therefore ends up with a lower revenue share β^H for any given level of η^H, as can be seen in the right panel of figure 3.4, where the dashed line always runs below the solid one. That is, a unit cost reduction of one supplier (with constant unit costs of the other supplier) actually leads to a lower realized revenue share for the producer, because supplier a experiences a strong gain in his bargaining power. The total realized revenue for the producer need not go down, however, even if the revenue *share* may decrease, because the lower unit costs of supplier a also lead to a higher input provision and thus to a higher total revenue *level*. Still, it is interesting to note that the headquarter revenue share tends to be highest with a strong *technological* asymmetry across components (see figure 3.3), while a strong cost asymmetry across suppliers may actually lead to a lower headquarter revenue share.

In figure 3.5 we take η^H as given and couple the cost asymmetry with a technological asymmetry across components. The solid lines refer to benchmark without cost differences (see figure 3.3), whereas the dashed lines depict the case where supplier a is the low-cost supplier.

The left panel also shows that lower unit costs c_a^M lead to a higher revenue share β_a. Furthermore, the figure shows that this increase (the distance between the solid and the dashed curve) is stronger, the lower is η_a. In other words, supplier a's marginal gain in bargaining power due to the lower unit cost is stronger if the input intensity of his component is low.[6] As a result of this, we see in the right panel of figure

[6] This is consistent with the argument of the concave/convex shape of the schedule in figure 3.3.

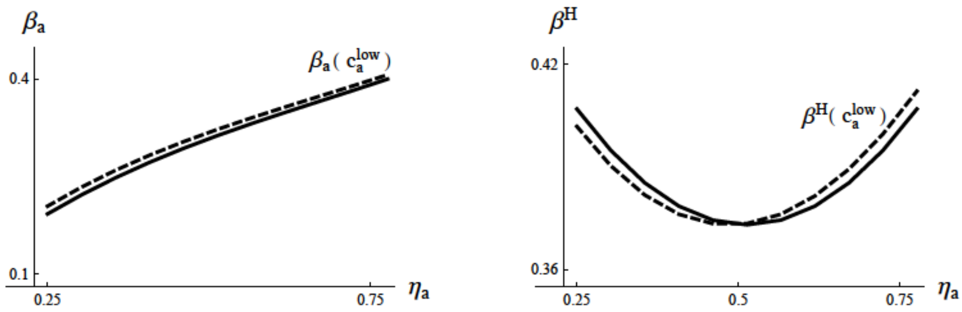


Figure 3.5: Asymmetries in the suppliers' unit costs and input intensities.
Solid lines: $c_a^M = c_b^M = 1$; dashed lines: $c_a^M = 0.2$, $c_b^M = 1$.
($\eta^H = 0.8$, $c^H = 1$, $\epsilon = 0.06$, and $\alpha = 0.92$)

3.5 that the headquarter revenue share goes down when η_a is low (because β_a rises substantially) whereas it goes up when η_a is high.

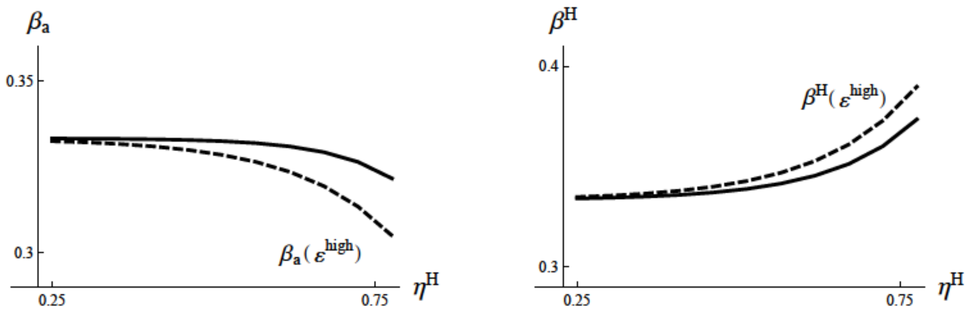


Figure 3.6: Component substitutability (I).
Solid lines: $\epsilon = 0.06$; dashed lines: $\epsilon = 0.09$.
($\eta_a = \eta_b = 0.5$, $c_a^M = c_b^M = 1$, $c^H = 1$, $\epsilon = 0.06$, and $\alpha = 0.92$)

Degree of component substitutability ϵ Finally, another parameter that influences the Shapley values and the revenue distribution is the degree of component substitutability ϵ. In figure 3.6, we again display the revenue shares as a function of η^H assuming symmetric components, but we now consider different values of ϵ. In particular, the solid lines refer to the previous parameter constellation with $\epsilon = 0.06$, whereas the dashed lines depict a case in which ϵ is higher ($\epsilon = 0.09$). A higher degree of substitutability leads to lower revenue shares for the suppliers and to a higher headquarter revenue share. The intuition is that the better substitutability lowers the bargaining powers of the suppliers, because the total revenue decreases by less when one supplier leaves the coalition of size 3, as his contribution can be replaced more easily with the input of the other supplier.

As shown in the right panel of figure 3.7, the U-shape of the β^H curve with respect to η_a prevails when assuming a higher value of ϵ, yet this curve is shifted upward, that is, the residual share β^H is increasing in ϵ. Furthermore, the left panel shows that a higher value of ϵ leads to a smaller revenue share β_a for low values of η_a but to a higher revenue share for high values of η_a. That is, for the unimportant component, higher substitutability clearly materializes in a lower bargaining power and the Shapley value goes down. Provided that one component is much more important than the other, however, better substitutability can even raise the bargaining power of the more important supplier. The reason is that the unimportant supplier experiences a substantial loss when ϵ goes up. This drop may, in turn, lead to a slight increase of both the producer's and the important supplier's revenue shares.

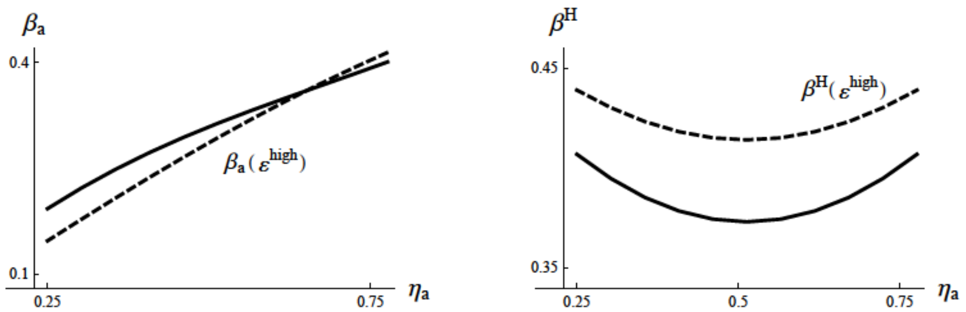


Figure 3.7: Component substitutability (II).
Solid lines: $\epsilon = 0.06$; dashed lines: $\epsilon = 0.09$.
($\eta^H = 0.8$, $c_a^M = c_b^M = 1$, $c^H = 1$, $\epsilon = 0.06$, and $\alpha = 0.92$)

3.3.3 Shapley value: A brief summary

We have introduced the Shapley value as the fundamental solution concept in the multilateral bargaining process in the ultimate stage of the game. Although our results rely on numerical simulations, we have derived some main insights that are worth summarizing:

1. With technological asymmetries across components, the supplier of the important component has a higher Shapley value and realizes a higher revenue share.
2. With cost asymmetries across components, the supplier of the low-cost component has a higher Shapley value and realizes a higher revenue share.
3. Higher headquarter-intensity tends to raise the producer's realized revenue share. This share tends to be higher when components are asymmetric in terms of their technological importance.
4. Better component substitutability lowers the realized revenue shares of the suppliers and raises the producer's revenue share, provided that the inputs are not too asymmetric.

So far, our analysis has rested on the assumption that both suppliers maintain ownership and property rights over their inputs and thus threaten to withhold their entire input levels in the bargaining process. We now alter this assumption and thereby move to the analysis of the organizational decision of the producer.

3.4 Outsourcing versus integration

In our game structure, the producer can decide whether to integrate supplier i within the boundaries of the firm or to keep the supplier as an external subcontractor. This ownership decision matters for the bargaining powers of the suppliers. Specifically, a vertically integrated supplier basically becomes an employee of the producer. The supplier therefore cannot threaten to take away the input during the bargaining, as the producer has the right to confiscate it. However, following the property rights approach to the firm (see Grossman and Hart, 1986; Hart and Moore, 1990; Antràs and Helpman, 2004), we assume that the producer still cannot fully make use of that input if the vertically integrated supplier refuses to collaborate. In particular, the headquarter can effectively only use the fraction $(1 - \delta_i)$ of the input, which in turn gives vertically integrated suppliers some bargaining power.

The parameter δ_i is thus a natural measure for the "sophistication" of the respective input. If δ_i is low, the producer can use most of the leftovers of the input, even if the affiliated supplier has dropped out of the coalition. This will be the case if the respective input is easy to handle for the producer and does not require specific knowledge to be usable. In contrast, if δ_i is high, the threat of an integrated supplier to drop out of the coalition is much more severe. This will be the case with highly sophisticated components that require special expertise.

An outsourced supplier can still threaten to take away the entire input level in the bargaining process owing to his ownership rights, regardless of the degree of sophistication of his input.

3.4.1 Implications for marginal contributions and Shapley values

This ownership decision affects the Shapley values, as it influences the suppliers' marginal contributions. Specifically, in coalitions of size 2, the total revenue does not fall to 0 if the supplier i is in the last position of a feasible permutation and leaves the coalition. The producer can rather keep the part $(1-\delta_i)$ of supplier i's input, and the remaining coalition of size one now earns $\hat{H}\left(\left(1-\delta_i\right)m_i\right)^{\alpha(1-\eta_H)}\eta_i^{\alpha(1-\epsilon)(1-\eta_H)/\epsilon}$. Therefore, the marginal contribution of a vertically integrated supplier to a coalition of size 2 is given by

$$MC_i^{2V} = \hat{H}\left(m_i^{\alpha(1-\eta_H)}\eta_i^{\frac{\alpha(1-\epsilon)(1-\eta_H)}{\epsilon}} - \left(\left(1-\delta_i\right)m_i\right)^{\alpha(1-\eta_H)}\eta_i^{\frac{\alpha(1-\epsilon)(1-\eta_H)}{\epsilon}}\right), \quad (3.18)$$

whereas the marginal contribution of an outsourced supplier and of the producer to such a coalition are given by equations (3.10) and (3.11), respectively, and correspond to the total revenue level.

Analogously, in a coalition of size 3, if the vertically integrated supplier i drops out, the remaining coalition of the producer and supplier j can still use the part $(1-\delta_i)$ of supplier i's input. His marginal contribution thus becomes

$$MC_i^3 = \hat{H}\left(\left(m_i^{\epsilon}\eta_i^{1-\epsilon} + m_j^{\epsilon}\eta_j^{1-\epsilon}\right)^{\alpha\left(1-\eta^H\right)/\epsilon} - \left(\left(\left(1-\delta_i\right)m_i\right)^{\epsilon}\eta_i^{1-\epsilon} + m_j^{\epsilon}\eta_j^{1-\epsilon}\right)^{\alpha\left(1-\eta^H\right)/\epsilon}\right) \quad (3.19)$$

with $i \neq j$. The marginal contributions of an outsourced supplier and of the producer to a coalition of size three are, respectively, given by equations (3.12) and (3.13). In the appendix to this chapter, we display the resulting system of equations to compute the Shapley values and the revenue shares for this generalized case where supplier can differ in terms of their organizational form.

3.4.2 Illustration: The organizational decision and the revenue distribution

We now illustrate the effects of the organizational decisions for the revenue distribution inside the firm. In figure 3.8, we depict the revenue share of supplier a as a function of the input intensity η_a for the four different organizational structures that the producer can choose in our model.[7] Several points are worth noting.

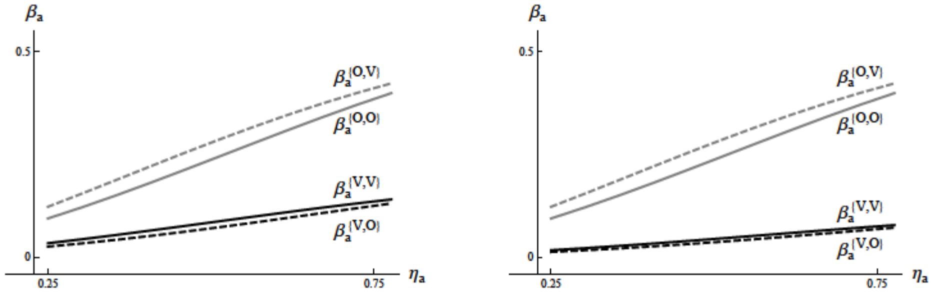


Figure 3.8: Outsourcing versus integration: the suppliers' revenue shares.
Left panel: $\delta_a = \delta_b = 0.9$; right panel: $\delta_a = 0.7$, $\delta_b = 0.9$.
($\eta^H = 0.8$, $c_a^M = c_b^M = 1$, $c^H = 1$, $\epsilon = 0.2$, and $\alpha = 0.92$)

First, for any given level of η, the revenue share of supplier a is higher if he is outsourced than if he is vertically integrated. More specifically, the $\beta_a^{\{O,O\}}$ curve runs above the $\beta_a^{\{V,O\}}$ curve, and the $\beta_a^{\{O,V\}}$ curve runs above the $\beta_a^{\{V,V\}}$ curve. The reason is that an outsourced supplier can threaten to withhold his entire input. Thus, an outsourced supplier makes higher marginal contributions to all feasible permutations (conditional on η_a) and thus has a higher Shapley value than an integrated supplier.

Second, notice that the revenue share of supplier a depends not only on his own organizational form but also on the organization of the other supplier. In particular, in both organizational forms supplier a receives a higher revenue share when supplier b is integrated than if supplier b is outsourced; that is, $\beta_a^{\{O,V\}} > \beta_a^{\{O,O\}}$ and $\beta_a^{\{V,V\}} > \beta_a^{\{V,O\}}$ for any given level of η_a. The intuition is that the producer can always rely on the fact that she would retain a part of input b when supplier b is vertically integrated. Because the two components are substitutes, the bargaining power of supplier a therefore decreases compared to the constellation where supplier b threatens to take away his entire input level.

Third, as in figure 3.3, supplier a's revenue share is increasing in the technological importance of his input regardless of the firm's organizational structure; that is, both outsourced and vertically integrated suppliers have a higher bargaining power if their respective input is technologically more important. Furthermore, the revenue shares $\beta_a^{\{O,V\}}$ and $\beta_a^{\{O,O\}}$ for outsourcing rise steeper in η_a than the curves $\beta_a^{\{V,V\}}$ and $\beta_a^{\{V,O\}}$. The reason is that the "threat potential" under vertical integration is a

[7] We assume fixed values for the headquarter-intensity η^H and the substitutability ϵ in this section, and we assume that the two suppliers have identical unit costs. Changes in those parameters would have qualitatively similar effects as illustrated in section 3.3.

constant fraction of that under outsourcing. With rising technological importance, the marginal gain in bargaining power is thus stronger if the respective supplier a is outsourced.

Fourth, we can also conduct comparative statics with respect to the parameter δ_i. The right panel of figure 3.8 is analogous to the left part but assumes a lower value of δ_a while δ_b stays constant. In other words, we assume that input b is now "more sophisticated" because the producer can use a lower fraction $(1 - \delta_b)$ only if the respective supplier b is vertically integrated and then refuses to collaborate. As can be seen in figure 3.8, the curves $\beta_a^{\{O,O\}}$ and $\beta_a^{\{O,V\}}$ remain unchanged when δ_a is reduced, and the curves $\beta_a^{\{V,O\}}$ and $\beta_a^{\{V,V\}}$ are shifted downward and the distance between those curves becomes smaller. If supplier a is outsourced, the change in the "sophistication" of his input does not matter for his bargaining power because he maintains all ownership rights and threatens to withhold the entire input in the bargaining process. If he is vertically integrated, however, his bargaining power is now lower when his input becomes less sophisticated, because the producer is able to effectively use a higher fraction if supplier a refuses to collaborate. This difference in bargaining powers for supplier a also depends on the organizational structure of supplier b, as argued earlier.

Finally, figure 3.9 depicts the residual revenue shares for the producer assuming the same parameter constellations as in figure 3.8. Notice that the headquarter revenue share is the highest when both suppliers are integrated ($\beta^H_{\{V,V\}}$) and the lowest when both are outsourced ($\beta^H_{\{O,O\}}$). The intermediate cases with one integrated and one outsourced supplier range in between. The intuition is clear: Because integrated suppliers have lower bargaining powers, the producer can retain a higher revenue share in the multilateral bargaining. A lower value of δ_a as in the right panel of figure 3.9 leaves the $\beta^H_{\{O,O\}}$ unaffected but shifts up the other β^H-curves. The reason is the following: If supplier a is an integrated affiliate, his bargaining power declines when his input becomes easier to handle. The producer can thus retain an even larger revenue share for herself.

Figure 3.9 also shows that the shape of the β^H-curve with respect to η_a now depends on the organizational structure of the firm. If both suppliers are outsourced, we are back to the U-shaped curve that we have already seen in figure 3.3. Yet when supplier a is integrated and b is outsourced, the headquarter's revenue share is increasing in η_a, while it is decreasing in η_a when supplier a is outsourced and b is integrated. Economically, for these intermediate cases we can conclude that the producer's revenue share increases with a rising technological importance of the integrated supplier. If supplier a is integrated and provides a technologically more important input, his bargaining power increases, but by less than if he were an external subcontractor. The bargaining power of the outsourced supplier b goes down as η_a increases, and in sum β^H can go up because the increase of β_a was

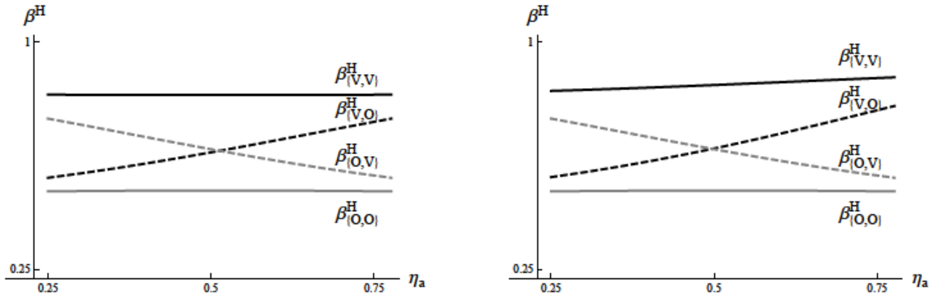


Figure 3.9: Outsourcing versus integration: the producer's revenue share.
Left panel: $\delta_a = \delta_b = 0.9$; right panel: $\delta_a = 0.7$, $\delta_b = 0.9$.
($\eta^H = 0.8$, $c_a^M = c_b^M = 1$, $c^H = 1$, $\epsilon = 0.2$, and $\alpha = 0.92$)

sufficiently small. On the other hand, if supplier a is outsourced and his input becomes more important, the rise in this bargaining power outweighs the declining bargaining power of the integrated supplier b, so that β^H goes down.

3.5 The producer's organizational decision

Thus far, we have analyzed how variations in the technology parameters and in the firm's organizational form affect the players' Shapley values and their realized revenue shares. We can now move to the producer's final organizational decision in the first stage of the game. When making this decision, the producer of course anticipates the implications for the bargaining process and the resulting revenue distribution in the ultimate stage of the game. She effectively chooses the tuple $\{O, O\}$, $\{O, V\}$, $\{V, O\}$ or $\{V, V\}$ that maximizes the overall payoff of the relationship, as given in equation (3.9), taking into account the firm's technology parameters.

In this section, we illustrate this payoff-maximizing organizational choice and focus on the firm's organizational structure for different types and degrees of asymmetries across the two manufacturing components. In particular, we focus on the following three asymmetries:

1. Differences in the input intensities η_a and η_b
2. Differences in the unit costs c_a^M and c_b^M
3. Differences in the components' sophistication (the threat points) δ_a and δ_b

3.5.1 Differences in the input intensities

Suppose the two components differ in their technological importance for the production process but are symmetric in terms of unit costs and threat points. The left panel of figure 3.10 illustrates the producer's final organizational decision for this case. On the horizontal axis, we display the headquarter-intensity η^H, and on the vertical axis the degree of the technological asymmetry (with $\eta_a = 1/2$ being the benchmark with symmetric components). The different colors specify which organizational form is profit maximizing.

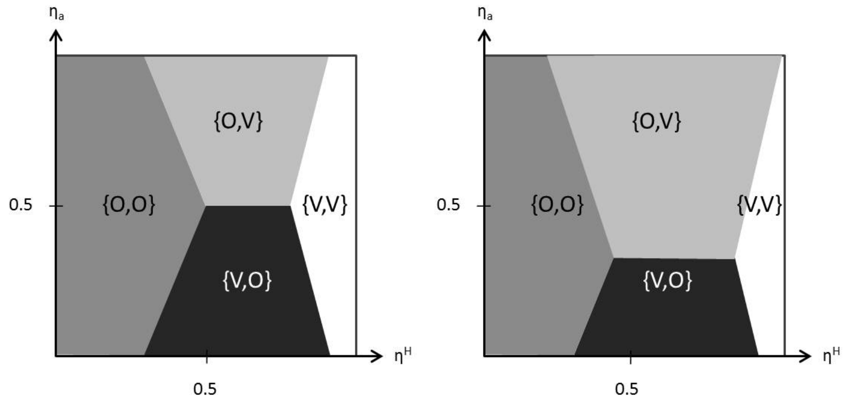


Figure 3.10: The organizational decision.
Left panel: $c_a^M = c_b^M$ and $\delta_a = \delta_b$; right panel: $c_a^M < c_b^M$ and/or $\delta_a < \delta_b$.

For sufficiently high headquarter-intensity, the producer chooses to vertically integrate *both* suppliers. What is the intuition for this result? When η^H is high, the components have low overall importance for the production process. The Shapley values of both suppliers would thus be quite low even as external subcontractors. By vertically integrating the suppliers, the producer further lowers their bargaining power and hence their incentives to contribute to the relationship. This exacerbation of the underinvestment problem for the suppliers is of lesser importance for the total surplus, however. It is more important to leave a large revenue share to the producer in order to minimize its underinvestment problem. Analogously, when η^H is sufficiently low, the producer chooses to outsource *both* suppliers. By leaving the ownership rights to the suppliers, their underinvestment problems are lowered because this decision endogenously leads to a higher Shapley value for them. In other words, the producer incentivizes the suppliers by effectively giving them more bargaining power.

The most interesting constellations occur for intermediate values of the headquarter-intensity η^H. Here we find that the producer chooses to outsource one supplier while vertically integrating the other. Such a coexistence of two organizational forms within the same firm (hybrid sourcing) is an empirically highly relevant phenomenon (Tomiura, 2007; Kohler and Smolka, 2012). Quite naturally, such a firm structure cannot occur in the baseline model by Antràs and Helpman (2004) with just one single supplier/component, but it can occur in our framework with multiple (that is at least two) suppliers.

When does hybrid sourcing occur, and which organizational mode is chosen for which component? The left panel of figure 3.10 suggests that a technological asymmetry across the two components makes the occurrence of hybrid sourcing overall more likely and that the producer tends to outsource the supplier with the technologically more important component. This effect can be seen by noting that the parameter range of η^H where hybrid sourcing is chosen expands the further away η_a is from the benchmark value of 1/2. Furthermore, whenever input a is the more important one ($\eta_a > 1/2$), only the organizational form $\{O, V\}$ prevails - and never the form $\{V, O\}$. For $\eta_a < 1/2$ we observe the opposite: only the form $\{V, O\}$ but never the form $\{O, V\}$.

Intuitively, at intermediate values of η^H, both the headquarter services and the component inputs matter substantially for the production process. The uniform organizational structures $\{O, O\}$ and $\{V, V\}$ are thus not payoff maximizing, as they exacerbate the underinvestment problem for the producer or, respectively, for the suppliers to an undue extent. Hybrid sourcing leads to a better balance of these underinvestment problems, and it is then relatively more important to properly incentivize the supplier of the more important component by leaving him the property rights over his assets.

3.5.2 Differences in unit costs

Now assume that the suppliers differ not only in their input intensities but also in their unit costs. In particular, we assume that supplier a is the low-cost supplier such that $c_a^M < c_b^M$. As we have shown earlier, this increases the Shapley value of supplier a by raising his input provision level and thus his marginal contributions.

The qualitative consequences for the organizational decision are illustrated in the right panel of figure 3.10. Similar as before, the producer still chooses to outsource (integrate) both suppliers for sufficiently high (low) values of η^H. If headquarter services (components) are highly important for the production process, it is crucial to give enough bargaining power to the producer (the suppliers) in order to minimize their underinvestment problems.

The most interesting implication is visible in the intermediate range of η^H, where the producer chooses hybrid sourcing. As can be seen, the organizational form $\{O, V\}$ is now much more prevalent in the right panel (where a has lower unit costs than b) than in the left panel of figure 3.10 where unit costs are symmetric across suppliers. That is, if the producer chooses to outsource only one supplier, it is likely to be the one with the lower unit costs. The reason is that this low-cost supplier chooses a higher input provision level and thus becomes more valuable for the firm. It is therefore important to properly incentivize this supplier by granting him the ownership rights over his assets.

Notice, however, that there are also constellations where the other hybrid sourcing mode $\{V, O\}$ is chosen, namely if η_a is sufficiently low. In that case, supplier b's technological importance is so large that it becomes even more important to incentivize that supplier, despite the fact that he has higher unit costs.

3.5.3 Differences in the components' sophistication

Finally, we analyze the scenario in which components differ in their input intensities and their "sophistication" while again assuming that unit costs are symmetric. In particular, suppose that $\delta_a < \delta_b$ holds; that is, we may think of input b as being the more sophisticated component that requires more specific knowledge to be usable.

The implications are also illustrated in the right panel of figure 3.10, as they are qualitatively similar to the case with unit cost differences. Given that η^H is in the intermediate range so that hybrid sourcing is chosen, our main finding is that the producer would more easily outsource the *less* sophisticated input a. The more sophisticated input b is, in contrast, kept within the firm boundaries for a wider parameter range as long as η_a is not too low.

The low value of δ_a implies that supplier a would have a substantially lower Shapley value as an integrated subsidiary than as an external subcontractor. In other words, supplier a can hardly be incentivized within the firm boundaries because his input is so easy to handle that he hardly has any bargaining power vis-à-vis the producer. For supplier b, the difference in organizational forms matters less for his incentives. He has high bargaining power even as an affiliate of the firm, owning to the sophistication of his component.

This is the reason why the producer would rather outsource the simpler component a, because the ownership rights are then an effective device to incentivize its supplier. This pattern changes only if component b is not only more sophisticated but also has a sufficiently higher input intensity. In that case, the standard incentive effect discussed in section 3.5.1 dominates, and we would observe the ownership structure $\{V, O\}$. If the input intensities are not too different, or if η_a even exceeds η_b, we have $\{O, V\}$ in the hybrid sourcing range.

3.6 Summary and discussion

In this chapter, we have provided an extension of the seminal model by Antràs and Helpman (2004). They considered an incomplete contracts model in which a producer interacts with one single supplier and then decides on that supplier's organizational form ("make or buy"). In our extension, there are two asymmetric manufacturing components and hence three parties who bargain over the surplus of the relationship: the producer and the two respective suppliers. Our approach relies on the Shapley value, which is the standard solution concept for such multilateral bargaining situations.

Some of our main results are consistent with Antràs and Helpman (2004). For example, we also find that if the headquarter-intensity of final goods production is very low, the firm will exclusively rely on outsourcing and that complete vertical integration is likely to prevail in highly headquarter-intensive firms. However, one key difference compared to Antràs and Helpman (2004) is that our model can quite naturally generate hybrid sourcing as the outcome of the producer's organizational choice. That is, our model may explain why firms choose different sourcing modes for different suppliers. Such a coexistence of organizational forms within the same firm is an empirically highly relevant phenomenon (Tomiura, 2007; Kohler and Smolka, 2012) and necessarily requires a model with multiple (that is, at least two) components.

Moreover, our model is well suited to analyze which sourcing mode is chosen for which supplier. We find that the producer tends to outsource the technologically more important components with a higher input intensity and components that are provided by suppliers with lower unit costs. Yet the producer tends to keep "sophisticated" inputs that require special expertise to be usable within the boundaries of the firm, while the producer chooses to outsource simpler and more standard components. These findings are consistent with the results by Schwarz and Suedekum (2014). In this chapter, we have explicitly highlighted the underlying theoretical foundations by discussing at length how these asymmetries across components affect the suppliers' bargaining powers (Shapley values) and their realized revenue shares in the negotiation with the producer.

Our results may provide a rationale for some recent empirical findings from the literature on multinational enterprises. In particular, Alfaro and Charlton (2009) and Corcos, Irac, Mion and Verdier (2013) report that MNEs tend to keep high-skill inputs, or components with a higher degree of asset specificity, within their boundaries. Although it is difficult to precisely formalize those notions of the "skill intensity" and the "asset specificity" of inputs, we believe that our theoretical results are consistent with those empirical findings. On one hand, our model predicts that outsourcing is more likely to occur for components with a higher input intensity, as this incentivizes the respective supplier. Yet inputs may also differ in terms of their inherent sophistication, which is not directly captured by their input intensities. Here, our theoretical results are in line with the empirical findings of Alfaro and Charlton (2009) and Corcos, Irac, Mion and Verdier (2013), as our model predicts that producers tend to keep more sophisticated manufacturing components in-house.

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3.8 Appendix

A.I Input provision levels

The headquarter and the suppliers choose the level of input provision that maximizes their profits $\beta^H R - c^H h$ or $\beta_i R - c_i m$, respectively. The first-order-condition for the headquarter is:

$$\pi_h^{H'} = \beta^H R_h^{'} - c^H = \beta^H \frac{\alpha\eta^H}{h} R - c^H = 0 \quad \Leftrightarrow \quad h = \frac{\alpha\beta^H\eta^H}{c^H} R \tag{A3.1}$$

Furthermore, the second-order-condition is satisfied:

$$\pi_{hh}^{H\,''} = -\frac{\alpha\eta^H R \left(1 - \alpha\eta^H\right)\beta^H}{h^2} < 0. \tag{A3.2}$$

Analogously, for supplier i the first-order-condition is

$$\pi_{i m_i}^{'} = \beta_i R_{m_i}^{'} - c_i^M = \beta_i \frac{\frac{m_i}{\eta_i}^{-(1-\epsilon)} \alpha \left(1 - \eta^H\right) R}{\eta_a \frac{m_a}{\eta_a}^{\epsilon} + \eta_b \frac{m_b}{\eta_b}^{\epsilon}} - c_i^M = 0. \tag{A3.3}$$

The second-order-condition is again satisfied:

$$\pi_{i m_i m_i}^{''} = -\frac{\alpha\beta_i \left(1 - \eta^H\right) R \frac{m_i}{\eta_i}^{\epsilon} \eta_i \left(\frac{m_j}{\eta_j}^{\epsilon} \eta_j \left(1 - \epsilon\right) + \frac{m_i}{\eta_i}^{\epsilon} \eta_i \left(1 - \alpha\left(1 - \eta^H\right)\right)\right)}{m_i^2 (\left(\eta_a \frac{m_a}{\eta_a}^{\epsilon} + \eta_b \frac{m_b}{\eta_b}^{\epsilon}\right)^2} < 0. \tag{A3.4}$$

This shows that the input provision levels given in equation (3.5) are maximizing the individual payoffs of the producer and, respectively, the suppliers in the fourth stage of the game.

A.II Shapley values with full ownership rights of suppliers

Using equation (3.17), the system of equations to determine the Shapley values and the revenue shares of suppliers a and b is given by

$$\beta_a = \frac{1}{6}\left(\alpha\left(1-\eta^H\right)\left(\frac{\alpha\left(1-\eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)}\beta_a^{\epsilon/(1-\epsilon)}\eta_a + c_b^{M-\epsilon/(1-\epsilon)}\beta_b^{\epsilon/(1-\epsilon)}\eta_b}\right)\right)^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}} \tag{A3.5}$$

$$\left(2\left(\alpha\left(1-\eta^H\right)\left(\frac{\alpha\left(1-\eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)}\beta_a^{\epsilon/(1-\epsilon)}\eta_a + c_b^{M-\epsilon/(1-\epsilon)}\beta_b^{\epsilon/(1-\epsilon)}\eta_b}\right)\right)^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\right.$$

$$- 2c_b^{M-\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\beta_b^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\eta_b^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\left(\frac{\alpha\left(1-\eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)}\beta_a^{\epsilon/(1-\epsilon)}\eta_a + c_b^{M-\epsilon/(1-\epsilon)}\beta_b^{\epsilon/(1-\epsilon)}\eta_b}\right)^{\alpha\left(1-\eta^H\right)}$$

$$\left. + c_a^{M-\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\beta_a^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\eta_a^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\left(\frac{\alpha\left(1-\eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)}\beta_a^{\epsilon/(1-\epsilon)}\eta_a + c_b^{M-\epsilon/(1-\epsilon)}\beta_b^{\epsilon/(1-\epsilon)}\eta_b}\right)^{\alpha\left(1-\eta^H\right)}\right)$$

and

$$
\begin{aligned}
\beta_b = \frac{1}{6} & \left(\alpha\left(1-\eta^H\right)\left(\frac{\alpha\left(1-\eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)}\beta_a^{\epsilon/(1-\epsilon)}\eta_a + c_b^{M-\epsilon/(1-\epsilon)}\beta_b^{\epsilon/(1-\epsilon)}\eta_b}\right)\right)^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}} \\
& \Bigg(2\left(\alpha\left(1-\eta^H\right)\left(\frac{\alpha\left(1-\eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)}\beta_a^{\epsilon/(1-\epsilon)}\eta_a + c_b^{M-\epsilon/(1-\epsilon)}\beta_b^{\epsilon/(1-\epsilon)}\eta_b}\right)\right)^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}} \\
& - 2c_a^{M-\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\beta_a^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\eta_a^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\left(\frac{\alpha\left(1-\eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)}\beta_a^{\epsilon/(1-\epsilon)}\eta_a + c_b^{M-\epsilon/(1-\epsilon)}\beta_b^{\epsilon/(1-\epsilon)}\eta_b}\right)^{\alpha\left(1-\eta^H\right)} \\
& + c_b^{M-\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\beta_b^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\eta_b^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\left(\frac{\alpha\left(1-\eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)}\beta_a^{\epsilon/(1-\epsilon)}\eta_a + c_b^{M-\epsilon/(1-\epsilon)}\beta_b^{\epsilon/(1-\epsilon)}\eta_b}\right)^{\alpha\left(1-\eta^H\right)}\Bigg).
\end{aligned}
\tag{A3.6}
$$

We solve this system numerically for β_a and β_b by assuming specific values of the parameters.

A.III Shapley values for different organizational structures

For different organizational structures, given by differences in the parameter δ, the system of equations to determine the Shapley values and the revenue shares of suppliers a and b is given by

$$
\begin{aligned}
\beta_a = \frac{1}{6} & \left(\alpha\left(1-\eta^H\right)\left(\frac{\alpha\left(1-\eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)}\beta_a^{\epsilon/(1-\epsilon)}\eta_a + c_b^{M-\epsilon/(1-\epsilon)}\beta_b^{\epsilon/(1-\epsilon)}\eta_b}\right)\right)^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}} \\
& \Bigg(2\left(\alpha\left(1-\eta^H\right)\left(\frac{\alpha\left(1-\eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)}\beta_a^{\epsilon/(1-\epsilon)}\eta_a + c_b^{M-\epsilon/(1-\epsilon)}\beta_b^{\epsilon/(1-\epsilon)}\eta_b}\right)\right)^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}} \\
& - 2\Bigg(c_b^{M-\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\beta_b^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\eta_b^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\left(\frac{\alpha\left(1-\eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)}\beta_a^{\epsilon/(1-\epsilon)}\eta_a + c_b^{M-\epsilon/(1-\epsilon)}\beta_b^{\epsilon/(1-\epsilon)}\eta_b}\right)^{\epsilon} \\
& + c_a^{M-\frac{\epsilon)}{1-\epsilon}}\beta_a^{\frac{\epsilon}{1-\epsilon}}\eta_a\left(\frac{\alpha\left(1-\delta_a\right)\left(1-\eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)}\beta_a^{\epsilon/(1-\epsilon)}\eta_a + c_b^{M-\epsilon/(1-\epsilon)}\beta_b^{\epsilon/(1-\epsilon)}\eta_b}\right)^{\epsilon}\Bigg)^{\alpha\left(1-\eta^H\right)} \\
& + c_a^{M-\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\beta_a^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\eta_a^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\Bigg(\left(\frac{\alpha\left(1-\eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)}\beta_a^{\epsilon/(1-\epsilon)}\eta_a + c_b^{M-\epsilon/(1-\epsilon)}\beta_b^{\epsilon/(1-\epsilon)}\eta_b}\right)^{\alpha\left(1-\eta^H\right)} \\
& - \left(\frac{\alpha\left(1-\delta_a\right)\left(1-\eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)}\beta_a^{\epsilon/(1-\epsilon)}\eta_a + c_b^{M-\epsilon/(1-\epsilon)}\beta_b^{\epsilon/(1-\epsilon)}\eta_b}\right)^{\alpha\left(1-\eta^H\right)}\Bigg)\Bigg)
\end{aligned}
\tag{A3.7}
$$

and

$$
\begin{aligned}
\beta_b = \frac{1}{6} & \left(\alpha\left(1-\eta^H\right)\left(\frac{\alpha\left(1-\eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)}\beta_a^{\epsilon/(1-\epsilon)}\eta_a + c_b^{M-\epsilon/(1-\epsilon)}\beta_b^{\epsilon/(1-\epsilon)}\eta_b}\right)\right)^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}} \\
& \left(2\left(\alpha\left(1-\eta^H\right)\left(\frac{\alpha\left(1-\eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)}\beta_a^{\epsilon/(1-\epsilon)}\eta_a + c_b^{M-\epsilon/(1-\epsilon)}\beta_b^{\epsilon/(1-\epsilon)}\eta_b}\right)\right)^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}}\right)
\end{aligned}
\tag{A3.8}
$$

$$
\begin{aligned}
&- 2 \left(c_a^{M - \frac{\epsilon}{1-\epsilon}} \beta_a{}^{\frac{\epsilon}{1-\epsilon}} \eta_a \left(\frac{\alpha \left(1 - \eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)} \beta_a^{\epsilon/(1-\epsilon)} \eta_a + c_b^{M-\epsilon/(1-\epsilon)} \beta_b^{\epsilon/(1-\epsilon)} \eta_b} \right)^{\epsilon} \right. \\
&\left. + c_b^{M - \frac{\epsilon}{1-\epsilon}} \beta_b{}^{\frac{\epsilon}{1-\epsilon}} \eta_b \left(\frac{\alpha \left(1 - \delta_b\right) \left(1 - \eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)} \beta_a^{\epsilon/(1-\epsilon)} \eta_a + c_b^{M-\epsilon/(1-\epsilon)} \beta_b^{\epsilon/(1-\epsilon)} \eta_b} \right)^{\epsilon} \right)^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}} \\
&+ c_b^{M - \frac{\alpha\left(1-\eta^H\right)}{\epsilon}} \beta_b{}^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}} \eta_b{}^{\frac{\alpha\left(1-\eta^H\right)}{\epsilon}} \left(\left(\frac{\alpha \left(1 - \eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)} \beta_a^{\epsilon/(1-\epsilon)} \eta_a + c_b^{M-\epsilon/(1-\epsilon)} \beta_b^{\epsilon/(1-\epsilon)} \eta_b} \right)^{\alpha\left(1-\eta^H\right)} \right. \\
&\left. \left(\frac{\alpha \left(1 - \delta : b\right) \left(1 - \eta^H\right)}{c_a^{M-\epsilon/(1-\epsilon)} \beta_a^{\epsilon/(1-\epsilon)} \eta_a + c_b^{M-\epsilon/(1-\epsilon)} \beta_b^{\epsilon/(1-\epsilon)} \eta_b} \right)^{\alpha\left(1-\eta^H\right)} \right) \Bigg)
\end{aligned}
$$

Similar to appendix A.II, we solve this system numerically for β_a and β_b by assuming specific values of the parameters.

Chapter 4

The extra costs of outsourcing

Co-authored with Christian Schwarz

4.1 Introduction

Firms can choose different sourcing strategies for the intermediate inputs of their final products. Manufacturing components can either be produced in-house by subsidiaries that are vertically integrated within the firm boundaries, or they may be subcontracted to external suppliers over which the firm has no direct control or ownership rights. One highly influential theory to understand firms' sourcing decisions is the property rights approach to the firm. This approach has received considerable empirical support in the recent literature. In particular, studies by Nunn and Trefler (2008), Bernard, Jensen, Redding and Schott (2010), Federico (2010), Defever and Toubal (2011) or Corcos, Irac, Mion and Verdier (2013), among others, find that many predictions of the baseline property rights model by Antràs and Helpman (2004) are consistent with firm-level evidence from various countries.

Within that theory, which relies crucially on incomplete contracts, a transfer of ownership rights raises a supplier's bargaining power and incentivizes him to invest into the relationship. That is, within the scope of this theory the *benefits* of outsourcing are emphasized. This is somewhat different in the other major theories to explain the organizational decisions of firms, such as the transaction cost, the managerial incentives or the knowledge capital approach. There is argued that outsourcing also induces *extra costs* - one might for example think of costs due to more ex post re-negotiations over quality issues, more difficult communication or a higher probability for adaptions of specifically tailored inputs. Consider the example of *Boeing* that sourced several inputs for its Dreamliner from outsourced suppliers. As some of these inputs did not fulfill the required properties, they had to be adapted and it came to costly time delays. Another example is the toy manufacturer *Lego* that produced its bricks for more than 40 years within the boundaries of the firm. During this time, the knowledge was not documented but given directly from worker to worker. Hence, when *Lego* decided to outsource a part of its production to *Flextronics* they underestimated the time and effort necessary to transfer the production knowledge to this outsourced supplier.[1]

To take into account these potential costs of outsourcing inspired by conceptual and empirical insights from the other major theories, we introduce unit cost differences into a property rights model of a firm and assume these extra unit costs of outsourcing to be borne by the suppliers. More specifically, we use an extension of the baseline property rights model by Antràs and Helpman (2004) that has the limitation that it assumes a single component supplier whose organizational form

[1] For more details on the examples see http://executive.mit.edu/blog/will-risk-result-in-reward-for-boeings-dreamliner and https://hbr.org/product/lego-group-an-outsourcing-journey/an/910M94-PDF-ENG.

is determined by the firm. As we are especially interested in how the extra costs of outsourcing affect the organizational choice with regard to components that differ with regard to their technological importance for the production, we use the model of Nowak, Schwarz and Suedekum (2016). In their model, they assume two imperfectly substitutable manufacturing components (each provided by a separate supplier) which can be asymmetric along various dimensions.

The producer's final organizational decision is driven by two countervailing effects in our model, which interact in shaping the overall value of the firm as well as the involved parties' investment incentives and bargaining powers. The "direct" effect captures the key mechanism of the property rights approach, the incentivizing impact of ownership rights. In addition, there is an "indirect" effect operating via the organization-specific unit costs. At first, we show that our model predicts in line with the property rights approach that higher headquarter-intensity lowers the firm's propensity to outsource and show the empirically highly relevant pattern of "hybrid sourcing" with one integrated and one outsourced component. Once the "indirect" effect is introduced, we show that extra costs of outsourcing make integration especially for the input with the lower technological importance for the production more likely.

The rest of this paper is organized as follows. In section 4.2, we give a brief review over the mechanisms that may explain the higher costs under outsourcing. In section 4.3, we introduce the struture of the model, and section 4.4 analyzes the firms organizational decision and especially the effect of extra costs of outsourcing on this decision. Section 4.5 concludes.

4.2 Extra costs of outsourcing - a review of the literature

Apart from the property rights approach, there are at least three other major theoretical approaches that can be applied to the analysis of firms' organizational structures, and more specifically, to the question why firms choose particular sourcing modes for particular inputs:

- the transaction cost approach, which dates back to the seminal works by Coase (1937), Williamson (1975, 1985) and Dunning (1977),
- the managerial incentives approach with seminal contributions by Holmström and Milgrom (1991) and Aghion and Tirole (1997) and
- the knowledge capital approach due to Ethier (1986) and Ethier and Markusen (1996).

The property rights model emphasizes the benefits of outsourcing, namely the incentivizing effect of ownership rights. Yet, within those other major theoretical approaches it has been repeatedly argued that outsourcing - or more generally, an external organization of supplier relationships - also induces costs. In this section we briefly review some of those arguments.

1. Ex post negotiation and haggling

Following Coase's (1937) seminal theory, Williamson (1975, 1985) distinguishes between ex ante and ex post transaction costs. From an ex ante perspective it is often claimed that outsourcing implies lower unit costs, e.g. because external suppliers can better specialize. However, there can be substantial ex post costs of outsourcing due to re-negotiation and haggling. According to Costinot, Oldenski and Rauch (2011), problems may arise during the production of complex intermediates. Given that not all eventualities can be specified ex ante, this then necessitates costly adaption of the inputs ex post. For integrated suppliers these adaption costs are substantially lower, because haggling can be reduced or avoided. Ex post transaction costs in the context of the "make or buy" decision are further discussed by Bajari and Tadelis (2001), Tadelis (2002) or Novak and Wernerfelt (2012).

2. Communication

Cost advantages of an internal supplier organization may also arise because communication channels within the firm are easier and more direct. According to Crémer, Garicano and Prat (2007), agents within a firm often use technical languages or specific "codes" to communicate with each other. For a standard contract that compromises all information, shared technical languages and codes are irrelevant. However, if difficulties arise during the production of a more complex input, such common language codes reduce the costs of problem solving. Empirical evidence in support of this channel is provided by Li (2009). He analyzes foreign sourcing decisions of MNEs in China, and finds that reductions in offshoring costs are associated with substantial increases of intra-firm trade in the most communication-intensive industries.

3. Knowledge

Higher outsourcing costs may also arise as an internal organization facilitates the concentration of firm-specific knowledge. An early contribution emphasizing those aspects is Rugman (1986). In particular, Markusen (1995) and Ethier and Markusen (1996) argue that firms may fear a leakage of their "trade secrets" to external subcontractors, and would thus have to engage in costly measures to protect their firm-specific knowledge. Firms are thus reluctant to offshore their most important inputs, because the knowledge protection costs are then most severe. Recent work by Naghavi, Spies and Toubal (2011) finds support for this argument. They consider imitation risks associated with outsourcing, and find that French MNEs tend to keep highly knowledge-intensive inputs within their firm boundaries.

4. Control and monitoring costs

Costs for monitoring and control are typically lower for internal suppliers, since monitoring can be achieved more "economically" within the firm (Alchian and Demsetz, 1972). Several contributions emphasize that those higher control and monitoring costs have to be weighed against the benefits of outsourcing. According to Aghion and Tirole (1997), an outsourced agent may have more incentives to provide effort and to acquire relevant information. However, since the principal and the agent can have divergent interests, outsourcing also implies a costly loss of control. This trade-off is further studied in principal-agent models by Bental, Deffains and Demougin (2012), Bae et al. (2010), Grossman and Helpman (2004) and Agrawal (2002). A similar approach focusing on the delegation of authority in corporate organizations is due to Marin and Verdier (2008, 2012).

5. Quality

Drawing on the control and monitoring channel just described, Lu, Ng and Tao (2012) particularly identify lower quality as a potential cost of outsourcing. In their model, a component supplier's effort stochastically determines the quality of the manufacturing input and, thereby, the quality of the final product. The quality of the components is observable to the firm and to the supplier, but not verifiable by a court. When the supplier fails to deliver high-quality components, the court may make a mistake and fail to rule against the supplier. The authors show that product quality is lower under outsourcing compared to that under vertical integration in their model, particularly when contract enforcement becomes less effective. They test their model's predictions for a sample of firms producing in China, and find that a higher outsourcing share is associated with lower quality of the final product.

6. Financial constraints

Finally, financial constraints may also explain higher costs of outsourcing. Carluccio and Fally (2012) consider a setting with incomplete capital markets where suppliers are credit constrained. Since integrated suppliers are part of a multinational firm network, they are less affected than independent outsourced suppliers by those constraints to finance their initial input investments (also see Keuschnigg and Devereux, 2009). A higher technological complexity of an intermediate often requires more financial participation of the supplier, so that extra costs of outsourcing may be particularly relevant for those sophisticated inputs.

Summing up, all of these arguments may explain why an internal organization of suppliers via vertical integration may lead to unit cost advantages, as economies of scope can be exploited. Our theoretical framework introduces the notion of cost differences into a property rights approach of the firm. We formalize the extra costs of outsourcing in the sense that a supplier's unit costs are higher as external subcontractor than as integrated affiliate, e.g. because of the financial channel or because he cannot easily access the firm's communication channels.

4.3 The model

4.3.1 Technology and demand

Our setup closely follows the one by Nowak, Schwarz and Suedekum (2016). We consider a firm that is the producer of a final good q. For the production of this final good, the firm has to combine headquarter services h and two different manufacturing components x_i (with $i \in (A, B)$). The headquarter services are provided by the firm herself, whereas the components x_A and x_B are produced by two suppliers, supplier A and B. The producer combines the three different inputs to the final good according to the following upper tier Cobb-Douglas production function:

$$q = \theta \left(\frac{h}{\eta^H}\right)^{\eta^H} \left(\frac{X}{1-\eta^H}\right)^{1-\eta^H}, \tag{4.1}$$

$$\text{with} \quad X = \left[\eta_A \left(\frac{x_A}{\eta_A}\right)^{\alpha} + \eta_B \left(\frac{x_B}{\eta_B}\right)^{\alpha}\right]^{\frac{1}{\alpha}}. \tag{4.2}$$

The parameter θ captures the firm's productivity, η^H stands for the importance of headquarter services ("headquarter-intensity") and $1 - \eta^H$ denotes the importance of the aggregate manufacturing component, X, for the production. This aggregate component input X is given by a constant elasticity of substitution (CES) function, as described in (4.2). η_i denotes the importance of component i for the aggregate component input X (with $\eta_A + \eta_B = 1$) and $\alpha \in (0, 1)$ describes the substitutability of the two components. The demand for the final good is iso-elastic, i.e.,

$$q = Y p^{-\frac{1}{(1-\beta)}}, \tag{4.3}$$

with p denoting the final good's price. $Y > 1$ is a demand shifter and $1/(1 - \beta) > 1$ is the elasticity of demand (with $\beta \in (0, 1)$). From equations (4.1) - (4.3) we can derive the firm's revenue level,

$$R = \theta^{\beta} Y^{1-\beta} \left[\left(\frac{h}{\eta^H}\right)^{\eta^H} \left(\frac{\left[\eta_A \left(\frac{x_A}{\eta_A}\right)^{\alpha} + \eta_B \left(\frac{x_B}{\eta_B}\right)^{\alpha}\right]^{\frac{1}{\alpha}}}{1-\eta^H}\right)^{1-\eta^H}\right]^{\beta}, \tag{4.4}$$

that depends on the producer's and the suppliers' input contributions h, x_A and x_B.

4.3.2 Structure of the game

In our paper, we analyze from which type of supplier the producer sources her manufacturing inputs. More precisely, the producer can decide for both components $i \in \{A, B\}$ whether the supplier of the respective component is external ("outsourced") or vertically integrated within the boundaries of the firm. This "make or buy" decision is made in an environment with incomplete contracts à la Grossman and Hart (1986) or Hart and Moore (1990) in which the input provisions of the producer and of the two suppliers are relationship-specific and noncontractible. This noncontractibility has to be understood in the sense that the characteristics of the inputs of the different inputs can neither be precisely specified ex ante nor verified by a third party ex post. The resulting production process can be modelled as the following five-stage game that we solve by backward induction:

1. The producer chooses simultaneously for both inputs the firm's organizational structure that is represented by a tuple $\Xi = \{\Xi_A, \Xi_B\}$. Within this tuple, $\Xi_i = O$ denotes outsourcing and $\Xi_i = V$ denotes vertical integration of the supplier of the respective component $i \in \{A, B\}$. There are hence four possible organizational structures: $\{O, O\}$, $\{O, V\}$, $\{V, O\}$ or $\{V, V\}$.

2. Given the organizational decision, the firm offers contracts to potential suppliers that may include a positive or negative participation fee τ_i to supplier $i \in \{A, B\}$.

3. For both components $i \in \{A, B\}$, there is a large number of potential suppliers, each with an outside opportunity w_i. These potential suppliers apply for the contract, and the producer chooses one supplier for each component $i \in \{A, B\}$.

4. The headquarter and the suppliers A and B decide independently on their noncontractible input provision levels h, x_A and x_B. The producer's unit costs are given by c_H, whereas the suppliers' unit costs of production for input $i \in \{A, B\}$ depend on the producer's organizational decision.

5. After the input investments are sunk, the three players bargain over the surplus value of the production of the final good. Output is produced and revenue is realized. Revenue is then distributed to the three players according to the outcome of the bargaining process.

The bargaining between the producer and the two suppliers over the surplus value of the production arises due to the noncontractibility of the input provisions. As the producer and the suppliers anticipate this bargaining, underinvestment problems emerge due to the assumed relationship-specifity. Following the property rights approach to the organization of firms, the bargaining and, thus, these underinvestment problems arise not only under outsourcing but also under integration. Only the degree of the respective player's underinvestment problem is determined by the producer's ownership decisions: In case of outsourcing, the respective supplier maintains property rights over his input and can threath to withhold his whole input in the bargaining. In contrast, in case of (vertical) integration, where the supplier is basically an employee of the firm, the producer has the property rights over the respective supplier's input. An integrated supplier can therefore not threath to withhold the *whole* input, but only a part of it that is due to his specific knowledge. Resulting from this allocation of property rights, the revenue share and the production incentives are higher for the supplier and lower for the producer under outsourcing than under integration.

In addition to this "direct" effect of the producer's organizational decision that captures the incentivizing impact of ownership rights, we assume that there is an "indirect" effect operating via the organization-specific unit costs. In line with the above presented arguments of the other approaches to the organization of firms, outsourcing is assumed to be associated with extra costs. More precisely, in our setup, the unit costs of supplier i under integration are given by the raw production cost c_i whereas those under outsourcing are $c_i + \rho^O$ with $\rho^O > 0$.

To sum these two effects up, outsourcing gives more production incentives to the supplier, however, is at the same time associated with higher unit costs than integration.

4.3.3 Solution of the game

Starting with stage 5, the surplus value over which the producer and the two suppliers bargain is the realized revenue level as given in equation (4.4). We denote the headquarter's revenue share by rs^H, and the suppliers' revenue shares by rs_A and rs_B. Revenue is distributed among the three players such that $rs^H + rs_A + rs_B = 1$.

In stage 4, where both the producer and the suppliers choose their input provision levels, they anticipate their revenue shares in the bargaining stage. More precisely, the producer chooses h so as to maximize $rs^H R - c_H h$ with c_H denoting the unit costs of headquarter services. Analogously, supplier $i \in \{A, B\}$ maximizes $rs_i R - c_i^{\Xi} x_i$, where c_i^{Ξ} denotes the organization-specific unit cost of the supplier. The resulting input provision levels of the producer and the suppliers, respectively, are given by:

$$h^* = \frac{\beta\eta^H rs^H}{c_H} R \quad \text{and} \quad x_i^* = \beta\left(1-\eta^H\right)\eta_i \frac{\left(\frac{rs_i}{c_i^{\Xi}}\right)^{\frac{1}{1-\alpha}}}{\eta_A\left(\frac{rs_A}{c_A^{\Xi}}\right)^{\frac{\alpha}{1-\alpha}} + \eta_B\left(\frac{rs_B}{c_B^{\Xi}}\right)^{\frac{\alpha}{1-\alpha}}} R \quad \text{with}$$

$$R^* = \Theta\left[\left(\frac{rs^H}{c_H}\right)^{\eta^H}\left(\eta_A\left(\frac{rs_A}{c_A^{\Xi}}\right)^{\frac{\alpha}{1-\alpha}} + \eta_B\left(\frac{rs_B}{c_B^{\Xi}}\right)^{\frac{\alpha}{1-\alpha}}\right)^{\frac{1-\alpha}{\alpha}\left(1-\eta^H\right)}\right]^{\frac{\beta}{1-\beta}} \tag{4.5}$$

where $\Theta = Y\left(\beta\theta\right)^{\frac{\beta}{1-\beta}}$ is an alternative measure of productivity. As can be seen from equation (4.5), both the revenue share and level affect the two parties' investment incentives: Ceteris paribus, a higher revenue share rs^H raises the headquarter's input provision h and, hence, the revenue level. However, a higher rs^H lowers the remaining share $1 - rs^H = rs_A + rs_B$ for the suppliers, and thereby their input provisions, which in turn reduces the revenue level. This relationship illustrates that the producer needs to properly incentivize the suppliers in order to tackle the underinvestment problem that is inherent in this game structure.

For the suppliers to apply for a contract, the payoff offered in stage 2 has to be at least equal to the outside option w_i. This payoff is the anticipated revenue and the participation fee, minus the costs of production. Thus, the participation constraint reads as:

$$rs_i R^* - c_i^{\Xi} x_i^* + \tau_i \geq w_i. \tag{4.6}$$

As the producer has no incentive to leave rents to the suppliers and can freely adjust the upfront payments in stage 2, those participation constraints will be satisfied with equality, that is, $\tau_i = w_i - rs_i R^* + c_i^{\Xi} x_i^*$. Finally, in the first stage the producer chooses the firm's organizational structure that maximizes her own payoff. Using the upfront payment, this implies that the producer's problem is equivalent to maximizing the joint payoff of all players:

$$\pi = R^* - c_H h^* - c_A^{\Xi} x_A^* - c_B^{\Xi} x_B^* - 2w_i, \tag{4.7}$$

which can be rewritten as follows by using the expressions from equation (4.5):

$$\pi = \Theta\left[1 - \beta\left(\eta^H rs^H + \left(1-\eta^H\right)\frac{c_A\eta_A\left(\frac{rs_A}{c_A^{\Xi}}\right)^{\frac{1}{1-\alpha}} + \eta_B c_B^{\Xi}\left(\frac{rs_B}{c_B^{\Xi}}\right)^{\frac{1}{1-\alpha}}}{\eta_A\left(\frac{rs_A}{c_A^{\Xi}}\right)^{\frac{\alpha}{1-\alpha}} + \eta_B\left(\frac{rs_B}{c_B^{\Xi}}\right)^{\frac{\alpha}{1-\alpha}}}\right)\right]$$

$$\left[\left(\frac{rs^H}{c_H}\right)^{\eta^H}\left(\eta_A\left(\frac{rs_A}{c_A^{\Xi}}\right)^{\frac{\alpha}{1-\alpha}} + \eta_B\left(\frac{rs_B}{c_B^{\Xi}}\right)^{\frac{\alpha}{1-\alpha}}\right)^{\frac{1-\alpha}{\alpha}\left(1-\eta^H\right)}\right]^{\frac{\beta}{1-\beta}} - 2w_i. \tag{4.8}$$

The producer chooses the tuple $\Xi = \{\Xi_A, \Xi_A\}$ that maximizes equation (4.8) for given parameters.

4.4 The firm's organizational choice

We now turn to this final organizational choice of the headquarter where the producer chooses the tuple $\Xi = \{\Xi_A, \Xi_B\}$, with $\Xi \in \{O, V\}$, anticipating the implications of her decision for the revenue distribution. To simplify the analysis, we consider the simplest possible case and assume the two suppliers' revenue shares to be exogeneously given by $rs_A = \kappa_A \delta_A$ for supplier A and $rs_B = \kappa_B \delta_B$ for supplier B. Within these equations, $0 < \kappa_i \leq 1/2$ is an exogeneous term and $0 < \delta_i \leq 1$ represents the fraction that supplier i can threath to withhold in the multilateral bargaining with the producer. This fraction is higher under outsourcing, where the supplier has the property rights over his input, than under integration, where the producer owns the property rights, i.e., $\delta_i^O = 1 > \delta_i^V > 0$. Hence, supplier i's revenue share is higher under outsourcing than under integration ($rs_i^O > rs_i^V$).[2]

4.4.1 Benchmark case: Only direct impact on the organizational choice

Assume at first that $\rho^O = 0$. In words, we shut down the indirect impact of the ownership decision and assume that the unit costs are not organization-specific. Then, the producer's organizational choice is only driven by the direct impact, i.e., by the incentive effect inherent of the property rights approach.

[2] Two remarks about this assumptions with regard to the revenue shares are necessary: First, in Nowak, Schwarz and Suedekum (2016), the revenue shares are endogeneously determined and the Shapley value – a standard solution concept in multilateral bargaining contexts (see Shapley, 1953; Acemoglu, Antràs and Helpman, 2007) – is used as the solution concept for the modeling of the bargaining process. However, as Nowak, Schwarz and Suedekum (2016) show, the possible asymmetry of the two suppliers makes it impossible to derive closed form solutions under the Shapley value in this setup such that only numerical results with regard to the input provisions, the revenue shares and the firm's organizational choice can be presented. Second, we assume here the revenue shares to be independent of η^H and η_i. This assumption might seem a little unrealistic, however, as a result, contrary to Nowak, Schwarz and Suedekum (2016), the firm's organizational choice is not affected by whether the inputs are complements or substitutes. As our aim in this paper is not to show the complete outsourcing strategies of firms, but to show the effect of extra costs of outsourcing on a firm's decision, the assumed revenue shares just crucially simplify the analysis.

The resulting choice for this case is depicted in the left panel of figure 4.1.[3] On the horizontal axis, we display the headquarter-intensity η^H and on the vertical axis, we display the degree of the technological asymmetry η_A, with $\eta_A = 1/2$ standing for symmetric components. The different colors specify which organizational form leads to the highest payoff of the firm for the different values of the headquarter intensity and technological asymmetry.

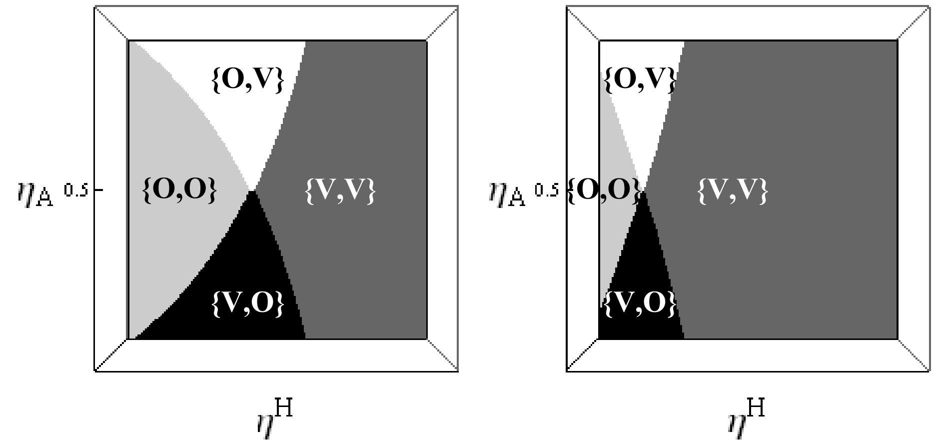

Figure 4.1: A firm's organizational choice without and with extra costs of outsourcing.
Left panel: $p^O = 0$. Right panel: $p^O = 0.1 > 0$.
Common parameters: $\alpha = 0.35$, $\beta = 0.8$, $c_A = c_B = 1$, $c_H = 1$, $\delta^O = 1$, $\delta^V = 0.95$, $\kappa_A = \kappa_B = 0.3$, $\rho^O = 0$, $\theta = 1$, $w_A = w_B = 1$, $Y = 1$.

In line with the property rights approach and the results of Nowak, Schwarz and Suedkeum (2016), figure 4.1 illustrates that the producer chooses outsourcing of both suppliers when the headquarter-intensity η^H is sufficiently low (light gray color). For a low headquarter-intensity, headquarter services are not so important for the production, but components are very important such that the suppliers should receive as much production incentives as possible. As the suppliers' bargaining powers and incentives are higher for outsourcing than for integration according to the direct property rights effect, i.e.,

$$\frac{\partial x_i}{\partial rs_i} = \frac{\Theta \eta_i \left(1 - \eta_H\right) \left(\frac{\delta_i \kappa_i}{c_i}\right)^{\frac{\alpha}{1-\alpha}} \left(\frac{1 - \delta_i \kappa_i - \delta_j \kappa_j}{c_H}\right)^{\frac{\beta \eta_H}{1-\beta}}}{(1-\alpha)(1-\beta)}.$$

[3]As we can depict the resulting organizational decision only numerically, the robustness of this result is shown in appendix A.I.

$$\left(\eta_i\left(\frac{\delta_i\kappa_i}{c_i}\right)^{\frac{\alpha}{1-\alpha}}+(1-\eta_i)\left(\frac{\delta_j\kappa_j}{c_j}\right)^{\frac{\alpha}{1-\alpha}}\right)^{\frac{(1-\alpha)\beta(1-\eta_H)}{\alpha(1-\beta)}-2}\cdot \tag{4.9}$$

$$\left((1-\beta)\left(1-\eta_i\right)\left(\frac{\delta_j\kappa_j}{c_j}\right)^{\frac{\alpha}{1-\alpha}}+(1-\alpha)\eta_i\left(1-\beta\eta^H\right)\left(\frac{\delta_i\kappa_i}{c_i}\right)^{\frac{\alpha}{1-\alpha}}\right)>0$$

with $i \neq j$, it is optimal for the producer to transfer ownership rights to the suppliers by choosing outsourcing. Analogously, for a sufficiently high importance of headquarter services for the production (high η^H), the producer chooses integration of both suppliers (dark gray color). Although the investment incentives of the suppliers are worse in that case, this is of lesser significance since components are not so important for the production process. The producer, on the other hand, provides a highly important input, and by choosing complete vertical integration, she can assign a high residual revenue share to herself to tackle her own underinvestment problem.

For intermediate values of the headquarter-intensity η^H both headquarter services and the component inputs are important for the production of the final good. Outsourcing or integration of *both* suppliers gives either too less production incentives to the producer or to the suppliers. Therefore, we find that the producer chooses to outsource one supplier while vertically integrating the other. Such an empirically highly relevant co-existence of both organizational forms within the same firm ("hybrid sourcing") is more likely, the higher is the technological asymmetry across the two components, i.e., the further away is η_A from the symmetric value of $1/2$. The direct impact on the organizational decision implies for the cases of "hybrid sourcing" that the producer always outsources the supplier with the technologically more important component, as it is relatively more important to properly incentivize this supplier by leaving him the property rights over his assets. That is, whenever input A is the more important one ($\eta_A > 1/2$), only the organizational form $\{O, V\}$ prevails (white) but never the form $\{V, O\}$. Vice versa, for $\eta_A < 1/2$ we only observe the form $\{V, O\}$ (black) but never the form $\{O, V\}$.

4.4.2 Organization-specific unit costs: Direct and indirect impact on the organizational decision

Now suppose that $\rho^O > 0$ holds so that outsourcing is associated with higher total unit costs than vertical integration. The producer's organizational decision for this case, which is influenced both by the direct and the indirect impact, is depicted in the right panel of figure 4.1.

To understand this organizational decision, note that higher unit costs lower a supplier's input provision, as given by (4.5):

$$\frac{\partial x_i}{\partial c_i} = -\frac{\Theta\eta_i\left(1-\eta^H\right)\left(\frac{\delta_i\kappa_i}{c_i^2}\right)^{\frac{1}{1-\alpha}}\left(\frac{1-\delta_i\kappa_i-\delta_j\kappa_j}{c_H}\right)^{\frac{\beta\eta^H}{1-\beta}}}{(1-\alpha)(1-\beta)}\cdot$$

$$\left(\eta_i\left(\frac{\delta_i\kappa_i}{c_i}\right)^{\frac{\alpha}{1-\alpha}}+(1-\eta_i)\left(\frac{\delta_j\kappa_j}{c_j}\right)^{\frac{\alpha}{1-\alpha}}\right)^{\frac{(1-\alpha)\beta(1-\eta_H)}{\alpha(1-\beta)}-2}\cdot \tag{4.10}$$

$$\left((1-\beta)(1-\eta_i)\left(\frac{c_i\delta_j\kappa_j}{c_j}\right)^{\frac{\alpha}{1-\alpha}}+(1-\alpha)\eta_i\left(1-\beta\eta_H\right)\left(\delta_i\kappa_i\right)^{\frac{\alpha}{1-\alpha}}\right)<0$$

with $i \neq j$. That is, outsourcing has two opposing effects on the producer's organizational decision: On the one hand, through the direct impact, a higher revenue share increases, ceteris paribus, the supplier's input provision (see equation (4.9)). However, on the other hand, through the indirect impact, higher unit costs under outsourcing decrease, ceteris paribus, the supplier's input provision under outsourcing (see equation 4.10)). Stated differently, the indirect impact makes integration per se more likely. It is however not clear, why one component should be more affected by this indirect impact than the other.

When the headquarter-intensity η^H is sufficiently high, the effect of the two opposite impacts is very straightforward and the producer vertically integrates both suppliers, independently of the technological asymmetry. The reasons are twofold: First, following the direct impact, headquarter services are highly important for the production process, thus it is most important to minimize the underinvestment problem for the producer which is achieved by vertical integration. Second, this choice is even reinforced through the indirect impact since vertical integration is also associated with lower unit costs than outsourcing. This possibility to exploit economies of scope thus renders the organizational form $\{V, V\}$ more prevalent, i.e., the dark gray area expands in the right panel of figure 4.1 as compared to the left panel.

This change is less equally distributed for the other extreme of production processes: Without additional outsourcing costs (for $\rho^O = 0$) the ownership choice $\{O, O\}$ is payoff-maximizing for low values of η^H because of the direct property rights effect. With $\rho^O > 0$, outsourcing is now associated with higher unit costs that do not affect the revenue shares rs_i. However, these costs decrease the suppliers' input provisions and, as a result, the firm's total revenue and payoff. As the lower unit costs under integration are not strong enough to countervail the lower revenue share and, thus, investment incentives under integration, from the firm's perspective, this decrease of both suppliers' input provisions can only be reduced by a higher headquarter input provision by the firm. To assign herself a higher revenue share, the producer has therefore an incentive to integrate one supplier. As it is less severe to decrease the revenue share of the technologically less important supplier, this supplier is integrated whereas the technologically more important supplier is still outsourced.

For intermediate values of η^H, we find that the producer still chooses hybrid sourcing such that she outsources the more important supplier. However, the parameter range where this happens is now shifted more to the left, i.e., to lower values of headquarter-intensity than before, since the producer chooses integration of both suppliers more easily.

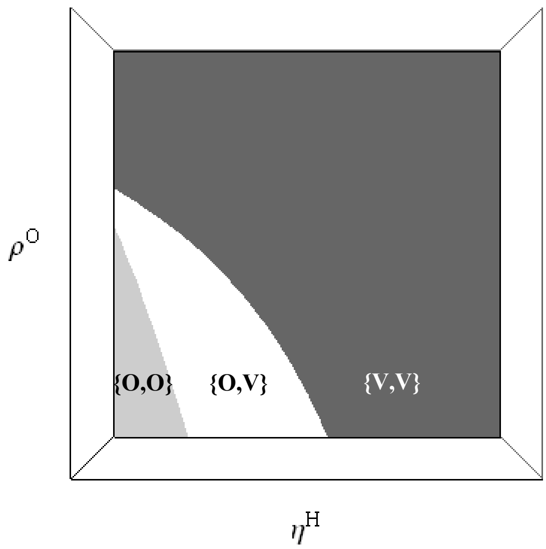

Figure 4.2: Transition to complete vertical integration for $\eta_A = 0.8$.
Common parameters: $\alpha = 0.35$, $\beta = 0.8$, $c_A = c_B = 1$, $c_H = 1$, $\delta^O = 1$, $\delta^V = 0.95$, $\kappa_A = \kappa_B = 0.3$, $\eta_A = 0.8$, $\theta = 1$, $w_A = w_B = 1$, $Y = 1$.

In the right panel of figure 4.1 we have assumed a specific value for ρ^O. When we increase the extra costs of outsourcing even further, the entire figure would eventually turn dark gray. That is, the producer would always choose $\{V, V\}$ if ρ^O is high enough. As depicted in figure 4.2[4] for a higher technological importance of input A, in the transition towards this extreme constellation, the switch from outsourcing to integration occurs later in the far left part of the figure where headquarter-intensity is very low, since the property rights effect has the strongest bite for the suppliers there. It also occurs later for constellations with a small technological asymmetry (for $\eta_A \approx 1/2$), as the induced push in investment incentives coming from the lower unit costs is then smaller.

[4]For robustness, we present this figure for different parameter constellations in appendix A.II.

4.5 Conclusion

There are several theories to explain firms' organizational decisions. Whereas the empirically highly relevant property rights approach emphasizes the *benefits* of outsourcing, the other major theories state that there are also *extra costs* associated with outsourcing. We give a review on the literature over the different mechanisms that constitute higher costs under outsourcing than under integration. We then introduce these extra costs of outsourcing into a property rights model with two imperfectly substitutable manufacturing components.

In this setup, there are two countervailing effects on a firm's organizational decision: the "direct" effect that captures the incentivizing effect of outsourcing inherent of the property rights approach and the "indirect" effect that is working through the organization-specific unit costs assumed by the other approaches. This indirect effect via the extra costs of outsourcing makes per se vertical integration of both inputs more likely. However, we show that this effect is stronger for the supplier of the technologically less important component.

This is a very simple setup, where the revenue shares are exogeneously given and independent of the headquarter-intensity and the supplier's input intensities, however, it clearly shows the implications of the "indirect" effect. It would be interesting to bring the results to the data.

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4.7 Appendix

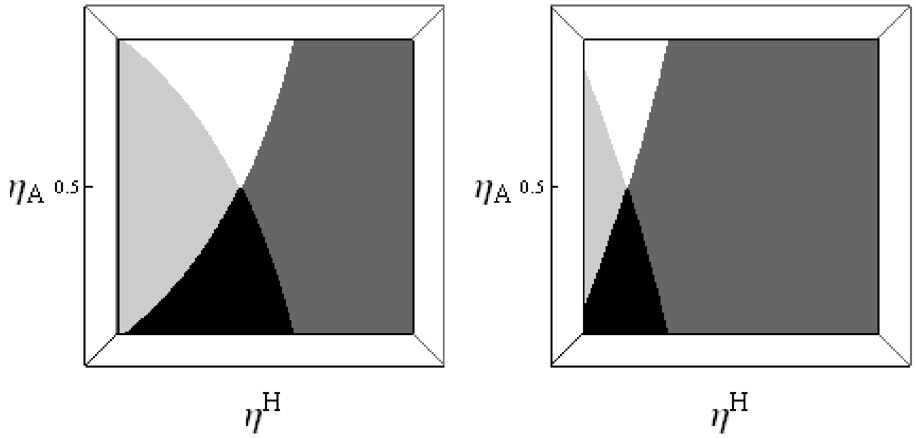
A.I Robustness of the producer's organizational decision

A.I.i Variation of α and β

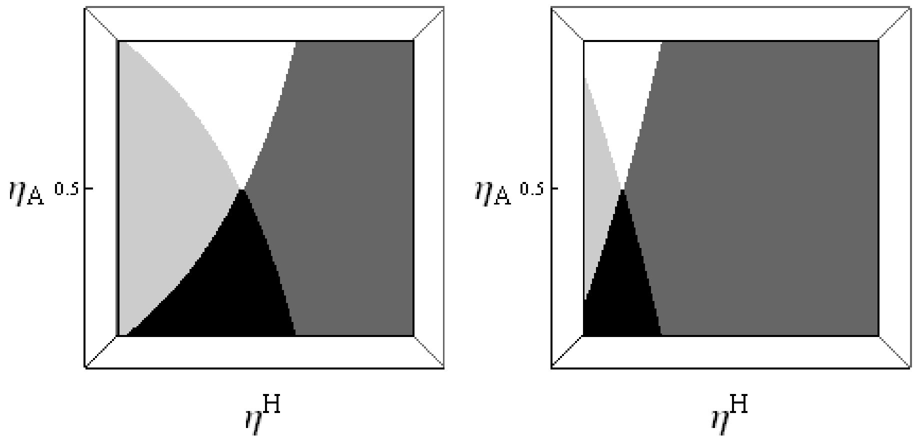
Common parameters: $c_A = c_B = 1$, $c_H = 1$, $\delta^O = 1$, $\delta^V = 0.95$, $\kappa_A = \kappa_B = 0.3$, $\rho^O = 0$, $\theta = 1$, $w_A = w_B = 0$, $Y = 1$.

Figures are analogous to figure 4.1 in the main text, but for different parameter constellations.

$\alpha < \beta$, **low substitutability**

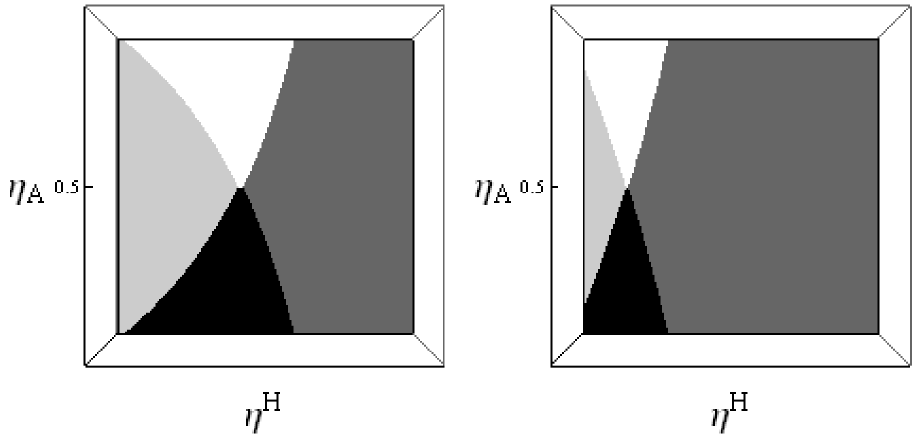


$\alpha = 0.1$, $\beta = 0.8$



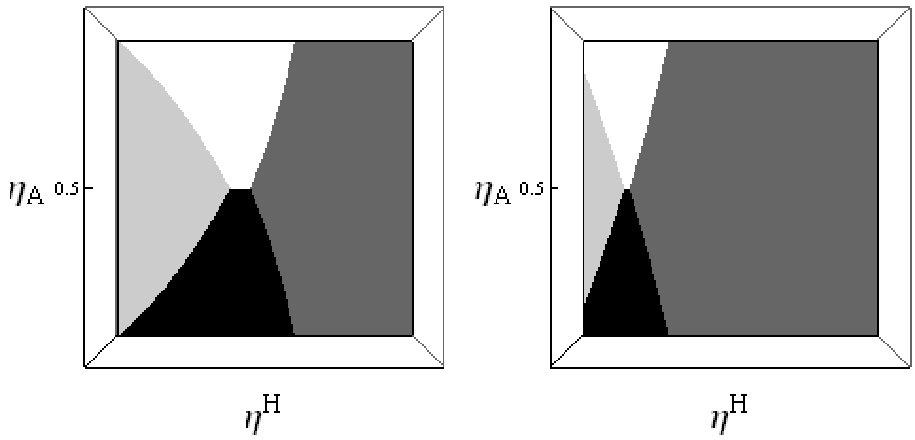
$\alpha = 0.05$, $\beta = 0.7$

$\alpha < \beta$, **high substitutability**

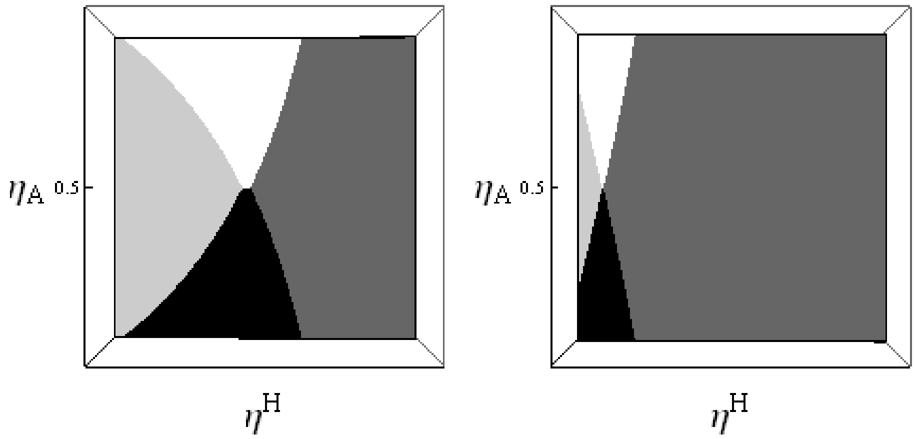


$\alpha = 0.5$, $\beta = 0.8$

$\alpha > \beta$, **very high substitutability**



$\alpha = 0.9$, $\beta = 0.8$

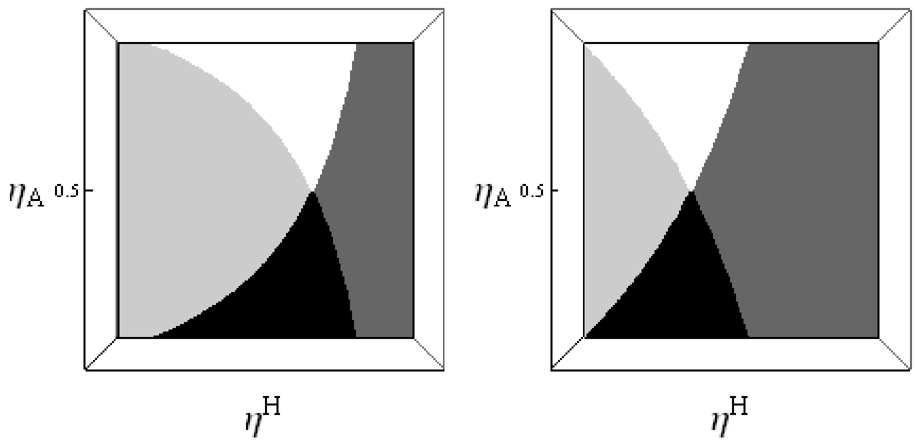


$\alpha = 0.7$, $\beta = 0.4$

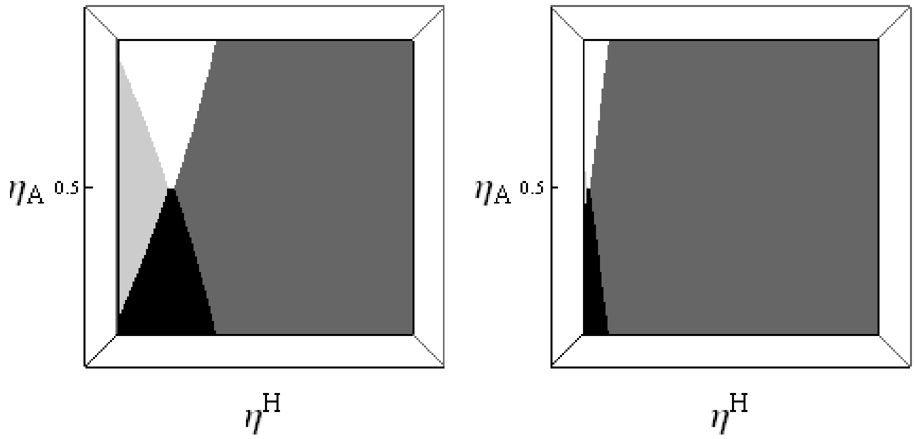
A.I.ii Variation of κ_A and κ_B

Common parameters: $\alpha = 0.35$, $\beta = 0.8$, $c_A = c_B = 1$, $c_H = 1$, $\delta^O = 1$, $\delta^V = 0.95$, $\rho^O = 0$, $\theta = 1$, $w_A = w_B = 0$, $Y = 1$.

Figures are analogous to figure 4.1 in the main text, but for different parameter constellations.



$\kappa_A = \kappa_B = 0.2$



$\kappa_A = \kappa_B = 0.4$

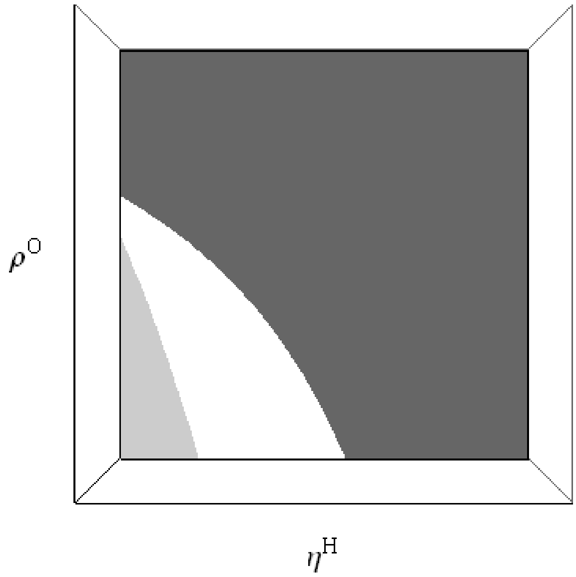
A.II Robustness of the effect of extra costs of outsourcing on the producer's organizational decision.

A.II.i Variation of α and β

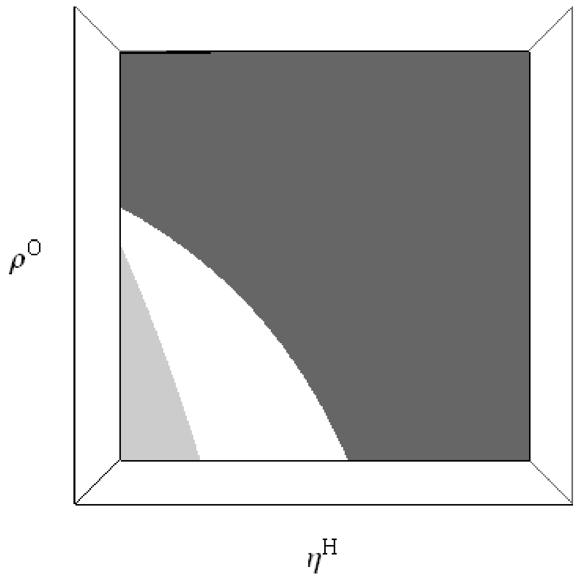
Common parameters: $c_A = c_B = 1$, $c_H = 1$, $\delta^O = 1$, $\delta^V = 0.95$, $\kappa_A = \kappa_B = 0.3$, $\eta_A = 0$, $\theta = 1$, $w_A = w_B = 0$, $Y = 1$.

Figures are analogous to figure 4.2 in the main text, but for different parameter constellations.

$\alpha < \beta$, **low substitutability**

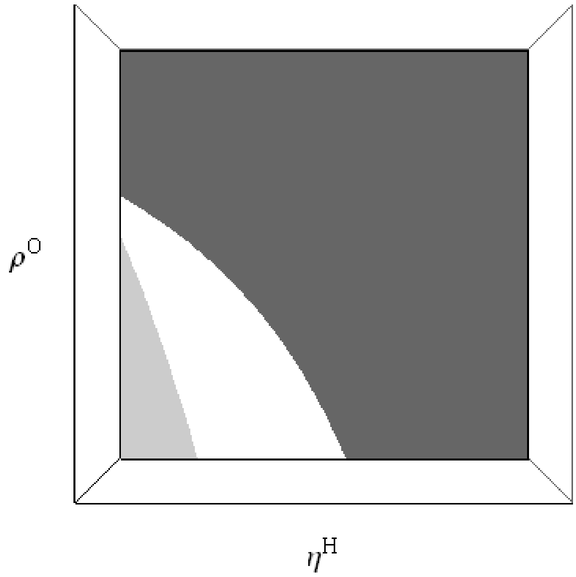


$\alpha = 0.1,\ \beta = 0.8$



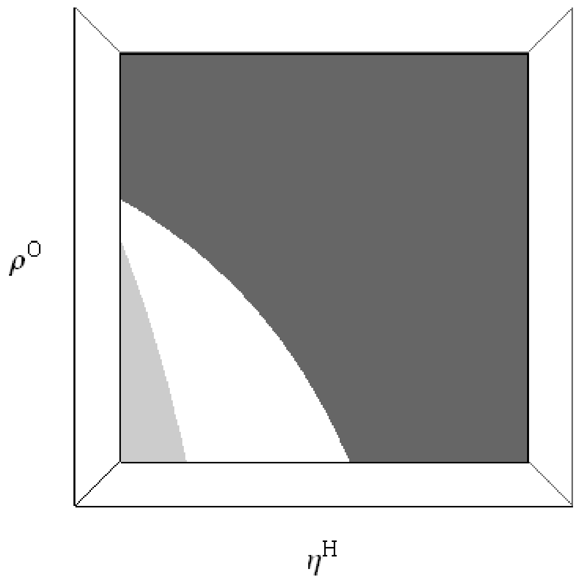
$\alpha = 0.05,\ \beta = 0.7$

$\alpha < \beta$, **high substitutability**

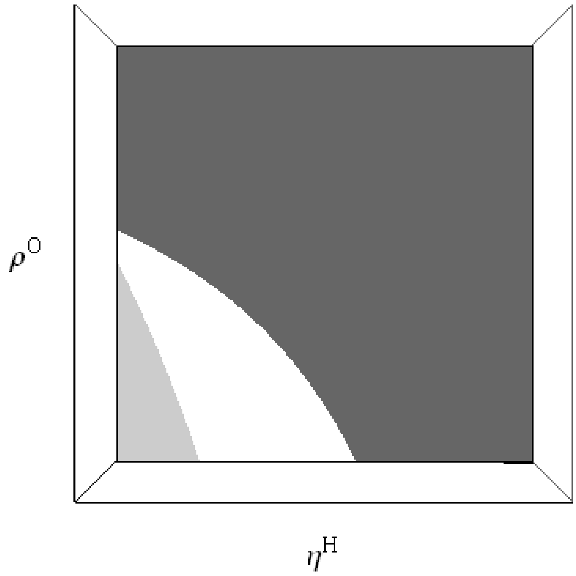


$\alpha = 0.5$, $\beta = 0.8$

$\alpha > \beta$, **very high substitutability**



$\alpha = 0.9$, $\beta = 0.8$

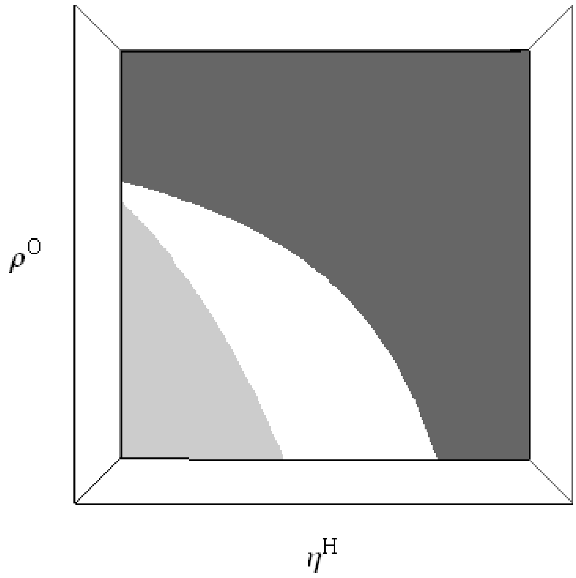


$\alpha = 0.7$, $\beta = 0.4$

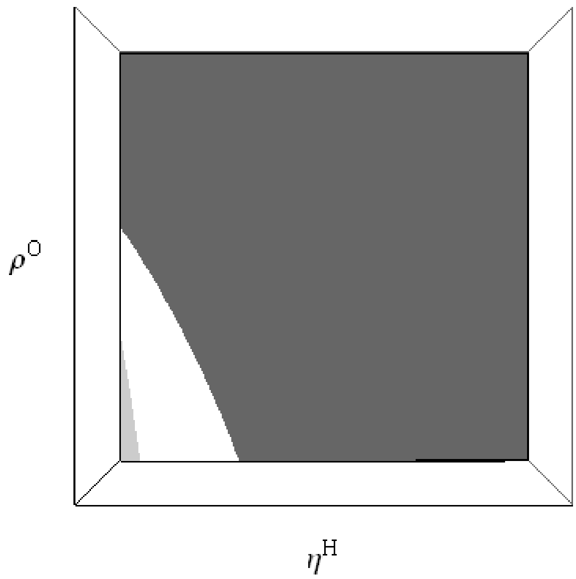
A.II.ii Variation of κ_A and κ_B

Common parameters: $\alpha = 0.35$, $\beta = 0.8$, $c_A = c_B = 1$, $c_H = 1$, $\delta^O = 1$, $\delta^V = 0.95$, $\eta_A = 0.8$, $\theta = 1$, $w_A = w_B = 0$, $Y = 1$.

Figures are analogous to figure 4.2 in the main text, but for different parameter constellations.



$\kappa_A = \kappa_B = 0.2$



$\kappa_A = \kappa_B = 0.4$

Chapter 5

Organizational decisions in multistage production processes

5.1 Introduction

Most production processes have multiple stages. Intermediate inputs are passed along the stages and are refined by a supplier in each of these stages until ultimately, in the last stage, a final good is produced that can be sold to consumers. Along the chain, the crucial "make-or-buy" decision needs to be made: For the input of each stage it must be decided whether it is sourced from a supplier that is vertically integrated within the boundaries of the firm or from an external, unaffiliated supplier.

In a seminal model, Antràs and Chor (2013) analyze this organizational problem for firms whose headquarter has control over the entire value chain. An example for such a firm is *Apple* that tasks *Foxconn* or *Pegatron* with the assembly of its products, but has beyond these assembly facilities own suppliers for its individual inputs.[1] However, in reality, the headquarter is in many cases not in charge of the control over the organizational decisions along the whole value chain. To give an example, consider the automotive sector where many manufacturing units are modularized. For example, the car manufacturer *smart* receives complete door/flap modules, cockpit modules and body panels.[2] The module suppliers only receive module specifications regarding design, shape and surface material. It is up to them to decide on development, technology and implementation of the modules. As a result, the input suppliers - and *not* the firm - choose their suppliers and decide on their organizational forms.[3]

In this paper, I provide an alternative mechanism to explain the organizational decisions in multistage production processes. More precisely, my contribution is to assume the suppliers of a firm to decide themselves on the organizational form of their own suppliers, and to analyze the implications of this assumption on the organizational decisions. My central finding is that the organizational decisions of the producer and a supplier are interrelated, particularly when production takes place sequentially, and depend on both the producer's and the suppliers' relative importance for the production.

[1] According to a list on its web page (see Apple, 2013), *Apple* has more than 200 input suppliers. For example, for its iPhone 5, *Apple* receives instead of a complete camera individual parts: The image sensors are provided by *Sony* and *OmniVision*, whereas the lenses are delivered by *Largan Precision* and *Genius Electronic Optical*.

[2] The door/flap modules are provided by *Magna Uniport*, the cockpit modules are supplied by *Continental* and the body panels are sourced from *Plasta*. Other examples are the complete door modules of *Ford* for its Fiesta (*Faurecia*), the complete door interior panellings of *BMW* for its 5 Series and the complete door panellings of *Mercedes* for its CLS Coupés (both *Johnson Controls*).

[3] See Automotive Netzwerk Suedwestfalen (2013), Daimler (2008), Faurecia (2012) and WIKO (2007).

In my model, I consider a firm that produces a final good whose production necessitates headquarter services and a manufacturing component. Headquarter services are provided by the firm herself, for the production of the manufacturing component a supplier ("supplier 1") is chosen. In contrast to Antràs and Helpman (2004), I assume production of supplier 1's manufacturing component to require an additional input provided by another supplier ("supplier 2"). The firm decides whether the downstream supplier 1 is integrated or outsourced. Supplier 1 then decides himself on the upstream supplier 2's organizational form, i.e., whether he is integrated or outsourced. These organizational decisions are made in an environment of incomplete contracts à la Grossman and Hart (1986) and Hart and Moore (1990). Due to this incompleteness, a bargaining about the division of surplus takes place after the production of inputs - underinvestment problems arise. In this bargaining, an outsourced supplier has the property rights over his input whereas an integrated supplier is basically an employee of the firm. Outsourcing thus implies a higher bargaining power and more production incentives for the respective supplier. Vice versa, integration of a supplier gives the respective decision maker more bargaining power and investment incentives. The essential trade-off underlying both the firm's and supplier 1's organizational decisions is thus between minimizing the own or the respective supplier's underinvestment problem.

Ultimately, I am interested in the organizational decisions with sequential production. However, in my model, sequentiality may arise both with regard to the bargaining structure and the timing of production. To separate the effects on the organizational decisions, I first analyze these decisions in the scenario of simultaneous production where the producer and the two suppliers decide at the same time on their input investments. With balanced revenue shares, supplier 1's decision depends solely on the suppliers' relative importance for the whole manufacturing input. In contrast, the organizational decision of the producer is not only driven by the producer's importance for the production but also by the two suppliers' relative importance. In a second step, I consider sequentiality of production and assume supplier 2 to invest prior to the producer and supplier 1. Due to this sequentiality, there is an "anticipation effect" of supplier 2: Supplier 2 anticipates the producer's input investment such that his input provision is increasing in the producer's importance for the production. Thus, supplier 1's organizational decision on supplier 2 is not only driven by the suppliers' relative importance but also by the headquarter-intensity. More precisely, the more relevant is the producer for the production, the less important it becomes to give supplier 2 investment incentives. Hence, integration of the upstream supplier 2 becomes more likely. Put differently, one of my main findings is that the two organizational decisions by the headquarter and the downstream supplier 1 are interrelated along the value chain.

This interrelation has to be understood in the sense that both the producer's and supplier 1's organizational decision depend on the producer's importance for the production. In other words, headquarter-intensity affects the bargaining relation between the upstream and the downstream supplier and, hence, the organizational structure of suppliers outside the realm of the producer. More specifically, due to supplier 2's anticipation of the producer's and supplier 1's investment, the decision of supplier 1 also depends on the level of the producer's importance. Thus, due to this anticipation effect, supplier 1's decision depends on factors outside the scope of the two suppliers' relation. A further main finding is that, in contrast to the results of Antràs and Chor (2013), my results also depend on the two suppliers' relative importance. The respective more important supplier should receive more investment incentives since his underinvestment problem is more relevant (incentive effect). As a result, despite the interrelation of the organizational decisions, the producer's importance for the production does not definitely pin down the degree of integration of the whole value chain: If the headquarter-intensity is very high, supplier 1 is clearly integrated. However, if supplier 2 is much more important than supplier 1, the incentive effect is stronger than the anticipation effect such that supplier 2 is still outsourced. As a result, even for this highly headquarter-intensive production process I do not observe a (completely) integrated value chain. This implies that not only the relevance of the producer but also the suppliers' relative importance is crucial for the degree of integration within a value chain.

I then assume that firms can freely decide on their decision structure. In other words, I assume that they can choose between the decision structures of *Apple* and *smart*. Which of the two structures is more likely to be chosen depends on the producer's and her direct supplier's productivity.

Thus, my overall results depend on the importance of the producer and the suppliers for the production and on their productivity, i.e., on factors that can be measured by data that are easily accessible.

The rest of this paper is organized as follows: In section 5.2 I introduce the structure of my model. Then, in section 5.3 and 5.4 I analyze the organizational decisions for the scenarios of simultaneous and sequential production. In section 5.5 I consider a slightly different setup for the decisions. Section 5.6 provides a comparison with the results of Antràs and Chor (2013) and a discussion of my main results. In section 5.7, I analyze firms' decisions with regard to their decision structure.

5.2 The model

5.2.1 Technology and demand

As in Antràs and Helpman (2004), I consider a firm that produces a final good q for which headquarter services h and a manufacturing component m are required. Headquarter services h are provided by the producer herself, whereas the manufacturing component m is sourced from a supplier ("supplier 1"). The inputs are combined to the final good by the following Cobb-Douglas production function:

$$q = \theta_H \left(\frac{h}{\eta_H}\right)^{\eta_H} \left(\frac{m}{1-\eta_H}\right)^{1-\eta_H}. \tag{5.1}$$

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

Antràs and Helpman (2004) disregard how the manufacturing component is produced, i.e., whether the firm's supplier produces the manufacturing component on his own or whether he has to subcontract a supplier. As long as contracts between the suppliers are complete, this differentiation is irrelevant. However, to exploit organizational decisions in multistage production processes, I extend their analysis and explicitly consider the manufacturing component provided by supplier 1 to be itself composed of two components m_1 and m_2. Component m_1 is provided by supplier 1 himself, whereas he has to employ a supplier of his own ("supplier 2") for the production of component m_2. m_1 and m_2 are combined to the manufacturing input by the following Cobb-Douglas production function:

$$m = \theta_1 \left(\frac{m_1}{\eta_1}\right)^{\eta_1} \left(\frac{m_2}{1-\eta_1}\right)^{1-\eta_1}. \tag{5.2}$$

θ_1 denotes supplier 1's productivity in the manufacturing input and $\eta_1 \in (0,1)$ is supplier 1's input intensity, i.e., the importance of supplier 1's input for the manufacturing component.

The demand for the final good is assumed to be iso-elastic:

$$q = Ap^{-\frac{1}{1-\rho}}. \tag{5.3}$$

Here, $A > 1$ is a demand shifter, p is the price of the final good and $1/(1-\rho)$ denotes the elasticity of demand (with $\rho \in (0,1)$).

Using equations (5.1) - (5.3) the revenue of the firm can be expressed as

$$R = A^{1-\rho} \left[\theta_H \left(\frac{h}{\eta_H}\right)^{\eta_H} \left(\frac{\theta_1 \left(\frac{m_1}{\eta_1}\right)^{\eta_1} \left(\frac{m_2}{1-\eta_1}\right)^{1-\eta_1}}{1-\eta_H} \right)^{1-\eta_H} \right]^{\rho}. \tag{5.4}$$

5.2.2 Organizational decisions

In this paper, I analyze the organizational forms chosen for the two suppliers of the manufacturing component - each of the two suppliers can either be vertically integrated within the boundaries of the firm or an external, outsourced supplier. These organizational decisions can be made in two different ways. For illustration, figure 5.1 depicts the underlying structure of the organizational decisions of Antràs and Chor (2013) and of my model, respectively. In this figure, the solid arrows indicate the flows of inputs, the dashed arrows show the organizational dependencies. In contrast to Antràs and Chor (2013) who consider the producer to decide herself on the organizational form of all her suppliers along the value chain, I assume the producer to decide only on her direct supplier 1's organizational form. Supplier 1 is then assumed to decide on his own on the organizational form of his supplier 2.

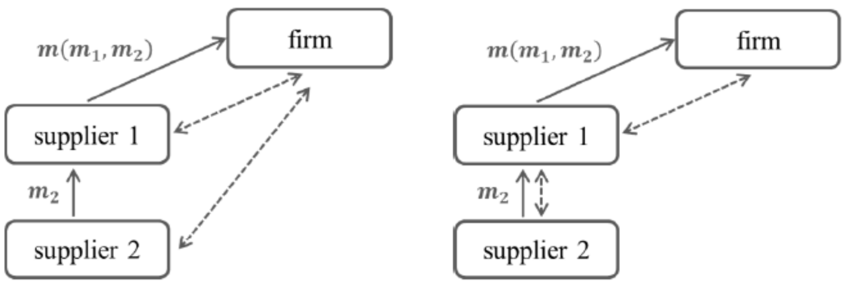


Figure 5.1: Structure of the organizational decisions.
Left panel: Antràs and Chor (2013). Right panel: my structure.

Consequently, in this paper, I analyze which organizational form both *the producer and supplier 1* choose for their respective suppliers. In particular, I am interested in the interrelation of these two decisions and want to analyze how supplier 1's decision is affected by the producer's decision.

5.2.3 Structure of the game

I assume contracts between all players to be incomplete[4], i.e., the input investments are considered to be noncontractible since they are too complex to be specified ex ante and nonverifiable to third-parties (as e.g. a court) ex post, as in Grossman and Hart (1986) and Hart and Moore (1990). As a result, the players renegotiate after the input investments have taken place; a bargaining over the distribution of surplus

[4] I also consider a scenario of complete contracts that leads to the first-best solution and serves as a benchmark, see appendix A.I.i.

arises. Since input investments are fully relationship-specific, hold-up problems arise and each player underinvests. The degree of a player's underinvestment problem depends on the revenue share he expects to receive in the ex post bargaining - the higher is this revenue share, the lower is his underinvestment problem. Integrated and outsourced suppliers differ in the level of these revenue shares: Since an integrated supplier is essentially an employee of the firm, he can threat to withhold only a part of his input. In contrast, an outsourced supplier can threat to withhold his whole input and, thus, has a higher bargaining power and receives a higher revenue share than an integrated supplier.

Within this environment, the production process can be modeled as a 7-stage game with the following timing of events:

1. The producer chooses the organizational form Ξ_1 of her direct supplier 1. $\Xi_1 = O$ denotes outsourcing and $\Xi_1 = V$ denotes (vertical) integration of supplier 1. Given this organizational decision, the firm offers contracts to potential suppliers. These contracts include an up-front participation fee τ_1 to supplier 1 that might be positive or negative.

2. There is a huge mass of potential suppliers, each with an outside option equal to w_1. The suppliers apply for the contract and the producer chooses one supplier for the production of the manufacturing component.

3. This supplier henceforth chooses the organizational form Ξ_2 of his own supplier 2. $\Xi_2 = O$ stands for outsourcing of the supplier and $\Xi_2 = V$ stands for (vertical) integration of the supplier. Based on this decision, supplier 1 offers contracts to potential suppliers. These contracts include again a (positive or negative) up-front participation fee τ_2 to supplier 2.

4. There is a huge mass of potential suppliers with an outside option equal to w_2 that apply for the contract. Supplier 1 chooses one supplier out of this mass.

5. The headquarter and supplier 1 and 2 decide on their noncontractible input provision levels (h, m_1 and m_2, respectively). Their unit costs of production are c_H, c_1 and c_2, respectively.

6. In a Nash bargaining, supplier 1 and 2 bargain over the surplus value of their relationship.

7. The producer and supplier 1 bargain in a Nash bargaining over the surplus value of the whole relationship. The final good is produced. Revenue is realized and distributed according to the outcome of the bargaining process.

In this setup, sequentiality may arise both with respect to the bargaining and to the production. Ultimately, I am interested in the organizational decisions in multistage production processes where both bargaining and production take place sequentially. However, to separate the effects resulting from the bargaining and those resulting from the production, in stage 5, I assume that production may take place in two different ways - production may either arise simultaneously or sequentially.[5]

If production takes place simultaneously, the players decide at the same time on their input investments in stage 5 of the game structure:

5.a. The producer and the two suppliers each decide independently from the other two players on their noncontractible input provision levels.

However, if production arises sequentially, investment decisions take place at different points of time. More precisely, I assume supplier 2 to invest prior to the producer and supplier 1 such that stage 5 is divided into two separate stages.[6]

5.b.
1. Supplier 2 decides on his noncontractible input provision level (m_2).
2. After the production of m_2, the producer and supplier 1 decide simultaneously on their noncontractible input provision levels (h and m_1, respectively).

In the following, I first analyze the producer's and supplier 1's organizational decision in the scenario of simultaneous production. Then, in a second step, I assume sequentiality of production with supplier 2 investing prior to the producer and supplier 1. In doing so, I highlight the influence of this sequentiality on the organizational decisions.

5.3 Simultaneous poduction

Analyzing first the scenario of simultaneous production, the producer and the suppliers make their investment decisions independently from the other players, as described in stage 5.a.

[5] Results are simpler if I assume a setup without participation fees. However, since in a setup with participation fees arises an additional effect through the timing of the producer's and the suppliers' investment decisions that does not exist in a setup without participation fees, in my paper, I mainly focus on the setup with participation fees. The other, simpler results are presented in section 5.5 and appendix A.III.

[6] I have also considered a further expanded sequentiality of the production process and have additionally assumed supplier 1 to invest previous to the producer. However, since the effect of sequentiality can clearly be seen in the "simpler" case with only supplier 2 investing previously, I only consider this constellation. Results are available on request.

5.3.1 Solution of the game

Solving by backward induction, in the last stage, the final good producer and her direct supplier 1 bargain over the distribution of the surplus value of the relationship. The producer receives a revenue share β_H, supplier 1 receives the remain $(1 - \beta_H)$. These revenue shares depend on the organizational form the producer chooses for supplier 1 in stage 1 that I will analyze below.

In stage 6, the suppliers bargain over the distribution of the suppliers' revenue share $(1 - \beta_H)$. Supplier 1 receives a revenue share β_1 of it, whereas supplier 2 receives the residual $(1 - \beta_1)$. The level of β_1 depends on supplier 1's organizational decision in stage 3 that will also be analyzed below.

In stage 5, the producer and the suppliers decide simultaneously on the input provisions for the production of the final good. In doing so, each player takes into account the revenue share he will receive in the bargaining and chooses the input provision that maximizes his respective profit. More precisely, the suppliers 1 and 2 choose the input provisions $m_1^{sim} = argmax_{m_1} \{(1 - \beta_H)\beta_1 R - c_1 m_1\}$ and $m_2^{sim} = argmax_{m_2} \{(1 - \beta_H)(1 - \beta_1) R - c_2 m_2\}$, respectively, whereas the producer chooses $h^{sim} = argmax_h \{\beta_H R - c_H h\}$. The resulting input provisions are given by:[7]

$$h^{sim} = \frac{\rho\eta_H\beta_H R^{sim}}{c_H}, \quad m_1^{sim} = \frac{\rho(1-\eta_H)\eta_1(1-\beta_H)\beta_1 R^{sim}}{c_1}$$

$$\text{and} \quad m_2^{sim} = \frac{\rho(1-\eta_H)(1-\eta_1)(1-\beta_H)(1-\beta_1) R^{sim}}{c_2} \tag{5.5}$$

$$\text{with} \quad R^{sim} = A\left[\rho\theta_H\left(\frac{\beta_H}{c_H}\right)^{\eta_H}\left(\theta_1(1-\beta_H)\left(\frac{\beta_1}{c_1}\right)^{\eta_1}\left(\frac{1-\beta_1}{c_2}\right)^{1-\eta_1}\right)^{1-\eta_H}\right]^{\frac{\rho}{1-\rho}}.$$

Equation (5.5) shows the trade-off between revenue share and revenue level: A higher revenue share raises, ceteris paribus, the respective own input provision. However, it reduces the respective supplier's input provision such that the revenue level and thus the own input provision also decrease.

In stage 4, supplier 2 only applies for the contract if his profit ${\pi_2}^{sim}$ - that consists of his expected payment minus his productions costs plus his participation fee - is at least equal to his outside option:

$${\pi_2}^{sim} = (1-\beta_1)(1-\beta_H)(1-\rho[1-\eta_1][1-\eta_H]) R^{sim} + \tau_2 \geq w_2. \tag{5.6}$$

[7] Since players anticipate that, with incomplete contracts, they will not receive the full return of their investment in the ex post bargaining, they have an incentive to provide less input than they would provide with complete contracts, i.e., they underinvest. These lower input provisions induce a lower revenue level. For more details see appendix A.I.ii.

Since there is no need to leave rents to supplier 2, supplier 1 chooses the participation fee in stage 3 such that it equals supplier 2's production costs and outside option minus his expected payment:

$$\tau_2 = w_2 - (1-\beta_1)(1-\beta_H)(1-\rho[1-\eta_1][1-\eta_H]) R^{sim}. \tag{5.7}$$

Supplier 1 then chooses the organizational form of supplier 2 that maximizes his own profit π_1^{sim} that is equal to his expected payment plus his own participation fee from the producer minus his own production costs and supplier 2's participation fee:

$$\pi_1^{sim} = (1-\beta_H)[1-\rho(1-\eta_H)[\beta_1\eta_1 + (1-\beta_1)(1-\eta_1)]] R^{sim} + \tau_1 - w_2. \tag{5.8}$$

For supplier 1 to participate in the production of the final good in stage 2, this profit must be at least equal to his outside option such that the participation fee is given by

$$\tau_1 = w_1 + w_2 - (1-\beta_H)[1-\rho(1-\eta_H)[\beta_1\eta_1 + (1-\beta_1)(1-\eta_1)]] R^{sim}. \tag{5.9}$$

Finally, in stage 1, the producer chooses the organizational form of supplier 1 that maximizes her own profit π_H^{sim} that consists of her expected payment minus her production costs and supplier 1's participation fee. Using equation (5.9), this profit - that is equal to the overall surplus - is given by[8]

$$\pi_H^{sim} = [1-\rho[(1-\beta_H)(1-\eta_H)[\beta_1\eta_1 + (1-\beta_1)(1-\eta_1)] + \beta_H\eta_H]] R^{sim} - w_1 - w_2. \tag{5.10}$$

5.3.2 Organizational decisions

As both the producer and supplier 1 will choose the organizational form of their supplier that maximizes their own profit, I use the above profit levels to determine the producer's and supplier 1's organizational decision. To decide whether integration or outsourcing leads to higher profits, I first derive the optimal revenue share with incomplete contracts and assume the producer and supplier 1 to be able to freely set the revenue share $\beta \in (0,1)$, as in Antràs and Helpman (2004, 2008) or Antràs and Chor (2013). Then, I compare this optimal revenue share with the revenue shares of integration and of outsourcing; the organizational form with the revenue share closest to the optimal revenue share leads to higher profits and is, thus, chosen.

Thereby, the producer or supplier 1, respectively, receive a revenue share β_j^V (with $j = \{H, 1\}$), when the supplier is an integrated supplier, and they receive a revenue

[8] As shown in appendix A.I.ii, due to underinvestment, this profit level is lower than it would be with complete contracts.

share β_j^O, when the supplier is an outsourced supplier. The supplier receives the residual $\left(1-\beta_j^V\right)$ or $\left(1-\beta_j^O\right)$, respectively. Since the producer and supplier 1 have better property rights over their supplier's component input in case of integration than in case of outsourcing, their revenue share is higher when the supplier is integrated than when he is outsourced. Vice versa, the supplier's revenue share is higher under outsourcing than under integration $\left(\beta_j^V > \beta_j^O \Leftrightarrow \left(1-\beta_j^O\right) > \left(1-\beta_j^V\right)\right)$.

Supplier 1's organizational decision I first consider supplier 1's decision on the organizational form of his supplier, supplier 2. To derive supplier 1's optimal revenue share, I differentiate supplier 1's profit (as given in equation (5.8)) with respect to β_1 and solve for β_1:

$$\beta_1^{sim} = \frac{\sqrt{b_1^{sim}} - \left(2\eta_1\left[1-\rho\left(\left[1-\eta_H\right]\left[1-\eta_1\right]+\eta_H\right)\right]+\rho\eta_H\right)}{2\left(\left[1-2\eta_1\right]\left[1-\rho\eta_H\right]\right)} \tag{5.11}$$

$$\text{with}\quad b_1^{sim} = \left(2\eta_1\left[1-\rho\left(\left[1-\eta_H\right]\left[1-\eta_1\right]+\eta_H\right)\right]+\rho\eta_H\right)^2 + 4\eta_1\left(1-2\eta_1\right)\left(1-\rho\eta_H\right)\left(1-\rho\left[1-\eta_1\right]\left[1-\eta_H\right]\right).$$

The black lines in figure 5.2 illustrate this optimal revenue share β_1^{sim} with respect to η_1 for different values of η_H. The revenue share in case of outsourcing (β_1^O) is depicted as gray, solid line and the revenue share in case of integration (β_1^V) as gray, dashed line.

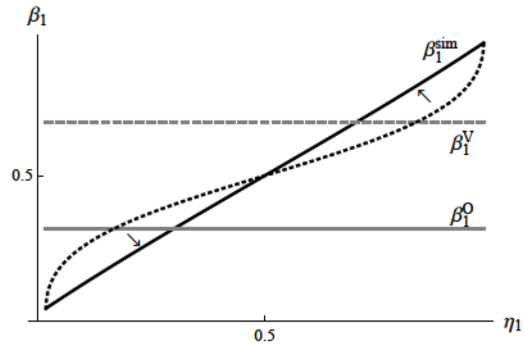


Figure 5.2: Optimal revenue share of supplier 1 with simultaneous production for varying input intensity.
Black, dotted line: low values of η_H. Black, solid line: high values of η_H.

In the following, I analyze the effect of changes of supplier 1's input intensity and of the headquarter-intensity on this optimal revenue share. In the main text I only discuss the economic intuition, the details are relegated to appendix A.II.i.a.

As both black lines in figure 5.2 are upward sloping, figure 5.2 illustrates that the optimal revenue share is an increasing function of supplier 1's input intensity η_1. Analytically,

$$\frac{\partial \beta_1^{sim}}{\partial \eta_1} > 0. \tag{5.12}$$

In line with Antràs and Helpman (2004), a higher importance of supplier 1's input for the manufacturing input implies a higher relevance of supplier 1's own underinvestment problem such that the optimal revenue share rises. I then compare this optimal revenue share with the revenue shares in case of integration and in case of outsourcing illustrated in figure 5.2: Since supplier 1's revenue share is higher when supplier 2 is integrated than when he is outsourced, I find that for low values of η_1, β_1^{sim} is closer to β_1^O such that outsourcing of supplier 2 is chosen. For high values of η_1, β_1^{sim} is closer to β_1^V such that integration of supplier 2 is chosen. Intuitively, the respective more important supplier's underinvestment problem is minimized by assigning him a revenue share as high as possible. The resulting organizational decision with respect to the input intensity η_1 for different parameter constellations is depicted in figure 5.3.

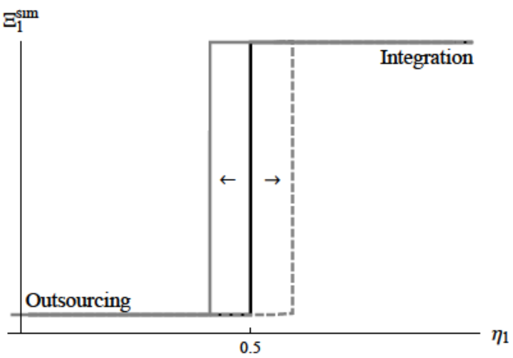


Figure 5.3: Organizational decision of supplier 1 with simultaneous production for varying input intensity.
Black line: $\beta_1^O = 1 - \beta_1^V$. Gray, solid line: $\beta_1^O < 1 - \beta_1^V$. Gray, dashed line: $\beta_1^O > 1 - \beta_1^V$.

The different parameter constellations are depicted by different color gradations. In all constellations outsourcing is chosen for low values of η_1 and integration is chosen for high values of η_1, however, the level of the input intensity at which the change from outsourcing to integration occurs (the "cutoff input intensity" η_1^{cf}) is subject to variation. The level of this cutoff input intensity depends on the level of the revenue shares β_1^V and β_1^O: The black line in figure 5.3 depicts the organizational decision for the special case of balanced revenue shares, i.e., when β_1^O and β_1^V are located equidistantly around $\beta_1^{sim}(\eta_1 = 1/2) \approx 1/2$[9]. As illustrated, in this case the cutoff input intensity η_1^{cf} is equal to 1/2. Once there is an imbalance in the revenue shares, η_1^{cf} deviates from 1/2. A higher β_1^V or β_1^O ($\beta_1^O > \left(1-\beta_1^V\right)$) increases, ceteris paribus, the range in which β_1^{sim} is closer to β_1^O and in which thus outsourcing prevails. As a result, the cutoff input intensity rises and $\eta_1^{cf} > 1/2$. This is illustrated by the gray, dashed line in figure 5.3. Vice versa, a lower β_1^V or β_1^O ($\beta_1^O < \left(1-\beta_1^V\right)$) reduces the range in which β_1^{sim} is closer to β_1^O such that outsourcing is less prevalent. In this case, the cutoff input intensity falls: $\eta_1^{cf} < 1/2$ (gray, solid line in figure 5.3).

Since I am especially interested in the interrelations of the producer's and supplier 1's organizational decision, I analyze the effect of changes of η_H on β_1^{sim} and, thus, on supplier 1's organizational decision. In figure 5.2, the effect of an increase of the headquarter-intensity η_H on the optimal revenue share is ambigious: If $\eta_1 < 1/2$, the black, dotted line that indicates a low η_H runs above the black, solid line that stands for a high η_H, and vice versa if $\eta_1 > 1/2$. In accordance with this graphical observation, the derivation of β_1^{sim} with respect to η_H depends on the level of η_1:

$$\frac{\partial \beta_1^{sim}}{\partial \eta_H} \begin{cases} < 0, & \text{if } \eta_1 < \frac{1}{2} \\ > 0, & \text{if } \eta_1 > \frac{1}{2}. \end{cases} \tag{5.13}$$

More precisely, for $\eta_1 < 1/2$, a rise of the headquarter-intensity leads to a decrease of the revenue share, whereas for $\eta_1 > 1/2$, this leads to an increase of the revenue share. A rise of η_H implies a lower importance of the whole manufacturing input for the production process. As a result, both suppliers' input provisions decrease (see equation (5.5)). To provide an incentive for the respective more important supplier, he should receive a larger optimal revenue share, i.e., for low values of supplier 1's input intensity, supplier 2 should receive a higher revenue share and for high values of supplier 1's input intensity, supplier 1 should receive a higher revenue share. With regard to the organizational decision this finding implies that for $\eta_1 < 1/2$, a rise of η_H makes outsourcing more likely, and that for $\eta_1 > 1/2$, a rise of η_H makes integration more likely.

Since in the case of balanced revenue shares the cutoff input intensity η_1^{cf} equals 1/2, there is thus no effect of η_H on this cutoff intensity. Hence, in this case the producer's importance for the production has no effect on supplier 1's organizational decision. However, with imbalanced revenue shares, η_1^{cf} differs from 1/2 and, thus, varies with η_H. η_H has a counteracting, alleviating effect. More precisely, if β_1^V or β_1^O are higher such that outsourcing becomes more likely, $\eta_1^{cf} > 1/2$ and is thus in the range of η_1 where a rise of η_H shifts the optimal revenue share upwards. To give the more important supplier 1 more incentives, integration becomes more likely. In

[9] Since $\beta_1^{sim}(\eta_1 = 1/2)$ is indeterminate, knowing that $\partial\beta_1^{sim}/\partial\eta_1 > 0$, I can approximately determine $\beta_1^{sim}(\eta_1 = 1/2)$ using $1/2\left[\beta_1^{sim}(\eta_1 = 0.51) + \beta_1^{sim}(\eta_1 = 0.49)\right] = 1/2$.

contrast, if β_1^V or β_1^O are lower and integration becomes more likely, η_1^{cf} is smaller than 1/2. For $\eta_1 < 1/2$, a shift of η_H makes outsourcing more likely.[10]

I can summarize my findings as following:

PROPOSITION 1 *For low values of the input intensity η_1, supplier 1 chooses outsourcing of supplier 2. For high values of η_1, integration is profit-maximizing. The cutoff input intensity η_1^{cf} which induces the change in supplier 1's organizational decision depends on the level of the revenue shares β_1^O and β_1^V, and on η_H.*

i. If β_1^O and β_1^V are balanced, i.e., $\beta_1^O = 1-\beta_1^V$, η_1^{cf} is equal to 1/2 - independent from the level of the headquarter-intensity η_H.

ii. With imbalanced revenue shares β_1^O and β_1^V ($\beta_1^O \neq 1-\beta_1^V$), the cutoff input intensity η_1^{cf} differs from 1/2 and varies with the level of η_H.

A higher revenue share β_1^O or β_1^V raises, ceteris paribus, the probability of outsourcing. A higher headquarter-intensity reduces the probability of outsourcing.

A lower revenue share β_1^O or β_1^V reduces, ceteris paribus, the probability of outsourcing. A higher headquarter-intensity raises the probability of outsourcing.

The producer's organizational decision In the next step, I consider the producer's decision in the first stage of the game on the organizational form of her direct supplier, supplier 1. I again first derive the optimal revenue share[11] and differentiate the producer's profit (given by (5.10)) with respect to β_H and solve for β_H:

$$\beta_H^{sim} = \tag{5.14}$$

$$\frac{\eta_1 + (2-\eta_1)\,\eta_H\,(1-\rho\,(1-\eta_H)) + \beta_1\,(1-2\eta_1)\,(1-\eta_H)\,(1+\rho\eta_H)\,\sqrt{(1-\eta_H)\,\sqrt{b_H^{sim}}}}{2\,(\eta_H - (1-\eta_H)\,((1-\eta_1) - \beta_1\,(1-2\eta_1)))}$$

with $\quad b_H^{sim} = \left(4\,(1-\rho)\,\eta_H + (1-\eta_H)\,(\eta_1 + \rho\,(2-\eta_1)\,\eta_H + \beta_1\,(1-2\eta_1)\,(1-\rho\eta_H))^2\right).$

[10] An alternative approach to determine supplier 1's profit-maximizing organizational decision that leads to the same results is to compare the profits in case of outsourcing and integration. Integration is chosen whenever holds

$$\pi_1^{sim\,V} > \pi_1^{sim\,O} \;\Leftrightarrow\; \left[\frac{\beta_1^{V\,\eta_1}\left(1-\beta_1^V\right)^{1-\eta_1}}{\beta_1^{O\,\eta_1}\left(1-\beta_1^O\right)^{1-\eta_1}}\right]^{\frac{\rho(1-\eta_H)}{1-\rho}} \frac{1-\rho\,(1-\eta_H)\left[\beta_1^V\eta_1 + \left(1-\beta_1^V\right)(1-\eta_1)\right]}{1-\rho\,(1-\eta_H)\left[\beta_1^O\eta_1 + \left(1-\beta_1^O\right)(1-\eta_1)\right]} > 1.$$

[11] Note that the residual revenue share supplier 1 receives is the whole suppliers' revenue share that is distributed between the two suppliers. In the end, supplier 1 receives only a fraction $\beta_1 \cdot (1-\beta_H)$ of the revenue.

In figure 5.4, I depict this optimal revenue share β_H^{sim} (black lines) subject to a variation of η_H for given values of η_1.[12] The gray, solid line depicts the producer's revenue share in case of outsourcing (β_H^O) and the gray, dashed line depicts the producer's revenue share in case of integration (β_H^V).

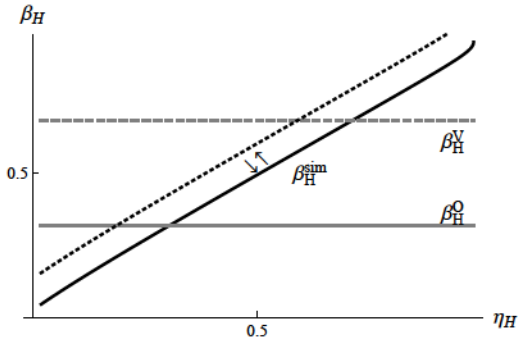


Figure 5.4: Optimal revenue share of the producer with simultaneous production for varying headquarter-intensity.
Black, dotted line: low or high values of η_1. Black, solid line: intermediate values of η_1.

Analyzing the effects of changes of η_H and η_1 on the producer's optimal revenue share, I find that (for the concrete derivatives see appendix A.II.i.b)

$$\frac{\partial \beta_H^{sim}}{\partial \eta_H} > 0. \tag{5.15}$$

As the producer's revenue share is higher for integration than for outsourcing, a higher headquarter-intensity makes integration more likely. The resulting organizational decision is depicted in figure 5.5.

Analogously to figure 5.3, the different color gradations in figure 5.5 stand for different paramter constellations of β_H^O and β_H^V. They differ with regard to the level of headquarter-intensity (the "cutoff headquarter-intensity" η_H^{cf}) at which the change from outsourcing to integration arises. The black line represents the organizational

[12] β_H^{sim} depends on the revenue share supplier 1 receives (β_1). Since it depends not only on η_H and η_1, but also on the level of β_1^O and β_1^V, whether β_1 is equal to β_1^O or to β_1^V, I have to make an assumption about the level of these revenue shares. Since with balanced revenue shares, supplier 1's organizational decision is independent from the importance of the producer, I assume for simplicity that $\beta_1^O = \left(1 - \beta_1^V\right)$ holds such that - following proposition 1 - supplier 1 chooses $\beta_1 = \beta_1^O$ if $\eta_1 < 1/2$ and $\beta_1 = \beta_1^V$ if $\eta_1 > 1/2$. In this case, I can clearly see whether the producer's decision depends on the two suppliers' input intensities. For robustness, I provide in appendix A.II.i.c the results for $\beta_1^O > \left(1 - \beta_1^V\right)$.

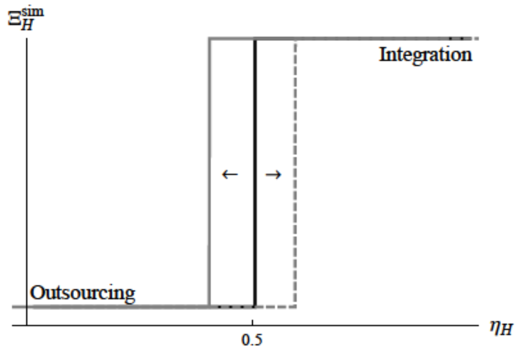


Figure 5.5: Organizational decision of the producer with simultaneous production for varying headquarter-intensity.
Black line: $\beta_H^O = 1 - \beta_H^V$. Gray, solid line: $\beta_H^O < 1 - \beta_H^V$. Gray, dashed line: $\beta_H^O > 1 - \beta_H^V$.

decision for balanced revenue shares $\beta_H^O = 1 - \beta_H^V$. In this case, η_H^{cf} is equal to $1/2$. As for the decision of supplier 1, with imbalanced revenue shares, the higher is β_H^O or β_H^V, the higher is η_H^{cf} (gray, dashed line) and, thus, the more likely becomes outsourcing, and vice versa for a lower β_H^O or β_H^V (gray, solid line).

To determine the interdependencies of the producer's and supplier 1's organizational decisions, I analyze in the next step the effect of supplier 1's input intensity η_1 on β_H^{sim} and on the producer's organizational decision. Figure 5.4 illustrates that the black, dotted line that represents intermediate values of η_1 runs for all values of η_H above the black, solid line that depicts low or high values of η_1. Thus, interestingly, the derivation of β_H^{sim} with respect to η_1 is independent from the level of the headquarter-intensity:

$$\frac{\partial \beta_H^{sim}}{\partial \eta_1} \begin{cases} < 0, & \text{if } \eta_1 < \frac{1}{2} \\ > 0, & \text{if } \eta_1 > \frac{1}{2}. \end{cases} \tag{5.16}$$

It is negative if $\eta_1 < 1/2$ and positive if $\eta_1 > 1/2$. The intuition for this finding is the following: If η_1 rises, the importance of headquarter services for the production remains constant, however, the suppliers' investment incentives change. Since the producer anticipates supplier 1's organizational decision with respect to supplier 2, he also anticipates the effects of these changes. If $\eta_1 < 1/2$, supplier 1 chooses outsourcing of supplier 2 and receives a smaller fraction of the suppliers' revenue share than supplier 2: $\beta_1^O < \left(1 - \beta_1^O\right)$. Thus, if η_1 rises, supplier 1's input provision increases, however, it increases less than supplier 2's input provision decreases. As a result, the level of the manufacturing input and, thus, the revenue level would decrease. To avoid this, the producer wants to strengthen the suppliers' production incentives by assigning them a larger share of the revenue.

Contrary, if $\eta_1 > 1/2$, supplier 1 chooses integration of supplier 2 and his fraction of the suppliers' revenue share is higher than supplier 2's fraction: $\beta_1^V > \left(1-\beta_1^V\right)$. An increase of η_1 then leads to a higher increase of supplier 1's input provision than the decrease of supplier 2's input provision. As a result, the level of the manufacturing input and the revenue level increase and it is not so important for the producer to incentivize the suppliers. Instead, she can assign herself a larger share of the revenue. As a result, if $\eta_1 < 1/2$, a higher input intensity of supplier 1 makes outsourcing more likely, and if $\eta_1 > 1/2$, a higher input intensity of supplier 1 makes integration more likely. Since an increase of η_1 first increases and then decreases the prevalence of outsourcing, and, thus, the cutoff headquarter-intensity, outsourcing is most prevalent for $\eta_1 = 1/2$, i.e., when the suppliers are equally important for the manufacturing input. The higher is the asymmetry in the suppliers' input intensities, the less prevalent becomes outsourcing.

Summing up, due to the producer's anticipation of supplier 1's organizational decision and of the effects of her own decision on the suppliers, the cutoff headquarter-intensity η_H^{cf} varies even with balanced revenue shares:[13]

PROPOSITION 2 *For low values of the headquarter-intensity, the producer chooses outsourcing of supplier 1 and for high values of the headquarter-intensity, she chooses integration. The cutoff headquarter-intensity η_H^{cf} at which the change in the producer's organizational decision arises, depends on the level of η_1: With balanced revenue shares, outsourcing of supplier 1 becomes more likely, the more similar are the suppliers in their importance for the manufacturing input.*[14]

Interrelation of the producer's and supplier 1's organizational decisions
To illustrate the interrelation of the organizational decisions with simultaneous production, I combine the producer's and supplier 1's decision in one figure: Figure 5.6 illustrates the resulting combined organizational decisions of both the producer (Ξ_H^{sim}) and supplier 1 (Ξ_1^{sim}) under the assumption of balanced revenue shares of supplier 1 as $\Xi^{sim} = \{\Xi_H^{sim}, \Xi_1^{sim}\}$. "O" denotes outsourcing of the respective supplier

[13] The producer's profit-maximizing organizational decision on supplier 1 is the same when comparing the profits in case of outsourcing with those in case of integration. Integration is chosen if $\pi_H^V > \pi_H^O$, i.e., if

$$\left[\frac{\beta_H^{V\,\eta_H}\left(1-\beta_H^V\right)^{1-\eta_H}}{\beta_H^{O\,\eta_H}\left(1-\beta_H^O\right)^{1-\eta_H}}\right]^{\frac{\rho}{1-\rho}} \frac{1-\rho\left[\left(1-\beta_H^V\right)\left(1-\eta_H\right)\left[\left(1-\beta_1\right)\left(1-\eta_1\right)+\beta_1\eta_1\right]+\beta_H^V\eta_H\right]}{1-\rho\left[\left(1-\beta_H^O\right)\left(1-\eta_H\right)\left[\left(1-\beta_1\right)\left(1-\eta_1\right)+\beta_1\eta_1\right]+\beta_H^O\eta_H\right]} > 1.$$

[14] If β_1^O and β_1^V are imbalanced, it depends on the distance of supplier 1's input intensity to η_1^{cf} whether integration or outsourcing is chosen.

and "V" stands for integration. On the horizontal axis, I display the headquarter-intensity η_H and on the vertical axis, I display the input intensity η_1.

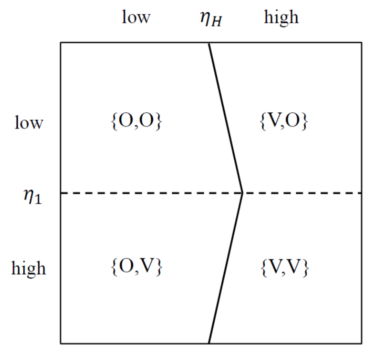


Figure 5.6: Organizational decisions of the producer and supplier 1 with simultaneous production.

As figure 5.6 shows, there result four different combined organizational decisions: $\{O, O\}$, $\{O, V\}$, $\{V, O\}$ and $\{V, V\}$. The organizational decision of supplier 1 depends on the level of input intensity: If η_1 is low, supplier 1 chooses outsourcing and if η_1 is high, he chooses integration of supplier 2. Since the black, dashed separating line does not vary with the level of η_H, figure 5.6 illustrates that supplier 1's decision is solely driven by η_1. The organizational decision of the producer is a function of the headquarter-intensity: For low values of η_H, i.e., if η_H is to the left of the black, solid line, the producer chooses outsourcing of supplier 1. Vice versa, for high values of η_H, i.e., if η_H is to the right of this line, the producer chooses integration. In contrast to the separating line of the input intensity, the line that separates low and high values of the headquarter-intensity is not straight but curved: The more similar are the suppliers in their importance, the more is the line tilted to the right. As a result, the range in which the producer chooses outsourcing of supplier 1 increases. Using proposition 1 and 2, I can summarize my findings for the case of simultaneous production as follows:

PROPOSITION 3 *Assuming simultaneous production and balanced revenue shares of supplier 1, the producer's decision depends on supplier 1's importance for the manufacturing input, however, the organizational decision of supplier 1 is solely driven by the two suppliers' input intensities and is independent from the producer's importance for the production. In particular, a higher similarity of the suppliers' input intensities drives outsourcing of supplier 1.*

Hence, both the producer's and supplier 1's organizational decisions depend on their own importance for the production relative to the importance of the supplier.

This incentive effect is in line with the result of Antràs and Helpman (2004) with one supplier where the respective more important player should be assigned better production incentives. However, beyond that, in my model, the producer's decision depends on the level of the suppliers' input intensities, i.e., on the relative importance of the suppliers for the manufacturing component. Since these input intensities are not part of the producer's relation to her supplier, the producer's decision is driven by factors that are out of the scope of the producer. Put differently, the suppliers' relative importance affects the organizational structure outside the realm of the suppliers.

5.4 Sequential production

So far, analyzing a simultaneous production process, I have shown the effect of the sequential bargaining structure on the organizational decisions. In the following, to analyze the effect of sequentiality of production on the organizational decisions, I assume supplier 2 to invest prior to the producer and supplier 1 such that production takes place in two stages, as described in stage 5.b above. More precisely, supplier 2 first chooses his input provision level. Afterwards, supplier 1 and the producer decide at the same time, independently from each other, on their investment levels.

5.4.1 Solution of the game

Solving by backward induction, in stage 5.2, the producer and supplier 1 first choose the input provisions that maximize their respective own profit. Their profit-maximizing input provisions are as for simultaneous production given by equation (5.5). However, in contrast to the previous analysis, the revenue R^{seq} cannot be finally determined at this stage since it depends additionally on supplier 2's input provision:

$$R^{seq} =$$

$$\left(A^{1-\rho}\left[\rho^{1-\frac{1-\phi}{\rho}}\theta_H\left(\theta_1\frac{\beta_H}{c_H}\right)^{\eta_H}\left(\left[\frac{\beta_1\left(1-\beta_H\right)}{c_1}\right]^{\eta_1}\left[\frac{m_2}{\left(1-\eta_1\right)\left(1-\eta_H\right)}\right]^{1-\eta_1}\right)^{1-\eta_H}\right]^{\rho}\right)^{\frac{1}{\phi}}$$

$$\text{with } \phi = 1-\rho\left(1-\left[1-\eta_1\right]\left[1-\eta_H\right]\right) < 1. \tag{5.17}$$

When supplier 2 decides in stage 5.1 on this input provision, he anticipates supplier 1's and the producer's input provisions and thus this revenue level and chooses $m_2^{seq} = argmax_{m_2}\left\{\left(1-\beta_H\right)\left(1-\beta_1\right)R^{seq} - c_2m_2\right\}$. This gives his profit-maximizing input provision:

$$m_2^{seq} = \frac{\rho\,(1-\eta_H)\,(1-\eta_1)\,(1-\beta_H)\,(1-\beta_1)\,R^{seq}}{c_2\phi} \tag{5.18}$$

$$\text{with} \quad R^{seq} = A\left[\rho\theta_H\left(\frac{\beta_H}{c_H}\right)^{\eta_H}\left(\theta_1\,(1-\beta_H)\left(\frac{\beta_1}{c_1}\right)^{\eta_1}\left(\frac{1-\beta_1}{c_2\phi}\right)^{1-\eta_1}\right)^{1-\eta_H}\right]^{\frac{\rho}{1-\rho}}.$$

As shown in appendix A.I.iii, comparing supplier 2's input provision and the revenue level to those in the scenario of simultaneous production, I find that both the input provision and the revenue level are now inversely related to ϕ, i.e., they are both higher with sequential production than with simultaneous production: Since supplier 2 anticipates the producer's and supplier 1's investments, he invests more than with sequential production - independent of the revenue level. This higher investment raises the revenue and, as a result, the producer's and supplier 1's investments are higher as well.

Thus, contrary to the analysis of Antràs and Chor (2013) where the investments can be sequential complements or sequential substitutes, due to the assumed Cobb-Douglas production function, in my analysis the players' investments are always sequential complements. Thereby, it is important to note that supplier 2's input provision increases more than the input provisions of the producer and supplier 1.

Using the above equations, supplier 1's profit for sequential production can be depicted as following:

$$\pi_1^{seq} = (1-\beta_H)\left[1-\rho\,(1-\eta_H)\left[\beta_1\eta_1 + \frac{(1-\beta_1)\,(1-\eta_1)}{\phi}\right]\right]R^{seq} - \tau_1 - w_2. \tag{5.19}$$

Proceeding as in the scenario of simultaneous production gives the total payoff of the relationship:[15/16]

[15] Comparing this payoff with the payoff in the scenario of simultaneous production, there are two countervailing effects on the payoff: On the one hand, the revenue with sequential production is higher than the revenue with simultaneous production. On the other hand, due to the higher input provisions, the costs are higher as well. Since the first effect is stronger than the second one, the payoff with sequential production is higher than the payoff with simultaneous production, as illustrated in appendix A.I.iii.

[16] However, following appendix A.I.iv, the input provisions, the revenue and the profit are still lower than with complete contracts. The intuition is that there are two counteracting effects with sequential production processes: On the one hand, there is supplier 2's anticipation effect that raises the input provisions, the revenue and the profit ($\psi_{seq} > 1$). On the other hand, contract incompleteness leads to an underinvestment in terms of lower input provisions, a lower revenue and a lower payoff ($\psi_{sim} < 1$). The second, negative effect exceeds the first, positive effect such

$$\pi_H^{seq} = \left[1 - \rho \left[(1-\beta_H)(1-\eta_H)\left[\beta_1\eta_1 + \frac{(1-\beta_1)(1-\eta_1)}{\phi}\right] + \beta_H\eta_H\right]\right] R^{seq} - w_1 - w_2. \tag{5.20}$$

5.4.2 Organizational decisions

Using these profit levels, I analyze in the following the effect of sequentiality of production on the organizational decisions. Since sequentiality of production mainly changes supplier 1's organizational decision, in the main text, I only present supplier 1's organizational decision, whereas the producer's decision is presented in appendix A.II.ii.b.

Supplier 1's organizational decision Similarly to above, I start with solving for supplier 1's optimal revenue share β_1^{seq}:

$$\beta_1^{seq} = \frac{\sqrt{b_1^{seq}} - \rho\eta_1^2(1-\eta_H)(\phi+\rho) - \eta_1(2-\rho(3-\rho\eta_H))}{2(1-\rho\eta_H)(1-\eta_1(1+\phi))}$$
$$\text{with} \quad \mu = 4[1-\rho][1-\rho\eta_H][1-\eta_1(1+\phi)] \tag{5.21}$$
$$+\eta_1\left[2+\rho^2\left([1-\eta_1]\eta_1[1-\eta_H]^2+\eta_H\right)-\rho(3-\eta_1[1-\eta_H])\right]^2.$$

Figure 5.7 is analogous to figure 5.2 and depicts supplier 1's optimal revenue share with respect to η_1 for different values of η_H (black lines). Analyzing the effects of η_1 and η_H on supplier 1's optimal revenue share with sequential production, the concrete derivatives are relegated to appendix A.II.ii.a.

The crucial difference compared to the scenario of simultaneous production is the effect of the headquarter-intensity on the optimal revenue share: Contrary to the scenario of simultaneous production where the direction of the effect depends on the level of input intensity, in figure 5.7 the black, solid line that represents a high level of headquarter-intensity runs for *all* values of the input intensity above the black, dotted line that stands for a low level of headquarter-intensity. Hence,

$$\frac{\partial\beta_1^{seq}}{\partial\eta_H} > 0, \tag{5.22}$$

that in the scenario of sequential production, the input provisions, the revenue and the profit are still lower than in the case of complete contracts. Thus, sequentiality of the production process does not eliminate the underinvestment problem, however, sequentiality reduces it. This finding is in line with Zhang and Zhang (2013) who introduce sequentiality in Hart's 1995 model of one producer and one supplier bargaining about the ownership of the firm.

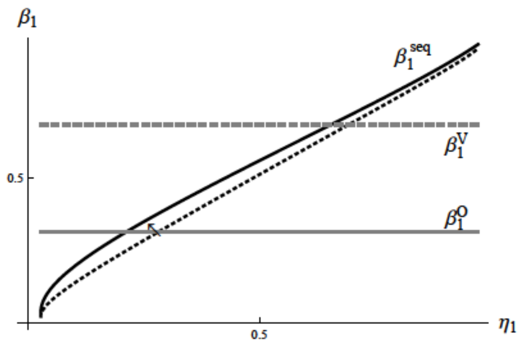


Figure 5.7: Optimal revenue share of supplier 1 with sequential production for varying input intensity.
Black, dotted line: low values of η_H. Black, solid line: high values of η_H.

which holds irrespective of η_1. The positive relation implies that a rise of the headquarter-intensity raises the optimal revenue share β_1^{seq} for all suppliers' input intensites, i.e., irrespective of which supplier is relatively more important for the production of the whole manufacturing input. The intuition is the following: A higher importance of headquarter services, i.e., a lower importance of the component for the production causes, ceteris paribus, lower input provisions of both suppliers. However, a rise of η_H increases the producer's input provision. Since supplier 2 anticipates this higher investment, a higher η_H not only reduces, but also raises supplier 2's input provision. As a result, it becomes less important to incentivize supplier 2 for the production. Instead, supplier 1's optimal revenue share β_1^{seq} increases. Thus, due to the anticipation effect of sequential production a higher headquarter-intensity makes integration for all values of the input intensity more likely.

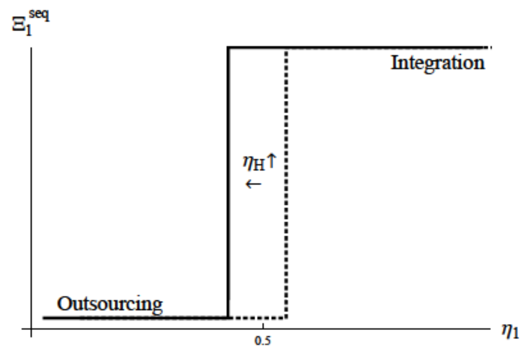


Figure 5.8: Optimal revenue share of supplier 1 with sequential production for varying input intensity.
Black, dotted line: low values of η_H. Black, solid line: high values of η_H.

Assuming balanced revenue shares, the resulting organizational decision of supplier 1 with respect to the input intensity is illustrated by the black lines in figure 5.8. As with simultaneous production, supplier 1 chooses for low values of η_1 outsourcing of supplier 2 and for high values of η_1, he chooses integration. However, in contrast to simultaneous production, the cutoff input intensity varies even with balanced revenue shares with η_H:[17] The black, dotted line that represents low values of η_H is to the right of the black, solid line that stands for high values of η_H. Since the optimal revenue share is increasing in η_H, a higher headquarter-intensity lowers the cutoff intensity η_1^{cf} and increases the range of η_1 in which supplier 1 chooses integration of supplier 2. I can summarize this result as following:

PROPOSITION 4 *With sequential production, the cutoff input intensity η_1^{cf} which induces a change in supplier 1's organizational decision varies even with balanced revenue shares with the level of η_H: The higher is η_H, the more prevalent becomes integration, i.e., the lower is η_1^{cf}.*

Interrelation of the producer's and supplier 1's organizational decisions
Figure 5.9 combines the resulting organizational decisions of the producer and supplier 1. The left panel depicts these organizational decisions once again in the scenario of simultaneous production and the right panel depicts them in the scenario of sequential production.

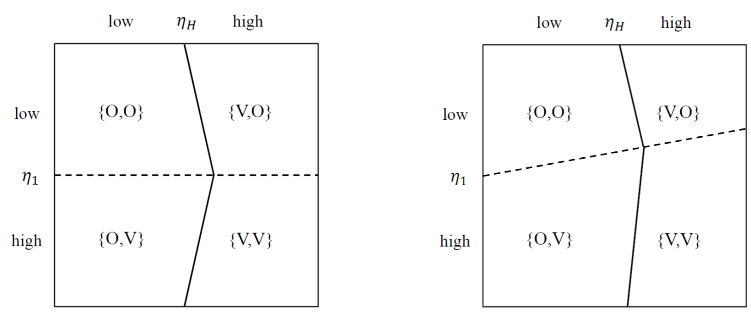


Figure 5.9: Organizational decisions of the producer and supplier 1.
Left panel: simultaneous production. Right panel: sequential production.

As illustrated in the right panel, in the scenario of sequential production, the producer's decision is still driven by η_H and η_1: If η_H is to the left of the black, solid line,

[17] This is why I assume balanced revenue shares in the simultaneous scenario. With imbalanced revenue shares, the organizational decision would also vary with simultaneous production such that the effect of sequentiality of production would not be as clear as with balanced revenue shares.

the producer chooses outsourcing of supplier 1 and if η_H is to the right of this line, she chooses integration.[18] The crucial difference concerns supplier 1's decision: If η_1 is above the black, dashed line, supplier 1 still chooses outsourcing of supplier 2 and if η_1 is below this line, he chooses integration. However, with sequentiality of production, the separating line of the input intensity varies with the level of η_H. More precisely, the line is rotated upwards with an increase of the headquarter-intensity. As a result, the higher is η_H, the more likely becomes integration. Proposition 5 then follows.

PROPOSITION 5 *With sequential production, due to the anticipation effect, supplier 1's organizational decision is no longer solely driven by his input intensity but also depends on the producer's importance for the production such that the two decisions are interrelated.*

Due to supplier 2's anticipation of the producer's and supplier 1's investment levels, the producer's and supplier 1's decisions are interrelated in the sense that a higher headquarter-intensity not only increases the probability that the producer chooses integration of supplier 1, but it also raises the probability that supplier 1 chooses integration of his own supplier 2. Vice versa, a lower headquarter-intensity increases the probability of outsourcing for both suppliers. Because of this anticipation effect the producer's relevance for the production affects organizational decisions outside the realm of the producer. In other words, supplier 1's decision depends on factors that are outside the scope of the two suppliers' relation and that only directly influence the relation of the producer and supplier 1.

5.5 Setup without participation fees

My model differs from the one by Antràs and Chor (2013) not only in terms of the bargaining structure, but also with respect to the profits that are maximized.[19] In their baseline setup, they assume the producer to maximize her *own* profit. In contrast, as in Antràs (2003), Antràs and Helpman (2004) or Schwarz and Suedekum (2014), in my model, I assume participation fees such that the respective *joint* profit is maximized. Therefore, I analyze in the following a setup without participation

[18] More precisely, as illustrated in appendix A.II.ii.b, for low values of ρ, a higher input intensity first tilts the separating line to the right and then it is tilted back to the left. However, contrary to my findings in the simultaneous scenario, for high values of ρ, it is always tilted to the right when the input intensity increases - independent of the level of η_1.

[19] In addition, I only consider two suppliers instead of a continuum of suppliers and focus on the complements case only whereas they distinguish between complements and substitutes. These differences are discussed in the next section.

fees, similar to Antràs and Chor (2013). In doing so, I only present the central results in the main text, the details are depicted in appendix A.III.

With simultaneous production, supplier 1's optimal revenue share is given by

$$\beta^{sim}_{1,wo} = \eta_1 + \frac{(1-\rho)(1-\eta_1)}{1-\rho\eta_H}. \tag{5.23}$$

Contrary to the results of simultaneous production with participation fees, this optimal revenue share is for all values of η_1 increasing in the headquarter-intensity. Intuitively, a higher importance of headquarter services lowers both suppliers' investment incentives. As supplier 1 only considers his own payoff and not the joint payoff with supplier 2, he can no longer retain (part of) supplier 2's profit. As a result, he no longer assigns a higher revenue share to the more important supplier. Instead, he has an incentive to always assign himself a higher revenue share. A higher headquarter-intensity then increases the probability of integration even with simultaneous production - independent of the level of the revenue shares in case of integration and of outsourcing, i.e., independent of whether revenue shares are balanced or not. More interestingly, the effect of a higher headquarter-intensity on the revenue share is positively related to the level of the headquarter-intensity such that a higher headquarter-intensity leads to an overproportional higher probability of integration.

The producer's optimal revenue share is

$$\beta^{sim}_{H,wo} = 1 - \rho(1-\eta_H). \tag{5.24}$$

Interestingly, in contrast to the constellation with participation fees, $\beta^{sim}_{H,wo}$ is independent from η_1. The intuition is that the importance of supplier 1 relative to supplier 2 only directly affects the two suppliers' investment incentives and has no direct impact on the producer's input provision. Since the producer no longer can retain the suppliers' profit but maximizes his own profit, he does not consider the effect of his decision on the two suppliers' relation.

With sequential production, the optimal revenue shares of supplier 1, $\beta^{seq}_{1,wo}$, and the producer, $\beta^{seq}_{H,wo}$, are identical to the optimal revenue shares with simultaneous production. The intuition for this finding is that with sequential production both the producer's and supplier 1's input provisions and the revenue are increasing to the same extent. In contrast, with participation fees and joint payoff maximizing, the optimal revenue share supplier 1 chooses takes supplier 2's disproportionate higher input provision into account and this also affects the producer's optimal revenue share.

Summing up, without participation fees, a higher headquarter-intensity makes integration of supplier 2 even with simultaneous production more likely. Sequentiality of production has no effect on the revenue shares and, thus, the producer's and supplier 1's organizational decisions.

5.6 Discussion and comparison with Antràs and Chor (2013)

Comparing my results for sequential production with those of Antràs and Chor (2013), it is important to note that they consider a measure one of production stages (and thus suppliers), whereas I only assume two suppliers. Adopting their notation of "upstream" and "downstream" stages, each stage comprises only one supplier: Supplier 2 is the upstream supplier and supplier 1 is the downstream supplier. As a result, I cannot make a statement about the range of stages that are vertically integrated/outsourced, but only about the probability of integration/outsourcing within a given stage.

In addition, whereas Antràs and Chor (2013) distinguish between complements and substitutes, in my setup, the inputs are always complements. For complements, their model predicts outsourcing of the upstream supplier [2] and integration of the downstream supplier [1]. I obtain this organizational structure if the headquarter-intensity is high and the input intensity is low. Beyond this result, my model generates in dependence of the level of the headquarter-intensity and the level of the input intensity all four combinations of organizational forms. If the headquarter-intensity is low and the input intensity is high, I even observe integration of the upstream supplier and outsourcing of the downstream supplier, a result that arises in their model only for the case of substitutes.

Antràs and Chor (2013) find a positive relationship between the headquarter-intensity and the range of stages that are integrated. In line with their finding, due to supplier 2's anticipation of the producer's and supplier 1's investment, I find that a higher headquarter-intensity increases the probability of integration in *all* stages, i.e., for both supplier 1 and supplier 2: Since with sequential production the decision of supplier 1 is interrelated to the producer's decision, a rise of η_H makes integration in both the upstream stage and the downstream stage more likely - despite the decision on the organizational decision of the upstream supplier is outside the realm of the producer. This relation persists if I consider a setup without participation fees, similar to Antràs and Chor (2013).

In one of their extensions, Antràs and Chor (2013) consider their suppliers to differ not only with respect to their level of downstreamness but also by a term Ψ (and the level of unit costs). This term Ψ is related to my input intensity η_1 since it is assumed to cover differences in the effects of the suppliers' inputs on the output level.

However, in their model, the decision whether the upstream/downstream stages are integrated or outsourced depends as in their baseline setup only on whether the inputs are complements or substitutes. This is contrary to my finding that the level of η_1 affects the organizational decisions of both the producer and supplier 1. In other words, in my model, there is an additional incentive effect. The dependency of the organizational decisions from η_1 persists in a setup without participation fees. There, the level of η_1 no longer affects the organizational decision of the producer, however, it still drives the organizational decision of supplier 1. Thus, since my results also depend on the two suppliers' relative importance, the headquarter-intensity does not definitely pin down the degree of integration of the whole value chain. For high values of the headquarter-intensity, the producer chooses integration of supplier 1. However, there are two counteracting effects with regard to supplier 2's organizational form: The anticipation effect and the incentive effect. Supplier 2's anticipation of the investment level makes integration of supplier 2 more likely, however, a higher importance of supplier 2 makes outsourcing more likely. If supplier 2 is much more important than supplier 1, the incentive effect is stronger than the anticipation effect such that supplier 2 is still outsourced. As a result, there is no (completely) integrated value chain.

Thus, in contrast to Antràs and Chor (2013), in my bargaining setup, both the producer's importance *and* the suppliers' relative importance are crucial for the degree of integration within a value chain.

Predictions of the organizational decisions Structuring the organizational decisions of the producer and supplier 1, I can derive predictions about firms' organizational decisions. Contrary to Antràs and Chor (2013), due to my model setup, these predictions do not hinge on the elasticity of substitution that is hard to measure empirically. Instead, my predictions are driven by the level of headquarter-intensity and of input intensity. Even though the headquarter-intensity and the input intensity cannot directly be observed, several empirical investigations of the property rights theory have shown that such an intensity can be measured by capital intensity, skill intensity or R&D intensity (see for an overview Antràs, 2014).

In my model, outsourcing of both suppliers ($\{O, O\}$) arises when the headquarter-intensity and the input intensity are low, i.e., when the manufacturing component is important for the production of the final good and supplier 2's input is important for the manufacturing component. Thus, I expect to find such a disintegrated value chain when the lowest stage of the value chain has the highest content for the production.

Outsourcing of the downstream supplier and integration of the upstream supplier ($\{O, V\}$) occurs when the headquarter-intensity is low and the input intensity is high, i.e., when the manufacturing component is important for the production of the final good but supplier 2's input is not so important for the manufacturing component. As a result, hybrid sourcing of the suppliers with outsourcing of the downstream stage should arise in value chains where the downstream supplier has the highest content in the value chain.

In contrast, when the headquarter-intensity is high and the input intensity is low, i.e., when headquarter services are important for the production of the final good but supplier 2's input is important for the manufacturing component, integration of the downstream supplier and outsourcing of the upstream supplier ($\{V, O\}$) is chosen. Such a controlling interest of the producer should thus arise in value chains where the producer has the highest content but the upstream supplier is also important.

Integration of both suppliers ($\{V, V\}$) arises, when both the headquarter-intensity and the input intensity are high, i.e. when headquarter services are more important for the production of the final good and supplier 2's input is not so important for the manufacturing component. I expect such an integrated value chain thus when the producer has the highest content but his downstream supplier is relatively more important for the manufacturing component.

Overall, my results predict that firms with a higher headquarter-intensity are more likely to have integrated downstream *and* upstream suppliers. The higher is the input intensity, i.e., the more important is the downstream supplier, the higher is the probability of an integrated upstream supplier. However, there is no clear effect of the input intensity on the organizational form of the downstream supplier. More precisely, with participation fees, for low values of the input intensity, a higher input intensity implies a higher probability of an outsourced downstream supplier and vice versa for high values of the input intensity. However, as discussed above, this only holds for low values of ρ. As shown in appendix A.II.ii.b, for high values of ρ, a higher input intensity always increases the probability of outsourcing. In addition, without participation fees, there is no effect of the suppliers' input intensities on the organizational form of the downstream supplier.

5.7 *Apple* or *smart*?

So far, I have derived predictions about the organizational decisions along the whole value chain in a setup where the producer only decides on the organizational form of her direct supplier, i.e., in terms of the examples of the introduction for the *smart* structure. Alternatively, as analyzed by Antràs and Chor (2013), the producer could decide on the organizational form of all suppliers along the value chain (the *Apple* structure). In the next step, I extend my analysis and assume firms to be able to decide on their decision structure, and derive predictions about these decisions.

More precisely, I analyze for different parameter constellations whether firms have higher profits as *Apple* or *smart*.

To make this decision, I first derive the profit for the *Apple* structure under the assumed Cobb-Douglas production function. In doing so, to facilitate the analysis, I assume a setup without participation fees, as in Antràs and Chor (2013). I then compare this profit level with the corresponding profit level of sequential production under the *smart* structure as given by (A5.38).[20]

In the *Apple* setup, as depicted in the left panel of figure 5.1, production always takes place sequentially. In the bargaining, the producer negotiates with *each* of her two suppliers on the distribution of the respective surplus value of the relationship: The producer and supplier 2 bargain over the value of supplier 2's input contribution, i.e., about the revenue R_2 of the (unfinished) good that is increasing in the producer's productivity in using supplier 2's input, θ_{H2}. The producer and supplier 1 bargain over the surplus value of their relationship, R_{diff}, that is the difference between the total revenue and the revenue of supplier 2's input provision: $R_{\text{diff}} = R_{12H} - R_2$. The level of the total revenue and, thus, the revenue difference is higher, the higher is the productivity of the producer in combining the inputs to the final good, θ_H. To avoid confusion with the revenue shares of the *smart* structure, I denote the producer's revenue share in the bargaining with supplier 1 as β_{H1} and in the bargaining with supplier 2 as β_{H2}, whereby supplier 1 or supplier 2, respectively, receive the residual revenue share. The resulting profit level of the producer for the *Apple* structure is given by

$$\begin{aligned}\pi_H^{Apple} &= \beta_{H1} R_{\text{diff}}^{Apple} + \beta_{H2} R_2^{Apple} - c_H h^{Apple} \\ &= \beta_{H1}\left(1-\rho\eta_H\right) R_{12H}^{Apple} + \left(\beta_{H2}-\beta_{H1}\right) R_2^{Apple},\end{aligned} \tag{5.25}$$

whereas the producer's profit in the *smart* case is

$$\pi_H^{smart} = \pi_{H,wo}^{seq} = \beta_H R^{seq} - c_H h^{seq} = \beta_H \left(1-\rho\eta_H\right) R^{seq}. \tag{5.26}$$

The total relative profit π_{rel} is then given as following:

$$\pi_{\text{rel}} = \frac{\pi_H^{Apple}}{\pi_H^{smart}} \tag{5.27}$$

$$= \frac{1}{\beta_H\left(1-\rho\eta_H\right)} \left(\frac{\frac{(1-\beta_{H2})\theta_{H2}}{c_2}}{\theta_H \left(\frac{\beta_H}{c_H}\right)^{\eta_H} \left(\theta_1\left(1-\beta_H\right)\left(\frac{\beta_1}{c_1}\right)^{\eta_1}\left(\frac{1-\beta_1}{c_2\phi}\right)^{1-\eta_1}\right)^{1-\eta_H}} \right)^{\frac{\rho}{1-\rho}} (\beta_{H2}+$$

[20] Technology and demand, the detailed game structure and the solution of the game are relegated to appendix A.IV.

$$\beta_{H1}\left((1-\rho\eta_H)\left(\left(\frac{\left(\frac{\beta_{H1}}{c_H}\right)^{\eta_H}\left(\frac{1-\beta_{H1}}{c_1}\right)^{\eta_1(1-\eta_H)}}{\left(\frac{(1-\beta_{H2})\theta_{H2}}{c_2}\right)^{\eta_1(1-\eta_H)+\eta_H}((1-\eta_1)(1-\eta_H))^{(1-\eta_1)(1-\eta_H)}}\right)^{\frac{\rho}{\phi}}-1\right)\right).$$

In dependence on the values of the different parameters, this relative profit can be lower or higher than 1. In the following, I analyze the effect of changes of the parameters on the relative profit level. Thereby, I relegate the derivations to appendix A.IV.iv and only discuss the economic intuition of the main results in this section.[21] Before going into detail, note that due to the assumed Cobb-Douglas production function, the revenue difference R_{diff} may be negative if θ_{H2} is higher than θ_H and, hence, the results may be distorted. To circumvent this problem, I assume that θ_{H2} is relatively lower than θ_H, i.e., I assume the producer to be much less productive in using supplier 2's input than in producing the final good.[22]

Analyzing the effect of parameter changes under this assumption, I find that a higher productivity of supplier 1 in using supplier 2's input decreases the relative profit:

$$\frac{\partial\pi_{\text{rel}}}{\partial\theta_1} < 0. \tag{5.28}$$

The intuition is that a higher productivity of supplier 1 in producing the whole manufacturing input raises under the *smart* structure, ceteris paribus, the amount of the whole manufacturing input and, as a result, the revenue and the profit are higher as well. On the contrary, this productivity has no effect on the profit level in the *Apple* case. As a result, the *smart* structure becomes more likely.

A higher productivity of the producer in combining the inputs to the final good also makes the *smart* structure more likely:

$$\frac{\partial\pi_{\text{rel}}}{\partial\theta_H} < 0. \tag{5.29}$$

This is because in the *smart* case the producer's and both suppliers' input provisions are increasing in the producer's productivity in combining all inputs to the final good, whereas in the *Apple* case supplier 2's input provision instead depends on the producer's productivity to use only this input.

[21]Since I cannot determine the sign of the derivations analytically, I provide, on request, a MATHEMATICA 9.0 file in which I graphically illustrate the sign under the assumption of profit-maximizing organizational decisions.

[22] Without this assumption, there are outliers with regard to the sign of the derivations.

If this productivity of using supplier 2's input increases, the *Apple* structure becomes more likely:

$$\frac{\partial \pi_{\text{rel}}}{\partial \theta_{H2}} > 0. \tag{5.30}$$

Intuitively, a higher productivity of the producer in using supplier 2's input increases the profit under the *Apple* structure, whereas it has no effect on the profit level in the *smart* case.

The effect of both the headquarter-intensity and the input intensity on the relative profit is not clear:

$$\frac{\partial \pi_{\text{rel}}}{\partial \eta_H} \gtrless 0 \quad \text{and} \quad \frac{\partial \pi_{\text{rel}}}{\partial \eta_1} \gtrless 0. \tag{5.31}$$

Only if θ_{H2} is very low, a higher headquarter-intensity or input intensity, respectively, clearly raises the relative profit such that the *Apple* structure becomes more likely.

Summing up, my results predict that firms are more likely to have a *smart* structure, the higher is the productivity of the downstream supplier in using the upstream suppliers' input and the higher is the productivity of the producer in combining the final good. Contrary, the more productive is the producer in using the upstream input and the higher is the technological importance of the producer or the downstream supplier, respectively, the less likely becomes the *smart* structure.

5.8 Conclusion

Most production processes consist of multiple stages. Antràs and Chor (2013) analyze organizational decisions in such a production process and assume the producer to bargain herself with all her suppliers. However, firms not always have an overview about their overall supplier structure, they often only know their direct suppliers and, thus, can only bargain with these direct suppliers. I therefore provide an additional mechanism to Antràs and Chor (2013). In doing so, I extend the baseline model of Antràs and Helpman (2004) and assume the manufacturing component provided by a firm's (direct) supplier 1 to be itself composed of two inputs such that supplier 1 has to subcontract an own supplier 2. In contrast to Antràs and Chor (2013), I assume the firm to decide only on the organizational form of supplier 1. Supplier 1 decides himself on the organizational form of supplier 2.

In my setup, sequentiality may arise with regard to the bargaining and the production. To separate the effects resulting from these two types of sequentiality, I first analyze a scenario of simultaneous production where all players invest at the same time. In this scenario, the incentive effect is at work: Both the producer and supplier 1 choose outsourcing of their respective supplier when this supplier is relatively more important for the production. In contrast, when the respective supplier is relatively less important, the producer and supplier 1 choose integration of the supplier. Whereas the producer's decision is additionally driven by the level of the input intensity, the decision of supplier 1 whether to integrate or to outsource his supplier depends solely on this input intensity and is thus independent from the producer's relevance for the production if revenue shares are assumed to be balanced.

I then introduce sequentiality of production and assume supplier 2 to invest prior to the producer and supplier 1. As a result, supplier 2 anticipates the producer's (and supplier 1's) investment. Due to this anticipation, the decision of supplier 1 to choose integration of supplier 2 is positively related to the headquarter-intensity of production. Thus, with sequentiality of production the organizational decision of supplier 1 is interrelated to the producer's decision. This interrelation also arises if I consider an alternative setup without participation fees, and has to be understood in the sense that a higher headquarter-intensity makes integration of both suppliers more likely, as in Antràs and Chor (2013). Thus, supplier 1's organizational decision with regard to supplier 2 depends additionally on the producer's importance that is outside the scope of the two suppliers' relation. However, since - contrary to Antràs and Chor (2013) - my results also depend on the two suppliers' relative importance, the headquarter-intensity does not definitely pin down the degree of integration of the whole value chain. Instead, both the producer's importance and the suppliers' relative importance determine the degree of integration within a value chain.

Finally, I allow firms to choose their decision structure, i.e., they can choose between deciding on all their suppliers' organizational forms and deciding only on their direct supplier's organizational form. I find that a higher productivity of the firm in combining the final good and a higher productivity of the direct supplier to combine the manufacturing input make the choice of deciding over all suppliers less likely, whereas a higher productivity of the producer in using supplier 2's input increases the probability of choosing to decide over all suppliers along the value chain.

In my model, there are several aspects left for future research: First of all, I consider a production process with only two suppliers. An obvious extension would be to incorporate a continuum of suppliers to analyze the interdependencies along the whole value chain. In addition, it would be interesting to test my predictions considering the organizational decisions and the chosen decision structures empirically.

5.9 References

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5.10 Appendix

A.I Input provisions, revenue, profit and price

A.I.i Complete contracts

A.I.i.a Producer only contracts with supplier 1

In a benchmark scenario of complete contracts, each player is bounded to provide the inputs in the amount stipulated in the contract - neither player can deviate from the arrangement.[23] The producer contracts the headquarter services h provided by herself and the suppliers' manufacturing component m provided by supplier 1. Supplier 1 then has to agree by contract with supplier 2 on the input provisions m_1 and m_2 to produce m. The production process can be modeled as a 6-stage game with the following timing of events:

1. The firm offers contracts to potential suppliers. These contracts stipulate the suppliers' input provision of the whole manufacturing component m and comprise the (ex post) payment to supplier 1 (s_1) and an up-front participation fee τ_1 to supplier 1 that might be positive or negative.
2. There is a huge mass of potential suppliers. Each of these suppliers has an outside option equal to w_1. The suppliers apply for the contract and the producer chooses one supplier for the production of the manufacturing component.
3. On the basis of his contract, supplier 1 offers contracts to potential suppliers. These contracts stipulate supplier 2's input provision for the manufacturing component m_2, the (ex post) payment to supplier 2 (s_2) and a (positive or negative) up-front participation fee τ_2 to supplier 2.
4. There is a huge mass of potential suppliers, each with an outside option equal to w_2, that apply for the contract. Supplier 1 chooses one supplier.

[23] Complete contracts also eliminate possible problems associated with input quality. However, in my model I neglect this aspect and focus solely on quantity aspects.

5. The headquarter and supplier 1 and 2 produce their inputs h, m_1 and m_2, respectively. Production costs are given by c_H, c_1 and c_2, respectively.
6. The final good is produced. Revenue is realized and each player receives the payment stipulated in the contracts.

This game is solved by backward induction: In the last stage of the game where the players' inputs are combined to the final good, each player receives the payment specified in the contract, i.e., supplier 1 receives the payment s_1 and supplier 2 receives the payment s_2 while the producer retains the residual $(R - s_1 - s_2)$.

In stage 5, all players produce their inputs in the amounts h, m_1 and m_2, respectively, as stipulated in the contracts.

For supplier 2 to accept the contract offered by supplier 1 in stage 4, his profit π_2 - that equals the payment from supplier 1 plus his participation fee from supplier 1 minus his production costs $(c_2 m_2)$ - must be at least equal to his outside option:

$$\pi_2 = (s_2 + \tau_2) - c_2 m_2 \geq w_2. \tag{A5.1}$$

Since there is no need to leave rents to his supplier, supplier 1 sets the net payment to supplier 2 $(s_2 + \tau_2)$ such that supplier 2's profit is exactly equal to the outside option: $s_2 + \tau_2 = c_2 m_2 + w_2$.

In contracting with supplier 2 on how to produce the manufacturing component in stage 3, supplier 1 maximizes the profit

$$\pi_1 = (s_1 + \tau_1) - c_1 m_1 - (s_2 + \tau_2) \tag{A5.2}$$

that is equal to the net payment from the headquarter $(s_1 + \tau_1)$ minus supplier 1's production costs $(c_1 m_1)$ and the net payment to supplier 2. Using supplier 2's participation constraint, the suppliers' input provisions are chosen such that the suppliers' total profit

$$\pi_1 = (s_1 + \tau_1) - c_1 m_1 - c_2 m_2 - w_2 \tag{A5.3}$$

is maximized. In his production decision, supplier 1 has to ensure that the suppliers produce the whole manufacturing input m^{cc} specified by the producer's contract in stage 1. Consequently, m_1 and m_2 are chosen to solve

$$\max_{\{m_1, m_2\}} [(s_1 + \tau_1) - c_1 m_1 - c_2 m_2 - w_2] \quad \text{s.t.} \quad \theta_1 \left(\frac{m_1}{\eta_1}\right)^{\eta_1} \left(\frac{m_2}{1-\eta_1}\right)^{1-\eta_1} = m^{cc}. \tag{A5.4}$$

Standard maximization gives $m_1/m_2 = c_1/c_2 \; \eta_1/(1-\eta_1)$. Using this relation in the constraint in (A5.4), the optimal input provisions of the suppliers are given by

$$m_1^{cc} = \left(\frac{c_2}{c_1}\right)^{1-\eta_1} \eta_1 \, \frac{m^{cc}}{\theta_1} \quad \text{and} \quad m_2^{cc} = \left(\frac{c_1}{c_2}\right)^{\eta_1} (1-\eta_1) \, \frac{m^{cc}}{\theta_1} \tag{A5.5}$$

and depend positively on m^{cc}. In stage 2, supplier 1 accepts the producer's contract only when the profit for the *whole* manufacturing component is at least equal to his outside option:

$$\pi_1 = (s_1 + \tau_1) - c_M m - w_2 \geq w_1. \tag{A5.6}$$

$c_M m$ denotes the whole manufacturing production costs whereby $c_M = \left(c_1^{\eta_1} c_2^{1-\eta_1}\right)/\theta_1$ indicates the corresponding unit costs. Since the producer leaves no rents to supplier 1, supplier 1 receives the production costs plus both suppliers' outside options as payment from the producer. The producer chooses the input provisions h and m that maximize her own profit - that is equal to the revenue of the final good minus her production costs and the net payment to supplier 1 - in stage 1:

$$\pi_H = R - c_H h - c_M m - w_1 - w_2. \tag{A5.7}$$

Standard maximization gives the relation $h/m = c_M/c_H \; \eta_H/(1-\eta_H)$ between the headquarter's and the suppliers' input provisions. The resulting profit-maximizing input provisions are given as following:

$$h^{cc} = \frac{\rho\eta_H}{c_H} R^{cc} \quad \text{and} \quad m^{cc} = \frac{\rho\left(1-\eta_H\right)}{c_M} R^{cc} \quad \text{with} \quad R^{cc} = A\left[\frac{\rho\theta_H}{c_H^{\eta_H} c_M^{1-\eta_H}}\right]^{\frac{\rho}{1-\rho}}. \tag{A5.8}$$

Using m^{cc} and $c_M = \left(c_1^{\eta_1} c_2^{1-\eta_1}\right)/\theta_1$, the suppliers' input provisions (from (A5.5)) are given by

$$m_1^{cc} = \frac{\rho\eta_1\left(1-\eta_H\right)}{c_1} R^{cc} \text{ and } m_2^{cc} = \frac{\rho\left(1-\eta_1\right)\left(1-\eta_H\right)}{c_2} R^{cc}. \tag{A5.9}$$

The resulting overall payoff of the relationship is

$$\pi_H^{cc} = \left(1-\rho\right) R^{cc} - w_1 - w_2 \tag{A5.10}$$

and the price of the final good is given by

$$p^{cc} = \frac{c_H^{\eta_H}}{\rho\theta_H}\left(\frac{c_1^{\eta_1} c_2^{1-\eta_1}}{\theta_1}\right)^{1-\eta_H}. \tag{A5.11}$$

A.I.i.b Producer contracts with both suppliers

With complete contracts, the input provisions of all three players are the same if the producer contracts herself with both suppliers. Then, the production process is reduced to a 4-stage game with the following timing of events:

1. The firm offers contracts to potential suppliers of the two inputs 1 and 2. These contracts stipulate the respective supplier's input provision m_i $(i = 1, 2)$ and comprise the (ex post) payment to the respective supplier s_i, and an up-front participation fee τ_i to the respective supplier that might be positive or negative.

2. There is a huge mass of potential suppliers. Each of these suppliers has an outside option equal to w_i. The suppliers apply for the contract and the producer chooses one supplier for the production of each input.

3. The headquarter and supplier 1 and 2 produce their inputs h, m_1 and m_2, respectively.

4. The final good is produced. Revenue is realized and each player receives the payment stipulated in the contracts.

Solving by backward induction, stages 4 and 3 are analogous to stages 6 and 5 above.

In stage 2, the suppliers only accept the producer's contract offer when the respective supplier's profit π_i $(i = 1, 2)$ is at least equal to the respective supplier's outside option w_i:

$$\pi_i = (s_i + \tau_i) - c_i m_i \geq w_i. \tag{A5.12}$$

The producer sets the net payment to the respective supplier i $(s_i + \tau_i)$ such that his profit exactly equals his outside option: $s_i + \tau_i = c_i m_i + w_i$. Hence, each supplier's net payment is still equal to his production costs plus his outside option.

In stage 1 where the producer decides on the contract design, she chooses the input provisions h, m_1 and m_2 that maximize her own profit:

$$\max_{\{h,m_1,m_2\}} \pi_H = R - c_H h - c_1 m_1 - c_2 m_2 - w_1 - w_2. \tag{A5.13}$$

Differentiating this profit with respect to h, m_1 and m_2 and solving for these input provisions gives the same profit-maximizing input provisions as in (A5.8) and (A5.9). The producer's profit is still given by (A5.10) and the price is still as in (A5.11).

A.I.ii Comparison - Complete contracts and simultaneous production

A.I.ii.a Input provisions and revenue

Comparing the input provisions and the revenue in the scenario of simultaneous production with those calculated in the scenario of complete contracts, the ratios of the input provisions and the revenue in the two scenarios are a function of the players' revenue shares and smaller than one:

$$\begin{aligned} \frac{h^{sim}}{h^{cc}} &= \psi_{sim}\beta_H < 1\ , \\ \frac{m_1^{sim}}{m_1^{cc}} &= \psi_{sim}\left(1-\beta_H\right)\beta_1 < 1\ , \\ \frac{m_2^{sim}}{m_2^{cc}} &= \psi_{sim}\left(1-\beta_H\right)\left(1-\beta_1\right) < 1 \\ \text{and } \frac{R^{sim}}{R^{cc}} &= \psi_{sim} < 1 \end{aligned} \tag{A5.14}$$

$$\text{with} \quad \psi_{sim} = \left[\beta_1^{(1-\eta_H)\eta_1}\left(1-\beta_1\right)^{(1-\eta_H)(1-\eta_1)}\beta_H^{\eta_H}\left(1-\beta_H\right)^{(1-\eta_H)}\right]^{\frac{\rho}{1-\rho}} < 1.$$

A.I.ii.b Total profit

Comparing the simultaneous profit level with that in the case of complete contracts gives

$$\frac{\pi_H^{sim}}{\pi_H^{cc}} = \frac{\left[1-\rho\left[\left(1-\beta_H\right)\left(1-\eta_H\right)\left[\beta_1\eta_1+\left(1-\beta_1\right)\left(1-\eta_1\right)\right]+\beta_H\eta_H\right]\right]R^{sim}-w_1-w_2}{\left(1-\rho\right)R^{cc}-w_1-w_2}. \tag{A5.15}$$

It can be immediatly seen that the profit in the case of incomplete contracts is lower than in the case of complete contracts when assuming zero outside options ($w_1 = w_2 = 0$):

$$\frac{\pi_H^{sim}}{\pi_H^{cc}} = \psi_{sim}\frac{1-\rho\left[\beta_H\eta_H+\left(1-\beta_H\right)\left(1-\eta_H\right)\left[\left(1-\beta_1\right)\left(1-\eta_1\right)+\beta_1\eta_1\right]\right]}{1-\rho} < 1. \tag{A5.16}$$

This result also holds for $w_1 > 0$, $w_2 > 0$.

A.I.ii.c Price

With simultaneous production, the price of the final good is given by

$$p^{sim} = \frac{1}{\rho\theta_H}\left(\frac{c_H}{\beta_H}\right)^{\eta_H}\left(\frac{c_1^{\eta_1}c_2^{1-\eta_1}}{\theta_1\left(1-\beta_1\right)^{1-\eta_1}\beta_1^{\eta_1}}\right)^{1-\eta_H}. \tag{A5.17}$$

This price is higher than the price in the scenario of complete contracts:

$$\frac{p^{sim}}{p^{cc}} = \psi_{sim}^{-\frac{1-\rho}{\rho}} > 1. \tag{A5.18}$$

A.I.iii Comparison - Simultaneous and sequential production

A.I.iii.a Input provisions and revenue

With sequential production, the input provisions and the revenue level are higher than with simultaneous production:

$$\begin{gathered}\frac{h^{seq}}{h^{sim}} = \frac{m_1^{seq}}{m_1^{sim}} = \psi_{seq} > 1,\\ \frac{m_2^{seq}}{m_2^{sim}} = \psi_{seq}^{\frac{1-\rho}{\rho(1-\eta_1)(1-\eta_H)}+1} > 1\\ \text{and}\quad \frac{R^{seq}}{R^{sim}} = \psi_{seq} > 1\\ \text{with}\ \ \psi_{seq} = \phi^{-\frac{\rho(1-\eta_1)(1-\eta_H)}{1-\rho}} = \phi^{1-\frac{\phi}{1-\rho}} > 1.\end{gathered} \tag{A5.19}$$

A.I.iii.b Total profit

Comparing the payoffs of both scenarios, I find:

$$\frac{\pi_H^{seq}}{\pi_H^{sim}} = \frac{\left[1-\rho\left[(1-\beta_H)(1-\eta_H)\left[\beta_1\eta_1 + \frac{(1-\beta_1)(1-\eta_1)}{\phi}\right] + \beta_H\eta_H\right]\right] R^{seq} - w_1 - w_2}{\left[1-\rho\left[(1-\beta_H)(1-\eta_H)\left[\beta_1\eta_1 + (1-\beta_1)(1-\eta_1)\right] + \beta_H\eta_H\right]\right] R^{sim} - w_1 - w_2}. \tag{A5.20}$$

Assuming zero outside options ($w_1 = w_2 = 0$), it is easy to see that the payoff with sequential production is higher than the payoff with simultaneous production (given in (5.10)):

$$\frac{\pi_H^{seq}}{\pi_H^{sim}} = \psi_{seq} \frac{\left[1-\rho\left[(1-\beta_H)(1-\eta_H)\left[\beta_1\eta_1 + \frac{(1-\beta_1)(1-\eta_1)}{\phi}\right] + \beta_H\eta_H\right]\right]}{\left[1-\rho\left[(1-\beta_H)(1-\eta_H)\left[\beta_1\eta_1 + (1-\beta_1)(1-\eta_1)\right] + \beta_H\eta_H\right]\right]} > 1. \tag{A5.21}$$

This result holds as well for positive outside options ($w_1 > 0$, $w_2 > 0$).

A.I.iii.c Price

Simple maths shows that the price is given by:

$$p^{seq} = \frac{1}{\rho\theta_H}\left(\frac{c_H}{\beta_H}\right)^{\eta_H}\left(\frac{c_1^{\eta_1}c_2^{1-\eta_1}}{\theta_1(1-\beta_1)^{1-\eta_1}\beta_1^{\eta_1}}\right)^{1-\eta_H}\phi^{(1-\eta_1)(1-\eta_H)}. \tag{A5.22}$$

Comparing the prices with sequential and simultaneous production, I find that the price is lower with sequential production than with simultaneous production:

$$\frac{p^{seq}}{p^{sim}} = \Psi_{seq}^{-\frac{1-\rho}{\rho}} < 1. \tag{A5.23}$$

A.I.iv Comparison - Complete contracts and sequential production

A.I.iv.a Input provisions and revenue

With sequential production, the input provisions and the revenue are still lower than with complete contracts:

$$\begin{aligned}
\frac{h^{seq}}{h^{cc}} &= \psi_{sim}\psi_{seq}\beta_H < 1,\\
\frac{m_1^{seq}}{m_1^{cc}} &= \psi_{sim}\psi_{seq}\beta_1(1-\beta_H) < 1,\\
\frac{m_2^{seq}}{m_2^{cc}} &= \psi_{sim}\psi_{seq}^{\frac{1-\rho}{\rho(1-\eta_1)(1-\eta_H)}+1}(1-\beta_1)(1-\beta_H) < 1,\\
\text{and} \quad \frac{R^{seq}}{R^{cc}} &= \psi_{sim}\psi_{seq} < 1,
\end{aligned} \tag{A5.24}$$

with ψ_{sim} and ψ_{seq} as defined in A.I.ii and A.I.iii.

A.I.iv.b Total profit

Under the assumption of zero outside options, I can directly see that the profit is still lower than with complete contracts:

$$\frac{\pi_H^{seq}}{\pi_H^{cc}} = \psi_{sim}\psi_{seq}^{\frac{1-\rho}{\rho(1-\eta_1)(1-\eta_H)}+1} \frac{1-\rho\left[\beta_H\eta_H + (1-\beta_H)(1-\eta_H)\left[\frac{(1-\beta_1)(1-\eta_1)}{\phi} + \beta_1\eta_1\right]\right]}{1-\rho}$$

$$< 1. \tag{A5.25}$$

A.I.iv.c Price

The price is higher than with complete contracts:

$$\frac{p^{seq}}{p^{cc}} = (\psi_{sim}\psi_{seq})^{-\frac{1-\rho}{\rho}} > 1. \tag{A5.26}$$

A.II Organizational decisions

A.II.i Simultaneous production

A.II.i.a Concrete derivatives of β_1^{sim}

The derivation of supplier 1's optimal revenue share with respect to η_1 is given by

$$\frac{\partial\beta_1^{sim}}{\partial\eta_1} = \underbrace{\frac{1}{(1-2\eta_1)^2(1-\rho\eta_H)}}_{>0} \cdot d_{1,\eta_1}^{sim} \quad \text{with}$$

$$d_{1,\eta_1}^{sim} = (1-\rho(1-2(1-\eta_1)\eta_1)(1-\eta_H)) \cdot$$
$$\left(\frac{1-2\rho(1-\eta_1)\eta_1(1-\eta_H)}{\sqrt{(2\eta_1(1-\rho((1-\eta_H)(1-\eta_1)+\eta_H))+\rho\eta_H)^2 + 4\eta_1(1-2\eta_1)(1-\rho\eta_H)(1-\rho(1-\eta_1)(1-\eta_H))}} - 1\right) > 0.$$

Simple maths shows that d_{1,η_1}^{sim} is for $0 < \eta_1 < 1$, $0 < \eta_H < 1$ and $0 < \rho < 1$ positive. As a result, the derivation of β_1^{sim} with respect to η_1 is positive.

The derivation of β_1^{sim} with respect to η_H is

$$\frac{\partial\beta_1^{sim}}{\partial\eta_H} = \frac{\rho}{\underbrace{2(1-\rho\eta_H)^2}_{>0}\underbrace{(1-2\eta_1)}_{?}} \cdot d_{1,\eta_H}^{sim} \quad \text{with}$$

$$d_{1,\eta_H}^{sim} = \frac{2(1-\eta_1)\eta_1(3-2\rho(1+(1-\rho)(1-\eta_1)\eta_1)) + \rho(1-2(1-\eta_1)\eta_1(1-2(1-\rho)(1-\eta_1)\eta_1))\eta_H}{\sqrt{(2\eta_1(1-\rho((1-\eta_H)(1-\eta_1)+\eta_H))+\rho\eta_H)^2 + 4\eta_1(1-2\eta_1)(1-\rho\eta_H)(1-\rho(1-\eta_1)(1-\eta_H))}}$$
$$-1-2\eta_1(1-\rho)(1-\eta_1) < 0.$$

Since simple maths shows that d_{1,η_H}^{sim} is for $0 < \eta_1 < 1$, $0 < \eta_H < 1$ and $0 < \rho < 1$ negative, the sign of the derivation of β_1^{sim} with respect to η_H depends on the sign of $(1 - 2\eta_1)$ and, thus, on the level of η_1. For $\eta_1 < 1/2$, $(1 - 2\eta_1)$ is positive and the derivation is negative. For $\eta_1 > 1/2$, $(1 - 2\eta_1)$ is negative. As a result, the derivation is positive.

A.II.i.b Concrete derivatives of β_H^{sim}

The derivation of β_H^{sim} with respect to η_H is given by

$$\frac{\partial \beta_H^{sim}}{\partial \eta_H} = \underbrace{\frac{1}{2\left(\eta_H - \left(1 - \beta_1\left(1 - 2\eta_1\right) - \eta_1\right)\left(1 - \eta_H\right)\right)^2}}_{>0} \cdot d_{H,\eta_H}^{sim} \quad \text{with}$$

$$d_{H,\eta_H}^{sim} = \frac{\sqrt{1-\eta_H}\left(2 - \left(1 + \beta_1\eta_1 + \left(1 - \beta_1\right)\left(1 - \eta_1\right)\right)\left(1 - \eta_H\right)\left(\eta_1 + \rho\left(2 - \eta_1\right)\eta_H + \beta_1\left(1 - 2\eta_1\right)\left(1 - \rho\eta_H\right)\right)\right)}{\sqrt{\left(4\left(1-\rho\right)\eta_H + \left(1 - \eta_H\right)\left(\eta_1 + \rho\left(2 - \eta_1\right)\eta_H + \beta_1\left(1 - 2\eta_1\right)\left(1 - \rho\eta_H\right)\right)^2\right)}}$$
$$- \left(1 + \beta_1\eta_1 + \left(1 - \beta_1\right)\left(1 - \eta_1\right)\right)\left(1 - \eta_H\right) > 0$$

Since d_{H,η_H}^{sim} is for $0 < \eta_1 < 1$, $0 < \eta_H < 1$ and $0 < \rho < 1$ positive, the derivation is positive as well.

The derivation of the producer's optimale revenue share with respect to η_1 is

$$\frac{\partial \beta_H^{sim}}{\partial \eta_1} = \overbrace{\left(1 - 2\beta_1\right)}^{?} \cdot \overbrace{\frac{\left(1 - \eta_H\right)\left(1 - \rho\eta_H\right)}{2\left(\left(1 - \eta_1 + \beta_1\left(-1 + 2\eta_1\right)\right)\left(-1 + \eta_H\right) + \eta_H\right)^2}}^{>0} \cdot d_{H,\eta_1}^{sim} \quad \text{with}$$

$$d_{H,\eta_1}^{sim} = \left(\frac{\sqrt{1-\eta_H}\left(\eta_1 + \left(2 - \rho\right)\left(2 - \eta_1\right)\eta_H + \beta_1\left(1 - 2\eta_1\right)\left(1 - \left(2 - \rho\right)\eta_H\right)\right)}{\sqrt{4\left(1 - \rho\right)\eta_H + \left(1 - \eta_H\right)\left(\eta_1 + \rho\left(2 - \eta_1\right)\eta_H + \beta_1\left(1 - 2\eta_1\right)\left(1 - \rho\eta_H\right)\right)^2}}\right) - 1 < 0.$$

Simple maths shows that d_{H,η_1}^{sim} is always negative. As a result, the sign of the derivation of the producer's optimal revenue depends on the sign of $(1 - 2\beta_1)$: If $\beta_1 < 1/2$, this term is positive and the derivation is thus negative. Vice versa, if $\beta_1 > 1/2$, the term is negative and the derivation is positive.

In the main text, I assume balanced revenue shares. Then, supplier 1 chooses outsourcing of supplier 2 if $\eta_1 < 1/2$ such that β_1 is smaller than 1/2. If $\eta_1 > 1/2$, supplier 2 chooses integration and β_1 is higher than 1/2. Hence, if $\eta_1 < 1/2$, the derivation is negative, and if $\eta_1 > 1/2$, the derivation is positive.

A.II.i.c The producer's organizational decision with $\beta_1^O > 1 - \beta_1^V$

If supplier 1's revenue shares in case of integration and outsourcing are not balanced, it no longer solely depends on the level of η_1 whether supplier 1 chooses integration or outsourcing of supplier 2 and whether $\beta_1 > 1/2$ or $\beta_1 < 1/2$ holds. In the following I show the resulting optimal revenue share and the organizational decision of the producer.

In figure 5.10, I assume imbalanced revenue share β_1^O and β_1^V with $\beta_1^O < 1/2 < \beta_1^V$. The black lines in figure 5.10 illustrate the producer's optimal revenue share subject to a variation of η_H. Since the derivation of β_H^{sim} with respect to η_H is independent from the level of β_1 positive, the two black lines are still upwards sloping.

In addition, as with balanced revenue shares, as long as $\beta_1^O < 1/2 < \beta_1^V$ holds, $\frac{\partial \beta_H^{sim}}{\partial \eta_1}$ is for low values of η_1 negative and for high values of η_1, it is positive. As a result, a rise of η_1 first induces a convergence of the black, dotted line of low or high vales of η_1 to the black, dashed line of intermediate values of η_1, and then a divergence. However, the input intensity at which this switch from convergence to divergence arises is no longer equal to 1/2. Following proposition 1, with $\beta_1^O > 1 - \beta_1^V$, the cutoff input intensity that induces a switch between outsourcing and integration of supplier 2 is higher than 1/2 and as a result, the above switch arises as well for η_1 higher than 1/2.

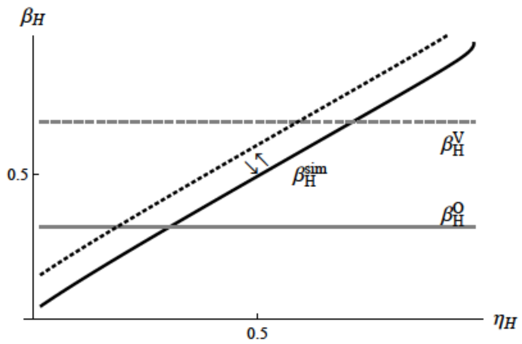

Figure 5.10: Optimal revenue share of the producer with simultaneous production for varying headquarter-intensity with imbalanced revenue shares $\beta_1^O > 1 - \beta_1^V$. Black, dotted line: low or high values of η_1. Black, solid line: intermediate values of η_1.

The resulting organizational decision is hence the same as with balanced revenue shares: As depicted in figure 5.11, for low values of η_H the producer chooses outsourcing of supplier 1 and for high values of η_H, she chooses integration. A rise of η_1 first increases the probability of outsourcing and then decreases it. However, in contrast to balanced revenue shares, outsourcing is no longer most likely, the more similar are the two suppliers in their input intensity. Instead, the switch in the direction of the effect of η_1 on the probability of outsourcing arises for a value of η_1 higher than 1/2.[24]

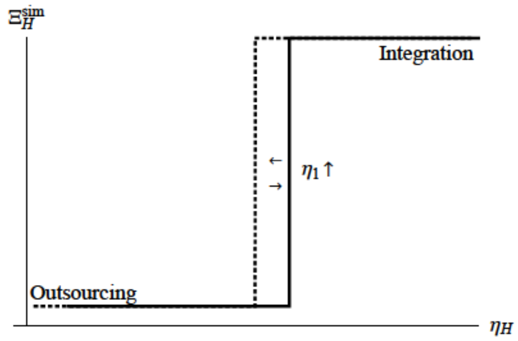

Figure 5.11: Organizational decision of the producer with simultaneous production for varying headquarter-intensity with imbalanced revenue shares $\beta_1^O > 1 - \beta_1^V$. Black, dotted line: low or high values of η_1. Black, solid line: intermediate values of η_1.

If I assume imbalanced revenue shares β_1^O and β_1^V with $1/2 < \beta_1^O < \beta_1^V$, the derivation $\frac{\partial \beta_H^{sim}}{\partial \eta_1}$ is always positive. Then, a higher input intensity only raises the optimal revenue share. As a result, the probability of outsourcing is decreasing in the input intensity, i.e., outsourcing of supplier 1 becomes less likely, the more important is supplier 1. Analogously, with $\beta_1^O < \beta_1^V < 1/2$, $\frac{\partial \beta_H^{sim}}{\partial \eta_1}$ is always negative such that a higher input intensity reduces the optimal revenue share and increases the probability of outsourcing. Hence, outsourcing of supplier 1 is most likely, when supplier 2 is the important supplier for the manufacturing input.

Analogously, with $\beta_1^O < 1 - \beta_1^V$, the change in the producer's organizational decision arises for a value of η_1 lower than 1/2.

A.II.ii Sequential production

A.II.ii.a Concrete derivatives of β_1^{seq}

The derivation of β_1^{seq} with respect to η_1 can be depicted as

$$\frac{\partial \beta_1^{seq}}{\partial \eta_1} = \underbrace{\frac{1}{2\left(1 - \eta_1\left(1+\phi\right)\right)^2\left(1 - \rho\eta_H\right)}}_{>0} \cdot d_{1,\eta_1}^{seq} \quad \text{with}$$

[24] Since the effect of η_1 on the producer's optimal revenue share has the same direction for all values of headquarter-intensity, this result is independent of whether the producer's revenue shares of integration and outsourcing are balanced or not.

$$d^{seq}_{1,\eta_1} = \eta_1^2(1-\eta_H)\rho^3(1-(1-\eta_1)(1-\eta_H))^2 - \rho^2\left(2\eta_1(1-\eta_H)\left(2\eta_1^2(1-\eta\mathrm{H}) - (1-3\eta_1)\eta_H - \eta_1 + 1\right) + \eta_H\right)$$
$$+ \frac{d^{seq,help}_{1,\eta_1}}{2\sqrt{\eta_1\left(\eta_1\left(\rho^2\left((1-\eta_1)\eta_1(1-\eta_H)^2+\eta_H\right) - \rho(3-\eta_1(1-\eta_H))\right)+2\right)^2 + 4(1-\rho)(1-\rho\eta_H)(1-\eta_1(\phi+1))\right)}}$$
$$+ \rho(3 - 2\eta_1(-2\eta_1(1-\eta_H) - \eta_H + 1)) - 2 > 0 \quad \text{and}$$
$$d^{seq,help}_{1,\eta_1} = \left(\eta_1(1-\eta_1(\phi+1))\right)\left(\left(\rho^2\left((1-\eta_1)\eta_1(1-\eta_H)^2+\eta_H\right) - \rho(3-\eta_1(1-\eta_H)) + 2\right)^2\right.$$
$$+ 2\eta_1\left(\rho^2(1-2\eta_1)(1-\eta_H)^2 + \rho(1-\eta_H)\right)\left(\rho^2\left((1-\eta_1)\eta_1(1-\eta_H)^2+\eta_H\right) - \rho(3-\eta_1(1-\eta_H)) + 2\right)$$
$$+4(1-\rho)(1-\rho\eta_H)(\rho\eta_1(1-\eta_H) - \phi - 1)) + (\eta_1(-2\rho\eta_1(1-\eta_H) + \phi + 1) + 1)$$
$$\left(\eta_1\left(\rho^2\left((1-\eta_1)\eta_1(1-\eta_H)^2+\eta_H\right) - \rho(3-\eta_1(1-\eta_H)) + 2\right)^2 + 4(1-\rho)(1-\rho\eta_H)(1-\eta_1(\phi+1))\right)\Big) > 0.$$

Since d^{seq}_{1,η_1} is always positive, the derivation is positive as well.

The derivation of supplier 1's optimal revenue share with respect to η_H is given by

$$\frac{\partial\beta_1^{seq}}{\partial\eta_H} = \underbrace{\frac{\rho\eta_1}{2\left(1-\eta_1\left(1+\phi\right)\right)^2\left(1-\rho\eta_H\right)^2}}_{>0} \cdot d^{seq}_{1,\eta_H} \quad \text{with}$$

$$d^{seq}_{1,\eta_H} = \frac{d^{seq,help}_{1,\eta_H}}{\sqrt{\eta_1\left(\eta_1\left(\rho^2\left((1-\eta_1)\eta_1(1-\eta_H)^2+\eta_H\right) - \rho(3-\eta_1(1-\eta\mathrm{H})) + 2\right)^2 + 4(1-\rho)(1-\rho\eta_H)(1-\eta_1(\phi+1))\right)}}$$
$$- (1-\rho)\left(2 - \eta_1\left(\rho(-2\eta_1(-2\eta_1(1-\eta_H) - 5\eta_H + 3) - 6\eta_H + 1) + (1-\eta_1)(1-\phi)^2 - 4\eta_1 + 7\right)\right) > 0 \quad \text{and}$$
$$d^{seq,help}_{1,\eta_H} = \eta_1\left(\rho^2\left((1-\eta_1)\eta_1(1-\eta_H)^2+\eta_H\right) - \rho(3-\eta_1(1-\eta_H)) + 2\right)^2(1-\eta 1(-\rho(1-\eta_1)\eta_H - \eta_1 + \phi + 2))$$
$$+ (1-\rho\eta_H)(1-\eta_1(\phi+1))(-\rho(2-\eta_1(\rho(\phi+1)(1-\eta_1(1-\eta_H))(1-2(1-\eta_1)\eta_1(1-\eta_H))$$
$$- \rho(-\eta_1(-3\eta_1(1-\eta_H)((1-\eta_1)(1-\eta_H)+2) - 4\eta_H + 5) + 4\eta_H + 3) - \eta_1(1-3\eta_1(1-\eta_H)) + 4(\eta_H + 2)))$$
$$- 6\eta_1 + 2).$$

Simple maths shows that d^{seq}_{1,η_H} is for $0 < \eta_1 < 1$, $0 < \eta_H < 1$ and $0 < \rho < 1$ positive. Hence, the derivation is positive as well.

A.II.ii.b Changes in the producer's organizational decision

Proceeding in a similar manner as with simultaneous production, the producer's optimal revenue share in case of sequential production is given as

$$\beta_H^{seq} = \frac{\eta_H\left(2-\eta_1+\rho\left(1-\phi\right)\left(1-\eta_H\right) - \rho\left(3-\eta_1-\eta_H\right)\right) + \beta_1\left(1-\eta_H\right)\left(1+\rho\eta_H\right)\left(1-\eta_1\left(1+\phi\right)\right) + b_H^{seq}}{2\left(\eta_H\left(2-\rho\eta_H\right) + \left(1-\eta_H\right)\left(\eta_1\left(1-\rho\eta_H\right) + \beta_1\left(1-\eta_1\left(2-\rho\left(1+\phi\right)\right)\right)\right) - 1\right)}$$

$$\text{with } b_H^{seq} = \eta_1\left(1-\rho\right) - \sqrt{\left(1-\eta_H\right)\left(1-\rho\eta_H\right)}\sqrt{\eta_H\left(1-\rho\eta_H\right)\left(4-\rho\left(4-\rho\left(1-\eta_H\right)\eta_H\right)\right)}$$
$$\overline{+\left(1-\eta_H\right)\left(\left(1-\rho\eta_H\right)\left(\eta_1^2\left(1-\rho\left(1-\eta_H\right)\right)^2 + \beta_1^2\left(1-\eta_1\left(1+\phi\right)\right)^2\right) - 2\rho\eta_1\eta_H\left(3-\rho\left(3-\rho\left(1-\eta_H\right)\eta_H\right)\right)}$$
$$\overline{+2\beta_1\left(1-\eta_1\left(1+\phi\right)\left(\rho\eta_H\left(1-\rho\eta_H\right) + \eta_1\left(1-\rho\left(1+\rho\left(1-\eta_H\right)\eta_H\right)\right)\right)\right)\right)}.$$

In figure 5.12, I illustrate this optimal revenue share with respect to η_H for different values of η_1 as black lines. In the left panel of figure 5.12, I assume low values of ρ, and in the right panel, I assume high values of ρ. As before, the gray, solid line stands for the producer's revenue share in case of outsourcing and the gray, dashed line depicts the revenue share in case of integration.

As illustrated by the black, upward sloping lines in both panels of figure 5.12, the derivation of the producer's optiake-mal revenue share with respect to the headquarter-intensity is positive:

$$\frac{\partial \beta_H^{seq}}{\partial \eta_H} = \frac{d_{H,\eta_H}^{seq}}{\underbrace{2((1-\eta_H)(\eta_1(1-\rho\eta_H)+\beta_1(1-\eta_1(\phi+1)))+\eta_H(2-\rho\eta_H)-1)^2}_{>0}} \quad \text{with}$$

$$\begin{aligned}
d_{H,\eta_H}^{seq} = {} & (\eta_H(2-\rho\eta_H)+(\eta_H-1)(\eta_1(\rho\eta_H-1)+\beta_1(\eta_1(-\rho\eta_1-\rho(1-\eta_1)\eta_H+2)-1))-1) \\
& \left((\beta_1\eta_1+1)\left(-3(1-\eta_1)\eta_H^2+(2-4\eta_1)\eta_H+\eta_1\right)\rho^2+(\eta_1+2\eta_H+\beta_1(-2\eta_H+\eta_1(-2\eta_1+2(\eta_1+1)\eta_H-1)\right. \\
& +1)-3)\rho-\beta_1(1-2\eta_1)-\eta_1+2)-((\rho\beta_1(1-\eta_1)\eta_1-\rho\eta_1)(1-\eta_H)-2\rho\eta\mathrm{H}-\eta_1(1-\rho\eta_H) \\
& -\beta_1(1-\eta_1(\phi+1))+2)\left((1-\rho)\eta_1+\eta_H\left((1-\eta_H)(\eta_1(1-\eta_H)+\eta_H)\rho^2-(-\eta 1-\eta_H+3)\rho-\eta_1+2\right)\right. \\
& \left.+\beta_1(1-\eta_H)(\rho\eta_H+1)(1-\eta_1(\phi+1))\right) \\
& -((\eta_H(2-\rho\eta_H)+(1-\eta_H)(\eta_1(1-\rho\eta_H)+\beta_1(1-\eta_1(\phi+1)))-1)\,(-\rho(1-\eta_H)\,(\eta_H(1-\rho\eta_H) \\
& (4-\rho(4-\rho(1-\eta_H)\eta_H))+(1-\eta_H)\left((\beta_1^2(1-\eta_1(2-\rho(1-(1-\eta_1)(1-\eta_H))))^2+\eta_1^2(1-\rho(1-\eta_H))^2\right) \\
& (1-\rho\eta_H)-2\rho\eta_1\eta_H(3-\rho(3-\rho(1-\eta_H)\eta_H))+2\beta_1(1-\eta_1(2-\rho(1-(1-\eta_1)(1-\eta_H)))) \\
& (\rho\eta_H(1-\rho\eta_H)+\eta_1(1-\rho(\rho(1-\eta_H)\eta_H+1)))))-(1-\rho\eta_H)\,(\eta_H(1-\rho\eta_H)(4-\rho(4-\rho(1-\eta_H)\eta_H)) \\
& +(1-\eta_H)\left((\beta_1^2(1-\eta_1(2-\rho(1-(1-\eta_1)(1-\eta_H))))^2+\eta_1^2(1-\rho(1-\eta_H))^2\right)(1-\rho\eta_H) \\
& -2\rho\eta_1\eta_H(3-\rho(3-\rho(1-\eta_H)\eta_H))+2\beta_1(1-\eta_1(2-\rho(1-(1-\eta_1)(1-\eta_H))))(\rho\eta_H(1-\rho\eta_H) \\
& +\eta_1(1-\rho(\rho(1-\eta_H)\eta_H+1)))))+(1-\eta_H)(1-\rho\eta_H)\,(-\rho\eta_H(1-\rho\eta_H)(\rho\eta_H-\rho(1-\eta_H)) \\
& +2\rho\eta_1\eta_H(3-\rho(3-\rho(1-\eta_H)\eta_H))-\rho\eta_H(4-\rho(4-\rho(1-\eta_H)\eta_H))+(1-\rho\eta_H)(4-\rho(4-\rho(1-\eta_H)\eta_H)) \\
& +(1-\eta_H)\left(2\eta_1\eta_H(\rho\eta_H-\rho(1-\eta_H))\rho^2-\left(\beta_1^2(1-\eta_1(2-\rho(1-(1-\eta_1)(1-\eta_H))))^2+\eta_1^2(1-\rho(1-\eta_H))^2\right)\rho\right. \\
& -2\eta_1(3-\rho(3-\rho(1-\eta_H)\eta_H))\rho+2\beta_1(1-\eta_1)\eta_1(\rho\eta_H(1-\rho\eta_H)+\eta_1(1-\rho(\rho(1-\eta_H)\eta_H+1)))\rho \\
& +\left(2\rho(1-\eta_1)\eta_1(1-\eta_1(2-\rho(1-(1-\eta_1)(1-\eta_H))))\beta_1^2+2\rho\eta_1^2(1-\rho(1-\eta_H))\right)(1-\rho\eta_H) \\
& \left.+2\beta_1(1-\eta_1(2-\rho(1-(1-\eta_1)(1-\eta_H))))\left(-\eta_H\rho^2+(1-\rho\eta_H)\rho-\eta_1(\rho(1-\eta_H)-\rho\eta_H)\rho\right)\right) \\
& -2\beta_1(\rho\eta_H(1-\rho\eta_H)+\eta_1(1-\rho(\rho(1-\eta_H)\eta_H+1)))(1-\eta_1(\phi+1))+(1-\rho\eta_H)\left(-\eta_1^2(1-\rho(1-\eta_H))^2\right. \\
& \left.\left.-\beta_1^2(1-\eta 1(\phi+1))^2\right))\right)-2(1-\eta_H)(1-\rho\eta_H)((\rho\beta_1(1-\eta_1)\eta_1-\rho\eta_1)(1-\eta_H)-2\rho\eta_H-\eta_1(1-\rho\eta_H) \\
& -\beta_1(1-\eta_1(\phi+1))+2)\,(\eta_H(1-\rho\eta_H)(4-\rho(4-\rho(1-\eta_H)\eta_H))+(1-\eta_H)\,(-2\rho\eta_1\eta_H(3-\rho \\
& (3-\rho(1-\eta_H)\eta_H))+2\beta_1(\rho\eta_H(1-\rho\eta_H)+\eta_1(1-\rho(\rho(1-\eta_H)\eta_H+1)))(1-\eta_1(\phi+1)) \\
& +(1-\rho\eta_H)\left(\eta_1^2(1-\rho(1-\eta_H))^2+\beta_1^2(1-\eta_1(\phi+1))^2\right))))\,\Big(2\sqrt{(1-\eta_H)(1-\rho\eta_H)} \\
& \overline{(\eta_H(1-\rho\eta_H)(4-\rho(4-\rho(1-\eta_H)\eta_H))+(1-\eta_H)\,(-2\rho\eta_1\eta_H(3-\rho(3-\rho(1-\eta_H)\eta_H))} \\
& \overline{+2\beta_1(\rho\eta_H(1-\rho\eta_H)+\eta_1(1-\rho(\rho(1-\eta_H)\eta_H+1)))(1-\eta_1(\phi+1))} \\
& \overline{+(1-\rho\eta_H)\left(\eta_1^2(1-\rho(1-\eta_H))^2+\beta_1^2(1-\eta_1(\phi+1))^2\right)))}\Big)^{-1} > 0.
\end{aligned}$$

However, in contrast to the scenario of simultaneous production, the direction of the effect of η_1 on β_H^{seq} no longer solely depends on the level of η_1, instead it is ambigious and varies with the level of η_H and ρ. The concrete derivative of the producer's optimal revenue share with respect to η_1 is

$$\frac{\partial \beta_H^{seq}}{\partial \eta_1} = \frac{d_{H,\eta_1}^{seq}}{\underbrace{2((1-\eta_H)((1-\rho\eta_H)+\beta_1(1-\eta_1(\phi+1)))+\eta_H(2-\rho\eta_H)-1)^2}_{>0}} \quad \text{with}$$

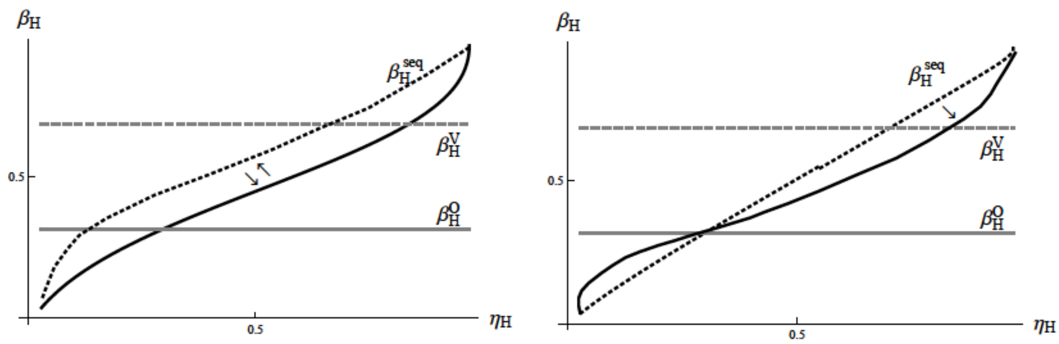

Figure 5.12: Optimal revenue share of the producer with simultaneous production for varying headquarter-intensity and elasticity of demand.
Left panel: low values of ρ. Black, dotted line: low or high values of η_1. Black, solid line: intermediate values of η_1.
Right panel: high values of ρ. Black, dotted line: low values of η_1. Black, solid line: high values of η_1.

$$
\begin{aligned}
d^{seq}_{H,\eta_1} = {} & ((1-\eta_H)(\eta_1(1-\rho\eta_H)+\beta_1(1-\eta_1(\phi+1)))+\eta_H(2-\rho\eta_H)-1)\,(-(1-\eta_H)\,(\eta_H\,(\rho^2(1-\eta_H) \\
& (\eta_1(1-\eta_H)+\eta_H)-\rho(-\eta_1-\eta_H+3)-\eta_1+2)+\beta_1(1-\eta_H)(\rho\eta_H+1)(1-\eta_1(1+\phi))+(1-\rho)\eta_1) \\
& (\beta_1(\rho\eta_1(1-\eta_H)-\phi-1)-\rho\eta_H+1)+\eta_H\,(\rho^2(1-\eta_H)^2+\rho-1)-((1-\eta_H)^2(1-\rho\eta_H) \\
& ((1-\rho\eta_H)\,(2\beta_1^2(1-\eta_1(\phi+1))(\rho\eta_1(1-\eta_H)-\phi-1)+2\eta_1(1-\rho(1-\eta_H))^2) \\
& +2\beta_1(\eta_1(1-\rho(\rho(1-\eta_H)\eta_H+1))+\rho\eta_H(1-\rho\eta_H))(\rho\eta_1(1-\eta_H)-\phi-1) \\
& +2\beta_1(1-\rho(\rho(1-\eta_H)\eta_H+1))(1-\eta_1(\phi+1))-2\rho\eta_H(3-\rho(3-\rho(1-\eta_H)\eta_H)))-2(1-\eta_H)^2 \\
& (1-\rho\eta_H)(\beta_1(\rho\eta_1(1-\eta_H)-\phi-1)-\rho\eta_H+1)\,((1-\eta_H)\,((1-\rho\eta_H)\,(\eta_1^2(1-\rho(1-\eta_H))^2 \\
& +\beta_1^2(1-\eta_1(\phi+1))^2)+2\beta_1(1-\eta_1(\phi+1))(\eta_1(1-\rho(\rho(1-\eta_H)\eta_H+1))+\rho\eta_H(1-\rho\eta_H)) \\
& -2\rho\eta_1\eta_H(3-\rho(3-\rho(1-\eta_H)\eta_H)))+\eta_H(1-\rho\eta_H)(4-\rho(4-\rho(1-\eta_H)\eta_H)))) \\
& (2\sqrt{(1-\eta_H)(1-\rho\eta_H)\,((1-\eta_H)\,((1-\rho\eta_H)\,(\eta_1^2(1-\rho(1-\eta_H))^2+\beta_1^2(1-\eta_1(\phi+1))^2) +2\beta_1(1-\eta_1(\phi+1))(\eta_1(1-\rho(\rho(1-\eta_H)\eta_H+1))+\rho\eta_H(1-\rho\eta_H)) -2\rho\eta_1\eta_H(3-\rho(3-\rho(1-\eta_H)\eta_H)))+\eta_H(1-\rho\eta_H)(4-\rho(4-\rho(1-\eta_H)\eta_H)))})^{-1} \\
& +\beta_1(1-\eta_H)(\rho\eta_H+1)(\rho\eta_1(1-\eta_H)-\phi-1)-\rho+1)\,.
\end{aligned}
$$

I am not able to find the sign for concrete parameter ranges of η_1, η_H and ρ. However, there are some basic relations:[25] If ρ is low, I find the same relation as with simultaneous production. As illustrated in the left panel of figure 5.12, the black, dotted line that represents low or high values of η_H runs for all values of η_1 above the black, solid line that stands for intermediate values of η_1. However, the critical input intensity at which the change in the direction arises is no longer equal to 1/2.

For high values of ρ holds:

$$
\frac{\partial \beta_H^{seq}}{\partial \eta_1} \begin{cases} > 0, & \text{if } \eta_H \text{ is small} \\ < 0, & \text{if } \eta_H \text{ is high.} \end{cases} \tag{A5.27}
$$

[25] The corresponding MATHEMATICA 9.0 file is available on request.

This relation is illustrated in the right panel of figure 5.12 where the black, dotted line stands for low values of η_1 whereas the black, solid line stands for high values of η_1. For low values of η_H, the black, solid line runs above the black, dotted line and for high values of η_H, the black, solid line runs below the black, dotted line. So, if η_H is low, an increase of η_1 raises β_H^{seq}, and if η_H is high, an increase of η_1 lowers β_H^{seq}. The critical value of η_H^c for which there is a change in the sign of the derivation depends on η_1.

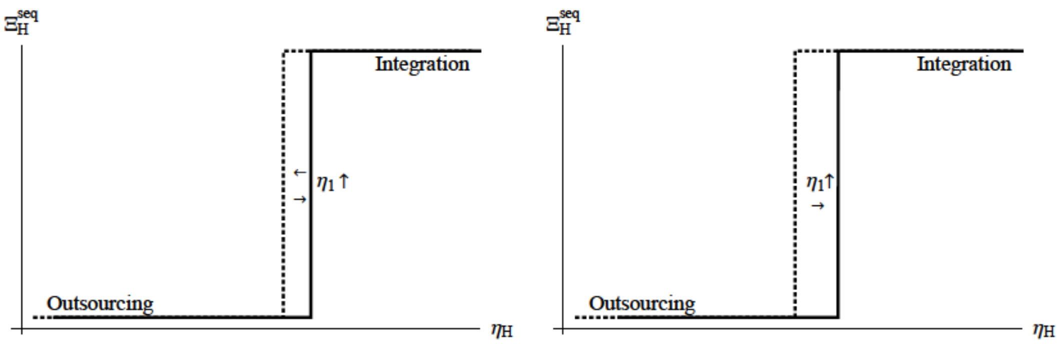

Figure 5.13: Organizational decision of the producer with simultaneous production for varying headquarter-intensity and elasticity of demand.
Left panel: low values of ρ. Black, dotted line: low or high values of η_1. Black, solid line: intermediate values of η_1.
Right panel: high values of ρ. Black, dotted line: low values of η_1. Black, solid line: high values of η_1.

The resulting organizational decision is depicted in figure 5.13. Since the effect of η_1 on the optimal revenue share depends on the level of ρ, the effect of η_1 on the organizational decision also depends on ρ. In the left panel of figure 5.13, I depict the organizational decision for low values of ρ, and in the right panel I assume high values of ρ.

As with simultaneous production, for low values of the headquarter-intensity, outsourcing is profit-maximizing for the producer and for high values of the headquarter-intensity integration is profit-maximizing. For low values of ρ, i.e., in the left panel of figure 5.13, a rise of η_1 first raises and then decreases the probability of outsourcing. If ρ is high, i.e., in the right panel, there is only a positive effect of η_1 on the probability of outsourcing.

A.III Setup without participation fees

A.III.i Simultaneous production

With simultaneous production, supplier 1 chooses the organizational form of supplier 2 that maximizes

$$\pi_{1,wo}^{sim} = (1 - \beta_H)\,\beta_1 R^{sim} - c_1 m_1^{sim}, \tag{A5.28}$$

whereas the producer makes his organizational decision subject to

$$\pi_{H,wo}^{sim} = \beta_H R^{sim} - c_H h^{sim} \tag{A5.29}$$

with m_1^{sim}, h^{sim} and R^{sim} as defined in (5.5).

Organizational decision of supplier 1 To derive supplier 1's optimal revenue share, I differentiate the above profit $\pi_{1,wo}^{sim}$ with respect to β_1 and solve for β_1:

$$\beta_{1,wo}^{sim} = \eta_1 + \frac{(1-\rho)\,(1-\eta_1)}{1-\rho\eta_H}. \tag{A5.30}$$

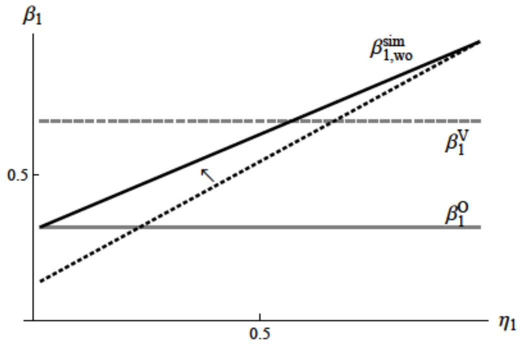

Figure 5.14: Optimal revenue share of supplier 1 with simultaneous production without participation fees for varying input intensity.
Black, dotted line: low values of η_H. Black, solid line: high values of η_H.

Figure 5.14 is analogous to figure 5.2 in the main text and illustrates this optimal revenue share with respect to η_1 for different values of η_H.

Both the increasing black lines and the positive sign of the derivation with respect to the input intensity depict that the revenue share is an increasing function of η_1:

$$\frac{\partial \beta_{1,wo}^{sim}}{\partial \eta_1} = \frac{\rho\,(1-\eta_H)}{1-\rho\eta_H} > 0. \tag{A5.31}$$

In figure 5.14 the black, solid line that represents high values of η_H runs for all values of η_1 above the black, dotted line that stands for low values of η_H. Analytically, this is reflected by the positive sign of the derivation with respect to η_H:

$$\frac{\partial \beta_{1,wo}^{sim}}{\partial \eta_H} = \frac{\rho\,(1-\rho)\,(1-\eta_1)}{(1-\rho\eta_H)^2} > 0. \tag{A5.32}$$

Since $\beta^{sim}_{1,wo}$ is increasing in η_1 and supplier 1's revenue share is lower for outsourcing than for integration, supplier 1 chooses for low values of η_1 outsourcing of supplier 2 and for high values of η_1, he chooses integration. This is illustrated in figure 5.15. As a higher headquarter-intensity shifts the optimal revenue share upwards, the cutoff input intensity is decreasing in η_H. Hence, the black, dotted line that represents low values of η_H is to the right of the black, solid line that stands for high values of η_H.

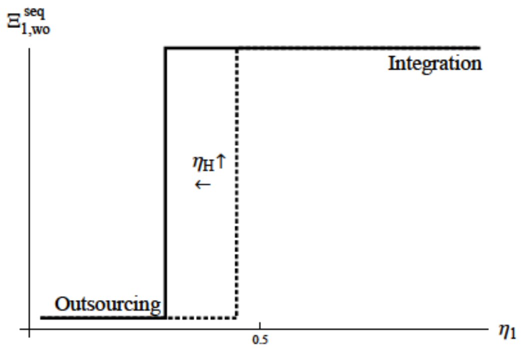

Figure 5.15: Organizational decision of supplier 1 with simultaneous production without participation fees for varying input intensity.
Black, dotted line: low values of η_H. Black, solid line: high values of η_H.

Interestingly, the strength of the effect of a higher input intensity on the revenue share is independent from the level of the input intensity, whereas the effect of a higher headquarter-intensity on the revenue share is positively related to the level of the headquarter-intensity:

$$\frac{\partial^2 \beta^{sim}_{1,wo}}{\partial \eta_1^2} = 0 \quad \text{and} \quad \frac{\partial^2 \beta^{sim}_{1,wo}}{\partial \eta_H^2} = \frac{2\rho^2 (1-\rho)(1-\eta_1)}{(1-\rho\eta_H)^3} > 0. \tag{A5.33}$$

In other words, the higher is the headquarter-intensity, the overproportional higher is the optimal revenue share and, thus, the overproportional higher is the probability of integration.

Organizational decision of the producer In a similar manner, I can derive the producer's optimal revenue share:

$$\beta^{sim}_{H,wo} = 1 - \rho(1-\eta_H). \tag{A5.34}$$

This optimal revenue share is depicted in figure 5.16 which is analogous to figure 5.4 of the main text.
As the black line is increasing in η_H and the corresponding derivation has a positive sign, the revenue share is higher, the higher is η_H:

$$\frac{\partial \beta^{sim}_{H,wo}}{\partial \eta_H} = \rho > 0. \tag{A5.35}$$

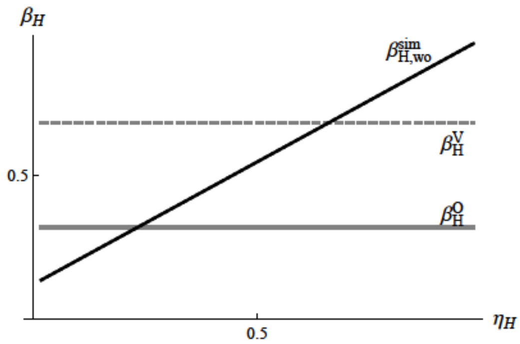

Figure 5.16: Optimal revenue share of the producer with simultaneous production without participation fees for varying headquarter-intensity.
Black, dotted line: low values of η_1. Black, solid line: high values of η_1.

In contrast to the constellation with participation fees, the derivation with respect to η_1 equals zero such that $\beta_{H,wo}^{sim}$ is independent from η_1:

$$\frac{\partial \beta_{H,wo}^{sim}}{\partial \eta_1} = 0. \tag{A5.36}$$

In accordance with this, in figure 5.16, the black, dotted line that stands for low values of η_1 and the black, solid line that depicts high values of η_1 are identical.

As in the main section, the producer chooses for low values of η_H outsourcing of supplier 1. For high values of η_H, she chooses integration. However, since a higher input intensity has no effect on the optimal revenue share, the cutoff headquarter-intensity depends solely on the level of β_H^O and β_H^V. This can be seen in figure 5.17 where the black, dotted line and the black, solid line are again identical.

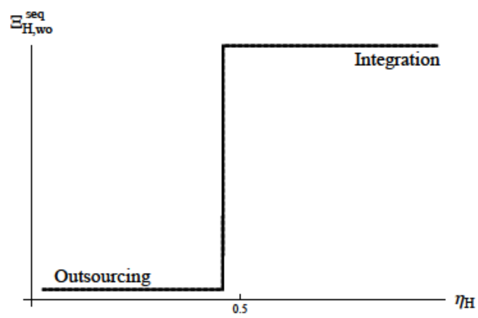

Figure 5.17: Organizational decision of the producer with simultaneous production without participation fees for varying headquarter-intensity.
Black, dotted line: low values of η_1. Black, solid line: high values of η_1.

Interrelation of the producer's and supplier 1's organizational decisions
Figure 5.18 is analogous to figure 5.6 in the main text and illustrates the resulting

combined organizational decisions of both the producer (Ξ_H^{sim}) and supplier 1 (Ξ_1^{sim}) as $\{\Xi_H^{sim}, \Xi_1^{sim}\}$.

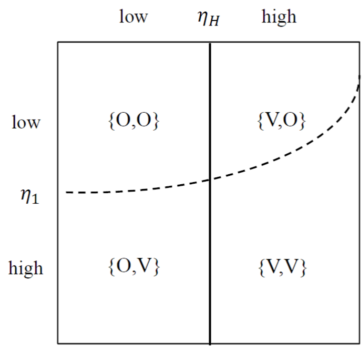

Figure 5.18: Organizational decisions of the producer and supplier 1 without participation fees with simultaneous production.

As before, if η_1 is above the black, dashed line, supplier 1 chooses outsourcing and if η_1 is below this line, he chooses integration of supplier 2. Analogously, if η_H is to the left of the black, solid line, the producer chooses outsourcing of supplier 1 and if η_H is to the right of this line, the producer chooses integration. However, in contrast to the straight black, dashed line with participation fees, without participation fees, the black, dashed line that separates low and high values of input intensity is rotated upwards with an increase of the headquarter-intensity such that integration of supplier 2 becomes more likely. In addition, the black, solid separating line of input intensity is no longer curved but straight, i.e., the producer's decision no longer depends on the suppliers' input intensities.

A.III.ii Sequential production

With sequential production, supplier 1's profit is given by

$$\pi_{1,wo}^{seq} = (1-\beta_H)\,\beta_1 R^{seq} - c_1 m_1^{seq} \tag{A5.37}$$

and the producer's profit is

$$\pi_{H,wo}^{seq} = \beta_H R^{seq} - c_H h^{seq}. \tag{A5.38}$$

m_1^{seq} and h^{seq} are again definded as in (5.5) and R^{seq} is defined as in (5.18).

Organizational decision of supplier 1 As before, I differentiate supplier 1's profit with respect to β_1 and solve for β_1 to derive the optimal revenue share

$$\beta_{1,wo}^{seq} = \eta_1 + \frac{(1-\rho)\,(1-\eta_1)}{1-\rho\eta_H}. \tag{A5.39}$$

that is identical to the optimal simultaneous revenue share without participation fees.

Organizational decision of the producer To compare the producer's optimal revenue share, I differentiate the producer's profit and solve for β_H:

$$\beta^{seq}_{H,wo} = 1 - \rho\left(1 - \eta_H\right). \tag{A5.40}$$

It is also equal to the optimal simultaneous revenue share without participation fees.

A.IV *Apple* or *smart*

A.IV.i Technology and demand

If the producer only uses supplier 2's input, output is given by the linear production function

$$q_2 = \theta_{H2} m_2, \tag{A5.41}$$

whereby θ_{H2} denotes the producer's productivity in using supplier 2's input. This output is then combined with the producer's and supplier 1's input to the final good by the following Cobb-Douglas production function:

$$q_{12H} = \theta_H \left(\frac{h}{\eta_H}\right)^{\eta_H} \left(\frac{\left(\frac{m_1}{\eta_1}\right)^{\eta_1} \left(\frac{\theta_{H2} m_2}{1-\eta_1}\right)^{1-\eta_1}}{1-\eta_H}\right)^{1-\eta_H}. \tag{A5.42}$$

Using (5.3), the value of supplier 2's input contribution is given by

$$R_2 = A^{1-\rho} \left(\theta_{H2} m_2\right)^{\rho} \tag{A5.43}$$

and the resulting revenue level of the final good is

$$R_{12H} = A^{1-\rho} \left(\theta_H \left(\frac{h}{\eta_H}\right)^{\eta_H} \left(\frac{\left(\frac{m_1}{\eta_1}\right)^{\eta_1} \left(\frac{\theta_{H2} m_2}{1-\eta_1}\right)^{1-\eta_1}}{1-\eta_H}\right)^{1-\eta_H}\right)^{\rho}. \tag{A5.44}$$

A.IV.ii Structure of the game

Contrary to the *smart* bargaining structure, production of the two suppliers always takes place sequentially under the *Apple* structure. More precisely, in line with Antràs and Chor (2013), the timing of events is the following:

1. The producer chooses the organizational form Ξ_i $(i \in (1, 2))$ of *both* suppliers and offers contracts to potential suppliers.

2. There is a huge mass of potential suppliers, each with an outside option equal to w_i, that apply for the contract. The producer chooses one supplier for the production of each input.
3. Supplier 2 decides on his noncontractible input provision level m_2.
4. The producer and supplier 2 bargain over the value that supplier 2 has contributed, i.e., about the revenue R_2 this (unfinished) good would generate.
5. After receiving the unfinished good, the producer and supplier 1 choose their noncontractible input provision levels h and m_1.
6. The producer and supplier 1 bargain over the surplus value of their relationship, i.e. about the difference in the revenue level $R_{\text{diff}} = R_{12H} - R_2$.
7. The final good is produced. Revenue is realized and the firm receives the total revenue.

A.IV.iii Solution the game

Solving by backward induction, in stage 6, the producer receives a revenue share β_{H1}, whereas supplier 1 receives the residual $(1-\beta_{H1})$. With profit maximimization in stage 5, the producer and supplier 1 choose the input provisions h^{Apple} and m_1^{Apple} that are a function of these revenue shares:

$$h^{Apple} = \frac{\rho\beta_{H1}\eta_H}{c_H} R_{12H}^{Apple} \quad \text{and} \quad m_1^{Apple} = \frac{\rho\left(1-\beta_{H1}\right)\eta_1\left(1-\eta_H\right)}{c_1} R_{12H}^{Apple} \quad \text{with}$$

$$R_{12H}^{Apple} = \left(A^{1-\rho}\left(\rho^{\frac{1-\phi}{\rho}}\theta_H\left(\frac{\beta_{H1}}{c_H}\right)^{\eta_H}\left(\left(\frac{1-\beta_{H1}}{c_1}\right)^{\eta_1}\left(\frac{\theta_{H2}m_2}{\left(1-\eta_1\right)\left(1-\eta_H\right)}\right)^{1-\eta_1}\right)^{1-\eta_H}\right)^{\rho}\right)^{\frac{1}{\phi}} \tag{A5.45}$$

with ϕ as defined in (5.17). As in Antràs and Chor (2013), the input provisions do not depend on the marginal revenue contribution R_{diff}, but on the total revenue generated up to this stage, R_{12H}^{Apple}. In the bargaining of the producer and supplier 2 in stage 4, the producer receives the share β_{H2} and supplier 2 receives $(1-\beta_{H2})$. The level of supplier 2's input provision is driven by these revenue shares and by the revenue of the unfinished product up to this stage, R_2^{Apple}:

$$m_2^{Apple} = \rho\left(1-\beta_{H2}\right)c_2 R_2^{Apple} \quad \text{with} \quad R_2^{Apple} = A\left(\frac{\rho\theta_{H2}\left(1-\beta_{H2}\right)}{c_2}\right)^{\frac{\rho}{1-\rho}}. \tag{A5.46}$$

Using supplier 2's input provision, total revenue becomes

$$R_{12H}^{Apple} = A\rho^{\frac{\rho}{1-\rho}}\left(\theta_H\left(\frac{\beta_{H1}}{c_H}\right)^{\eta_H}\left(\left(\frac{1-\beta_{H1}}{c_1}\right)^{\eta_1}\left(\frac{\left(\frac{(1-\beta_{H2})\theta_{H2}}{c_2}\right)^{\frac{1}{1-\rho}}}{\left(1-\eta_1\right)\left(1-\eta_H\right)}\right)^{1-\eta_1}\right)^{1-\eta_H}\right)^{\frac{\rho}{\phi}} \tag{A5.47}$$

and the profit level for the *Apple* case is given by

$$\pi_H^{Apple} = \beta_{H1} R_{\text{diff}}^{Apple} + \beta_{H2} R_2^{Apple} - c_H h^{Apple} = \beta_{H1}\left(1-\rho\eta_H\right) R_{12H}^{Apple} + \left(\beta_{H2}-\beta_{H1}\right) R_2^{Apple}$$

$$= \beta_{H1}\left(1-\rho\eta_H\right) A\rho^{\frac{\rho}{1-\rho}} \left(\theta_H \left(\frac{\beta_{H1}}{c_H}\right)^{\eta_H} \left(\left(\frac{1-\beta_{H1}}{c_1}\right)^{\eta_1} \left(\frac{\left(\frac{(1-\beta_{H2})\theta_{H2}}{c_2}\right)^{\frac{1}{1-\rho}}}{\left(1-\eta_1\right)\left(1-\eta_H\right)}\right)^{1-\eta_1}\right)^{1-\eta_H}\right)^{\frac{\rho}{\phi}}$$

$$+ \left(\beta_{H2}-\beta_{H1}\right) A \left(\frac{\rho\theta_{H2}\left(1-\beta_{H2}\right)}{c_2}\right)^{\frac{\rho}{1-\rho}}. \tag{A5.48}$$

A.IV.iv Concrete derivatives of the relative profits

The derivation of the relative profit with respect to θ_1 is given by

$$\begin{aligned}
\frac{\partial\pi_{\text{rel}}}{\partial\theta_1} = &-\frac{\rho(1-\eta_H)}{(1-\rho)(1-\rho\eta_H)}(1-\beta_{H2})^{\frac{\rho}{1-\rho}}\,\theta_H^{\frac{\rho}{\rho-1}}\,\theta_{H2}^{\frac{\rho}{1-\rho}}\,(1-\beta_H)^{-\frac{\rho(\eta_H-1)}{\rho-1}}\,\beta_H^{\frac{\rho\eta_H}{\rho-1}-1}\\
&(\rho(\eta_1-1)\eta_H-\rho\eta_1+1)^{-\frac{\rho(\eta_1-1)(\eta_H-1)}{\rho-1}}\,\theta_1^{\frac{1-\rho\eta_H}{\rho-1}}\,c_H^{-\frac{\rho\eta_H}{\rho-1}}\,(1-\beta_1)^{\frac{\rho(\eta_1-1)(\eta_H-1)}{\rho-1}}\,\beta_1^{-\frac{\rho\eta_1(\eta_H-1)}{\rho-1}}\,c_1^{\frac{\rho\eta_1(\eta_H-1)}{\rho-1}}\\
&c_2^{\frac{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H)}{\rho-1}}\left(\beta_{H2}+\beta_{H1}\left((1-\rho\eta_H)(1-\eta_1)^{\frac{1-\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}-1}(1-\eta_H)^{\frac{1-\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}-1}\right.\right.\\
&(1-\beta_{H1})^{-\frac{\rho\eta_1(\eta_H-1)}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}\,\beta_{H1}^{\frac{\rho\eta_H}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}\,(1-\beta_{H2})^{\frac{1}{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H)-1}+1}\,\theta_H^{\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}\\
&\left.\left.\theta_{H2}^{\frac{1}{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H)-1}+1}\,c_1^{\frac{\rho\eta_1(\eta_H-1)}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}\,c_2^{\frac{1}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}-1}\,c_H^{-\frac{\rho\eta_H}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}-1\right)\right).
\end{aligned} \tag{A5.49}$$

The derivation of the relative profit with respect to θ_H is

$$\begin{aligned}
\frac{\partial\pi_{\text{rel}}}{\partial\theta_H} = &-\frac{\rho}{(1-\rho)(1-\rho\eta_H)}(1-\beta_{H2})^{\frac{\rho}{1-\rho}}\,\theta_H^{\frac{1}{\rho-1}}\,\theta_{2H}^{\frac{\rho}{1-\rho}}\,(1-\beta_H)^{-\frac{\rho(\eta_H-1)}{\rho-1}}\,\beta_H^{\frac{\rho\eta_H}{\rho-1}-1}\\
&(1-\eta_1)^{-\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}\,(1-\eta_H)^{-\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}\,(\rho(\eta_1-1)\eta_H-\rho\eta_1+1)^{\frac{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H-1)}{\rho-1}-1}\\
&\theta_1^{-\frac{\rho(\eta_H-1)}{\rho-1}}\,(1-\beta_1)^{\frac{\rho(\eta_1-1)(\eta_H-1)}{\rho-1}}\,\beta_1^{-\frac{\rho\eta_1(\eta_H-1)}{\rho-1}}\,c_1^{\frac{\rho\eta_1(\eta_H-1)}{\rho-1}}\,c_2^{\frac{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H)}{\rho-1}-1}\,c_H^{-\rho\eta_H\left(\frac{1}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}+\frac{1}{\rho-1}\right)}\\
&\left(\rho(\beta_{H2}-1)(\rho\eta_H-1)(1-\eta_1)^{\frac{1}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}\,(1-\eta_H)^{\frac{1}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}\,(1-\beta_{H1})^{\frac{\rho\eta_1(1-\eta_H)}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}\right.\\
&\beta_{H1}^{\frac{\rho\eta_H}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}+1}\,(1-\beta_{H2})^{\frac{1}{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H)-1}}\,\theta_H^{\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}\,\theta_{2H}^{\frac{1}{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H)-1}+1}\,c_1^{\frac{\rho\eta_1(\eta_H-1)}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}\\
&c_2^{\frac{1}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}-c_2(\beta_{H1}-\beta_{H2})(1-\eta_1)^{\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}\,(1-\eta_H)^{\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}\\
&\left.(\rho(\eta_1-1)\eta_H-\rho\eta_1+1)\,c_H^{\frac{\rho\eta_H}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}\right).
\end{aligned} \tag{A5.50}$$

The derivation of the relative profit with respect to θ_{H2} is given by

$$
\begin{aligned}
\frac{\partial \pi_{\mathrm{rel}}}{\partial \theta_{H2}} = {} & \frac{\rho}{(1-\rho)(1-\rho\eta_H)} (1-\beta_{H2})^{\frac{\rho}{1-\rho}} \theta_H^{\frac{\rho}{\rho-1}} \theta_{H2}^{\frac{1}{1-\rho}-2} (1-\beta_H)^{-\frac{\rho(\eta_H-1)}{\rho-1}} \beta_H^{\frac{\rho\eta_H}{\rho-1}-1} (1-\eta_1)^{-\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} \\
& (1-\eta_H)^{-\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} (\rho(\eta_1-1)\eta_H-\rho\eta_1+1)^{\frac{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H-1)}{\rho-1}-1} \theta_1^{-\frac{\rho(\eta_H-1)}{\rho-1}} (1-\beta_1)^{\frac{\rho(\eta_1-1)(\eta_H-1)}{\rho-1}} \\
& \beta_1^{-\frac{\rho\eta_1(\eta_H-1)}{\rho-1}} (1-\beta_{H1})^{-\frac{\rho\eta_1(\eta_H-1)}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} c_1^{\frac{\rho\eta_1(\eta_H-1)}{\rho-1}} c_2^{\frac{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H)}{\rho-1}-1} c_H^{-\rho\eta_H\left(\frac{1}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}+\frac{1}{\rho-1}\right)} \\
& \Bigg((\beta_{H2}-1)(\rho\eta_H-1)(1-\eta_1)^{\frac{1}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} (1-\eta_H)^{\frac{1}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} \beta_{H1}^{\frac{\rho\eta_H}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}+1} \\
& (1-\beta_{H2})^{\frac{1}{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H)-1}} \theta_H^{\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} \theta_{H2}^{\frac{1}{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H)-1}+1} c_1^{\frac{\rho\eta_1(\eta_H-1)}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} c_2^{\frac{1}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} \\
& -c_2(\beta_{H1}-\beta_{H2})(1-\eta_1)^{\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} (1-\eta_H)^{\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} (\rho(\eta_1-1)\eta_H-\rho\eta_1+1) \\
& (1-\beta_{H1})^{\frac{\rho\eta_1(\eta_H-1)}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} c_H^{\frac{\rho\eta_H}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} \Bigg).
\end{aligned}
\tag{A5.51}
$$

The derivations with regard to the η^H and η_1 are provided on request in a MATHEMATICA 9.0 file.

Chapter 6

The decision whether to integrate or to outsource - combining ex ante distortions and ex post inefficiencies

6.1 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 6.2. 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.

[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).

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 - 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

[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).

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.

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 6.2 gives a more detailed illustration of the different examples. In section 6.3, I introduce the structure of my model. I then analyze the resulting organizational decisions under exogenously given probabilities in section 6.4. In section 6.5, I analyze a supplier's incentive to become a competitor and the effect on the producer's organizational decision. Section 6.6 provides an analysis whether the producer can prevent the duopoly through a transfer payment. Section 6.7 concludes and summarizes the main results of the analysis.

6.2 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.

6.3 The model

6.3.1 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:

$$y_H = \theta_H \left(\frac{h}{\eta_H}\right)^{\eta_H} \left(\frac{m}{(1-\eta_H)}\right)^{(1-\eta_H)} \tag{6.1}$$

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:

$$p = (A/Y)^{1-\alpha}\,. \tag{6.2}$$

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 (6.1) and (6.2), the revenue of the firm is given by

$$R = p\, y_H = p\, \theta_H \left[\left(\frac{h}{\eta_H}\right)^{\eta_H} \left(\frac{m}{(1-\eta_H)}\right)^{(1-\eta_H)}\right]. \tag{6.3}$$

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

6.3.2 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 6.1: 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

[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.

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.

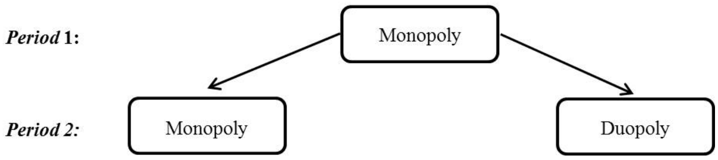

Figure 6.1: Overview over the market structure in the different periods.

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.

↙

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.

[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.

6.3.3 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.

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:

$$p_{Mon} = (A/y_H)^{1-\alpha}\,. \tag{6.4}$$

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:

$$h^*_{Mon} = \frac{\alpha\beta_H\eta_H}{c_H} R^*_{Mon} \quad \text{and} \quad m^*_{Mon} = \frac{\alpha(1-\beta_H)(1-\eta_H)}{c_M} R^*_{Mon} \tag{6.5}$$

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

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.

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:

$$p_{Duo} = \left(A/(y_H + y_C)\right)^{1-\alpha}, \tag{6.6}$$

where the output of the competitor is given by

$$y_C = \theta_C \left(\frac{h_{Duo,C}}{\eta_H}\right)^{\eta_H} \left(\frac{m_{Duo,C}}{(1-\eta_H)}\right)^{(1-\eta_H)} \quad \text{with } \ \alpha\theta_H < \theta_C < \theta_H. \tag{6.7}$$

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

$$R_{Duo,C} = \left(A/(y_H + y_C)\right)^{1-\alpha} \ \theta_C \ \left[\left(\frac{h_{Duo,C}}{\eta_H}\right)^{\eta_H} \left(\frac{m_{Duo,C}}{(1-\eta_H)}\right)^{(1-\eta_H)}\right]. \tag{6.8}$$

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 (6.3), also depends on both the producer's and the competitor's output:

$$R_{Duo} = \left(A/(y_H + y_C)\right)^{1-\alpha} \ \theta_H \ \left[\left(\frac{h_{Duo}}{\eta_H}\right)^{\eta_H} \left(\frac{m_{Duo}}{(1-\eta_H)}\right)^{(1-\eta_H)}\right]. \tag{6.9}$$

[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.

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 $h_{Duo} = \mathrm{argmax}_h \{\beta_H R_{Duo} - c_H h\}$ and $m_{Duo} = \mathrm{argmax}_m \{(1-\beta_H) R_{Duo} - c_M m\}$ for her supplier, those for the competitor and his supplier are given by $h_{Duo,C} = \mathrm{argmax}_h \{\beta_H R_{Duo,C} - c_H h\}$ and $m_{Duo,C} = \mathrm{argmax}_m \{(1-\beta_H) R_{Duo,C} - c_M m\}$. 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 productivity of both the producer, θ_H, and her competitor, θ_C:

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

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

$$m^*_{Duo,C} = \frac{(1+\alpha)\,(1-\beta_H)\,(1-\eta_H)}{c_M}\frac{\theta_H}{\theta_C+\theta_H}R^*_{Duo,C} \tag{6.10}$$

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

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

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 $w=0$:

$$\pi^{\Xi}_{M,Duo} = \left(1-\frac{(1+\alpha)\,\theta_C\,(1-\eta_H)}{\theta_C+\theta_H}\right)(1-\beta_H)\,R^*_{Duo} \geq 0. \tag{6.11}$$

This leaves the producer with a profit of

$$\pi^{\Xi}_{H,Duo} = \left(1-\frac{(1+\alpha)\,\theta_C\eta_H}{\theta_C+\theta_H}\right)\beta_H R^*_{Duo}, \tag{6.12}$$

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

$$\pi^{\Xi}_{H,Duo,C} = \left(1 - \frac{(1+\alpha)\,\theta_H \eta_H}{\theta_C + \theta_H}\right) \beta_H R^*_{Duo,C} \quad \text{and} \tag{6.13}$$

$$\pi^{\Xi}_{M,Duo,C} = \left(1 - \frac{(1+\alpha)\,\theta_H\,(1-\eta_H)}{\theta_C + \theta_H}\right) (1-\beta_H)\, R^*_{Duo,C}. \tag{6.14}$$

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 $w = 0$:

$$\pi^{\Xi}_{M,Mon} = (1 - \alpha\,(1-\eta_H))\left(1 - \beta^{\Xi}_H\right) R^*_{Mon} \geq 0. \tag{6.15}$$

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,

$$\pi^{\Xi}_{H,Mon} = (1 - \alpha\eta_H)\,\beta^{\Xi}_H R^*_{Mon}, \tag{6.16}$$

but her expected profit over *both* periods:

$$\pi^{\Xi}_H = \pi^{\Xi}_{H,Mon} + \left(\left(1 - pr^{\Xi}\right)\pi^{\Xi}_{H,Mon} + pr^{\Xi}\pi^{\Xi}_{H,Duo}\right) = \frac{\beta^{\Xi}_H R^*_{Mon}}{1-\alpha}\cdot \tag{6.17}$$

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

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 (6.12),

$$\frac{\pi^{\Xi}_{H,Mon}}{\pi^{\Xi}_{H,Duo}} = \frac{(1-\alpha)\left(\frac{\alpha}{1+\alpha}\right)^{\frac{\alpha}{1-\alpha}} (1-\alpha\eta_H)\,(\theta_C+\theta_H)^{\frac{1}{1-\alpha}}}{\theta_C^{\frac{\alpha}{1-\alpha}}\,(\theta_H - \alpha\theta_C)\,(\theta_H + (1 - \eta_H\,(1+\alpha)))} > 1, \tag{6.18}$$

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^{Ξ}_H, 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.

6.4 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

$$\pi_H^O\left(pr^O = 0\right) = \pi_{H,Mon}^O + \pi_{H,Mon}^O \text{ and } \pi_H^V\left(pr^V = 0\right) = \pi_{H,Mon}^V + \pi_{H,Mon}^V \tag{6.19}$$

and the producer chooses outsourcing whenever

$$\pi_H^{rel}\left(pr^O = pr^V = 0\right) = \frac{\pi_H^O\left(pr^O = 0\right)}{\pi_H^V\left(pr^V = 0\right)} \tag{6.20}$$

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

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:

$$\eta_H^{crit} = 1 - \frac{Log\left[\beta_H^V\right] - Log\left[\beta_H^O\right]}{2\alpha\left(ArcTanh\left[1-2\beta_H^O\right] - ArcTanh\left[1-2\beta_H^V\right]\right)}. \tag{6.21}$$

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 6.2 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.

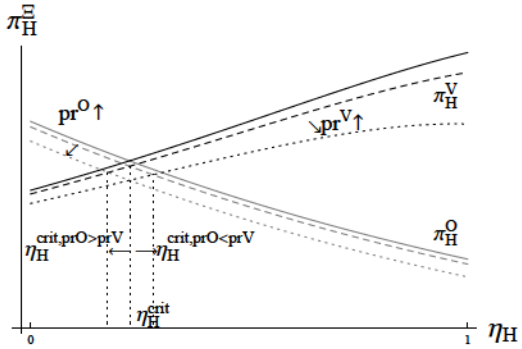

Figure 6.2: Profits under integration and outsourcing with ex post inefficiencies associated with outsourcing and integration.

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 the

[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.

producer is indifferent between outsourcing and integration if

$$\pi_H^O\left(pr^O=0\right)+\frac{\partial\pi_H^O}{\partial pr^O}\cdot pr^O=\pi_H^V\left(pr^V=0\right)+\frac{\partial\pi_H^V}{\partial pr^V}\cdot pr^V \quad \text{with} \tag{6.22}$$

$$\frac{\partial\pi_H^\Xi}{\partial pr^\Xi}=-\frac{\beta_H^\Xi R_{Mon}^*}{1-\alpha}\cdot \tag{6.23}$$

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

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 ((6.18)), the marginal change in profit induced by a risk of knowledge absorption, as described by (6.23), 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 6.2. 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 $\pi_{H,Duo}^{rel}$ simplifies to

$$\pi_{H,Duo}^{rel}=\frac{\pi_{H,Duo}^O}{\pi_{H,Duo}^V}=\left(\left(\frac{1-\beta_H^O}{1-\beta_H^V}\right)^{\alpha(1-\eta_H)}\left(\frac{\beta_H^O}{\beta_H^V}\right)^{1-\alpha(1-\eta_H)}\right)^{\frac{1}{1-\alpha}} \tag{6.24}$$

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_H^{crit}, as defined in (6.21). This cutoff headquarter-intensity and the profits under integration or outsourcing for different risk levels are also depicted in figure 6.2. 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_H^{crit}. 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 ($\eta_H^{crit,prO>prV} < \eta_H^{crit}$). 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 ($\eta_H^{crit,prO<prV} > \eta_H^{crit}$). 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_H^{crit}: As the cutoff headquarter-intensity η_H^{crit} 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 (6.22) can be rewritten as

$$\pi_H^O\left(pr^O = p\right) + \frac{\partial \pi_H^O}{\partial pr^O}\left(pr^O - p\right) = \pi_H^V\left(pr^V = p\right) + \frac{\partial \pi_H^V}{\partial pr^V}\left(pr^V - p\right) \tag{6.25}$$

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.

6.5 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

$$\frac{\pi_{H,Duo,C}^*}{\pi_{M,Mon}^*}=\frac{\left(\frac{1+\alpha}{\alpha}\,\theta_C\right)^{\frac{\alpha}{1-\alpha}}\beta_H^{\Xi}\left(\theta_C-\alpha\theta_H\right)\left(\theta_C+\left(1-\eta_H\left(1+\alpha\right)\right)\theta_H\right)}{\left(1-\alpha\right)\left(1-\beta_H^{\Xi}\right)\left(1-\alpha\left(1-\eta_H\right)\right)\left(\theta_C+\theta_H\right)^{\frac{2-\alpha}{1-\alpha}}}>1. \tag{6.26}$$

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

$$\eta_H^{comp,\Xi}= \tag{6.27}$$

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

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]

$$\frac{\partial \eta_H^{comp,\Xi}}{\partial \frac{\theta_C}{\theta_H}} > 0. \tag{6.28}$$

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):

$$\frac{\partial \eta_H^{comp,\Xi}}{\partial \beta_H^{\Xi}} > 0. \tag{6.29}$$

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,

[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.

becoming a competitor implies a stronger increase of the revenue share for the integrated supplier than for the outsourced supplier such that becoming a competitor and, thus, having a duopoly is much more attractive for an integrated supplier than for an outsourced supplier.

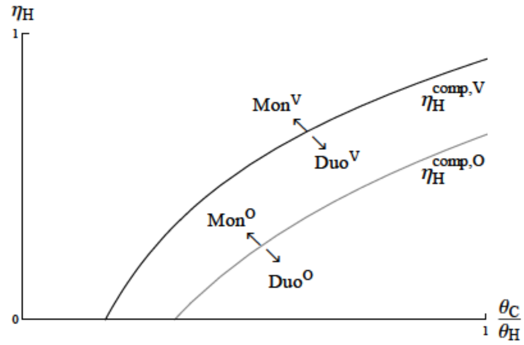

Figure 6.3: Critical competitor headquarter-intensity at which a supplier is indifferent between monopoly and duopoly.

The competitor headquarter-intensity, $\eta_H^{comp,\Xi}$, and the above shown properties are illustrated in figure 6.3 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 6.3 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 6.3 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 6.2 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 supplier, 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.

6.6 Prevention of a duopoly

If the supplier decides to become a competitor, the producer has lower profits than in monopoly ((6.18)). 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

$$loss_H = \pi^*_{H,Mon} - \pi^*_{H,Duo}. \tag{6.30}$$

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,

$$gain_C = \pi^*_{H,Duo,C} - \pi^*_{M,Mon}. \tag{6.31}$$

That is, to be binding, the transfer payment has to be lower than the loss of the producer, given by (6.30), but higher than the gain of the supplier, defined in (6.31). 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

$$\eta_H^{prev,\Xi} = \tag{6.32}$$

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

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.

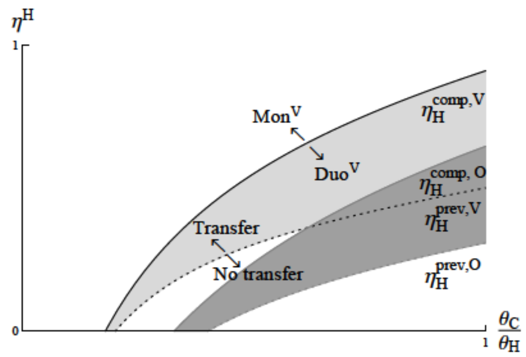

Figure 6.4: Critical prevention headquarter-intensity at which the producer is indifferent between paying a transfer or not.

Figure 6.4 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]

$$\frac{\partial \eta_H^{prev,\Xi}}{\partial \frac{\theta_C}{\theta_H}} > 0. \tag{6.33}$$

This is illustrated by the curvature of the black, dotted and the gray, dotted line in figure 6.4 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:

$$\frac{\partial \eta_H^{prev,\Xi}}{\partial \beta_H} > 0. \tag{6.34}$$

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 6.4, 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.,

$$\frac{\eta_H^{comp,\Xi}}{\eta_H^{prev,\Xi}} > 1, \tag{6.35}$$

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

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 6.4. 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.

6.7 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.

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6.9 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

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

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

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

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

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

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:

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

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

$$\begin{aligned}\nu_{\theta_C/\theta_H}&=(1+\alpha)^{\frac{\alpha}{1-\alpha}}\left(\left((1-\alpha)\,\alpha+1\right)\left(\frac{\theta_C}{\theta_H}\right)-\alpha^2\right)\left(1+\left(\frac{\theta_C}{\theta_H}\right)-(1+\alpha)\,\eta_H\right)\\&\quad+(1-\alpha)\,(1+\alpha)^{\frac{1}{1-\alpha}}\,\eta_H\left(\frac{\theta_C}{\theta_H}\right)\left(\left(\frac{\theta_C}{\theta_H}\right)-\alpha\right)>0.\end{aligned}$$

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:

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

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

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:

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

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

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

$$\begin{aligned}\text{and } \tau_{\theta_C/\theta_H} = &\left(\left(1+\alpha\right)^{\frac{1}{1-\alpha}}\beta_H\theta_H\left(\frac{\theta_C}{\theta_H}\right)^{\frac{\alpha}{1-\alpha}}\left(1+\left(\frac{\theta_C}{\theta_H}\right)\right)^{\frac{-1}{1-\alpha}}\left(\alpha-\left(\frac{\theta_C}{\theta_H}\right)\left(2-\alpha\left(\frac{\theta_C}{\theta_H}\right)\right)\right)\right.\\ &\left.-\left(1-\alpha\right)\alpha^{\frac{1}{1-\alpha}}\left(1-2\beta_H\right)\theta_H\left(1+\left(\frac{\theta_C}{\theta_H}\right)\right)\right)^2 > 0.\end{aligned} \tag{A6.9}$$

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

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

$$\begin{aligned}\frac{\partial \eta_H^{prev,\Xi}}{\partial \beta_H} = &\frac{\zeta_{\beta_H}\left(\left(2-\alpha\right)\alpha^{\frac{1}{1-\alpha}}\left(1+\alpha\right)^{\frac{-\alpha}{1-\alpha}}\left(1-\left(\frac{\theta_C}{\theta_H}\right)^{-\frac{\alpha}{1-\alpha}}\right)\left(1+\left(\frac{\theta_C}{\theta_H}\right)\right)^{\frac{2-\alpha}{1-\alpha}}-\alpha^2\left(1+\left(\frac{\theta_C}{\theta_H}\right)^2\right)+\left(2+4\alpha\right)\right)}{\epsilon_{\beta_H}}\\ &> 0\end{aligned} \tag{A6.10}$$

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

$$\begin{aligned}\text{and } \epsilon_{\beta_H} = &\left(\left(1+\alpha\right)^{\frac{1}{1-\alpha}}\beta_H\theta_H\left(\frac{\theta_C}{\theta_H}\right)^{\frac{\alpha}{1-\alpha}}\left(1+\left(\frac{\theta_C}{\theta_H}\right)\right)^{\frac{-1}{1-\alpha}}\left(\alpha-\left(\frac{\theta_C}{\theta_H}\right)\left(2-\alpha\left(\frac{\theta_C}{\theta_H}\right)\right)\right)\right.\\ &\left.-\left(1-\alpha\right)\alpha^{\frac{1}{1-\alpha}}\left(1-2\beta_H\right)\theta_H\left(1+\left(\frac{\theta_C}{\theta_H}\right)\right)\right)^2 > 0.\end{aligned}$$

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:

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

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

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

Chapter 7

Conclusion

This thesis analyzes organizational decisions of multinational firms. It consists of five contributions to the literature that are at the intersection of international trade, industrial economics and organizational economics. In these contributions, I extend the literature on organizational decisions of multinational firms in various directions. In the following, I summarize the resulting main new insights.

In chapters 2 to 4, I extend the literature on organizational decisions in "spider" production processes, where different inputs enter production in no particular order.

In the first contribution, chapter 2, where we analyze a "spider" setup with suppliers that may be asymmetric with regard to the organizational forms and the input characteristics, we can derive predictions *which* of the two inputs is sourced from an integrated supplier and *which* is sourced from an outsourced supplier under hybrid sourcing. More precisely, we find that the more important input is sourced from an outsourced supplier if the two manufacturing inputs are substitutes, i.e, for low demand elasticity, whereas it might be sourced from an integrated supplier if the inputs are complements, i.e., under high demand elasticity. We provide anecdotal evidence for this observation, however, the empirical analysis is left for future research. In addition, we find that lower unit costs and lower sophistication make outsourcing more likely. These findings are new from a theoretical perspective, however, they are in line with empirical analyses already carried out.

Chapter 3 that is basically a spin-off product of chapter 2 and depicts the analysis in more detail, contributes to a better understanding of the multilateral bargaining of the producer with the two suppliers and of the implications on the revenue distribution.

In chapter 4, where outsourcing is not only assumed to be associated with benefits but also with extra costs, it is not clear, why one component should be more affected by this indirect impact than the other. We show, however, that integration becomes especially for the input with the lower technological importance for the production more likely - a result that has not been found so far.

Chapter 5 contributes to the literature on "snake" production processes where inputs enter the production process in a particular order. If the producer no longer makes organizational decisions along the whole value chain, but only with regard to her direct supplier, the decisions are furthermore interrelated and depend along the whole value chain on the producer's importance for the production. However, the organizational decisions also depend on the two suppliers' relative importance such that the producer's importance for the production does not definitely pin down the degree of integration of the whole value chain. This is both from the theoretical and empirical point of view a new result. It would be interesting to extend the model to a continuum of suppliers and to bring these results to the data.

Finally, in chapter 6 where I combine the baseline trade-off of the property rights approach with the risk of knowledge absorption inherent of the knowledge protection approach, however, under *both* organizational forms, I show that an integrated supplier has a higher risk to become a competitor than an outsourced supplier. Hence, contrary to the central result of the knowledge protection approach, the risk of knowledge absporption makes outsourcing more likely. It is left for future research to extend the theoretical analysis for differences in product quality and to test this new relation empirically.

Summing up, the presented different contributions to the literature deliver important predictions to better understand and manage multinational firms' organizational decisions. However, to test their empirical relevance, it is necessary to first bring them to the data.

Eidesstattliche Versicherung

Ich, Verena Nina Nowak, versichere an Eides statt, dass die vorliegende Dissertation von mir selbstständig, und ohne unzulässige fremde Hilfe, unter Beachtung der „Grundsätze zur Sicherung guter wissenschaftlicher Praxis an der Heinrich-Heine-Universität Düsseldorf“ erstellt worden ist.

Düsseldorf, 24. Juni 2016

Unterschrift