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Editor:

Prof. Dr. Hans‐Theo Normann
Düsseldorf Institute for Competition Economics (DICE)
Phone: +49(0) 211‐81‐15125, e‐mail: normann@dice.hhu.de

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Organizational Decisions in Multistage Production Processes

Verena Nowak*

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Abstract

Organizational decisions in multistage production processes are often not made by the downstream headquarter firm, but by the various intermediate inputs suppliers along the value chain themselves. We 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. We find that the producer's and the supplier's organizational decisions are interrelated, particularly when production decisions occur sequentially. For instance, our model predicts that a higher technological importance of the downstream supplier raises the probability that the upstream supplier is vertically integrated. We also compare our model to the framework by Antras and Chor (2013) who assume that the headquarter makes all organizational decisions along the value chain. Then, we 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.

JEL codes: D23, L23
Keywords: outsourcing, vertical integration, property rights, sequential production processes

* Düsseldorf Institute for Competition Economics (DICE), Heinrich-Heine-University Düsseldorf, nowak@dice.hhu.de.

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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 supplier of each stage it must be decided whether he is vertically integrated within the boundaries of the firm or 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: APPLE tasks Foxconn or Pegatron with the assembly of its products, but has beyond these assembly facilities own suppliers for the 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, we provide an alternative mechanism to explain the organizational decisions in multistage production processes. More precisely, our 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. Our 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.

In our model, we 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), we 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 the incompleteness, a bargaining about the division of surplus takes place after the production of inputs such that underinvestment problems arise. In this bargaining, an outsourced supplier has more property rights over his input than an integrated supplier. Outsourcing thus implies a higher bargaining power and more production incentives for the respective supplier. Vice versa, integration of a supplier gives the other player 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.

[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).

Ultimately, we are interested in the organizational decisions with sequential production. However, in our model, sequentiality may arise with regard to the bargaining structure and the production. To separate the effects on the organizational decisions, we 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, we 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 our 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 that are outside the scope of the two suppliers' relation. A further main finding is that, in contrast to the results of Antràs and Chor (2013), our 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 we do not observe a (completely) integrated value chain. This implies that not only the relevance of the producer is crucial for the degree of integration within a value chain, but also the suppliers' relative importance.

We then assume that firms can freely decide on their decision structure. In other words, we 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, our 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 2 we introduce the structure of our model. Then, in section 3 and 4 we analyze the organizational decisions for the scenarios of simultaneous and sequential production. In section 5 we consider an alternative basis for the decisions. Section 6 provides a comparison with the results of Antràs and Chor (2013) and a discussion of our main results. In section 7, we analyze firm's decisions with regard to their decision structure.

2 The Model

2.1 Technology and Demand

As in Antràs and Helpman (2004), we 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:

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

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, we 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:

$$m = \theta_1 \left(\frac{m_1}{\eta_1}\right)^{\eta_1} \left(\frac{m_2}{1-\eta_1}\right)^{1-\eta_1}. \tag{2}$$

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:

$$q = Ap^{-\frac{1}{1-\rho}}. \tag{3}$$

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 (1) - (3) the revenue of the firm can be expressed as

$$R = A^{1-\rho} \left[\theta_H \left(\frac{h}{\eta_H}\right)^{\eta_H} \left(\frac{\theta_1 \left(\frac{m_1}{\eta_1}\right)^{\eta_1} \left(\frac{m_2}{1-\eta_1}\right)^{1-\eta_1}}{1-\eta_H}\right)^{1-\eta_H}\right]^{\rho}. \tag{4}$$

2.2 Organizational Decisions

In this paper, we 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 1 depicts the underlying structure of the organizational decisions of

Antràs and Chor (2013) and of our 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, we 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.

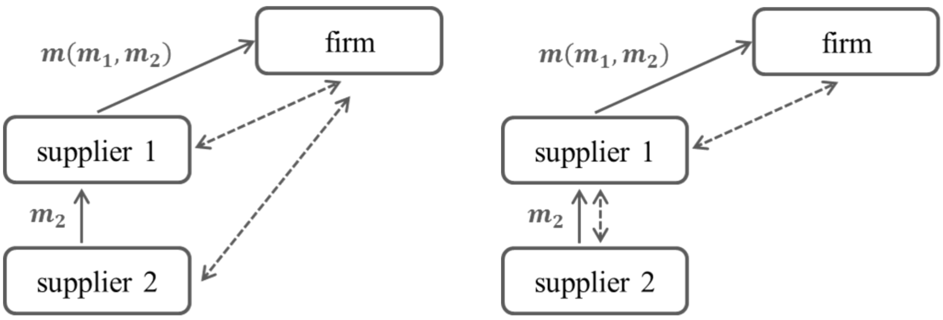

Figure 1: Structure of the organizational decisions.
Left panel: Antràs and Chor (2013). Right panel: our structure.

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

2.3 Structure of the Game

We assume contracts between all players to be incomplete[4], i.e., the input investments are considered to be non-contractible since they are too complex to be specified ex ante and non-verifiable 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 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

[4] We also consider a scenario of complete contracts that leads to the first-best solution and serves as a benchmark, see Appendix A.1.

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 non-contractible 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. Supplier 1 and 2 bargain over the surplus value of their relationship.
7. The producer and supplier 1 bargain 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, we are 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, we 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 non-contractible input provision levels.

However, if production arises sequentially, investment decisions take place at different points of time. More precisley, we 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 non-contractible input provision level (m_2).
   2. After the production of m_2, the producer and supplier 1 decide simultaneously on their non-contractible input provision levels (h and m_1, respectively).

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

[5] Results are simpler if we 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 our paper, we mainly focus on the setup with participation fees. The other, simpler results are presented in section 5 and Appendix C.

[6] We 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, we only consider this constellation. Results are available on request.

3 Simultaneous Production

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.

3.1 Solving 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 we 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 producer chooses $h^{sim} = argmax_h \{\beta_H R - c_H h\}$, whereas the suppliers choose the amounts $m_1^{sim} = argmax_{m_1} \{(1-\beta_H)\beta_1 R - c_1 m_1\}$ or $m_2^{sim} = argmax_{m_2} \{(1-\beta_H)(1-\beta_1) R - c_2 m_2\}$, respectively. The resulting input provisions are given by:[7]

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

$$\text{and} \quad m_2^{sim} = \frac{\rho (1-\eta_H)(1-\eta_1)(1-\beta_H)(1-\beta_1) R^{sim}}{c_2} \tag{5}$$

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

Equation (5) 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:

$${\pi_2}^{sim} = (1-\beta_1)(1-\beta_H)(1-\rho[1-\eta_1][1-\eta_H]) R^{sim} + \tau_2 \geq w_2. \tag{6}$$

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:

$$\tau_2 = w_2 - (1-\beta_1)(1-\beta_H)(1-\rho[1-\eta_1][1-\eta_H]) R^{sim}. \tag{7}$$

Supplier 1 then chooses the organizational form of supplier 2 that maximizes his own profit π_1^{sim} that

[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.2.

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:

$$\pi_1^{sim} = (1-\beta_H)\left[1-\rho\left(1-\eta_H\right)\left[\beta_1\eta_1 + \left(1-\beta_1\right)\left(1-\eta_1\right)\right]\right] R^{sim} + \tau_1 - w_2. \tag{8}$$

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

$$\tau_1 = w_1 + w_2 - (1-\beta_H)\left[1-\rho\left(1-\eta_H\right)\left[\beta_1\eta_1 + \left(1-\beta_1\right)\left(1-\eta_1\right)\right]\right] R^{sim}. \tag{9}$$

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 (9), this profit - that is equal to the overall surplus - is given by[8]

$$\pi_H^{sim} = \left[1-\rho\left[\left(1-\beta_H\right)\left(1-\eta_H\right)\left[\beta_1\eta_1 + \left(1-\beta_1\right)\left(1-\eta_1\right)\right] + \beta_H\eta_H\right]\right] R^{sim} - w_1 - w_2. \tag{10}$$

3.2 Organizational Decisions

As both the producer and supplier 1 will choose the organizational form of their supplier that maximizes their own profit, we 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, we 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, we 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 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 when he is outsourced than when he is integrated $\left(\beta_j^V > \beta_j^O \;\Leftrightarrow\; \left(1-\beta_j^O\right) > \left(1-\beta_j^V\right)\right)$.

Supplier 1's Organizational Decision We first consider supplier 1's decision on the organizational form of his supplier, supplier 2. To derive supplier 1's optimal revenue share, we differentiate supplier 1's profit (as given in equation (8)) with respect to β_1 and solve for β_1:

$$\beta_1^{sim} = \frac{\sqrt{b_1^{sim}} - \left(2\eta_1\left[1-\rho\left(\left[1-\eta_H\right]\left[1-\eta_1\right]+\eta_H\right)\right]+\rho\eta_H\right)}{2\left(\left[1-2\eta_1\right]\left[1-\rho\eta_H\right]\right)} \quad \text{with} \tag{11}$$

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

[8] As shown in Appendix A.2, due to underinvestment, this profit level is lower than it would be with complete contracts.

The black lines in figure 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.

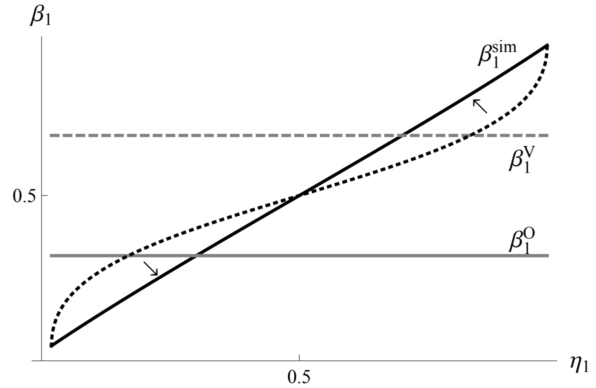

Figure 2: Optimal revenue share β_1^{sim} subject to a variation of η_1.
Black, dotted line: low values of η_H. Black, solid line: high values of η_H.

In the following, we 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 we only discuss the economic intuition, the details are relegated to Appendix B.1.1.

As both black lines in figure 2 are upward sloping, figure 2 illustrates that the optimal revenue share is an increasing function of supplier 1's input intensity η_1. Analytically,

$$\frac{\partial \beta_1^{sim}}{\partial \eta_1} > 0. \tag{12}$$

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. We then compare this optimal revenue share with the revenue shares in case of integration and in case of outsourcing illustrated in figure 2: Since supplier 1's revenue share is higher when supplier 2 is integrated than when he is outsourced, we 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 3.

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 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 ($\beta_1^O > \left(1 - \beta_1^V\right)$)

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

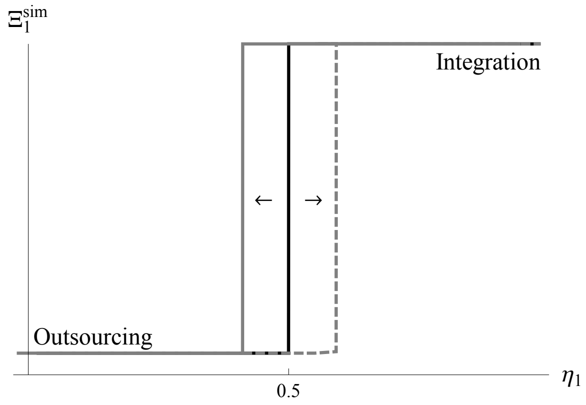

Figure 3: Organizational decision of supplier 1 Ξ_1^{sim} subject to a variation of η_1.
Black line: $\beta_1^O = 1 - \beta_1^V$. Gray, solid line: $\beta_1^O < 1 - \beta_1^V$. Gray, dashed line: $\beta_1^O > 1 - \beta_1^V$.

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 3. Vice versa, a lower β_1^V or β_1^O $(\beta_1^O < (1 - \beta_1^V))$ 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 3).

Since we are especially interested in the interrelations of the producer's and supplier 1's organizational decision, we analyze the effect of changes of η_H on β_1^{sim} and, thus, on supplier 1's organizational decision. In figure 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:

$$\frac{\partial \beta_1^{sim}}{\partial \eta_H} \begin{cases} < 0, & \text{if } \eta_1 < \frac{1}{2} \\ > 0, & \text{if } \eta_1 > \frac{1}{2}. \end{cases} \tag{13}$$

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)). 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, we have $\eta_1^{cf} > 1/2$ and are 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 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]

We can summarize our 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, we consider the producer's decision in the first stage of the game on the organizational form of her direct supplier, supplier 1. We again first derive the optimal revenue share[11] and differentiate the producer's profit (given by (10)) with respect to β_H and solve for β_H:

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

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

In figure 4, we 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).

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

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

[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.

[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, we 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, we assume for simplicity that $\beta_1^O = (1-\beta_1^V)$ 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, we can clearly see whether the producer's decision depends on the two suppliers' input intensities. For robustness, we provide in Appendix B.1.3 the results for $\beta_1^O > (1-\beta_1^V)$.

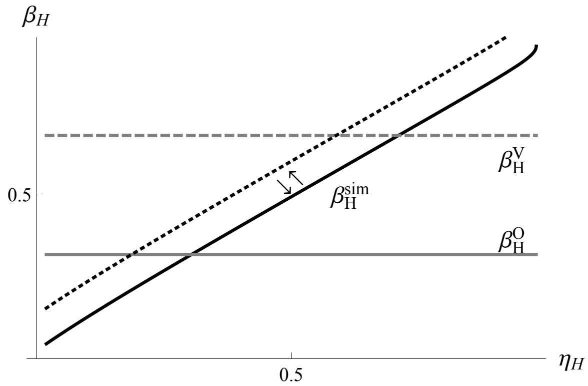

Figure 4: Optimal revenue share β_H^{sim} subject to a variation of η_H.
Black, dotted line: low or high values of η_1. Black, solid line: intermediate values of η_1.

Analyzing the effects of changes of η_H and η_1 on the producer's optimal revenue share, we find that (for the concrete derivatives see Appendix B.1.2)

$$\frac{\partial \beta_H^{sim}}{\partial \eta_H} > 0. \tag{14}$$

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.

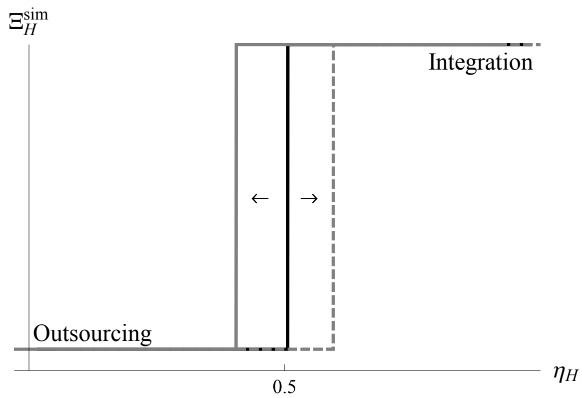

Figure 5: Organizational decision of the producer Ξ_H^{sim} subject to a variation of η_H.
Black line: $\beta_H^O = 1 - \beta_H^V$. Gray, solid line: $\beta_H^O < 1 - \beta_H^V$. Gray, dashed line: $\beta_H^O > 1 - \beta_H^V$.

Analogously to figure 3, the different color gradations in figure 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 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 decision, we 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 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:

$$\frac{\partial \beta_H^{sim}}{\partial \eta_1} \begin{cases} < 0, & \text{if } \eta_1 < \frac{1}{2} \\ > 0, & \text{if } \eta_1 > \frac{1}{2}. \end{cases} \tag{15}$$

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, we combine the producer's and supplier 1's decision in one figure: Figure 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

[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

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

[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.

shares of supplier 1 as $\Xi^{sim} = \left\{\Xi_H^{sim}, \Xi_1^{sim}\right\}$. "O" denotes outsourcing of the respective supplier and "V" stands for integration. On the horizontal axis, we display the headquarter intensity η_H and on the vertical axis, we display the input intensity η_1.

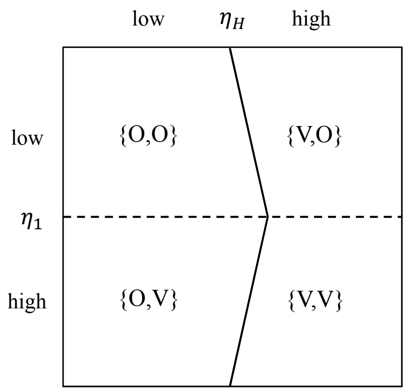

Figure 6: Organizational decisions of the producer and supplier 1 with simultaneous production.

As figure 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 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, we can summarize our 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.*

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 our 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.

4 Sequential Production

So far, analyzing a simultaneous production process, we have have seen the effect of the bargaining structure on the organizational decisions. In the following, to analyze the effect of sequentiality of production on the organizational decisions, we 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.

4.1 Solving 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). 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:

$$R^{seq} = \left(A^{1-\rho} \left[\rho^{1-\frac{1-\phi}{\rho}} \theta_H \left(\theta_1 \frac{\beta_H}{c_H} \right)^{\eta_H} \left(\left[\frac{\beta_1 (1-\beta_H)}{c_1} \right]^{\eta_1} \left[\frac{m_2}{(1-\eta_1)(1-\eta_H)} \right]^{1-\eta_1} \right)^{1-\eta_H} \right]^{\rho} \right)^{\frac{1}{\phi}} \tag{16}$$

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

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 $m_2^{seq} = argmax_{m_2} \{(1-\beta_H)(1-\beta_1) R^{seq} - c_2 m_2\}$. This gives his profit-maximizing input provision:

$$m_2^{seq} = \frac{\rho (1-\eta_H)(1-\eta_1)(1-\beta_H)(1-\beta_1) R^{seq}}{c_2 \phi} \tag{17}$$

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

As shown in Appendix A.3, comparing supplier 2's input provision and the revenue level to those in the scenario of simultaneous production, we 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 our 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:

$$\pi_1^{seq} = (1-\beta_H) \left[1 - \rho (1-\eta_H) \left[\beta_1 \eta_1 + \frac{(1-\beta_1)(1-\eta_1)}{\phi} \right] \right] R^{seq} - \tau_1 - w_2. \tag{18}$$

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

$$\pi_H^{seq} = \left[1 - \rho\left[\left(1-\beta_H\right)\left(1-\eta_H\right)\left[\beta_1\eta_1 + \frac{\left(1-\beta_1\right)\left(1-\eta_1\right)}{\phi}\right] + \beta_H\eta_H\right]\right] R^{seq} - w_1 - w_2. \tag{19}$$

4.2 Organizational Decisions

Using these profit levels, we 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, we only present supplier 1's organizational decision, whereas the producer's decision is presented in Appendix B.2.2.

Supplier 1's Organizational Decision Similarly to above, we start with solving for supplier 1's optimal revenue share β_1^{seq}:

$$\beta_1^{seq} = \frac{\sqrt{b_1^{seq}} - \rho\eta_1^2\left(1-\eta_H\right)\left(\phi+\rho\right) - \eta_1\left(2-\rho\left(3-\rho\eta_H\right)\right)}{2\left(1-\rho\eta_H\right)\left(1-\eta_1\left(1+\phi\right)\right)} \quad \text{with}$$

$$\mu = 4\left[1-\rho\right]\left[1-\rho\eta_H\right]\left[1-\eta_1\left(1+\phi\right)\right] + \eta_1\left[2+\rho^2\left(\left[1-\eta_1\right]\eta_1\left[1-\eta_H\right]^2+\eta_H\right) - \rho\left(3-\eta_1\left[1-\eta_H\right]\right)\right]^2.$$

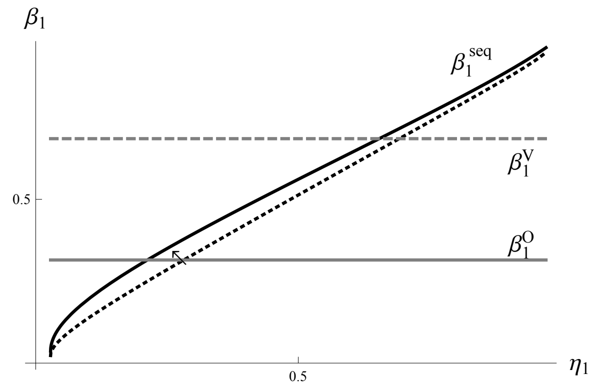

Figure 7: Optimal revenue share β_1^{seq} subject to a variation of η_1.
Black, dotted line: low values of η_H. Black, solid line: high values of η_H.

Figure 7 is analogous to figure 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 B.2.1.

[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.3.

[16] However, following Appendix A.4, 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 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.

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 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,

$$\frac{\partial \beta_1^{seq}}{\partial \eta_H} > 0, \tag{20}$$

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.

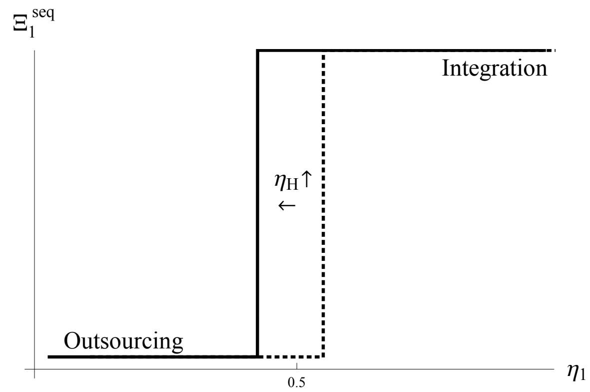

Figure 8: Organizational decision of supplier 1 subject to a variation of η_1.
Black, dotted line: low values of η_H. Black, solid line: high values of η_H.

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 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. We 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}.*

[17] This is why we 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.

Interrelation of the Producer's and Supplier 1's Organizational Decisions Figure 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.

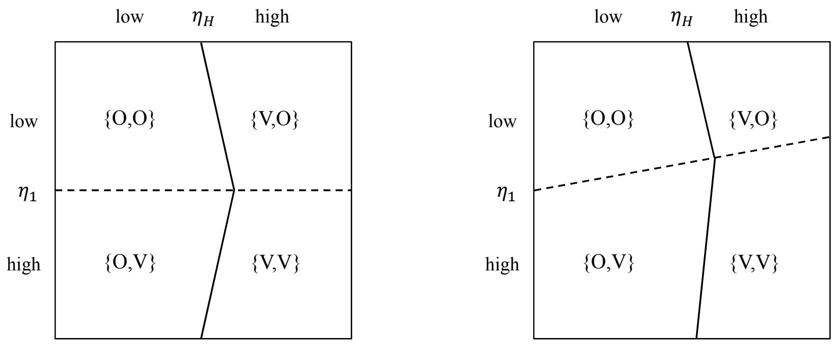

Figure 9: Organizational decisions of the producer and supplier 1.
Left panel: simultaneous production. Right panel: sequential production.

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, 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.

[18] More precisely, as illustrated in Appendix B.2.2, 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 our 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.

5 Setup without Participation Fees

Our 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 our model, we assume participation fees such that the respective *joint* profit is maximized. Therefore, we analyze in the following a setup without participation fees, similar to Antràs and Chor (2013) . In doing so, we only present the central results in the main text, the details are depicted in Appendix C.

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

$$\beta_{1,wo}^{sim} = \eta_1 + \frac{(1-\rho)(1-\eta_1)}{1-\rho\eta_H}. \tag{21}$$

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. As a result, a higher headquarter intensity 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.

The producer's optimal revenue share is

$$\beta_{H,wo}^{sim} = 1 - \rho(1-\eta_H). \tag{22}$$

Interestingly, in contrast to the constellation with participation fees, $\beta_{H,wo}^{sim}$ 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, $\beta_{1,wo}^{seq}$, and the producer, $\beta_{H,wo}^{seq}$, 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.

[19] In addition, we 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.

6 Discussion and Comparison with Antràs and Chor (2013)

Comparing our 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 we 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, we 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 our setup, the inputs are always complements. For complements, their model predicts outsourcing of the upstream supplier [2] and integration of the downstream supplier [1]. We obtain this organizational structure if the headquarter intensity is high and the input intensity is low. Beyond this result, our 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, we 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, we 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 we 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 our 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 our finding that the level of η_1 affects the organizational decisions of both the producer and supplier 1. In other words, in our 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 our 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 our 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, we can derive predictions about firms' organizational decisions. Contrary to Antràs and Chor (2013), due to our model setup, these predictions do not hinge on the elasticity of substitution that is hard to measure empirically. Instead, our 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 our 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, we 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. We 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, our 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 B.2.2, 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.

7 APPLE or SMART?

So far, we 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, we extend our analysis and assume firms to be able to decide on their decision structure, and derive predictions about these decisions. More precisely, we analyze for different parameter constellations whether firms have higher profits as APPLE or SMART.

To make this decision, we first derive the profit for the APPLE structure under the assumed Cobb-Douglas production function. In doing so, to facilitate the analysis, we assume a setup without participation fees, as in Antràs and Chor (2013). We then compare this profit level with the corresponding profit level of sequential production under the SMART structure as given by (66).[20]

In the APPLE setup, as depicted in the left panel of figure 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, we 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

$$\pi_H^{\text{APPLE}} = \beta_{H1} R_{\text{diff}}^{\text{APPLE}} + \beta_{H2} R_2^{\text{APPLE}} - c_H h^{\text{APPLE}} = \beta_{H1} \left(1 - \rho\eta_H\right) R_{12H}^{\text{APPLE}} + \left(\beta_{H2} - \beta_{H1}\right) R_2^{\text{APPLE}}, \tag{23}$$

whereas the producer's profit in the SMART case is

$$\pi_H^{SMART} = \pi_{H,wo}^{seq} = \beta_H R^{seq} - c_H h^{seq} = \beta_H \left(1 - \rho\eta_H\right) R^{seq}. \tag{24}$$

The total relative profit π_{rel} is then given as following:

$$\pi_{\text{rel}} = \frac{\pi_H^{\text{APPLE}}}{\pi_H^{\text{SMART}}} = \frac{1}{\beta_H \left(1 - \rho\eta_H\right)} \left(\frac{\frac{(1-\beta_{H2})\theta_{H2}}{c_2}}{\theta_H \left(\frac{\beta_H}{c_H}\right)^{\eta_H} \left(\theta_1 \left(1 - \beta_H\right) \left(\frac{\beta_1}{c_1}\right)^{\eta_1} \left(\frac{1-\beta_1}{c_2\phi}\right)^{1-\eta_1}\right)^{1-\eta_H}} \right)^{\frac{\rho}{1-\rho}} \cdot$$

$$\left(\beta_{H1} \left(\left(1 - \rho\eta_H\right) \left(\frac{\left(\frac{\beta_{H1}}{c_H}\right)^{\eta_H} \left(\frac{1-\beta_{H1}}{c_1}\right)^{\eta_1(1-\eta_H)}}{\left(\frac{(1-\beta_{H2})\theta_{H2}}{c_2}\right)^{\eta_1(1-\eta_H)+\eta_H} \left(\left(1-\eta_1\right)\left(1-\eta_H\right)\right)^{(1-\eta_1)(1-\eta_H)}} \right)^{\frac{\rho}{\phi}} - 1 \right) + \beta_{H2} \right). \tag{25}$$

[20] Technology and demand, the detailed game structure and the solution of the game are relegated to Appendix D.

In dependence on the values of the different parameters, this relative profit can be lower or higher than 1. In the following, we analyze the effect of changes of the parameters on the relative profit level. Thereby, we relegate the derivations to Appendix D 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, we assume that θ_{H2} is relatively lower than θ_H, i.e., we 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, we find that a higher productivity of supplier 1 in using supplier 2's input decreases the relative profit:

$$\frac{\partial \pi_{\text{rel}}}{\partial \theta_1} < 0. \tag{26}$$

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:

$$\frac{\partial \pi_{\text{rel}}}{\partial \theta_H} < 0. \tag{27}$$

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.

If this productivity of using supplier 2's input increases, the APPLE structure becomes more likely:

$$\frac{\partial \pi_{\text{rel}}}{\partial \theta_{H2}} > 0. \tag{28}$$

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:

$$\frac{\partial \pi_{\text{rel}}}{\partial \eta_H} \gtrless 0 \quad \text{and} \quad \frac{\partial \pi_{\text{rel}}}{\partial \eta_1} \gtrless 0. \tag{29}$$

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, our 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.

[21] Since we cannot determine the sign of the derivations analytically, we provide, on request, a MATHEMATICA 9.0 file in which we 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.

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. We therefore provide an additional mechanism to Antràs and Chor (2013). In doing so, we 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), we 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 our setup, sequentiality may arise with regard to the bargaining and the production. To separate the effects resulting from these two types of sequentiality, we 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.

We 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 we 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) - our 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, we 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. We 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 deciding over all suppliers along the value chain.

In our model, there are several aspects left for future research: First of all, we 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 our predictions considering the organizational decisions and the chosen decision structures empirically.

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Appendix

A Input Provisions, Revenue, Profit and Price

A.1 Complete Contracts

A.1.1 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.
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:

$$\pi_2 = (s_2 + \tau_2) - c_2 m_2 \geq w_2. \tag{30}$$

[23] Complete contracts also eliminate possible problems associated with input quality. However, in our model we neglect this aspect and focus solely on quantity aspects.

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

$$\pi_1 = (s_1 + \tau_1) - c_1 m_1 - (s_2 + \tau_2) \tag{31}$$

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

$$\pi_1 = (s_1 + \tau_1) - c_1 m_1 - c_2 m_2 - w_2 \tag{32}$$

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

$$\max_{\{m_1, m_2\}} \left[(s_1 + \tau_1) - c_1 m_1 - c_2 m_2 - w_2\right] \quad \text{s.t.} \quad \theta_1 \left(\frac{m_1}{\eta_1}\right)^{\eta_1} \left(\frac{m_2}{1 - \eta_1}\right)^{1-\eta_1} = m^{cc}. \tag{33}$$

Standard maximization gives $m_1/m_2 = c_1/c_2 \; \eta_1/\left(1 - \eta_1\right)$. Using this relation in the constraint in (33), the optimal input provisions of the suppliers are given by

$$m_1^{cc} = \left(\frac{c_2}{c_1}\right)^{1-\eta_1} \eta_1 \, \frac{m^{cc}}{\theta_1} \quad \text{and} \quad m_2^{cc} = \left(\frac{c_1}{c_2}\right)^{\eta_1} (1 - \eta_1) \, \frac{m^{cc}}{\theta_1} \tag{34}$$

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:

$$\pi_1 = (s_1 + \tau_1) - c_M m - w_2 \geq w_1. \tag{35}$$

$c_M m$ 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:

$$\pi_H = R - c_H h - c_M m - w_1 - w_2. \tag{36}$$

Standard maximization gives the relation $h/m = c_M/c_H \; \eta_H/\left(1 - \eta_H\right)$ between the headquarter's and the suppliers' input provisions. The resulting profit-maximizing input provisions are given as following:

$$h^{cc} = \frac{\rho \eta_H}{c_H} R^{cc} \quad \text{and} \quad m^{cc} = \frac{\rho\left(1 - \eta_H\right)}{c_M} R^{cc} \quad \text{with} \quad R^{cc} = A \left[\frac{\rho \theta_H}{c_H^{\eta_H} c_M^{1-\eta_H}}\right]^{\frac{\rho}{1-\rho}}. \tag{37}$$

Using m^{cc} and $c_M = \left(c_1^{\eta_1} c_2^{1-\eta_1}\right)/\theta_1$, the suppliers' input provisions (from (34)) are given by

$$m_1^{cc} = \frac{\rho \eta_1 \left(1 - \eta_H\right)}{c_1} R^{cc} \text{ and } m_2^{cc} = \frac{\rho\left(1 - \eta_1\right)\left(1 - \eta_H\right)}{c_2} R^{cc}. \tag{38}$$

The resulting overall payoff of the relationship is

$$\pi_H^{cc} = (1-\rho)\, R^{cc} - w_1 - w_2 \tag{39}$$

and the price of the final good is given by

$$p^{cc} = \frac{c_H^{\eta_H}}{\rho\theta_H}\left(\frac{c_1^{\eta_1} c_2^{1-\eta_1}}{\theta_1}\right)^{1-\eta_H}. \tag{40}$$

A.1.2 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:

$$\pi_i = (s_i + \tau_i) - c_i m_i \geq w_i. \tag{41}$$

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:

$$\max_{\{h, m_1, m_2\}} \pi_H = R - c_H h - c_1 m_1 - c_2 m_2 - w_1 - w_2. \tag{42}$$

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 (37) and (38). The producer's profit is still given by (39) and the price is still as in (40).

A.2 Comparison - Complete Contracts and Simultaneous Production

A.2.1 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:

$$\frac{h^{sim}}{h^{cc}} = \psi_{sim}\beta_H < 1 \, ,$$

$$\frac{m_1^{sim}}{m_1^{cc}} = \psi_{sim} \left(1 - \beta_H\right) \beta_1 < 1 \, ,$$

$$\frac{m_2^{sim}}{m_2^{cc}} = \psi_{sim} \left(1 - \beta_H\right) \left(1 - \beta_1\right) < 1 \tag{43}$$

$$\text{and } \frac{R^{sim}}{R^{cc}} = \psi_{sim} < 1$$

$$\text{with} \quad \psi_{sim} = \left[\beta_1^{(1-\eta_H)\eta_1} \left(1 - \beta_1\right)^{(1-\eta_H)(1-\eta_1)} \beta_H^{\eta_H} \left(1 - \beta_H\right)^{(1-\eta_H)}\right]^{\frac{\rho}{1-\rho}} < 1.$$

A.2.2 Total Profit

Comparing the simultaneous profit level with that in the case of complete contracts gives

$$\frac{\pi_H^{sim}}{\pi_H^{cc}} = \frac{\left[1 - \rho \left[\left(1 - \beta_H\right)\left(1 - \eta_H\right)\left[\beta_1\eta_1 + \left(1 - \beta_1\right)\left(1 - \eta_1\right)\right] + \beta_H\eta_H\right]\right] R^{sim} - w_1 - w_2}{\left(1 - \rho\right) R^{cc} - w_1 - w_2}. \tag{44}$$

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 ($w_1 = w_2 = 0$):

$$\frac{\pi_H^{sim}}{\pi_H^{cc}} = \psi_{sim} \frac{1 - \rho \left[\beta_H\eta_H + \left(1 - \beta_H\right)\left(1 - \eta_H\right)\left[\left(1 - \beta_1\right)\left(1 - \eta_1\right) + \beta_1\eta_1\right]\right]}{1 - \rho} < 1. \tag{45}$$

This result also holds for $w_1 > 0$, $w_2 > 0$.

A.2.3 Price

With simultaneous production, the price of the final good is given by

$$p^{sim} = \frac{1}{\rho\theta_H} \left(\frac{c_H}{\beta_H}\right)^{\eta_H} \left(\frac{c_1^{\eta_1} c_2^{1-\eta_1}}{\theta_1 \left(1 - \beta_1\right)^{1-\eta_1} \beta_1^{\eta_1}}\right)^{1-\eta_H} . \tag{46}$$

This price is higher than the price in the scenario of complete contracts:

$$\frac{p^{sim}}{p^{cc}} = \psi_{sim}^{-\frac{1-\rho}{\rho}} > 1. \tag{47}$$

A.3 Comparison - Simultaneous and Sequential Production

A.3.1 Input Provisions and Revenue

With sequential production, the input provisions and the revenue level are higher than with simultaneous production:

$$\begin{aligned} \frac{h^{seq}}{h^{sim}} = \frac{m_1^{seq}}{m_1^{sim}} &= \psi_{seq} > 1, \\ \frac{m_2^{seq}}{m_2^{sim}} &= \psi_{seq}{}^{\frac{1-\rho}{\rho(1-\eta_1)(1-\eta_H)}+1} > 1 \\ \text{and} \quad \frac{R^{seq}}{R^{sim}} &= \psi_{seq} > 1 \\ \text{with} \quad \psi_{seq} = \phi^{-\frac{\rho(1-\eta_1)(1-\eta_H)}{1-\rho}} &= \phi^{1-\frac{\phi}{1-\rho}} > 1. \end{aligned} \tag{48}$$

A.3.2 Total Profit

Comparing the payoffs of both scenarios, we find:

$$\frac{\pi_H^{seq}}{\pi_H^{sim}} = \frac{\left[1-\rho\left[(1-\beta_H)(1-\eta_H)\left[\beta_1\eta_1 + \frac{(1-\beta_1)(1-\eta_1)}{\phi}\right] + \beta_H\eta_H\right]\right] R^{seq} - w_1 - w_2}{\left[1-\rho\left[(1-\beta_H)(1-\eta_H)\left[\beta_1\eta_1 + (1-\beta_1)(1-\eta_1)\right] + \beta_H\eta_H\right]\right] R^{sim} - w_1 - w_2}. \tag{49}$$

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 (10)):

$$\frac{\pi_H^{seq}}{\pi_H^{sim}} = \psi_{seq} \frac{\left[1-\rho\left[(1-\beta_H)(1-\eta_H)\left[\beta_1\eta_1 + \frac{(1-\beta_1)(1-\eta_1)}{\phi}\right] + \beta_H\eta_H\right]\right]}{\left[1-\rho\left[(1-\beta_H)(1-\eta_H)\left[\beta_1\eta_1 + (1-\beta_1)(1-\eta_1)\right] + \beta_H\eta_H\right]\right]} > 1. \tag{50}$$

This result holds as well for positive outside options ($w_1 > 0$, $w_2 > 0$).

A.3.3 Price

Simple maths shows that the price is given by:

$$p^{seq} = \frac{1}{\rho\theta_H}\left(\frac{c_H}{\beta_H}\right)^{\eta_H}\left(\frac{c_1^{\eta_1} c_2^{1-\eta_1}}{\theta_1 (1-\beta_1)^{1-\eta_1} \beta_1^{\eta_1}}\right)^{1-\eta_H} \phi^{(1-\eta_1)(1-\eta_H)}. \tag{51}$$

Comparing the prices with sequential and simultaneous production, we find that the price is lower with sequential production than with simultaneous production:

$$\frac{p^{seq}}{p^{sim}} = \Psi_{seq}{}^{-\frac{1-\rho}{\rho}} < 1. \tag{52}$$

A.4 Comparison - Complete Contracts and Sequential Production

A.4.1 Input Provisions and Revenue

With sequential production, the input provisions and the revenue are still lower than with complete contracts:

$$\begin{gathered}\frac{h^{seq}}{h^{cc}} = \psi_{sim}\psi_{seq}\beta_H < 1, \\ \frac{m_1^{seq}}{m_1^{cc}} = \psi_{sim}\psi_{seq}\beta_1\left(1-\beta_H\right) < 1, \\ \frac{m_2^{seq}}{m_2^{cc}} = \psi_{sim}\psi_{seq}^{\frac{1-\rho}{\rho(1-\eta_1)(1-\eta_H)}+1}\left(1-\beta_1\right)\left(1-\beta_H\right) < 1, \\ \text{and} \quad \frac{R^{seq}}{R^{cc}} = \psi_{sim}\psi_{seq} < 1,\end{gathered} \tag{53}$$

with ψ_{sim} and ψ_{seq} as defined in A.2 and A.3.

A.4.2 Total Profit

Under the assumption of zero outside options, we can directly see that the profit is still lower than with complete contracts:

$$\frac{\pi_H^{seq}}{\pi_H^{cc}} = \psi_{sim}\psi_{seq}^{\frac{1-\rho}{\rho(1-\eta_1)(1-\eta_H)}+1}\frac{1-\rho\left[\beta_H\eta_H+\left(1-\beta_H\right)\left(1-\eta_H\right)\left[\frac{(1-\beta_1)(1-\eta_1)}{\phi}+\beta_1\eta_1\right]\right]}{1-\rho} < 1. \tag{54}$$

A.4.3 Price

The price is higher than with complete contracts:

$$\frac{p^{seq}}{p^{cc}} = \left(\psi_{sim}\psi_{seq}\right)^{-\frac{1-\rho}{\rho}} > 1. \tag{55}$$

B Organizational Decisions

B.1 Simultaneous Production

B.1.1 Concrete Derivatives of β_1^{sim}

The derivation of supplier 1's optimal revenue share with respect to η_1 is given by

$$\frac{\partial \beta_1^{sim}}{\partial \eta_1} = \underbrace{\frac{1}{\left(1-2\eta_1\right)^2\left(1-\rho\eta_H\right)}}_{>0} \cdot d_{1,\eta_1}^{sim} \quad \text{with}$$

$$d_{1,\eta_1}^{sim} = \left(1-\rho\left(1-2\left(1-\eta_1\right)\eta_1\right)\left(1-\eta_H\right)\right)\cdot$$
$$\left(\frac{1-2\rho\left(1-\eta_1\right)\eta_1\left(1-\eta_H\right)}{\sqrt{\left(2\eta_1\left(1-\rho\left(\left(1-\eta_H\right)\left(1-\eta_1\right)+\eta_H\right)\right)+\rho\eta_H\right)^2+4\eta_1\left(1-2\eta_1\right)\left(1-\rho\eta_H\right)\left(1-\rho\left(1-\eta_1\right)\left(1-\eta_H\right)\right)}}-1\right)>0.$$

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

$$\frac{\partial \beta_1^{sim}}{\partial \eta_H} = \frac{\rho}{\underbrace{2\left(1-\rho\eta_H\right)^2}_{>0}\underbrace{\left(1-2\eta_1\right)}_{?}} \cdot d_{1,\eta_H}^{sim} \quad \text{with}$$

$$d_{1,\eta_H}^{sim} = \frac{2\left(1-\eta_1\right)\eta_1\left(3-2\rho\left(1+\left(1-\rho\right)\left(1-\eta_1\right)\eta_1\right)\right)+\rho\left(1-2\left(1-\eta_1\right)\eta_1\left(1-2\left(1-\rho\right)\left(1-\eta_1\right)\eta_1\right)\right)\eta_H}{\sqrt{\left(2\eta_1\left(1-\rho\left(\left(1-\eta_H\right)\left(1-\eta_1\right)+\eta_H\right)\right)+\rho\eta_H\right)^2+4\eta_1\left(1-2\eta_1\right)\left(1-\rho\eta_H\right)\left(1-\rho\left(1-\eta_1\right)\left(1-\eta_H\right)\right)}}$$
$$-1-2\eta_1\left(1-\rho\right)\left(1-\eta_1\right)<0.$$

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.

B.1.2 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, we 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.

B.1.3 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 we show the resulting optimal revenue share and the organizational decision of the producer.

In figure 10, we 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 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.

The resulting organizational decision is hence the same as with balanced revenue shares: As depicted in figure 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,

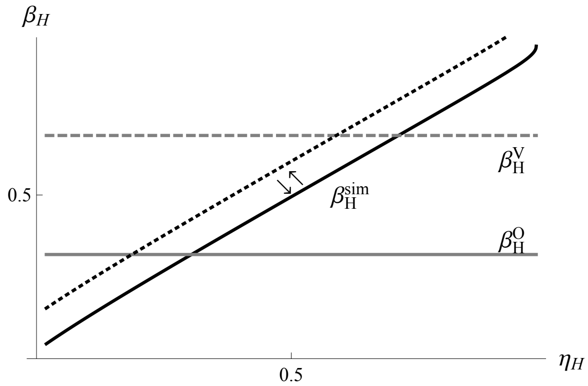

Figure 10: Optimal revenue share β_H^{sim} subject to a variation of η_H with $\beta_1^O > 1 - \beta_1^V$.
Black, dotted line: low or high values of η_1. Black, solid line: intermediate values of η_1.

the 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]

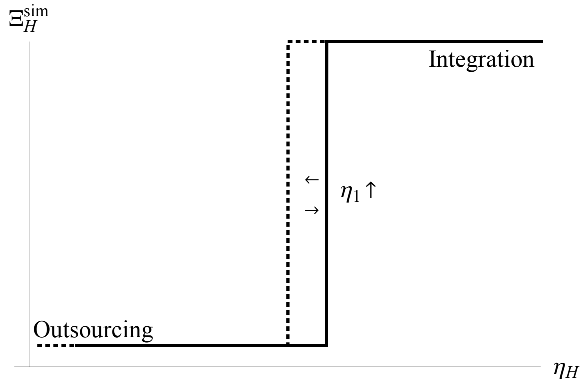

Figure 11: Organizational decision of the producer Ξ_H^{sim} subject to a variation of η_H with $\beta_1^O > 1 - \beta_1^V$.
Black, dotted line: low or high values of η_1. Black, solid line: intermediate values of η_1.

If we 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.

[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.

B.2 Sequential Production

B.2.1 Concrete Derivatives of β_1^{seq}

The derivation of β_1^{seq} with respect to η_1 can be depicted as

$$\frac{\partial \beta_1^{seq}}{\partial \eta_1} = \underbrace{\frac{1}{2\left(1-\eta_1\left(1+\phi\right)\right)^2\left(1-\rho\eta_H\right)}}_{>0} \cdot d_{1,\eta_1}^{seq} \quad \text{with}$$

$$\begin{aligned}
d_{1,\eta_1}^{seq} &= \eta_1^2(1-\eta_H)\rho^3(1-(1-\eta_1)(1-\eta_H))^2 - \rho^2\left(2\eta_1(1-\eta_H)\left(2\eta_1^2(1-\eta\mathrm{H}) - (1-3\eta_1)\eta_H - \eta_1 + 1\right) + \eta_H\right) \\
&+ \frac{d_{1,\eta_1}^{seq,help}}{2\sqrt{\eta_1\left(\eta_1\left(\rho^2\left((1-\eta_1)\eta_1(1-\eta_H)^2+\eta_H\right) - \rho(3-\eta_1(1-\eta_H))\right)+2\right)^2 + 4(1-\rho)(1-\rho\eta_H)(1-\eta_1(\phi+1))\Big)}} \\
&+ \rho(3 - 2\eta_1(-2\eta_1(1-\eta_H) - \eta_H + 1)) - 2 > 0 \quad \text{and}
\end{aligned}$$

$$\begin{aligned}
d_{1,\eta_1}^{seq,help} &= \Big(\eta_1(1-\eta_1(\phi+1))\Big(\left(\rho^2\left((1-\eta_1)\eta_1(1-\eta_H)^2+\eta_H\right) - \rho(3-\eta_1(1-\eta_H)) + 2\right)^2 \\
&+ 2\eta_1\left(\rho^2(1-2\eta_1)(1-\eta_H)^2 + \rho(1-\eta_H)\right)\left(\rho^2\left((1-\eta_1)\eta_1(1-\eta_H)^2+\eta_H\right) - \rho(3-\eta_1(1-\eta_H)) + 2\right) \\
&+4(1-\rho)(1-\rho\eta_H)(\rho\eta_1(1-\eta_H) - \phi - 1)\Big) + (\eta_1(-2\rho\eta_1(1-\eta_H) + \phi + 1) + 1) \\
&\Big(\eta_1\left(\rho^2\left((1-\eta_1)\eta_1(1-\eta_H)^2+\eta_H\right) - \rho(3-\eta_1(1-\eta_H)) + 2\right)^2 + 4(1-\rho)(1-\rho\eta_H)(1-\eta_1(\phi+1))\Big)\Big) > 0.
\end{aligned}$$

Since d_{1,η_1}^{seq} 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

$$\frac{\partial \beta_1^{seq}}{\partial \eta_H} = \underbrace{\frac{\rho\eta_1}{2\left(1-\eta_1\left(1+\phi\right)\right)^2\left(1-\rho\eta_H\right)^2}}_{>0} \cdot d_{1,\eta_H}^{seq} \quad \text{with}$$

$$\begin{aligned}
d_{1,\eta_H}^{seq} &= \frac{d_{1,\eta_H}^{seq,help}}{\sqrt{\eta_1\left(\eta_1\left(\rho^2\left((1-\eta_1)\eta_1(1-\eta_H)^2+\eta_H\right) - \rho(3-\eta_1(1-\eta\mathrm{H}))\right)+2\right)^2 + 4(1-\rho)(1-\rho\eta_H)(1-\eta_1(\phi+1))\Big)}} \\
&- (1-\rho)\left(2 - \eta_1\left(\rho(-2\eta_1(-2\eta_1(1-\eta_H) - 5\eta_H + 3) - 6\eta_H + 1) + (1-\eta_1)(1-\phi)^2 - 4\eta_1 + 7\right)\right) > 0 \quad \text{and}
\end{aligned}$$

$$\begin{aligned}
d_{1,\eta_H}^{seq,help} &= \eta_1\left(\rho^2\left((1-\eta_1)\eta_1(1-\eta_H)^2+\eta_H\right) - \rho(3-\eta_1(1-\eta_H)) + 2\right)^2(1-\eta 1(-\rho(1-\eta_1)\eta_H - \eta_1 + \phi + 2)) \\
&+ (1-\rho\eta_H)(1-\eta_1(\phi+1))(-\rho(2-\eta_1(\rho(\phi+1)(1-\eta_1(1-\eta_H))(1-2(1-\eta_1)\eta_1(1-\eta_H)) \\
&- \rho(-\eta_1(-3\eta_1(1-\eta_H)((1-\eta_1)(1-\eta_H)+2) - 4\eta_H + 5) + 4\eta_H + 3) - \eta_1(1-3\eta_1(1-\eta_H)) + 4(\eta_H+2))) \\
&- 6\eta_1 + 2).
\end{aligned}$$

Simple maths shows that d_{1,η_H}^{seq} is for $0 < \eta_1 < 1$, $0 < \eta_H < 1$ and $0 < \rho < 1$ positive. Hence, the derivation is positive as well.

B.2.2 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

$$\beta_H^{seq} = \frac{\eta_H\left(2-\eta_1+\rho\left(1-\phi\right)\left(1-\eta_H\right)-\rho\left(3-\eta_1-\eta_H\right)\right)+\beta_1\left(1-\eta_H\right)\left(1+\rho\eta_H\right)\left(1-\eta_1\left(1+\phi\right)\right)+b_H^{seq}}{2\left(\eta_H\left(2-\rho\eta_H\right)+\left(1-\eta_H\right)\left(\eta_1\left(1-\rho\eta_H\right)+\beta_1\left(1-\eta_1\left(2-\rho\left(1+\phi\right)\right)\right)\right)-1\right)}$$

with $b_H^{seq} = \eta_1\left(1-\rho\right)-\sqrt{\left(1-\eta_H\right)\left(1-\rho\eta_H\right)}\sqrt{\eta_H\left(1-\rho\eta_H\right)\left(4-\rho\left(4-\rho\left(1-\eta_H\right)\eta_H\right)\right)}$

$$\overline{+\left(1-\eta_H\right)\left(\left(1-\rho\eta_H\right)\left(\eta_1^2\left(1-\rho\left(1-\eta_H\right)\right)^2+\beta_1^2\left(1-\eta_1\left(1+\phi\right)\right)^2\right)-2\rho\eta_1\eta_H\left(3-\rho\left(3-\rho\left(1-\eta_H\right)\eta_H\right)\right)\right.}$$
$$\overline{\left.+2\beta_1\left(1-\eta_1\left(1+\phi\right)\left(\rho\eta_H\left(1-\rho\eta_H\right)+\eta_1\left(1-\rho\left(1+\rho\left(1-\eta_H\right)\eta_H\right)\right)\right)\right)\right)}.$$

In figure 12, we 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 12, we assume low values of ρ, and in the right panel, we 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.

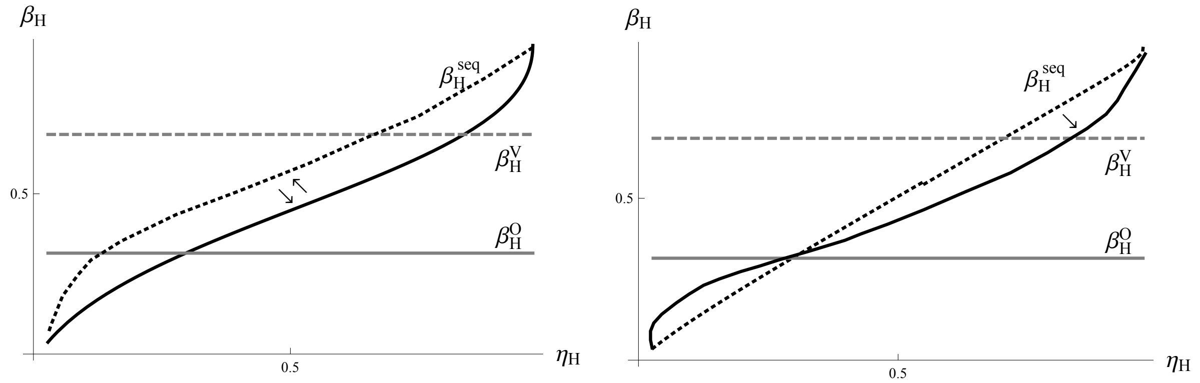

Figure 12: Optimal revenue share β_H^{seq} subject to a variation of η_H.
Left panel: low values of ρ. Black, dotted line: low or high values of η_1. Black, solid line: intermediate values of η_1.
Right panel: high values of ρ. Black, dotted line: low values of η_1. Black, solid line: high values of η_1.

As illustrated by the black, upward sloping lines in both panels of figure 12, the derivation of the producer's optimal 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^{seq}_{H,\eta_H} = (\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) \\
&\big((\beta_1\eta_1+1)\big(-3(1-\eta_1)\eta_H^2+(2-4\eta_1)\eta_H+\eta_1\big)\rho^2+(\eta_1+2\eta_H+\beta_1(-2\eta_H+\eta_1(-2\eta_1+2(\eta_1+1)\eta_H-1) \\
&+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)\big((1-\rho)\eta_1+\eta_H\big((1-\eta_H)(\eta_1(1-\eta_H)+\eta_H)\rho^2-(-\eta 1-\eta_H+3)\rho-\eta_1+2\big) \\
&+\beta_1(1-\eta_H)(\rho\eta_H+1)(1-\eta_1(\phi+1))) \\
&-((\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)\big((\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\big) \\
&(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)\big((\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\big)(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)\big(2\eta_1\eta_H(\rho\eta_H-\rho(1-\eta_H))\rho^2-\big(\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\big)\rho \\
&-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 \\
&+\big(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))\big)(1-\rho\eta_H) \\
&+2\beta_1(1-\eta_1(2-\rho(1-(1-\eta_1)(1-\eta_H))))\big(-\eta_H\rho^2+(1-\rho\eta_H)\rho-\eta_1(\rho(1-\eta_H)-\rho\eta_H)\rho\big)\big) \\
&-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)\big(-\eta_1^2(1-\rho(1-\eta_H))^2 \\
&-\beta_1^2(1-\eta 1(\phi+1))^2\big)\big)\big)-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)\big(\eta_1^2(1-\rho(1-\eta_H))^2+\beta_1^2(1-\eta_1(\phi+1))^2\big)\big)\big)\big)\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)\big(\eta_1^2(1-\rho(1-\eta_H))^2+\beta_1^2(1-\eta_1(\phi+1))^2\big)\big)\big)}\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

$$
\frac{\partial \beta_H^{seq}}{\partial \eta_1} = \frac{d^{seq}_{H,\eta_1}}{\underbrace{2((1-\eta_H)((1-\rho\eta_H)+\beta_1(1-\eta_1(\phi+1)))+\eta_H(2-\rho\eta_H)-1)^2}_{>0}} \quad \text{with}
$$

$$
\begin{aligned}
d^{seq}_{H,\eta_1} = {} & ((1-\eta_H)(\eta_1(1-\rho\eta_H)+\beta_1(1-\eta_1(\phi+1)))+\eta_H(2-\rho\eta_H)-1)\left(-(1-\eta_H)\left(\eta_H\left(\rho^2(1-\eta_H)\right.\right.\right.\\
& (\eta_1(1-\eta_H)+\eta_H)-\rho(-\eta_1-\eta_H+3)-\eta_1+2)+\beta_1(1-\eta_H)(\rho\eta_H+1)(1-\eta_1(1+\phi))+(1-\rho)\eta_1)\\
& (\beta_1(\rho\eta_1(1-\eta_H)-\phi-1)-\rho\eta_H+1)+\eta_H\left(\rho^2(1-\eta_H)^2+\rho-1\right)-((1-\eta_H)^2(1-\rho\eta_H)\\
& \left((1-\rho\eta_H)\left(2\beta_1^2(1-\eta_1(\phi+1))(\rho\eta_1(1-\eta_H)-\phi-1)+2\eta_1(1-\rho(1-\eta_H))^2\right)\right.\\
& +2\beta_1(\eta_1(1-\rho(\rho(1-\eta_H)\eta_H+1))+\rho\eta_H(1-\rho\eta_H))(\rho\eta_1(1-\eta_H)-\phi-1)\\
& +2\beta_1(1-\rho(\rho(1-\eta_H)\eta_H+1))(1-\eta_1(\phi+1))-2\rho\eta_H(3-\rho(3-\rho(1-\eta_H)\eta_H)))-2(1-\eta_H)^2\\
& (1-\rho\eta_H)(\beta_1(\rho\eta_1(1-\eta_H)-\phi-1)-\rho\eta_H+1)\left((1-\eta_H)\left((1-\rho\eta_H)\left(\eta_1^2(1-\rho(1-\eta_H))^2\right.\right.\right.\\
& \left.+\beta_1^2(1-\eta_1(\phi+1))^2\right)+2\beta_1(1-\eta_1(\phi+1))(\eta_1(1-\rho(\rho(1-\eta_H)\eta_H+1))+\rho\eta_H(1-\rho\eta_H))\\
& -2\rho\eta_1\eta_H(3-\rho(3-\rho(1-\eta_H)\eta_H)))+\eta_H(1-\rho\eta_H)(4-\rho(4-\rho(1-\eta_H)\eta_H))))\\
& \Big(2\sqrt{\begin{aligned}&(1-\eta_H)(1-\rho\eta_H)\left((1-\eta_H)\left((1-\rho\eta_H)\left(\eta_1^2(1-\rho(1-\eta_H))^2+\beta_1^2(1-\eta_1(\phi+1))^2\right)\right.\right.\\&+2\beta_1(1-\eta_1(\phi+1))(\eta_1(1-\rho(\rho(1-\eta_H)\eta_H+1))+\rho\eta_H(1-\rho\eta_H))\\&-2\rho\eta_1\eta_H(3-\rho(3-\rho(1-\eta_H)\eta_H)))+\eta_H(1-\rho\eta_H)(4-\rho(4-\rho(1-\eta_H)\eta_H)))\end{aligned}}\Big)^{-1}\\
& +\beta_1(1-\eta_H)(\rho\eta_H+1)(\rho\eta_1(1-\eta_H)-\phi-1)-\rho+1)\,.
\end{aligned}
$$

We are 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, we find the same relation as with simultaneous production. As illustrated in the left panel of figure 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:

$$
\frac{\partial \beta_H^{seq}}{\partial \eta_1} \begin{cases} > 0, & \text{if} \quad \eta_H \text{ is small} \\ < 0, & \text{if} \quad \eta_H \text{ is high.} \end{cases} \tag{56}
$$

This relation is illustrated in the right panel of figure 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.

The resulting organizational decision is depicted in figure 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 13, we depict the organizational decision for low values of ρ, and in the right panel we 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 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.

[25] The corresponding MATHEMATICA 9.0 file is available on request.

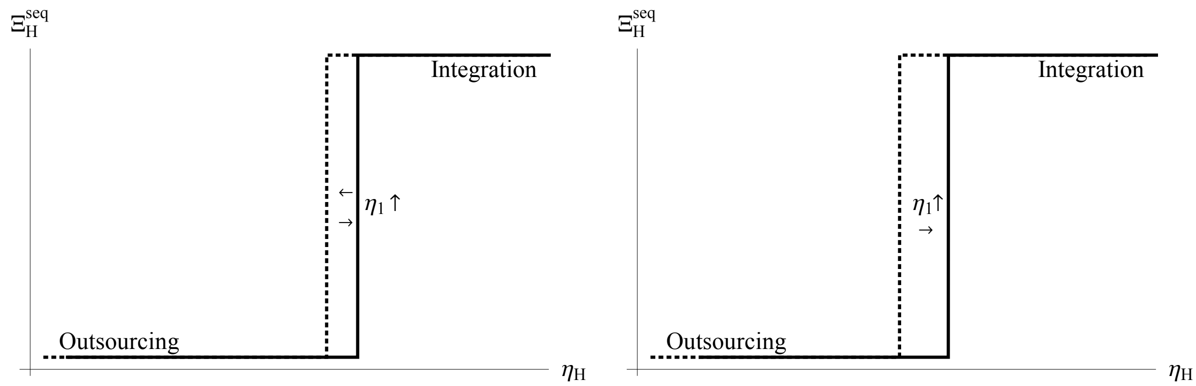

Figure 13: Organizational decision of the producer Ξ_H^{seq} subject to a variation of η_H.
Left panel: low values of ρ. Black, dotted line: low or high values of η_1. Black, solid line: intermediate values of η_1.
Right panel: high values of ρ. Black, dotted line: low values of η_1. Black, solid line: high values of η_1.

C Setup without Participation Fees

C.1 Simultaneous Production

With simultaneous production, supplier 1 chooses the organizational form of supplier 2 that maximizes

$$\pi_{1,wo}^{sim} = (1-\beta_H)\,\beta_1 R^{sim} - c_1 m_1^{sim}, \tag{57}$$

whereas the producer makes his organizational decision subject to

$$\pi_{H,wo}^{sim} = \beta_H R^{sim} - c_H h^{sim} \tag{58}$$

with m_1^{sim}, h^{sim} and R^{sim} as defined in (5).

Organizational Decision of Supplier 1 To derive supplier 1's optimal revenue share, we differentiate the above profit $\pi_{1,wo}^{sim}$ with respect to β_1 and solve for β_1:

$$\beta_{1,wo}^{sim} = \eta_1 + \frac{(1-\rho)\,(1-\eta_1)}{1-\rho\eta_H}. \tag{59}$$

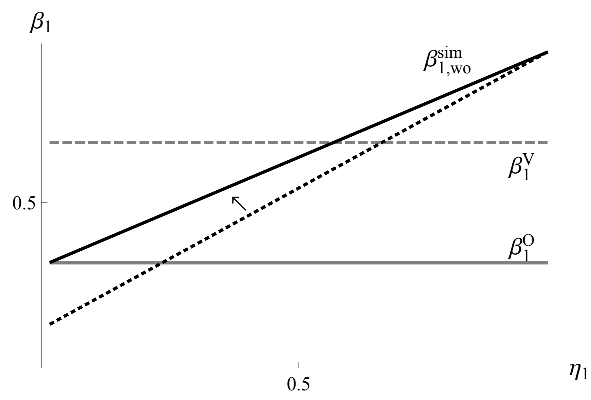

Figure 14: Optimal revenue share $\beta_{1,wo}^{sim}$ without participation fees subject to a variation of η_1.
Black, dotted line: low values of η_H. Black, solid line: high values of η_H.

Figure 14 is analogous to figure 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:

$$\frac{\partial \beta_{1,wo}^{sim}}{\partial \eta_1} = \frac{\rho\,(1-\eta_H)}{1-\rho\eta_H} > 0. \tag{60}$$

In figure 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:

$$\frac{\partial \beta_{1,wo}^{sim}}{\partial \eta_H} = \frac{\rho\,(1-\rho)\,(1-\eta_1)}{(1-\rho\eta_H)^2} > 0. \tag{61}$$

Since $\beta_{1,wo}^{sim}$ 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 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.

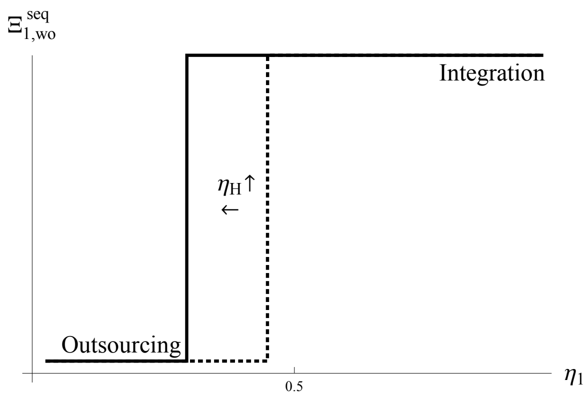

Figure 15: Organizational decision of supplier 1 $\Xi_{1,wo}^{sim}$ without participation fees subject to a variation of η_1.
Black, dotted line: low values of η_H. Black, solid line: high values of η_H.

Organizational Decision of the Producer In a similar manner, we can derive the producer's optimal revenue share:

$$\beta_{H,wo}^{sim} = 1-\rho\,(1-\eta_H)\,. \tag{62}$$

This optimal revenue share is depicted in figure 16 which is analogous to figure 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:

$$\frac{\partial \beta_{H,wo}^{sim}}{\partial \eta_H} = \rho > 0. \tag{63}$$

In contrast to the constellation with participation fees, the derivation with respect to η_1 equals zero

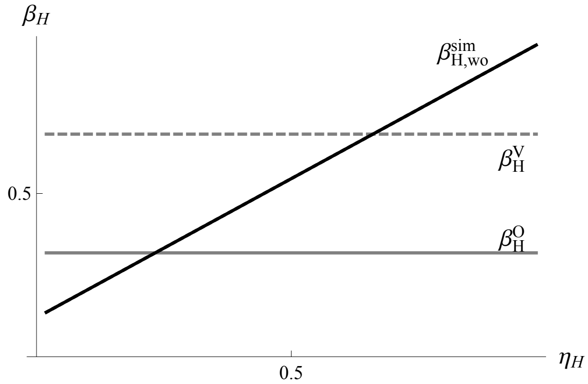

Figure 16: Optimal revenue share $\beta_{H,wo}^{sim}$ without participation fees subject to a variation of η_H. Black, dotted line: low values of η_1. Black, solid line: high values of η_1.

such that $\beta_{H,wo}^{sim}$ is independent from η_1:

$$\frac{\partial \beta_{H,wo}^{sim}}{\partial \eta_1} = 0. \tag{64}$$

In accordance with this, in figure 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 17 where the black, dotted line and the black, solid line are again identical.

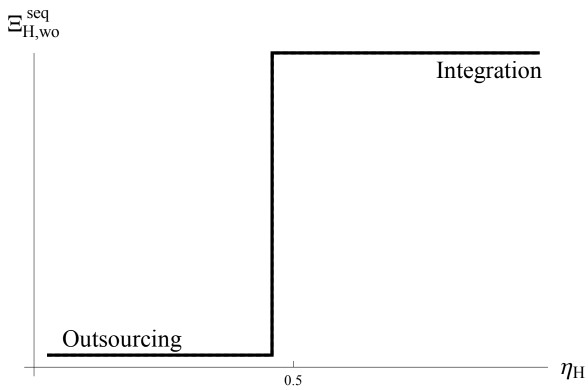

Figure 17: Organizational decision of the producer $\Xi_{H,wo}^{sim}$ without participation fees subject to a variation of η_H.
Black, dotted line: low values of η_1. Black, solid line: high values of η_1.

Interrelation of the Producer's and Supplier 1's Organizational Decisions Figure 18 is analogous to figure 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 $\left\{\Xi_H^{sim}, \Xi_1^{sim}\right\}$.

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,

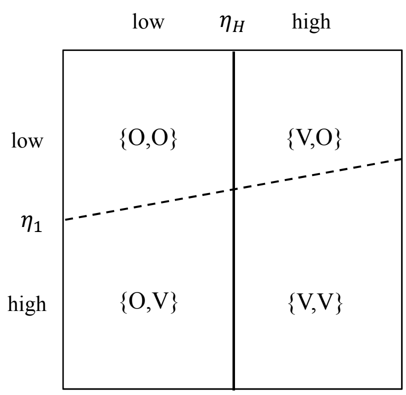

Figure 18: Organizational decisions of the producer and supplier 1 without participation fees with simultaneous production.

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.

C.2 Sequential Production

With sequential production, supplier 1's profit is given by

$$\pi_{1,wo}^{seq} = (1 - \beta_H)\,\beta_1 R^{seq} - c_1 m_1^{seq} \tag{65}$$

and the producer's profit is

$$\pi_{H,wo}^{seq} = \beta_H R^{seq} - c_H h^{seq}. \tag{66}$$

m_1^{seq} and h^{seq} are again definded as in (5) and R^{seq} is defined as in (17).

Organizational Decision of Supplier 1 As before, we differentiate supplier 1's profit with respect to β_1 and solve for β_1 to derive the optimal revenue share

$$\beta_{1,wo}^{seq} = \eta_1 + \frac{(1-\rho)\,(1-\eta_1)}{1-\rho\eta_H}. \tag{67}$$

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, we differentiate the producer's profit and solve for β_H:

$$\beta_{H,wo}^{seq} = 1 - \rho\,(1 - \eta_H)\,. \tag{68}$$

It is also equal to the optimal simultaneous revenue share without participation fees.

D APPLE or SMART

D.1 Technology and Demand

If the producer only uses supplier 2's input, output is given by the linear production function

$$q_2 = \theta_{H2} m_2, \tag{69}$$

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:

$$q_{12H} = \theta_H \left(\frac{h}{\eta_H}\right)^{\eta_H} \left(\frac{\left(\frac{m_1}{\eta_1}\right)^{\eta_1} \left(\frac{\theta_{H2} m_2}{1-\eta_1}\right)^{1-\eta_1}}{1-\eta_H}\right)^{1-\eta_H}. \tag{70}$$

Using (3), the value of supplier 2's input contribution is given by

$$R_2 = A^{1-\rho} \left(\theta_{H2} m_2\right)^{\rho} \tag{71}$$

and the resulting revenue level of the final good is

$$R_{12H} = A^{1-\rho} \left(\theta_H \left(\frac{h}{\eta_H}\right)^{\eta_H} \left(\frac{\left(\frac{m_1}{\eta_1}\right)^{\eta_1} \left(\frac{\theta_{H2} m_2}{1-\eta_1}\right)^{1-\eta_1}}{1-\eta_H}\right)^{1-\eta_H}\right)^{\rho}. \tag{72}$$

D.2 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 non-contractible 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 non-contractible 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.

D.3 Solving 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:

$$h^{\text{APPLE}} = \frac{\rho\beta_{H1}\eta_H}{c_H} R_{12H}^{\text{APPLE}} \quad \text{and} \quad m_1^{\text{APPLE}} = \frac{\rho\left(1-\beta_{H1}\right)\eta_1\left(1-\eta_H\right)}{c_1} R_{12H}^{\text{APPLE}} \quad \text{with}$$

$$R_{12H}^{\text{APPLE}} = \left(A^{1-\rho}\left(\rho^{\frac{1-\phi}{\rho}}\theta_H\left(\frac{\beta_{H1}}{c_H}\right)^{\eta_H}\left(\left(\frac{1-\beta_{H1}}{c_1}\right)^{\eta_1}\left(\frac{\theta_{H2}m_2}{\left(1-\eta_1\right)\left(1-\eta_H\right)}\right)^{1-\eta_1}\right)^{1-\eta_H}\right)^{\rho}\right)^{\frac{1}{\phi}} \tag{73}$$

with ϕ as defined in (16). 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}:

$$m_2^{\text{APPLE}} = \rho\left(1-\beta_{H2}\right)c_2 R_2^{\text{APPLE}} \quad \text{with} \quad R_2^{\text{APPLE}} = A\left(\frac{\rho\theta_{H2}\left(1-\beta_{H2}\right)}{c_2}\right)^{\frac{\rho}{1-\rho}}. \tag{74}$$

Using supplier 2's input provision, total revenue becomes

$$R_{12H}^{\text{APPLE}} = A\rho^{\frac{\rho}{1-\rho}}\left(\theta_H\left(\frac{\beta_{H1}}{c_H}\right)^{\eta_H}\left(\left(\frac{1-\beta_{H1}}{c_1}\right)^{\eta_1}\left(\frac{\left(\frac{(1-\beta_{H2})\theta_{H2}}{c_2}\right)^{\frac{1}{1-\rho}}}{\left(1-\eta_1\right)\left(1-\eta_H\right)}\right)^{1-\eta_1}\right)^{1-\eta_H}\right)^{\frac{\rho}{\phi}} \tag{75}$$

and the profit level for the APPLE case is given by

$$\begin{aligned}
\pi_H^{\text{APPLE}} &= \beta_{H1}R_{\text{diff}}^{\text{APPLE}} + \beta_{H2}R_2^{\text{APPLE}} - c_H h^{\text{APPLE}} = \beta_{H1}\left(1-\rho\eta_H\right)R_{12H}^{\text{APPLE}} + \left(\beta_{H2}-\beta_{H1}\right)R_2^{\text{APPLE}} \\
&= \beta_{H1}\left(1-\rho\eta_H\right)A\rho^{\frac{\rho}{1-\rho}}\left(\theta_H\left(\frac{\beta_{H1}}{c_H}\right)^{\eta_H}\left(\left(\frac{1-\beta_{H1}}{c_1}\right)^{\eta_1}\left(\frac{\left(\frac{(1-\beta_{H2})\theta_{H2}}{c_2}\right)^{\frac{1}{1-\rho}}}{\left(1-\eta_1\right)\left(1-\eta_H\right)}\right)^{1-\eta_1}\right)^{1-\eta_H}\right)^{\frac{\rho}{\phi}} \\
&\quad + \left(\beta_{H2}-\beta_{H1}\right)A\left(\frac{\rho\theta_{H2}\left(1-\beta_{H2}\right)}{c_2}\right)^{\frac{\rho}{1-\rho}}.
\end{aligned} \tag{76}$$

D.4 Concrete Derivatives of $\pi_{\mathbf{rel}}$

The derivation of the relative profit with respect to θ_1 is given by

$$\begin{aligned}
\frac{\partial \pi_{\text{rel}}}{\partial \theta_1} = & -\frac{\rho(1-\eta_H)}{(1-\rho)(1-\rho\eta_H)}(1-\beta_{H2})^{\frac{\rho}{1-\rho}}\theta_H^{\frac{\rho}{\rho-1}}\theta_{H2}^{\frac{\rho}{1-\rho}}(1-\beta_H)^{-\frac{\rho(\eta_H-1)}{\rho-1}}\beta_H^{\frac{\rho\eta_H}{\rho-1}-1} \\
& (\rho(\eta_1-1)\eta_H-\rho\eta_1+1)^{-\frac{\rho(\eta_1-1)(\eta_H-1)}{\rho-1}}\theta_1^{\frac{1-\rho\eta_H}{\rho-1}}c_H^{-\frac{\rho\eta_H}{\rho-1}}(1-\beta_1)^{\frac{\rho(\eta_1-1)(\eta_H-1)}{\rho-1}}\beta_1^{-\frac{\rho\eta_1(\eta_H-1)}{\rho-1}}c_1^{\frac{\rho\eta_1(\eta_H-1)}{\rho-1}} \\
& c_2^{\frac{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H)}{\rho-1}}\Bigg(\beta_{H2}+\beta_{H1}\Bigg((1-\rho\eta_H)(1-\eta_1)^{\frac{1-\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}-1}(1-\eta_H)^{\frac{1-\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}-1} \\
& (1-\beta_{H1})^{-\frac{\rho\eta_1(\eta_H-1)}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}\beta_{H1}^{\frac{\rho\eta_H}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}(1-\beta_{H2})^{\frac{1}{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H)-1}+1}\theta_H^{\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} \\
& \theta_{H2}^{\frac{1}{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H)-1}+1}c_1^{\frac{\rho\eta_1(\eta_H-1)}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}c_2^{\frac{1}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}-1}c_H^{-\frac{\rho\eta_H}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}-1\Bigg)\Bigg).
\end{aligned} \tag{77}$$

The derivation of the relative profit with respect to θ_H is

$$\begin{aligned}
\frac{\partial \pi_{\text{rel}}}{\partial \theta_H} = & -\frac{\rho}{(1-\rho)(1-\rho\eta_H)}(1-\beta_{H2})^{\frac{\rho}{1-\rho}}\theta_H^{\frac{1}{\rho-1}}\theta_{2H}^{\frac{\rho}{1-\rho}}(1-\beta_H)^{-\frac{\rho(\eta_H-1)}{\rho-1}}\beta_H^{\frac{\rho\eta_H}{\rho-1}-1} \\
& (1-\eta_1)^{-\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}(1-\eta_H)^{-\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}(\rho(\eta_1-1)\eta_H-\rho\eta_1+1)^{\frac{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H-1)}{\rho-1}-1} \\
& \theta_1^{-\frac{\rho(\eta_H-1)}{\rho-1}}(1-\beta_1)^{\frac{\rho(\eta_1-1)(\eta_H-1)}{\rho-1}}\beta_1^{-\frac{\rho\eta_1(\eta_H-1)}{\rho-1}}c_1^{\frac{\rho\eta_1(\eta_H-1)}{\rho-1}}c_2^{\frac{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H)}{\rho-1}-1}c_H^{-\rho\eta_H\left(\frac{1}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}+\frac{1}{\rho-1}\right)} \\
& \Bigg(\rho(\beta_{H2}-1)(\rho\eta_H-1)(1-\eta_1)^{\frac{1}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}(1-\eta_H)^{\frac{1}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}1-\beta_{H1})^{\frac{\rho\eta_1(1-\eta_H)}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} \\
& \beta_{H1}^{\frac{\rho\eta_H}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}+1}(1-\beta_{H2})^{\frac{1}{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H)-1}}\theta_H^{\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}\theta_{2H}^{\frac{1}{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H)-1}+1}c_1^{\frac{\rho\eta_1(\eta_H-1)}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} \\
& c_2^{\frac{1}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}-c_2(\beta_{H1}-\beta_{H2})(1-\eta_1)^{\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}(1-\eta_H)^{\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} \\
& (\rho(\eta_1-1)\eta_H-\rho\eta_1+1)c_H^{\frac{\rho\eta_H}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}\Bigg).
\end{aligned} \tag{78}$$

The derivation of the relative profit with respect to θ_{H2} is given by

$$\frac{\partial \pi_{\text{rel}}}{\partial \theta_{H2}} = \frac{\rho}{(1-\rho)(1-\rho\eta_H)} (1-\beta_{H2})^{\frac{\rho}{1-\rho}} \theta_H^{\frac{\rho}{\rho-1}} \theta_{H2}^{\frac{1}{1-\rho}-2} (1-\beta_H)^{-\frac{\rho(\eta_H-1)}{\rho-1}} \beta_H^{\frac{\rho\eta_H}{\rho-1}-1} (1-\eta_1)^{-\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}$$
$$(1-\eta_H)^{-\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} (\rho(\eta_1-1)\eta_H-\rho\eta_1+1)^{\frac{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H-1)}{\rho-1}-1} \theta_1^{-\frac{\rho(\eta_H-1)}{\rho-1}} (1-\beta_1)^{\frac{\rho(\eta_1-1)(\eta_H-1)}{\rho-1}}$$
$$\beta_1^{-\frac{\rho\eta_1(\eta_H-1)}{\rho-1}} (1-\beta_{H1})^{-\frac{\rho\eta_1(\eta_H-1)}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} c_1^{\frac{\rho\eta_1(\eta_H-1)}{\rho-1}} c_2^{\frac{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H)}{\rho-1}-1} c_H^{-\rho\eta_H\left(\frac{1}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}+\frac{1}{\rho-1}\right)}$$
$$\Bigg((\beta_{H2}-1)(\rho\eta_H-1)(1-\eta_1)^{\frac{1}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} (1-\eta_H)^{\frac{1}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} \beta_{H1}^{\frac{\rho\eta_H}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}+1}$$
$$(1-\beta_{H2})^{\frac{1}{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H)-1}} \theta_H^{\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} \theta_{H2}^{\frac{1}{\rho(\eta_1(-\eta_H)+\eta_1+\eta_H)-1}+1} c_1^{\frac{\rho\eta_1(\eta_H-1)}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} c_2^{\frac{1}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}}$$
$$-c_2(\beta_{H1}-\beta_{H2})(1-\eta_1)^{\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} (1-\eta_H)^{\frac{\rho}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} (\rho(\eta_1-1)\eta_H-\rho\eta_1+1)$$
$$(1-\beta_{H1})^{\frac{\rho\eta_1(\eta_H-1)}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} c_H^{\frac{\rho\eta_H}{\rho(\eta_1-1)\eta_H-\rho\eta_1+1}} \Bigg). \tag{79}$$

The derivations with regard to the headquarter intensity and the suppliers' input intensities are provided on request in the MATHEMATICA 9.0 file.

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Heinrich-Heine-University of Düsseldorf

Düsseldorf Institute for Competition Economics (DICE)

Universitätsstraße 1 _ 40225 Düsseldorf
www.dice.hhu.de

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