Cost Structure, Market Structure and Outsourcing[§]

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Abstract: A partial equilibrium model is developed to investigate the interplay of production technology and the difference of market structure between upstream and downstream markets on firms' outsourcing choice. It is found that whether outsourcing or vertical integration emerges as the optimal organizational structure depends not only on the cost structure of competing upstream firms, but also on the difference between the "thickness" of upstream and downstream markets. In industries where there are more (less) downstream firms than upstream suppliers, outsourcing is the optimal organization if and only if the upstream suppliers' technology exhibits economies (diseconomies) of scale. When the upstream firms experience constant return to scale, vertical integration is the optimal strategy, irrespective of the number of upstream and downstream firms. Using firm level data from the German cost structure survey over the period 1992 to 2001, we implement the above model by estimating a set of reduced-form equations. The empirical evidence supports the prediction of the theoretical model.

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Using firm level data from the German cost structure survey over the period 1992 to 2000, we implement the above model by estimating a set of reduced-form equations. We confirm empirically that upstream firms' cost structure as well as the difference between the horizontal competition at upstream and downstream market have important implications for firms' outsourcing decisions.

1. Introduction

Outsourcing or in-house production is a fundamental decision every firm has to face. In the last decades, outsourcing activities, especially international outsourcing, seem to be on a rising trend (McMillan, 1995; Abraham and Taylor, 1996; Campa and Goldberg, 1997; Hummels, Rapoport and Yi, 1998). Firms outsource not only their final-product-related services, but also many input-related activities, such as R&D, advertising, and the production and services of many other intermediate inputs. The optimal form of organization has been extensively studied in a bilateral-monopoly context based on the theory of asset specificity and incomplete contracts (Willamson, 1985; Grossman and Hart, 1986). This transaction-cost-based approach compares the governance costs of productions within a firm with the transaction costs of organizing production through the market, and predicts that vertical integration decreases with the number of actual or potential trading partners, increases with the investment in sunk assets necessary to support a type of transaction, and increases with the uncertainty associated with the transaction (Martin, 2002).

On the other hand, the neoclassical economic analysis focuses on production costs and views production cost savings as the motivation for firms' increasing outsourcing activities. This production-cost-based approach compares the production cost difference between internal and external production, and predicts that outsourcing occurs because outside suppliers benefit from economies of scale, smothers production schedules and centralization of expertise (see survey by Heshmati, 2000).

In the real world firms make their choice between organizing the production within the firm or through the market based on the savings not only on production cost but also on transaction costs. It is the consideration of economizing both production costs and transaction costs that determines firms choice between outsourcing and vertical integration. Despite its apparent theoretical importance, empirical relevance and potentially policy implications, there are very few theoretical or empirical papers in economics literature exploring the interplay between transaction costs and production costs.[1] An exception is Riordan and Williamson (1985), where the choice of organization form is examined in a common framework in which both production cost and transaction cost differences are expressed as a function of asset specificity.

As an attempt to build a bridge between the neoclassical and transaction cost modes of economic analysis, this paper develops a framework in which both transaction cost and production cost considerations are incorporated. Furthermore, the hypotheses derived from the model are empirically tested. In order to keep the model empirically testable, we focus on one aspect of the impact of transaction cost on outsourcing, namely the difference between the "thickness" of upstream and downstream markets.[2] When there are many potential downstream buyers, the hold-up problem faced by a upstream supplier owing to asset specificity and incomplete contract can be alleviated. This is because the danger of being held-up by its downstream partner is mitigated when there are alternative buys, whose presence gives the upstream supplier bargaining power and allows it to demand a remunerative price (McLaren, 2000). Indeed, transaction cost theory predicts that vertical integration should be less, the greater the differences between the number of firms at upstream and downstream market (Martin, 2002). The relation between market size and vertical disintegration is empirically confirmed by Holmes (1999).

Specifically, in this paper the interplay between the production technology of upstream suppliers and the difference between the number of firms at upstream and downstream market on firms' outsourcing choice is theoretically explored and empirically tested. Outsourcing is

[1] In management literature, some case studies (Dritna, 1994); Lacity, Willcocks and Feeny, 1996) suggest that firms in general overestimate the production cost advantages of outsourcing and underestimate the role of transaction costs.
[2] The "thickness" of the downstream (or upstream) market is defined as the potential number of firms in that market.

an endogenous choice in our set-up.[3] The attractiveness to outsource for a downstream firm depends not only on the number of its potential upstream suppliers, but also on the production cost of its suppliers, which in turn depends on how many of its rival firms have chosen to outsource or vertically integrate.

We find that it is not the number of firms at upstream or downstream market per se, but it is the difference in the thickness of these two markets, plus the production cost of potential suppliers that is pivotal for firms' outsourcing decisions. For industries where there are *more* downstream firms than potential upstream suppliers, outsourcing emerges as optimal strategy if and only if the suppliers experience *economies* of scale. On the other hand, in industries where there are *less* downstream firms than upstream firms, outsourcing is optimal if and only if the upstream suppliers experience *diseconomies* of scale.

This is because when the downstream market is "thicker" than the upstream market, each upstream supplier produces intermediate inputs for several downstream firms. Hence, the upstream suppliers with economies of scale produce at lower marginal costs than their counterparts in vertically integrated firms. However, this marginal cost advantage is reversed when the upstream suppliers produce with decreasing return to scale technology. On the other hand, when there are less downstream firms than upstream firms, several upstream suppliers share the input production of one downstream firm. Therefore, it is cheaper for a firm to outsource its input production to its upstream supplier(s) than to produce itself, if and only if the suppliers experience diseconomies of scale.

This result is in strong contrast with the findings in existing literature which is based on either only transaction cost approach or only production cost approach. Transaction cost theory

[3] Both Chen (2002) and Grossman and Helpman (2002) also endogenize organizational structure of firms. Chen (2002) investigates the role of strategic purchase and learning by doing in vertical disintegration. Grossman and Helpman (2002) analyse the trade-off between the cost of governance in an integrated firm v.s. the cost of searching partners and imperfect contracting for an outsourcing firm.

predicts that vertical integration decreases with the difference between the number of firms at upstream and downstream market. On the other hand, production cost theory says that outsourcing occurs because upstream suppliers benefit from economies of scale. Both predictions no longer hold true when the interdependence of transaction costs and production costs is taken into account.

Using firm level data from the German cost structure survey, we test our theoretical predictions from a panel of 14 industries consisting of 3120 firms (with 1690 upstream and 1430 downstream firms) from the German cost structure census over the period 1992-2001. It is found that except for one industry group, namely the manufacture of pharmaceuticals, medicinal chemicals and botanical products, our theoretical predictions are confirmed.

In the literature there is no well-defined method to measure outsourcing. For an outsourcing firm, its material costs increase but its total costs should decrease. In the empirical part of this paper, we interpret the evidence of outsourcing from the following three changes: a. an increase in intermediate material consumptions as a share of gross production; b. a decrease in labour input as a share of gross production; c. a decrease in cost of capital as a share of gross of production. Moreover, the mark-ups and economies of scale are simultaneously estimated for both downstream and upstream firms by adopting the approach of Klette (1999) with some modifications.

Although there are a number of empirical studies examining the impact of outsourcing on labour market and firm performance,[4] there are few empirical papers investigating the causes of outsourcing. To our knowledge this is the first empirical paper which analyses the determinants of outsourcing from both transaction cost and production cost considerations. Since the industry characteristics such as market structure and cost structure are the main

[4] For example, Feenstra and Hanson (1996) examine the impact of international outsourcing on the relative demand for skilled labour of US manufacturing industries for the period of 1972-1992. Goezig and Stephan

focus in our analysis, this study can hopefully contribute to explain the cross-sectional and cross-regional differences in outsourcing activities, which have been documented by some scholars (for example, Chinitz ,1961; Helper, 1991).

The paper is organized in four sections. Literature review and motivation are given in Section 1. In Section 2 we set up a basic model and solve for three different scenarios. In Section 3, the model is estimated and empirical results are presented. Conclusions are given in Section 4.

2. Model

In this section, we develop a model that explores the role of industry characteristics such as market structure and production technology in firms' outsourcing decisions. The focus is to investigate how horizontal competition in both upstream and downstream markets, as well as the production technology of the upstream suppliers affect firms' decision to outsource vs. vertically integrate.

There are N potential downstream purchasers and M potential upstream suppliers, respectively. For upstream supplier m (or upstream division m for an integrated firm), m=1,2,…,M, its production cost is given by $I(x_m)$, where x_m and $I(x_m)$ are the output and the total cost of supplier m. The price charged by upstream supplier m to its downstream purchaser(s) is r_m. Hence, the profit of upstream supplier m is given by $u_m = r_m x_m - I(x_m)$. On the other hand, for downstream firm n (or downstream division n for an integrated firm), n=1,2,…,N, the price it pays to its upstream supplier(s) for the intermediate good is β_n. The cost of transforming intermediate inputs into the final goods is $c(q_n)$. Hence, the total cost of producing the final good is $\beta_n q_n + c(q_n)$. The market demand for the final goods is $p(Q)$,

(2002) shows that firms tend to overestimate the benefits accruing from outsourcing of services which were previously provided internally.

where $p'(Q) < 0$, and $\Delta \equiv p''(Q)Q + (N+1)p'(Q) - c'' < 0$.[5] Therefore, the profit function of downstream firm n is given by $\pi_n = pq_n - (\beta_n q_n + c(q_n))$.

The timing of game is structured as follows:

Game:

Stage 1: Downstream firms decide to outsource or vertically integrate.

Stage 2: Upstream firms compete in intermediate input production by choosing input prices.

Stage 3: Downstream firms choose their output quantities and compete in final product market via. Cournot.

Since there is neither incomplete nor imperfect information involved in the game, the equilibrium concept we adopt is subgame perfect equilibrium. Before proceeding we would like to make the following assumptions.

Assumption 1: The ratio between the intermediate input and final output is 1.

Assumption 2: Each vertically integrated firm has only one upstream and downstream division. The upstream division of an integrated firm only produces the intermediate input for its downstream division.

Assumption 3: The demand and cost functions, $p(\cdot)$, $c(\cdot)$ *and* $I(\cdot)$ *behave so that a downstream firm's output decreases with its own marginal cost and increases with its competitors' marginal costs.*

We proceed with our analysis by classifying three scenarios according to the difference between the number of upstream suppliers and downstream firms.

2.1. There are more downstream firms than upstream suppliers, i.e., $N > M$.

The optimal make-or-buy decision of downstream firms is solved at the subgame perfect equilibrium. In order to do that, for any J, J= 0, 1, …, M-1, the first J downstream firms are

[5] This is the second order condition of downstream firms.

taken to be vertically integrated. W.L.O.G., they are assumed to be vertically integrated with the first J upstream supplier, respectively. The question is what kind of organization structure the last (N-J) downstream firms are going to choose?

Case 1: $J = M - 1$.

That is, the first $(M-1)$ firms are vertically integrated. In this case, the upstream firm M is a monopolist in upstream market. The last (N-M+1) downstream firms compare the profits under outsourcing (scenario (A)) with those under vertical integration (scenario (B)), and then make their make-or-buy decisions.

(A) If the last (N-M+1) firms choose to outsource, they buy their intermediate inputs from the monopolistic upstream supplier M for the price β_n^* and produce the final good q_n^*, where β_n^* and q_n^* satisfies the following conditions,[6]

a. $\beta_n^* > I'((N-M+1)q_n^*)$, and

$$p'(Q^*)q_n^* + p(Q^*) - \left(\beta_n^* + c'(q_n^*)\right) = 0 \text{, where } Q^* = \sum_{n=1}^{N} q_n^* \text{, for } n = M, M+1, \ldots, N .$$

b. On the other hand, for the first M-1 integrated firms,

$$\beta_n^* = I'(q_n^*) \text{, and } p'(Q^*)q_n^* + p(Q^*) - \left(\beta_n^* + c'(q_n^*)\right) = 0 \text{, for } n = 1,2,\ldots, M-1 .$$

(B) If one of the last (N-M+1) firms vertically integrates with the upstream supplier M, w.l.o.g., that is downstream firm M, then the equilibrium price of the intermediate inputs (β_n^*) and the equilibrium output of final good (q_n^*) satisfy:

$$\beta_n^* = I'(q_n^*) \text{, and } p'(Q^*)q_n^* + p(Q^*) - \left(I'(q_n^*) + c'(q_n^*)\right) = 0 \text{, where } Q^* = Nq_n^* .^{7} \quad (1)$$

[6] Due to symmetry of the last (N-M+1) firms, if one of them chooses to outsource, the rest firms also choose to outsource.

The last (N-M+1) downstream firms compare their profits under (A) with under (B), and choose between whether to buy the intermediate input from the upstream suppliers or to vertically integrate.

Case 2: $J \leq M - 2$.

Different from Case 1, in this case there are at least two upstream suppliers competing in producing homogenous intermediate inputs. The price of intermediate inputs is thereby reduced to suppliers' marginal cost of in industries where the upstream firms experience constant or increasing return to scale technology. But for industries where upstream suppliers have decreasing return to scale technology, the price is still higher than their marginal costs (Tirole 1993, P215). Given that the first J downstream firms are vertically integrated, we solve for the optimal strategy of the last (N-J) downstream firms. Again, we consider two scenarios:

(A) If the last (N-J) downstream firms decide to outsource, the equilibrium price of intermediate inputs (β_n^*), and the output of final goods (q_n^*) satisfies the following equations:

For $n = J+1,...,N$,

$$\beta_n^* = I'(\frac{q_{J+1}^* + ... + q_N^*}{M - J}) \text{ if } I'(\cdot) \leq 0 \text{, and } \beta_n^* > I'(\frac{q_{J+1}^* + ... + q_N^*}{M - J}) \text{ if } I'(\cdot) > 0 \text{. And}$$

$$p'(Q^*)q_n^* + p(Q^*) - \left(\beta_n^* + c'(q_n^*)\right) = 0 \text{, where } Q^* = \sum_{n=1}^{N} q_n^* .$$

For the first J integrated firms, $n = 1,2,...,J$,

$$\beta_n^* = I'(q_n^*) \text{, and } p'(Q^*)q_n^* + p(Q^*) - \left(\beta_n^* + c'(q_n^*)\right) = 0 .$$

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[7] The downstream firm M+1,…, firm N are assumed to be able to produce the intermediate good at the cost of an integrated firm.

(B) On the other hand, if the last (N-J) downstream firms choose to vertically integrate, the equilibrium prices of the intermediate goods is $\beta_n^* = I'(q_n^*)$. The equilibrium output of the final goods is q_n^*, which is the root to equation (1).

The last (N-J) downstream firms compare their profits under (A) with those under (B), and decide whether to outsource or vertical integrate.

From Case 1 and Case 2, the equilibrium strategy is described in Proposition 1.

Proposition 1: In industries where there are more potential downstream firms than upstream suppliers, outsourcing is the optimal organization structure if the production technology of upstream suppliers exhibits constant or decreasing return to scale[8]*. When the upstream suppliers experience either constant or decreasing return to scale, the vertical integration is the optimal organization structure.*

Proof: See Appendix

The intuition behind Proposition 1 is as follows. In industries where there are more potential downstream firms than upstream suppliers, each upstream supplier produces the intermediate input for several downstream purchasers. With economies of scale production technology, the upstream suppliers can produce the intermediate input at lower marginal cost than the upstream divisions in a vertically integrated firm. Accordingly, the cost of intermediate input is lower for an outsourcing downstream firm than for an integrated firm. This leads the downstream firms to chose outsource over vertically integration. In industries where upstream firms experience diseconomies of scale, the marginal cost of upstream suppliers is higher than that the upstream divisions in integrated firms. Accordingly, the cost of buying intermediate goods exceeds the cost of in-house production. As a consequence, the vertical integration is the optimal organization structure.

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[8] This is true as long as the production cost curve of upstream suppliers is sufficiently concave. That is, $\frac{I'(q_n^*)-I'((N-M+1)q_n^*)}{q_n^*} > \frac{(p'-c'')\Delta}{\Delta-(p''q_n^*+p')}$.

2.2 There are less downstream firms than upstream suppliers, i.e., $N < M$.

As in Section 2.1, we want to investigate the optimal strategy of the last (N-J) downstream firms, firm J+1, …, firm N, given that the first J downstream firms are vertically integrated with the first J upstream firms, respectively, for any J (J = 0, 1, …, N-1). As in the last subsection, two scenarios are considered.

(A) If the last (N-J) downstream firms choose to outsource, then the equilibrium price of the intermediate goods charged by the upstream suppliers is down to their marginal costs for industries where the potential upstream suppliers experience increasing or constant return to scale. This is because there are at least two upstream suppliers competing in selling the homogenous intermediate inputs to the downstream firms. But for upstream industries which exhibit diseconomies of scale, the upstream suppliers charge input price higher than their marginal costs (Again, Tirole 1993). Denote β_n^* and q_n^* as the equilibrium price of the intermediate goods and the equilibrium quantity of the final goods, respectively, they can be described as follows:

For $n = 1,2,..., J$, $\beta_n^* = I'(q_n^*)$, and $p'(Q^*)q_n^* + p(Q^*) - \left(\beta_n^* + c'(q_n^*)\right) = 0$.

For $n = J + 1,..., N$,

$$\beta_n^* = I'(\frac{q_{J+1}^* + ... + q_N^*}{M - J}) \text{ if } I'(\cdot) \le 0 \text{, and } \beta_n^* > I'(\frac{q_{J+1}^* + ... + q_N^*}{M - J}) \text{ if } I'(\cdot) > 0 \text{. And}$$

$$p'(Q^*)q_n^* + p(Q^*) - \left(\beta_n^* + c'(q_n^*)\right) = 0 \text{, where } Q^* = \sum_{n=1}^{N} q_n^* \text{ .}$$

(B) On the other hand, if the last (N-J) downstream firms decide to vertically integrate,[9] the equilibrium price of intermediate goods is $I'(q_n^*)$. And the equilibrium output of downstream firms is q_n^*, which is determined by equation (1).

The last (N-J) downstream firms compare their profits under scenario (A) and (B), and their equilibrium strategies are describe by the following Proposition.

Proposition 2: In industries where there are less downstream firms than potential upstream suppliers, and the potential upstream suppliers have diseconomies of scale, outsourcing is the optimal organization structure.[10] *In contrary, when the upstream suppliers have increasing or constant return to scale technology, vertical integration is the equilibrium strategy for the downstream firms.*

Proof: See Appendix

In industries where there are less downstream firms than potential upstream suppliers, the downstream firms choose outsourcing over vertical integration, only when the upstream firms have *decreasing* return to scale technology. This result is in strong contrast with that of Proposition 1. This seemly contra-intuitive result is due to the fact that several upstream suppliers share production of the intermediate inputs for one downstream firm in the case there are less downstream firms than potential upstream suppliers. Hence, when the upstream firms experience diseconomies of scale, it is cheaper for a downstream firm to buy the intermediate inputs from the upstream firms than to produce it by its integrated upstream division, and consequently outsourcing is the optimal organization structure for the downstream firms. Naturally when the upstream suppliers have increasing or constant return to scale technology, it is cheaper for the downstream firms to produce the intermediate inputs by their upstream divisions, and vertical integration is the optimal strategy.

[9] In this case, the last (M-N) upstream suppliers are inactive.

[10] The condition is that the upstream firms' cost function is sufficiently convex, i.e., $\frac{I'(q_n^*)-I'(\frac{N-J}{M-J}q_n^*)}{q_n^*} > \frac{(p'-c'')\Delta}{\Delta-(p''q_n^*+p')}$.

2.3 there are the same number of downstream and upstream firms, i.e., $N = M$.

In this subsection, the optimal strategy of downstream firms is analysed in industries where the number of downstream firms happens to be the same as the number of potential upstream suppliers. As in the last two subsections, we want to examine the optimal strategy of the last (N-J) downstream firms, (firm J+1, …, firm N), given that the first J downstream firms are vertically integrated with the first J upstream firms (J = 0, 1, …, N-1), respectively, for any J (J = 0, 1, …, N-1). As in Subsection 2.1, we consider the following two cases.

Case 1: $J = N - 1$

That is, except for the last downstream firm, firm N, all the other downstream firms are vertically integrated. To avoid double-marginalization problem, it is optimal for the downstream firm N to integrate with the upstream firm N, no matter what kind of production technology the upstream suppliers have.

Case 2: $J \leq N - 2$. *That is,* $J = 0,1,..., N - 2$.

The last (N-J) downstream firms compare their profits under outsourcing with those under vertical integration and then make their choices. We consider the following two scenarios.

(A) if the last (N-J) downstream firms outsource, since each downstream firm outsources its intermediate input to one and only one upstream supplier, and there are at least two upstream suppliers competing in the production of the homogenous intermediate inputs, the equilibrium price of intermediate inputs is simply the marginal cost of the upstream suppliers if they experience increasing or constant return to scale technology. That is $\beta_n^* = I'(x_n^*) = I'(q_n^*)$. On the other hand, for the upstream firms which have diseconomies of scale, the price they charge to their downstream purchasers is greater than their marginal costs i.e., $\beta_n^* > I'(q_n^*)$.

The equilibrium output of downstream firm, q_n^*, is the solution to the following equations.

$$p'(Q^*)q_n^* + p(Q^*) - \left(\beta_n^* + c'(q_n^*)\right) = 0 \text{, where } Q^* = Nq_n^* \text{ , } n = 1,2,\ldots,N \text{ .}$$

(B) On the other hand, if the last (N-J) downstream firms decide to vertically integrate, the equilibrium price of the intermediate goods and equilibrium quantity of the final product are given by β_n^* and q_n^*, respectively, where $\beta_n^* = I'(q_n^*)$, and q_n^* is the solution to equation (1).

Hence, the last (N-J) downstream firms pay the same price for the intermediate goods, produce the same amount of final product and earn the same profits under outsourcing as under vertical integration, as long as the upstream suppliers experience increasing or constant return to scale. According, the downstream firms are indifferent between outsourcing and vertical integration. However, when the upstream suppliers have diseconomies of scale technology, the downstream firms strictly prefer to vertically integrate. Summarizing Case 1 and Case 2, we obtain the following proposition.

Proposition 3: If the number of upstream and downstream firms happens to be the same, vertical integration is the optimal strategy of downstream firms, irrespective of the cost structure of upstream suppliers.

Proof: See Appendix

The logic behind this result is similar to those behind the previous two propositions. Since there are the same number of downstream and upstream firms, if outsourcing occurred, each upstream supplier would produce the intermediate input for one and only one downstream firm. Therefore, neither economies of scale nor diseconomies of scale production technology would bring marginal cost advantage to the potential upstream suppliers, and accordingly the input cost advantage to the outsourcing downstream firms. On top of it, vertically integrated structure benefits from the avoidance of double-marginalization problem. As a result, vertical integration is the optimal structure for industries where the downstream and upstream market structure are very similar.

2.4 the impact of cost structure and market structure on outsourcing

The above three Propositions can be summarized in the following theorem:

Theorem: Firms' outsourcing decision depends not only on the cost structure of the potential upstream suppliers, but also on the difference between the number of upstream and downstream firms.

a. *With upstream suppliers' technology exhibiting* ***economies*** (***diseconomies***) of *scale, downstream firms choose to outsource, when the number of downstream firms is* ***greater*** *(**less**) than that of potential upstream suppliers.*
b. *With upstream suppliers' technology exhibiting constant return* to *scale, downstream firms choose to vertically integrate, regardless the number of upstream and downstream firms.*
c. *When there are the same number of upstream and downstream firms, vertical integration is the optimal organization structure, irrespective of the production technology of both upstream and downstream firms.*

The asymptotic decision of downstream firms can be trivially obtained from the above theorem. As the number of downstream firms gets very large, there will eventually be more downstream firms than upstream firms, which leads to the following corollary.

Corollary: As the competition in downstream market gets very large, outsourcing (vertical integration) is firms' optimal strategy if upstream suppliers have increasing (decreasing or constant) return to scale technology.

The theorem tells us it is neither production technology per se, nor the horizontal competition at either downstream or upstream market per se, but rather the difference between the "thickness" of these two markets, plus the production technology that determines firms' outsourcing activities. For any given number of upstream firms and a given production technology, say, economies of scale, firms' incentive to outsource is affected discontinuously by the horizontal competition at downstream market. As long as there are less downstream firms than upstream suppliers, firms choose to vertically integrate. However, as soon as the number of downstream firms exceeds the number of upstream firms, firms switches to outsourcing. Therefore, for any given thickness of the upstream market, firms' outsourcing activity is a upward step function of the competition at downstream market when the upstream suppliers experience economies of scale, but a downward step function when they experience diseconomies of scale. If the upstream firms produce with constant return to scale technology, downstream firms always choose to vertically integrate, independent of the downstream market structure.

A well-known result in the literature is that a downstream monopolist prefers to vertically integrate owing to double-marginalization problem. From the above analysis, we know that this is only true when both upstream and downstream firms are monopolists in their respective markets. As soon as there is an entrant either at the upstream or the downstream market, outsourcing may become the optimal strategy.

3. Empirical Implementation

3.1 Estimation

We test the theoretical predictions derived from the model in the previous section by using a panel of firms of 14 industries from the German cost structure census over the period 1992-2000. Table 1 shows the name of industries and the number of firms in each industry. These industries belong to one of four major industry groups at the 2- or 3-digit level. Each major group consists of upstream and downstream industries at the 4-digit level[11] . We have in total 9 downstream and 5 upstream industries, and 3120 firms.

In the first step of the analysis we provide evidence that industries' outsourcing of intermediate production has been a predominant phenomenon over the period 1992-2000. Firms outsource in order to save resources either in terms of labour or capital. Although material costs increase when firms outsource, total costs should decrease. Thus, we interpret the following evidence as indication of outsourcing. (a) an increase in intermediate material consumptions (measured as a share of gross production). (b) a decrease in labour input as a share of gross production. (c) a decrease in cost of capital as a share of gross production.

Table 2 shows the results of regressions of dependent share variables according to (a), (b) and (c) on a linear time trend. We find that outsourcing is a significant phenomenon for downstream industries 34.10, 24.42 and 21.21-21.23, whereas outsourcing is not evident for industries 32.20, 32.30, 21.24 and 21.25.

The model outlined in the previous sections predicts that firms' choice of outsourcing depends on the economies of scale of upstream firms as well as on the difference between market thickness of downstream and upstream industries. Note that in order to capture the possible product differenciation in these industries, we use the mark-up (i.e., the degree of market competition) rather than the number of firms in our empirical analysis as the indicator of market thickness.

To simultaneously estimate the economies of scale and the mark-ups from firm-level data, we adopt the approach of Klette (1999) with some minor modifications.

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[11] An exception is 3-digit level industry 21.1 We have merged industries 2111 and 2112 due to the small number of firms in industry 2111.

We assume a production function $Q_{it} = A_i F_t(X_{it})$, where Q_{it} and X_{it} represent output and a vector of inputs for firm *i* in year *t*, respectively. And A_i denotes firm-specific productivity, while $F_t(\cdot)$ is common to all firms.

The relationship between output and inputs can be also expressed as $\Delta q_{it} = \sum \alpha_{it}^j \Delta x_{it}^j$, where small letters denote logarithm of variables, i.e., $\Delta x_{it} = \log X_{it} - \log X_{i,t-1}$, and α_{it}^j is the output elasticity of input *j*. As an example, $\Delta q_{it} = \log(Q_{it}) - \log(Q_{i,t-1})$. Note that we assume $\Delta a_i = 0$, i.e. A_i is firm-specific and time-invariant.

The output elasticity α_{it}^j and input x^j can be denoted as $a_{it}^j = \mu_{it} s_{it}^j$, where s_{it}^j is the cost share of input *j* relative to total revenue, defined as $s_{it}^j = \frac{w_{it}^j x_{it}^j}{p_{it} Q_{it}}$, and μ_{it} is the ratio between price and marginal costs (Klette, 1999).

Similar to Klette (1999) we make a distinction between variable inputs x^j and fixed inputs x^K. The industry-specific long and short run Returns to Scale (RS) are denoted as η_l and η_l^s, respectively, where $\eta_l = \sum_{j \in M} \alpha_l^j + \alpha_l^K = \eta_l^s + \alpha_l^K$, for industry $l = 1, \ldots, L$.

We implement the following approach to estimate RS

$$\Delta q_{it} = \lambda_{0l} + \lambda_{lt} + \eta_l^s \sum_{j \in M} \Delta x_{it}^j + \alpha_l^K \Delta x_{it}^K + \varepsilon_{it}\,, \qquad (2)$$

where λ_{0l} and λ_{lt} are industry-specific intercepts and time-effects, $t = 1, \ldots, T$, and ε_{it} is assumed to be iid $N(0, \sigma_\varepsilon)$.

Accordingly, we estimate industry-specific mark-ups μ_l from

$$\Delta q_{it} = \lambda_{0l} + \lambda_{lt} + \mu_l \sum_{j \in M} \bar{s}_{it}^j \Delta x_{it}^j + \alpha_l^K \Delta x_{it}^K + \varepsilon_{it} , \tag{3}$$

where $\bar{s}_{it}^j = 0.5(s_{it}^j + s_{i,t-1}^j)$. Note the similarity of (3) to the Törnquist index.

Results of the estimations are shown in Table 3. Note that Hausman tests on the differences between OLS and 2SLS, where current values of output differences have been instrumented with lagged values of output differences, turned out to be not significant, thus indicating that OLS yields both consistent and efficient estimates. Table 3 shows the average values of profit shares and summarizes the main results of the estimations.

3.2 Interpretation

Let's look at industry by industry. For automobile and freight vehicle industry (34), Table 3 tells us that the upstream parts suppliers have increasing return technology. In addition, since the markup of downstream automobile and trailer producers (1.000) is significantly less than those of upstream suppliers (1.041 and 1.058, respectively), the downstream market is thicker than the upstream market. The theory predicts that outsourcing is the equilibrium in this industry, which is indeed the case from Table 2.

The industry of the radio, television and communication equipment and apparatus (32) also confirms our theoretical predictions. Both upstream and downstream firms experiencing constant return to scale, and the competition among the downstream paper producers is less than their upstream input suppliers (average markup 1.009 and 1.031 for the downstream firms, respectively, but 1.083 for the upstream firms). The theory says that the firms of both downstream markets choose vertical integration, which is confirmed by Table 2.

With respective to the paper industry (21), the upstream suppliers have increasing return to scale, but downstream producers have different production technologies. For downstream industry 21.21, 21.22, and 21.23, the downstream market is thicker than the upstream market, the theory predicts that outsourcing is the equilibrium in these industries, which is consistent with Table 2. In contrast, for industry 21.24, the downstream market is *less* competitive than the upstream market (markup 1.119 for the downstream but 1.076 for the upstream market). Hence, vertical integration is the equilibrium in this industry, which is also consistent with Table 2 . For industry 21.25, the theory predicts outsourcing, which is contradicting the empirical evidence.

The troubling candidate is the industry (24.4) of Pharmaceutical, medicinal chemicals and botanical products. From Table 3 the production technology of upstream firms is constant return to scale, and the competition among the downstream producers is lower than among the upstream suppliers (with markup 0.931 and 1.093, respectively). According the theory, vertical integration is the optimal structure of this industry. But from Table 2, there is evidence of outsourcing. The inconsistency between the theoretical prediction and the empirical evidence is attributable to the undervalued R&D costs due to lack of R&D data. The industry of Pharmaceutical and medicinal chemicals is a high-tech industry. Firms are expected to have high R&D expenditures. Unfortunately, we don’t have data on firms’ R&D costs, except for R&D-related labor costs. If the R&D costs as a part of fixed costs were included, we would expect economies of scale for both upstream firms. Outsourcing would then be the equilibrium in this industry.

4. Conclusion

As an attempt to combine transaction-cost with production-cost approach to explain recently rising outsourcing activities, a framework is developed in which both the difference of market structure between upstream and downstream markets and the production technology of upstream firms are incorporated. It is found that it is not the difference in market thickness per se, but it is the interdependence of this difference with the cost structure of upstream firms that is crucial for firms' outsourcing choice. Outsourcing emerges as the equilibrium organization structure when there are more downstream firms than upstream firms and the production technology of upstream suppliers exhibits economies of scale. Outsourcing also prevails in industries where there are less firms at downstream market than at upstream market, but production technology of upstream firms exhibits diseconomies of scale. In any other industries, vertical integration is the optimal organization structure.

The theoretical predictions are tested by using a panel of 3120 firms belonging to 14 industries from 4 two-digit industry groups from the German cost structure census over the period 1992-2000. It is found that apart from one industry group, the theoretical hypothesis is consistent with the empirical findings.

Appendix:

Proof of Proposition 1: for any J, J= 0, 1, …, M-1, the first J downstream firms are assumed to be vertically integrated with the first J upstream supplier, respectively. We want to solve for the optimal strategy of the last (N-J) downstream firms. Let's consider two cases.

Case 1: $J = M - 1$.

That is, the first $(M-1)$ firms are vertically integrated. In this case, the upstream firm M is a monopolist in upstream market. Therefore, the price of intermediate goods paid by the last (N-M+1) downstream firms is higher than the marginal cost of the upstream supplier M. The last (N-M+1) downstream firms compare their profits when they outsource with those when they vertically integrate, and make make-or-buy decisions.

(A) If the last (N-M+1) firms choose to outsource, from the first order conditions of Stage 2 and Stage 3, we can derive β_n^{OS} and q_n^{OS} as follows:

$$\beta_n^{OS} \begin{cases} = I'(q_n^{OS}) & for \quad n = 1,2,...,M-1 \\ > I'((N-M+1)q_n^{OS}) & for \quad n = M, M+1,...,N \end{cases} \quad \text{, and}$$

$$p'(Q^{OS})q_n^{OS} + p(Q^{OS}) - \left(\beta_n^{OS} + c'(q_n^{OS})\right) = 0, \text{ for } n = 1,2,...,N, \; Q^{OS} = \sum_{n=1}^{N} q_n^{OS} . \quad (1)$$

(B) If one of the last (N-M+1) firms vertically integrates with their upstream supplier M, w.l.o.g., assuming it is firm M, then β_n^{VI} and q_n^{VI} satisfy:[12]

$$\beta_n^{VI} = I'(q_n^{VI}) \text{, and}$$

$$p'(Q^{VI})q_n^{VI} + p(Q^{VI}) - \left(I'(q_n^{VI}) + c'(q_n^{VI})\right) = 0, \text{ for } n = 1,2,...,N, \; Q^{VI} = Nq_n^{VI} . \quad (2)$$

Since $I'\left((N-M+1)q_n\right) \geq I'(q_n)$ for $I'(\cdot) \geq 0$, from equation (1) and (2) and Assumption 4 , we have that,

$$q_n^{OS} < q_n^{VI}, \text{ and thereby } \pi_n^{OS} < \pi_n^{VI}, \text{ for } I'(\cdot) \geq 0 \text{ and for } n = M, M+1,...,N .$$

Hence, the last (N-M+1) firms choose to vertically integrate for constant or decreasing return to scale.

On the other hand, for increasing return to scale $I(\cdot)$, $I'(\cdot) < 0$, from the first order conditions of Stage 3 under (A), we can derive the relationship between two endogenous variables of Stage 2 and Stage 3 as follows:

$$\frac{dQ}{d\beta_n} = \frac{1}{\Delta} \text{, and } \frac{dq_n}{d\beta_n} = \frac{\Delta - (p''q_n + p')}{\Delta(p' - c'')}, \text{ where } \Delta \equiv p''Q + (N+1)p' - c'' .$$

At Stage 2, $\because$ $x_m = q_m$ for $m = 1,..,M-1$, and $x_M = q_M + ... + q_N$,

[12] The rest downstream firms are assumed to be able to produce at the cost of an integrated firm.

$\therefore$ The first order condition of Stage 2, $x_m + \left(r_m - I'(x_m)\right)\dfrac{dx_m}{dr_m} = 0$, can be rewritten as

$$q_n + \left[\beta_n - I'((N-M+1)q_n)\right]\frac{dq_n}{d\beta_n} = 0 \text{, for } n = M,..,N .$$

That is, for the last symmetric (N-M+1) firms, we have

$$\beta_n = I'((N-M+1)q_n) - \frac{\Delta(p'-c'')}{\Delta - (p''q_n + p')}q_n .$$

Hence, $\beta_n < I'(q_n)$ if and only if

$$\frac{I'(q_n) - I'((N-M+1)q_n)}{q_n} > \frac{\Delta(p'-c'')}{(p''q_n + p') - \Delta}, \text{ for } n = M,..,N \qquad (*)$$

Comparing equation (1) and (2), we know that $q_n^{OS} > q_n^{VI}$ if $(*)$ holds true; i.e., downstream firms choose to outsource for $I'(\cdot) < 0$.

Case 2: $J \le M - 2$.

In this case there are at least two upstream suppliers competing in producing homogenous intermediate goods. The price of intermediate goods is thereby reduced to the marginal cost of the suppliers in industries where the upstream firms experience constant or increasing return to scale technology. But for industries where upstream suppliers have decreasing return to scale technology, the price is still higher than their marginal costs (Tirole 1993).

(A) If the last (N-J) downstream firms decide to outsource, from the first order conditions of Stage 2 and Stage 3, we have

For $n = 1,2,...,J$, $\beta_n^{OS} = I'(q_n^{OS})$, and $p'(Q^{OS})q_n^{OS} + p(Q^{OS}) - \left(I'(q_n^{OS}) + c'(q_n^{OS})\right) = 0$.

For $n = J+1,...,N$,

$$\beta_n^{OS} = I'\left(\frac{q_{J+1}^{OS} + ... + q_N^{OS}}{M-J}\right) \text{ if } I'(\cdot) \le 0 \text{, and } \beta_n^{OS} > I'\left(\frac{q_{J+1}^{OS} + ... + q_N^{OS}}{M-J}\right) \text{ if } I'(\cdot) > 0 \text{. And}$$

$$p'(Q^{OS})q_n^{OS} + p(Q^{OS}) - \left(\beta_n^{OS} + c'(q_n^{OS})\right) = 0 \text{, where } Q^{OS} = \sum_{n=1}^{N} q_n^{OS} . \qquad (3)$$

(B) On the other hand, if the last (N-J) downstream firms choose to vertically integrate, the equilibrium price of the intermediate goods is $\beta_n^{VI} = I'(q_n^{VI})$. The equilibrium output of the final goods is q_n^{VI},

$$p'(Q^{VI})q_n^{VI} + p(Q^{VI}) - \left(I'(q_n^{VI}) + c'(q_n^{VI})\right) = 0 \text{, for } n = 1,2,...,N \qquad (4)$$

Since $N > M$, we have that $\beta_n = I'(\frac{N-J}{M-J}q_n) < I'(q_n)$ for $I'(\cdot) < 0$,

and $\beta_n > I'(\frac{N-J}{M-J}q_n) > I'(q_n)$ for $I'(\cdot) > 0$, and $\beta_n = I'(\frac{N-J}{M-J}q_n) = I'(q_n)$ for $I'(\cdot) = 0$.

Comparing equation (3) and (4), it is obvious that

$$q_n^{OS} > q_n^{VI} \text{ if } I'(\cdot) < 0; \quad q_n^{OS} < q_n^{VI} \text{ if } I'(\cdot) > 0; \quad \text{and } q_n^{OS} = q_n^{VI} \text{ if } I'(\cdot) = 0.$$

Summarizing the results from Case 1 and Case 2, we obtain Proposition 1.#

Proof of Proposition 2: W.L.O.G., for any J, J= 0, 1, …, N-1, the first J downstream firms are assumed to be vertically integrated with the first J upstream supplier, respectively. We want to solve for the optimal strategy of the last (N-J) downstream firms.

(A) If the last (N-J) downstream firms decide to outsource, since there are at least two upstream suppliers competing in producing homogenous intermediate goods, the price of intermediate goods is reduced to the marginal cost of the suppliers if $I'(\cdot) \le 0$, but higher than the marginal costs if $I'(\cdot) > 0$. From the first order conditions of Stage 2 and Stage 3, we have

For $n = 1,2,..., J$, $\beta_n^{OS} = I'(q_n^{OS})$, and $p'(Q^{OS})q_n^{OS} + p(Q^{OS}) - \left(I'(q_n^{OS}) + c'(q_n^{OS})\right) = 0$.

For $n = J+1,..., N$,

$$\beta_n^{OS} = I'(\frac{q_{J+1}^{OS} + ... + q_N^{OS}}{M-J}) \text{ if } I'(\cdot) \le 0, \text{ and } \beta_n^{OS} > I'(\frac{q_{J+1}^{OS} + ... + q_N^{OS}}{M-J}) \text{ if } I'(\cdot) > 0. \text{ And}$$

$$p'(Q^{OS})q_n^{OS} + p(Q^{OS}) - \left(\beta_n^{OS} + c'(q_n^{OS})\right) = 0, \text{ where } Q^{OS} = \sum_{n=1}^{N} q_n^{OS}. \tag{5}$$

(B) On the other hand, if the last (N-J) downstream firms choose to vertically integrate, the equilibrium price of the intermediate goods is $\beta_n^{VI} = I'(q_n^{VI})$.[13] The equilibrium output of the final goods is q_n^{VI},

$$p'(Q^{VI})q_n^{VI} + p(Q^{VI}) - \left(I'(q_n^{VI}) + c'(q_n^{VI})\right) = 0, \text{ for } n = 1,2,..., N \tag{6}$$

Since $M > N$, we have that

$$I'\left(\frac{N-J}{M-J}q_n\right) > I'(q_n) \quad \text{for } I'(\cdot) < 0; \quad I'\left(\frac{N-J}{M-J}q_n\right) = I'(q_n) \text{ for } I'(\cdot) = 0.$$

[13] The last (M-N) upstream firms are inactive.

Comparing equation (5) and (6), we have that at symmetric equilibrium,

$$q_n^{OS} < q_n^{VI} \text{ if } I'(\cdot) < 0 \text{, and } q_n^{OS} = q_n^{VI} \text{ if } I'(\cdot) = 0 .$$

That is, if upstream firms have increasing or constant return to scale technology, it is optimal for downstream firms to vertically integrate.[14]

On the other hand, for decreasing return to scale $I(\cdot)$, i.e. $I'(\cdot) > 0$, from the first order conditions of Stage 3 under (A), we can derive the relationship between two endogenous variables of Stage 2 and Stage 3 as follows:

$$\frac{dQ}{d\beta_n} = \frac{1}{\Delta} \text{ , and } \frac{dq_n}{d\beta_n} = \frac{\Delta - (p''q_n + p')}{\Delta(p' - c'')} \text{ , where } \Delta \equiv p''Q + (N+1)p' - c'' .$$

At Stage 2, $\because$ $x_m = q_m$ for $m = 1,..., J$; and $x_m = \dfrac{q_{J+1} + ... + q_N}{M - J}$ for $m = J+1,..., M$.

$\therefore$ The first order condition of Stage 2, $x_m + \left(r_m - I'(x_m)\right)\dfrac{dx_m}{dr_m} = 0$, can be rewritten as

$q_n + \left[\beta_n - I'((N-J)q_n)\right]\dfrac{dq_n}{d\beta_n} = 0$, for $n = J+1,..., N$ and for the last symmetric (N-J) firms.

That is, $\beta_n = I'((N - M + 1)q_n) - \dfrac{\Delta(p' - c'')}{\Delta - (p''q_n + p')} q_n$.

Hence, $\beta_n < I'(q_n)$ if and only if

$$\frac{I'(q_n) - I'((N - M + 1)q_n)}{q_n} > \frac{\Delta(p' - c'')}{(p''q_n + p') - \Delta} \text{, for } n = J+1,..., N \qquad (**)$$

Comparing equation (5) and (6), we know that $q_n^{OS} > q_n^{VI}$ if $(**)$ holds true; i.e., downstream firms choose to outsource when $I'(\cdot) > 0$.

Summarizing the above results, we obtain Proposition 2.#

Proof of Proposition 3: for any J, J= 0, 1, …, M-1, the first J downstream firms are assumed to be vertically integrated with the first J upstream firms, respectively. Let's consider two cases.

Case 1: $J = N - 1$.

That is, except for the last downstream firm N and the last upstream firm M, the other firms are vertically integrated. To avoid double-marginalization, it is optimal for the last downstream firm N to vertically integrate with the last upstream M.

[14] When firms are indifferent between outsourcing and vertical integration, it is assumed that they outsource.

Case 2: $J \le N-2$.

(A) If the last (N-J) downstream firms decide to outsource, since there are at least two upstream suppliers competing in producing homogenous intermediate goods, the price of intermediate goods is thereby reduced to the marginal cost of the suppliers for $I'(\cdot) \le 0$, but higher than their marginal costs if $I'(\cdot) > 0$. From the first order conditions of Stage 2 and Stage 3, we have

For $n = 1,2,..., J$, $\beta_n^{OS} = I'(q_n^{OS})$, and $p'(Q\ )q_n^{OS} + p(Q\ ) - \left(I'(q_n^{OS}) + c'(q_n^{OS})\right) = 0$.

For $n = J+1,..., N$,

$$\beta_n^{OS} = I'(\frac{q_{J+1}^{OS} + ... + q_N^{OS}}{M-J}) \text{ if } I'(\cdot) \le 0, \text{ and } \beta_n^{OS} > I'(\frac{q_{J+1}^{OS} + ... + q_N^{OS}}{M-J}) \text{ if } I'(\cdot) > 0. \text{ And}$$

$$p'(Q^{OS})q_n^{OS} + p(Q^{OS}) - \left(\beta_n^{OS} + c'(q_n^{OS})\right) = 0, \text{ where } Q^{OS} = \sum_{n=1}^{N} q_n^{OS}. \tag{7}$$

(B) On the other hand, if the last (N-J) downstream firms choose to vertically integrate, the equilibrium price of the intermediate goods is $\beta_n^{VI} = I'(q_n^{VI})$. The equilibrium output of the final goods is q_n^{VI},

$$p'(Q^{VI})q_n^{VI} + p(Q^{VI}) - \left(I'(q_n^{VI}) + c'(q_n^{VI})\right) = 0, \text{ for } n = 1,2,..., N \tag{8}$$

Since $M = N$, we have that

$$\beta_n = I'\left(\frac{N-J}{M-J} q_n\right) = I'(q_n) \ \text{ for } I'(\cdot) \le 0; \text{ and } \beta_n > I'\left(\frac{N-J}{M-J} q_n\right) = I'(q_n) \text{ for } I'(\cdot) > 0;$$

Comparing equation (7) and (8), we obtain $q_n^{OS} = q_n^{VI}$ if $I'(\cdot) \le 0$, and $q_n^{OS} < q_n^{VI}$ if $I'(\cdot) > 0$.

Summarizing the results from Case 1 and Case 2, we obtain Proposition 3.#

Table 1. Definition of Industries, number of firms

Industry	D/U	(NACE rev. 1.1) classification	No. of firms
Manufacture of pulp, paper and paper products (21)			
Manufacture of pulp, paper and paperboard	U	21.1	197
Manufacture of articles of paper and paperboard (21.2)			
Manufacture of corrugated paper and paperboard and of containers of paper and paperboard	D	21.21	379
Manufacture of household and sanitary goods and of toilet requisites	D	21.22	70
Manufacture of paper stationery	D	21.23	136
Manufacture of wallpaper	D	21.24	18
Manufacture of other articles of paper and paperboard n.e.c.	D	21.25	149
Manufacture of pharmaceuticals, medicinal chemicals and botanical products (24.4)			
Manufacture of basic pharmaceutical products	U	24.41	20
Manufacture of pharmaceutical preparations	D	24.42	299
Manufacture of radio, television and communication equipment and apparatus (32)			
Manufacture of electronic valves and tubes and other electronic components	U	32.1	217
Manufacture of television and radio transmitters and apparatus for line telephony and line teleg	D	32.2	121
Manufacture of television and radio receivers, sound or video recording or reproducing apparatus	D	32.3	181
Manufacture of motor vehicles, trailers and semi-trailers (34)			
Manufacture of motor vehicles	D	34.1	73
Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers	U	34.2	686
Manufacture of parts and accessories for motor vehicles and their engines	U	34.3	570
		total	3120

U=Upstream, D=Downstream Industry

Table 2: Evidence of outsourcing of downstream industries

Downstream Industry	Material inputs	Labor inputs	Capital inputs	Evidence of outsourcing
34.10	+	-	-	yes
24.42	+	-	(–)	yes
32.20	(–)	(–)	(–)	no
32.30	(–)	-	-	no
21.21	+	-	-	yes
21.22	+	-	(–)	yes
21.23	+	-	-	yes
21.24	-	(-)	-	no
21.25	+	(–)	(–)	no

+ statistically significant at a 5 percent level
- statistically significant at a 5 percent level
(–) statistically not significant at a 5 percent level

Table 3: Average Profit Shares, estimated Markups and Returns to Scale

	Mean of Profit share (gross)[a]	Mean of Profit share (net)[b]	Markup[c]	RS (short run)[d]	RS (long run)[e]	Evidence of RS (long run)[f]
Manufacture of motor vehicles, trailers and semi-trailers (34)						
Upstream						
34.20	0.063	0.018	1.041	0.972	1.013	IRS*
			(0.007)	(0.006)	(0.006)	
34.30	0.097	0.024	1.058	0.959	1.014	IRS*
			(0.007)	(0.005)	(0.007)	
Downstream						
34.10	0.062	0.015	1.000	0.960	0.995	CRS[g]
			(0.016)	(0.013)	(0.008)	
Manufacture of pharmaceuticals, medicinal chemicals and botanical products (24.4)						
Upstream						
24.41	0.205	0.138	1.093	0.913	0.918	CRS[g]
			(0.060)	(0.050)	(0.094)	
Downstream						
24.42	0.144	0.077	0.931	0.897	0.921	DRS*
			(0.017)	(0.010)	(0.016)	
Manufacture of radio, television and communication equipment and apparatus (32)						
Upstream						
32.10	0.111	0.013	1.083	0.957	1.015	CRS[g]
			(0.016)	(0.013)	(0.015)	
Downstream						
32.20	0.076	0.015	1.031	0.952	0.973	CRS[g]
			(0.014)	(0.013)	(0.018)	
32.30	0.075	0.018	1.009	0.942	1.012	CRS[g]
			(0.021)	(0.018)	(0.019)	
Manufacture of pulp, paper and paper products (21)						
Upstream						
21.11, 21.12	0.095	0.028	1.076	0.992	1.032	IRS*
			(0.006)	(0.005)	(0.007)	
Downstream						
21.21	0.110	0.027	1.072	0.956	1.021	IRS*
			(0.007)	(0.007)	(0.009)	
21.22	0.107	0.033	0.886	0.900	0.918	DRS*
			(0.017)	(0.014)	(0.019)	
21.23	0.104	0.032	1.040	0.921	1.006	CRS[g]
			(0.011)	(0.011)	(0.013)	
21.24	0.088	0.016	1.119	1.024	0.982	CRS[g]
			(0.026)	(0.022)	(0.033)	
21.25	0.123	0.046	0.991	0.916	0.996	CRS[g]
			(0.022)	(0.016)	(0.015)	

RS=Return to Scale, I=increasing, D=decreasung, * statistically significant at a 5 percent level.
[a] of variable inputs, [b] of all inputs (variable and fixed), [c] ratio P/MC, [d] RS due to variable inputs [e] RS due to all inputs (variable and fixed), [f] Test of the null of CRS. [g] The null of CRS is not rejected at a 5 percent level.

Data Description

We utilize firm-level data of the German Cost Structure Census of manufacturing compiled by the Federal Statistical Office over the period 1992-2000. Only firms with 20 or more employees are covered. This data base comprises almost all large German manufacturing firms with 500 and more employees over the entire period. Firms with less than 500 employees are included as a random sample that can be assumed to be representative for the small firm segment as a whole. Usually the smaller firms report for four subsequent years and are then substituted by other small firms (rotating panel).[15]

We use gross production as measure of output. The available information in the cost structure survey on inputs comprises the number of employees, labor compensation, depreciation of capital, material inputs, rents and leases, energy consumption, commodity inputs, sales of commodities, expenses for external repair and contract work (farming out of production) as well as some other production related costs. Input and output series are deflated using industry-specific gross production and input price indices provided by the Federal Statistical Office.

In order to minimize number of reported zero input quantities,[16] we aggregated the inputs into the following categories: *(1) material inputs*: intermediate material consumption plus commodity inputs; *(2) labor compensation*: saleries and wages plus employer's social insurance contributions; *(3) energy consumption*; *(4) capital inputs* (internal and external): capital depreciation (internal) plus rents and leases (external), *(5) other inputs:* other expenses/costs related to production e.g. transportation services, consulting or marketing;

(6) external services: e.g. repair costs and external contract work (farming out of production).

[15] Annual publication "Kostenstrukturerhebung im Verarbeitenden Gewerbe", Fachserie 4, Reihe 4.3, Federal Statistical Office Germany.

[16] For some of the disaggregated inputs the median is zero e.g. external repair or commodity inputs.

Descriptive and summary statistics of these variables is given in Table A.1.

Table A.1 Summary Statistics

industry=21.12						
Variable	**N**	**Mean**	**Median**	**Std Dev**	**Minimum**	**Maximum**
$\sum \Delta x_{it}^{j}$	723	0.0052084	0.0186107	0.6980258	-3.5010915	4.2776326
$\sum \bar{s}_{it}^{j} \Delta x_{it}^{j}$	723	0.004818	0.0148839	0.6451854	-3.2850462	3.5059476
Δq_{it}	723	0.0090258	0.0352895	0.7050388	-3.5591231	4.3831853
Δx_{it}^{K}	723	0.0208974	-0.0011478	0.4209932	-3.2040333	4.3041604
industry=21.21						
	N	**Mean**	**Median**	**Std Dev**	**Minimum**	**Maximum**
$\sum \Delta x_{it}^{j}$	963	0.0258928	0.0305381	0.4925552	-4.3238677	3.024575
$\sum \bar{s}_{it}^{j} \Delta x_{it}^{j}$	963	0.0234416	0.0253489	0.4502464	-3.9899468	2.6135388
Δq_{it}	963	0.0265166	0.0304921	0.4872715	-4.1279828	3.1548552
Δx_{it}^{K}	963	0.0148273	-0.0016671	0.2628974	-3.1449463	3.6247483
industry=21.22						
	N	**Mean**	**Median**	**Std Dev**	**Minimum**	**Maximum**
$\sum \Delta x_{it}^{j}$	266	0.087446	0.0335431	0.405147	-1.6710825	2.4926201
$\sum \bar{s}_{it}^{j} \Delta x_{it}^{j}$	266	0.0731409	0.0302522	0.4195623	-2.7681464	2.8305853
Δq_{it}	266	0.0925404	0.0388029	0.3813545	-0.9083083	2.4343572
Δx_{it}^{K}	266	0.0432327	0.0111289	0.2476077	-1.1836425	1.9539636
industry=21.23						
	N	**Mean**	**Median**	**Std Dev**	**Minimum**	**Maximum**
$\sum \Delta x_{it}^{j}$	366	0.0051375	0.0095067	0.4819091	-3.0653191	2.5815036
$\sum \bar{s}_{it}^{j} \Delta x_{it}^{j}$	366	0.0027215	0.0066356	0.4448995	-3.2189421	2.4136701
Δq_{it}	366	-0.0014274	0.0078922	0.4670731	-2.8815944	2.6132311
Δx_{it}^{K}	366	0.0027046	0.010091	0.3074197	-2.0234494	3.1780997
industry=21.24						
	N	**Mean**	**Median**	**Std Dev**	**Minimum**	**Maximum**
$\sum \Delta x_{it}^{j}$	93	0.0459861	0.0294193	0.4621451	-2.3062266	2.4343983
$\sum \bar{s}_{it}^{j} \Delta x_{it}^{j}$	93	0.0430926	0.0256914	0.4336823	-2.1556579	2.2433137
Δq_{it}	93	0.0457506	0.0171719	0.4709101	-2.2994569	2.6634441
Δx_{it}^{K}	93	0.0439628	0.0086648	0.2544172	-0.2071941	2.1630706
industry=21.25						
	N	**Mean**	**Median**	**Std Dev**	**Minimum**	**Maximum**

$\sum \Delta x_{it}^{j}$	365	0.067389	0.0286584	0.4420476	-2.2350636	4.3658131
$\sum \bar{s}_{it}^{j} \Delta x_{it}^{j}$	365	0.0609528	0.0252238	0.4085804	-1.9812804	4.036668
Δq_{it}	365	0.0649684	0.0255725	0.4316059	-2.0140028	4.1631456
Δx_{it}^{K}	365	0.0502231	0.0024815	0.3410033	-0.6993393	3.9117969

industry=24.41						
	N	**Mean**	**Median**	**Std Dev**	**Minimum**	**Maximum**
$\sum \Delta x_{it}^{j}$	67	0.0672822	0.0505141	0.2214204	-0.5000666	0.9881985
$\sum \bar{s}_{it}^{j} \Delta x_{it}^{j}$	67	0.0527597	0.0388586	0.1774545	-0.5342341	0.7406748
Δq_{it}	67	0.0615969	0.0492295	0.2227516	-0.5573024	0.8710073
Δx_{it}^{K}	67	0.0133705	0.0103796	0.1259894	-0.6389148	0.3897293

industry=24.42						
	N	**Mean**	**Median**	**Std Dev**	**Minimum**	**Maximum**
$\sum \Delta x_{it}^{j}$	1122	0.0437682	0.044862	0.2729042	-2.4549994	1.8708506
$\sum \bar{s}_{it}^{j} \Delta x_{it}^{j}$	1122	0.0350077	0.0366927	0.2387039	-2.7452303	1.528943
Δq_{it}	1122	0.0352628	0.039854	0.2600308	-2.0686421	1.8344796
Δx_{it}^{K}	1122	0.0260449	0.0130287	0.1642539	-0.7495198	2.5673259

industry=32.10						
	N	**Mean**	**Median**	**Std Dev**	**Minimum**	**Maximum**
$\sum \Delta x_{it}^{j}$	576	0.0888324	0.072834	0.3964456	-3.5794689	3.5392386
$\sum \bar{s}_{it}^{j} \Delta x_{it}^{j}$	576	0.0751965	0.0633498	0.380185	-4.1947369	3.4885288
Δq_{it}	576	0.0975919	0.0863442	0.4045079	-3.4577964	3.6599771
Δx_{it}^{K}	576	0.0554216	0.0261469	0.3523875	-3.513382	4.2481335

industry=32.20						
	N	**Mean**	**Median**	**Std Dev**	**Minimum**	**Maximum**
$\sum \Delta x_{it}^{j}$	328	0.0509865	0.0324871	0.5248866	-4.0665881	2.4320447
$\sum \bar{s}_{it}^{j} \Delta x_{it}^{j}$	328	0.044267	0.0324952	0.4942269	-3.9762242	2.3525736
Δq_{it}	328	0.0496361	0.0502071	0.5136179	-4.0025612	2.4612378
Δx_{it}^{K}	328	0.0241231	0.014758	0.3082709	-4.1266221	2.327498

industry=32.30						
	N	**Mean**	**Median**	**Std Dev**	**Minimum**	**Maximum**
$\sum \Delta x_{it}^{j}$	565	0.0779997	0.0536414	0.3451824	-1.4074375	4.2147589
$\sum \bar{s}_{it}^{j} \Delta x_{it}^{j}$	565	0.0687687	0.0500873	0.3329547	-1.5429606	4.0460697
Δq_{it}	565	0.0763184	0.0522964	0.3512364	-1.4025684	4.1476407
Δx_{it}^{K}	565	0.0246211	-0.000157358	0.2536278	-0.5190998	4.11483

industry=34.10						
	N	**Mean**	**Median**	**Std Dev**	**Minimum**	**Maximum**
$\sum \Delta x_{it}^{j}$	317	0.1858502	0.0616975	0.6961895	-0.4566881	5.0740214

$\sum \bar{s}_{it}^{j} \Delta x_{it}^{j}$	317	0.1628428	0.058494	0.6043279	-0.427242	4.4342449
Δq_{it}	317	0.1793679	0.0765447	0.6875066	-0.5494069	4.9274617
Δx_{it}^{K}	317	0.1048413	0.0110806	0.5628581	-1.0263429	4.5636435

industry=34.20						
	N	**Mean**	**Median**	**Std Dev**	**Minimum**	**Maximum**
$\sum \Delta x_{it}^{j}$	1479	0.0078176	0.0093761	0.4667562	-4.6809657	4.2045751
$\sum \bar{s}_{it}^{j} \Delta x_{it}^{j}$	1479	0.0076452	0.0079824	0.4352343	-4.0810918	4.0137286
Δq_{it}	1479	-0.000509325	0.0037078	0.4706937	-4.6056023	4.2767871
Δx_{it}^{K}	1479	0.0297288	0.0113139	0.384048	-4.566166	4.6682714

industry=34.30						
	N	**Mean**	**Median**	**Std Dev**	**Minimum**	**Maximum**
$\sum \Delta x_{it}^{j}$	1553	0.0792693	0.0672639	0.5236657	-3.2162936	3.5953563
$\sum \bar{s}_{it}^{j} \Delta x_{it}^{j}$	1553	0.0674257	0.0607536	0.4860412	-3.1502719	3.4120821
Δq_{it}	1553	0.078784	0.0710374	0.5208374	-3.1705696	3.5871108
Δx_{it}^{K}	1553	0.0369426	0.0087335	0.310694	-4.0315347	4.6684365

References

Abraham, Katharine G., and Susan K. Taylor, "Firm's Use of Outside Contractors: Theory and Evidence," *Journal of Labor Economics* (14), (1996), 394-424.

Campa, Jose, and Linda Goldberg, "The Evolving External Orientation of Manufacturing Industries: Evidence from Four Countries," *Federal Reserve Bank of New York Economic Policy Review* (3), (1997), 53-81.

Chinitz, Benjamin, "Contrasts in Agglomeration: New York and Pittsburgh," *American Economic Review(Papers and Procedings),* LI (1961), 279-289.

Chen, Yongmin, "Vertical Integration," Mimeo, Department of Economics, University of Colorado at Boulder, (2002).

Dritna, R.E., "The Outsourcing Decision," *Management Accounting*, (1994), March 56-62.

Feenstra R.C. and G.H. Hanson, "Globalization, Outsourcing and Wage Inequality," *AER Papers and Proceedings*, Vol. 86, No.2 (1996), 240-245.

Goezig, B. and A. Stephan, "Outsourcing and Firm-Level Performance," *DIW Discussion Papers*, Oct. 2002.

Grossman, Sanford and Oliver Hart, "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration," *Journal of Political Economy* (94), (1986), 691-719.

Grossman, Gene M. and Elhanan Helpman ," Integration Specialization and Changing Nature of World Trade," *The Quarterly Journal of Economics*, (2002), 85-119.

Heshmati Almas, " Productivity Growth, Efficiency and Outsourcing in Manufacturing and Service Industries," *SSE/EFI Working Papers*, (2001), No. 394.

Helper, Susan, " Strategy and Irreversibility in Supplier Relations: The Case of the U.S. Automobile Industry," *Business History Review*, LXV (1991), 781-824.

Hummels, David, Dana Rapoport, and Kei-Mu Yi, ," Vertical Integration versus Outsourcing in Industry Equilibrium," *Federal Reserve Bank of New York Economic Review*, IV (1998), 79-99.

Holmes, J. Thomas, "Localization of Industry and Vertical Disintegration," *Review of Economics and Statistics* (81), (1999), 314-325.

Lacity, M.C., Willcocks, L.P. and Feeny D.F., " the Value of Selected IT Outsourcing Decision," Slogan *Management Review*, (1996), Spring 13-25.

McLaren, John, "Globalization and Vertical Structure," *American Economic Review* (90), (2000), 1239-1254.

McMillan, John, "Reorganizing Vertical Supply Relationship," in H. Sibert, ed., *Trends in Business Organization: Do Participation an Cooperation Increase Competitiveness* (Tübingen: J.C.B. Mohr, 1995)

Klette, T. J., "Market Power, Scale Economies and Productivity: Estimates From A Panel of Establishment Data," *Journal of Industrial Economics* (4), (1999), 452-476.

Marin, Stephan, *Advanced Industrial Economics*, 2002, Blackwell Publishers.

Riordan M.H. and Williamson O.E., " Asset Specificity and Economic Organization ," *International Journal of Industrial Organization 3*, (1984), 365-378.

Tirole, Jean, *The Theory of Industrial Organization*, 1993, Massachusetts, the MIT Press.

Williamson, Oliver E., *The Economic Institutions of Capitalism*, 1985, New York, Free Press.