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Alan V. Deardorff
University of Michigan

Simeon Djankov
World Bank and CEPR

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**Knowledge Transfer Under Subcontracting:**
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Alan Deardorff
University of Michigan
Ann Arbor, USA

Simeon Djankov^
World Bank and CEPR
Washington DC, USA

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Abstract

We investigate the significance of subcontracting arrangements as a source of knowledge transfer and increased efficiency for Czech firms during 1993 through 1996. We draw on detailed enterprise surveys and interviews with the managers of 373 manufacturing firms in the Prague region. The results suggest a positive correlation between employee training and subcontracting. Subcontracting is also associated with a reduction in variable costs and a price premium on the stock market. The effect of subcontracting on other firms in the same industry is weak. A high share of subcontracting activity in a particular industry is associated with increased valuation of firms without foreign partners as investors anticipate more subcontracting arrangements.

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# Knowledge Transfer under Subcontracting: Evidence from Czech Firms

## 1. Introduction

The current literature investigating the avenues of international knowledge transfer focuses primarily on the impact of foreign direct investment, joint ventures, and licensing agreements. Less attention has been devoted to analyzing the relative importance of subcontracting, defined as non-equity arrangements between firms, as a source of knowledge transfer. There are two reasons for this neglect. First, subcontracting has not been well-documented, since it does not involve movement of capital across borders or changes in the ownership structure of the subcontractor. Second, the majority of empirical studies on knowledge transfer have investigated companies in developed markets, where subcontracting is not a traditional method of cross-border cooperation. It is more common in North-South (or West-East) partnerships, where some uncertainty exists as to the ability of the South (East) subcontractor to maintain high quality and timely delivery. Subcontracts are used in such cases during a probation period after which successful partnerships may become joint ventures.

In this paper we explore the significance of subcontracting as a source of knowledge transfer and increased efficiency for Czech firms during 1993 through 1996. We draw on detailed enterprise surveys and interviews with the managers of 373 manufacturing firms in the Prague region. The data set is particularly appropriate to study this topic due to the large increase in subcontracting activity in the Czech Republic in the first half of the 1990s, as well as the openness of Czech managers in answering questions about the effects of subcontracting on their firms.

The results suggest that there is a positive correlation between employee training and subcontracting. Subcontracting is also associated with a reduction in variable costs and a price premium on the stock market. The effect of subcontracting on other firms in the same industry is weak. The variable costs of these firms are not affected by the share of subcontracting. A high share of subcontracting activity in a particular industry is, however, associated with increased valuation for firms without foreign partners as investors anticipate further cooperation. These results are consistent with previous studies (Haddad and Harrison (1993); Aitken and Harrison (1999)) on the absence of sector-specific productivity spillover effects of foreign direct investment.

The paper is organized as follows. Section 2 outlines the previous literature of cross-border partnerships and knowledge transfer. Section 3 develops the conceptual framework. Section 4 describes the data set and the interview questions concerning the role of subcontracting, and Section 5 sets out the estimation approach for the effect of subcontracting on the performance of Czech firms and their competitors. Section 6 concludes.

## 2. Cross-Border Knowledge Transfer

Most studies on international knowledge transfer have evolved in the context of the literature on macroeconomic growth and endogenous innovation. The basic argument in this literature is that the openness of a country to trade and investment enhances the transfer of knowledge from abroad. Such transfer can occur through formal channels like foreign direct investment, joint ventures, and licensing agreements. It can, however, also happen through less formal channels like subcontracting, arms-length trade in capital goods, or simply through learning from foreign competitors. The theory of knowledge transfer is developed in Findlay (1978) and

Grossman and Helpman (1991), while Blomstrom and Kokko (1998) survey the literature on the impact of foreign direct investment on firm efficiency in the host country.

Although empirical tests on the effect of these different channels of knowledge transfer require firm-level data, few papers focus on measurement at the micro level. Most scholars use country- or industry-level aggregates. Rodrik (1994) investigates capital goods imports as a source of technology transfer using a panel of forty-four countries. His study finds that industry performance, measured by total factor productivity growth, is positively correlated with the volume of imported capital goods. Coe and Helpman (1995) and Coe, Hoffmaiser, and Helpman (1997) use data on total imports to investigate the effect of foreign R&D on domestic productivity levels as it may be transmitted through trade more generally. Their findings suggest that foreign R&D positively affects domestic productivity, and that the magnitude of this effect increases with the openness of the economy. The study does not, however, specify the precise channels through which this R&D transfer takes place.

Little evidence is found of spillover effects from FDI to other firms in the same industry. The argument for expecting such spillovers is that once workers receive training, they have the incentive to leave the firm and sign with competitor firms whose managers want to increase their firms' efficiency. Aitken and Harrison (1999) study a panel of over 4,000 Venezuelan firms over the 1975-89 period and find negative spillover effects from FDI activity to domestic firms. Aitken, Harrison, and Lipsey (1996) find similar effects of U.S. investment in Mexico and Venezuela. They attribute this to the presence of fixed costs: once foreign subsidiaries gain a substantial share of the local market, domestic firms are forced to produce less. Even if some positive spillover effects from gaining new knowledge are present, they are more than counter-balanced by the negative effect of increasing fixed costs. Haddad and Harrison (1993) find similar results for a

panel of 2,000 Moroccan firms over 1985-89. In contrast, Blomstrom and Wolff (1989) find a positive spillover effect of foreign direct investment in Mexican industries. Sectors with high numbers of foreign subsidiaries show faster convergence of productivity levels to US norms. Again, it is not clear whether the positive effect is due to disciplining factors or to knowledge transfer.

The direct benefits to recipient firms from knowledge transfer through employee training have not been subject to empirical research. This is the case even though the theoretical literature that is based on formal linkages (FDI, joint ventures), assumes that there exist an advantage for the foreign subsidiary to enter a new market, and that this advantage most often takes the form of superior knowledge. Otherwise the entry would be unprofitable and would not happen. The theoretical literature does not, however, deal with the problem of worker retention. That is, how would managers (or foreign partners) prevent employees from leaving the company once they are trained? Or what prevents managers of local firms from going to a competitor once their foreign partner has provided training? The anecdotal evidence in Djankov and Hoekman (2000) provides some answers to this question in the Czech context. They find that managers of Czech firms are loyal to their contractors because they expect to be rewarded by the establishment of joint ventures in the future. Workers do not leave the company since they are offered higher wages than the prevailing market wage once trained. In this paper we provide comprehensive evidence on the effects of subcontracting.

## 3. Subcontracting in the West-East Context

We see the subcontracting process as being analogous to what firms do when they provide on-the-job training for their workers. A problem is explaining how the trainers keep the trainees

from, at best, leaving with their knowledge once they've got it and, at worst, going into competition with the trainer and undermining its market position. An answer to the first is simply that the trainers must increase what they pay once the training is provided, so that the firm/worker cannot do better on the open market. The answer to the second, within a Western economy, might be to use legal constraints on the workers, but in the West-East context these constraints will not work. The answer then is to make sure that the information cannot be used to the trainer's disadvantage. That is in part why we observe these subcontracts for only small parts of the production process: The foreign firms are not conveying enough information for the East subcontractors to replace them, but only to feed into them.

Suppose that each production step requires labor with particular characteristics, or it will not work at all. The needed labor characteristics are of many sorts. Some may be widely available on the market, and the firm can hire workers that already have them. Others will be very specific to the particular production step, perhaps even to the particular firm, and they may be hard or impossible to find on the market. In any case, firms cannot in general hire workers that already have all of the characteristics that are needed, and they must provide at least some training.

Once a worker is hired, the firm will pay it some wage (whatever it took to attract the worker from the market), train it, and then increase its wage to keep it from leaving. That will certainly be necessary for any characteristics that have been provided that are easily marketable. But it is probably necessary also for firm-specific characteristics, since the worker knows its value to the firm and the firm's cost of going through this search and training process again to replace it. A simple higher wage will not work, however, if the worker sees the training it has acquired as not just enabling it to add to the productivity of its employer, but also as enabling it to leave the firm and compete with it, lowering the firm's profits instead. The firm cannot afford to pay every

worker enough of a premium to prevent that kind of defection, and that is where legal restrictions (non-competition clauses in contracts, for example) may come in.

That is the story we see describing an ordinary Western firm. Turn now to the West-East context. In the West, we have many firms in some sort of equilibrium, producing with more or less stable labor forces that have characteristics that workers have picked up from education, previous employment, and their current employers. Wages will reflect the usual abundance and scarcity of workers, but also and more importantly, the abundance and scarcity of the characteristics (relative to their usefulness to employers). In the East, we may also have been in such an equilibrium, but with very different factor endowments and thus different prices of characteristics and different wages of workers. Or more likely we may be starting with the results of a non-market process that has generated quite different scarcities and abundances of characteristics than in the West.

There is an opportunity, as always when trade barriers fall, for differences in factor prices to create trade. If an Eastern firm could mimic all of the actions of a Western firm, including all the steps of production done by workers with identical machines, the Eastern workers having the same characteristics as the Western workers but paid Eastern wages, it is probable that the low average Eastern wage would enable it to produce at a lower cost and out-compete the Western firm. But there are several problems. First, it may not know the technology. Second, it may not be able to find workers with the required characteristics. Third, East products do not have the brand recognition necessary to penetrate Western markets successfully. And fourth, the Eastern firm may not be able to acquire capital with the right characteristics either. Actually, "knowing the technology" is not really a separate problem, since if you could get the right machines and workers with the right knowledge characteristics (including managers), then you would have the

technology. So it is the absence of required worker characteristics that prevents this kind of arbitrage from taking place. Trade will still occur, undoubtedly, but it will consist of the Eastern firms producing and exporting standardized products that they already know how to make, or perhaps some differentiated products that, because they have not been tailored to Western tastes or quality, will sell only due to their low price, if at all.

It is here, then, that some sort of cooperation between a Western and an Eastern firm can be profitable. The Western firm has the technology, which means that it has both workers and machines with the characteristics needed for its production processes. The machines themselves can be transported, and they will operate in the Eastern context as well as in the West, as long as workers are qualified to run them. Western workers too can be transported, but they will probably require a wage premium to do so. By working with the untrained Eastern workers for a period of time, they can transmit their own characteristics to them and then return home.[1] The result is a transmission of knowledge from firm to firm, accomplished in part by transmitting characteristics from worker to worker.

How might this process be organized? One possibility would be for an Eastern firm simply to purchase the technology from the Western firm and then use it independently. That is, for an appropriate fee it would purchase machines from the Western firm and pay also for a contingent of the Western firm's employees to come and train its own workers how to use them. This might work, but the incentives are stacked against it, since the trainers have little stake in the success of their trainees, and worse, they may be concerned about competition from them if they succeed.

A more promising approach is the one we focus on in this paper: subcontracting. By establishing an ongoing relationship between the two firms in which the Western firm will profit

not just from the Eastern firm's acquisition of the technology but from the successful use of it, the Western firm is given the incentive to make the arrangement work. Furthermore there is the added advantage that the Eastern firm now need not acquire the entire technology and need not develop its own market for selling the resulting product. By instead participating in only part of the production process and letting the Western firm handle its further processing and marketing, the Eastern firm has less to learn before the enterprise will become profitable. Also, the Western firm is to some extent protected from competition with its Eastern trainee.

What makes this process especially beneficial is the fact that, over time, the supply of these characteristics in the economy will expand and their prices will change, so that other firms and other industries will also become more productive. Therefore we see this process of technology transmission through subcontracting as generating not just the usual static gains from trade, but also a more dynamic change in the characteristics of the Eastern-country labor force that will show up in the long run as an expansion of its productivity.

Thus, our hypotheses are first that subcontracting between Western and Eastern firms serves as a channel for the transmission of knowledge that benefits both firms, and second that as a result of this transmission workers in the Eastern firms acquire characteristics that make them more productive, not only in the firms that receive the technology but also on the broader market of the Eastern country. The empirical analysis below investigates the evidence for both hypotheses, asking whether and to what extent subcontracting arrangements are associated with worker training and later increases in productivity and market valuation of firms. Interviews with general managers reveal that little employee turnover has taken place yet, due to the short time that has passed since subcontracting was allowed in the Czech Republic. We therefore do not expect to find direct effects on competitors from knowledge transfer. There may, however, be

indirect effects as contracted firms expand and use more skilled labor and material inputs at the expense of other firms. We look for such effects in the data.

## 4. The Data

The data set consists of balance sheet and profit and loss statements for a sample of 373 Czech manufacturing firms in the Prague region for the period 1993 through 1996. The survey was prepared by the authors and conducted by a local private consulting firm. Since a pilot study revealed that managers were sensitive to the confidentiality of the data, the questionnaire explained that the results of this survey would only be used in an aggregated form. At the time of the interview, managers were also presented with copies of an earlier study by one of the authors (Claessens and Djankov, 1999) which used similar surveys to analyze the effects of management turnover in the Czech Republic. Managers could retain this paper and see that the data were not used by the Czech government or their competitors.

The financial data include detailed information on output produced, firm expenditures, and employment. Data on sales, subsidies, and inventory changes are also provided. The latter allows revenue numbers to be adjusted for "production for the warehouse." The subsidies variable includes only direct subsidies from the budget and is equal to zero for all but three firms in the sample. Indirect subsidies, e.g., through directed credit or government guarantees, are not part of the data. Firm-specific output prices are also not available. Instead, producer price indices at the sector level, as reported by the national statistical office, are used to deflate nominal values. The sample is balanced, with all firms reporting data throughout the 1993 to 1996 period.

The survey data include a qualitative part with information on enterprises that have signed subcontracting agreements with foreign partners through 1997. In particular, we ask managers

"Are you involved in a subcontracting agreement with a foreign partner?" The year of creation of the relationship is also given. By the end of 1996, 201 firms (53.9% of the total) had established subcontracting arrangements with foreign companies (Table 1).

The data have the following selection characteristics. First, all firms were listed on the Prague Stock Exchange. This increases the likelihood of entering a subcontracting agreement since clear property rights exist on the assets of the Czech subcontractor. The sample covers large and medium size firms as small firms were not publicly traded. Within the group of listed firms, however, no bias exists as all firms were required to report.

We limit our sample to firms in and around Prague. Since this location is more conducive to linkages with foreign partners – closer to the German border, and with better transport infrastructure – we are likely biasing the results in favor of more subcontracting. There is also higher labor mobility in the Prague region than elsewhere – interviews with managers and workers reveal that labor is relatively immobile in the eastern part of the country. Our focus on the Prague region therefore enhances the possibility of movement of trained workers from subcontracting firms to other firms. Also, people in the Prague region are more likely to speak German than people in eastern Czech Republic which borders Poland and Slovakia. Thus the transfer of knowledge, if present, can be faster.

An additional reason for choosing a sample of Czech firms over similar samples from Hungary or Poland – the other two countries with significant foreign entry – is the absence of special provisions with regard to the treatment of foreign subsidiaries and subcontracting companies. There are no tax holidays or customs duties that apply to those firms in the Czech Republic. In comparison, firms with subcontracting agreements in Hungary pay lower taxes for

the first three years of the contract. To the econometrician, this may show up as increased productivity resulting from subcontracting.

The data are not subject to the usual caveats applied in work with firm-level data on Central and Eastern Europe as regards data quality. International accounting standards were adopted for all Czech firms in 1991. To study the effect of subcontracting on employee training and increased efficiency of firms, we relate subcontracting to two enterprise performance parameters over the period 1993 to 1996. In particular, we study whether the stocks of firms with subcontracts trade for higher ratios of market to replacement value, and also whether those firms have larger changes in the share of variable costs to sales. The variable cost share is taken to be indicative of variable cost per unit, under the assumption that output prices are constant. If subcontracting leads to knowledge transfer, enterprise performance and valuations would be improving once a firm signs a contract. The link with lower variable costs would be direct; the link with firm valuation would be indirect, since in a forward-looking market prices will incorporate the effect of knowledge transfer on subsequent firm performance.

Table 1 reports summary statistics. We use a variable representing market valuation, VALUE. To calculate it, we use the secondary market prices for firms at the end of January following the year for which we use accounting and subcontracting data. In this way we can be reasonably assured that the market has incorporated all available information. Using these prices, we calculate VALUE as the sum of market valuation and total debt outstanding, divided by the firm's replacement value, defined as net fixed assets plus inventory. The median VALUE across all firms is 0.627. Firms in high-skill intensive sectors and with valuable intangible assets will have high VALUE, while firms in physical-capital intensive industries and/or industries where the output prices are regulated will have low VALUE. The food sector has the highest median

(0.905), while clothing has the lowest (0.479). The variable VARCOS is defined as labor costs and material expenses as a fraction of total sales revenues. For the sample as a whole, this share averaged 0.885 in 1996. Stone and ceramics displayed the lowest share (0.804), while lumber and furniture firms could barely cover their variable costs (0.936).

[Table 1 here]

As control variables in the regressions, we use year and sector dummies (regional dummies are not significant). Sector dummies are commonly used in studies of firm performance to capture sector-specific shocks (e.g., increased demand for umbrellas in a rainy year), sector specific growth opportunities and other sector-specific characteristics affecting firm performance. Year dummies are included to correct for changes in the institutional environment, as well as economy wide shocks. Finally, to correct for possible endogeneity in the data, we use information on initial period, defined here as 1991, variable costs and firm size. We define size as the average number of employees. The average (median) size of firms in the sample was 1,311 (565) workers in 1996 (Table 1). The food sector had the smallest median size (211), while transport equipment had the largest (3,105).

Since we want to address the issue of knowledge transfer, several qualitative questions were asked. On the basis on these questions we construct the following variables, each of which is 1 if the general manager answered affirmatively to the question and 0 otherwise: Training, "Have (some of) your workers undergone new training in the past two years?"; Loss of Skilled Labor, "Have you lost skilled workers to your competitors?". Also, to look at the effect of subcontracting on changing the product mix and on the pricing by the local firm, the following question was addressed to subcontractors: "If you are engaged in a subcontracting arrangement, are the products you participate with 1. The same as what you were producing in the absence of

subcontracting; 2. Similar but not identical to what you produced in the absence of subcontracting; 3. New products for your company, produced specifically for this contract?" If the answer to this question was (1) we asked "If the products you participate with in the subcontracting arrangements are the same as what you were producing in the absence of subcontracting, has the price you receive for each unit 1. Remained about the same; 2. Decreased somewhat; 3. Decreased substantially; 4. Increased somewhat; 5. Increased substantially?"

[Table 2 here]

The results from the qualitative survey are detailed in Table 2. In almost two-thirds, 62%, of Czech firms which had subcontracting arrangements with foreign partners some training had taken place. In contrast, training had occurred in only 27% of firms in the comparator group. This difference is highly statistically significant, with a t-value of 7.524. The losses in skilled labor reported by managers are more similar – 17% of subcontracting firms and 29% of firms without foreign partners lost employees to their competitors. Still, the difference is statistically significant as subcontracting firms are better at retaining workers. There is no evidence of substantial reorientation in the product mix, at least in the initial period covered by our data. Only 14% of subcontractors reported that they had turned to the new products, designed specifically for the contract. In 68% of firms, there were no changes in the product mix whatsoever, while 18% of managers reported small changes (Table 2). Similarly, only 4% of managers of subcontracting firms reported a substantial increase in the price of their products, and there were no cases of substantial price reductions. In 43% of subcontracting firms the foreign partner agreed to buy the product at the then market price, while in the remaining firms there were only small changes in prices. This evidence suggests that, at least at the outset of subcontracting arrangements between Czech and foreign firms, the new partnerships did not change the product mix of pricing of Czech

firms. For the purposes of our analysis, these findings imply that the changes in cost structure and valuation of Czech firms that we may observe are not due to unobserved price and product heterogeneity in the data.

## 5. Evidence

To correct for the possible endogeneity of subcontracting arrangements, we perform the empirical analysis in two steps. First, we use a probit model to estimate the effect of initial profitability and size of firms on subsequent subcontracts. The hypothesis advanced in previous work (Djankov and Hoekman, 2000) is that the firms most likely to sign subcontracts were relatively profitable large firms who may have already had trading relations with their foreign partners even under central planning. These firms may have benefited from higher investment levels and better quality standards prior to their partnership, i.e., we will incorrectly attribute their better performance to subcontracting.

The approach we use is the Heckman (1974) two-step procedure for correcting sample selection bias. The method involves separate estimations of the subcontracting decision and the subsequent firm performance decision. The first step is a probit model to determine the probability of subcontracting based on the level of past performance. We use the 1991 VARCOS variable as an instrument, since it predicts the selection of firms for subcontracting arrangements but it less correlated with subsequent improvements in performance, and firm size, since foreign investors are more likely to be interested in larger firms, even adjusting for their relative performance (see, for example, Freund and Djankov, 1999). Both coefficients are significant at the 10% level (not shown). Interestingly, subcontracting is associated with higher initial variable cost. One explanation may be that the more efficient firms have already been offered joint

ventures of FDI. Consistent with the results of the previous literature, larger firms attract more sub-contracting.

The second step involves an ordinary least squares estimation, using only the firms with subcontracting agreements, and results in sample selection bias, defined as the omitted variable problem.[2] The Heckman procedure provides for a specification of the omitted variable that can be used in the truncated sample, only subcontracting firms, to alleviate sample selection. The results from the estimation are reported in Table 3, where the inverse Mills ratio for each firm computed in the first step is used as a separate explanatory variable.

[Table 3 here]

We use a balanced panel, i.e., all years and all firms in each year together. This gives us a pooled sample of 1,492 observations – 373 firms with four years of data. F-tests reject the hypothesis that a common constant term across firms is appropriate, with a statistics of 1.24 and a cut-off value of 1.00. The Hausman-specification tests indicate that either the fixed or random effects model can be used. We choose the random effects model as the benchmark specification, but report fixed-effects estimates as well. From a practical standpoint, fixed effects estimation is costly in terms of degrees of freedom, and in a longitudinal data set such as ours, random effects have some intuitive appeal. From an economic standpoint, the fixed effects estimator forces firm's heterogeneity to be constant over time. But in the period of large structural and other changes, this assumption may be hard to support. The random-effects model also has some drawbacks. It does not account for the association of individual firm performance across years. An alternative specification would, however, require semi-parametric estimation, which imposes too much structure on the firm's decisions. In particular, we would have to assume profit maximization and optimal investment behavior for all firms at all times.

The coefficients on Subcontracting, a dummy variable which is 1 if the firm is involved in subcontracting this year, 0 otherwise, are significant in all specifications (Table 3). The results have a ready economic interpretation. The presence of subcontracting is associated with an increase of 0.116 (random-effects model) in VALUE, which is a 16% premium compared to the average VALUE of all firms as reported in Table 1. Similarly, Czech subcontracting firms have a 0.028 lower share of variable costs when compared to the control group. Thus in both cases, we find some support for the hypothesis that subcontracting increases firm efficiency, possibly by providing transfer of knowledge. As discussed earlier, this result are not spurious, i.e., the increase in efficiency is not due to price increases rather than productivity enhancement.

The year dummies are strongly significant in explaining differences in valuation and variable costs, with 1993 displaying positive coefficients (relative to the numeraire, 1994) while 1995 and 1996have negative coefficients. Since the Czech Republic entered a period of slow growth in late 1995, these results may proxy for economy-wide macroeconomic changes. The sector dummies are highly significant as a group, with light industries (e.g., textiles, food and beverage) showing positive coefficients in the VALUE regressions and negative coefficients in the VARCOS regressions (not shown). In contrast, heavy industries (e.g., machinery, chemicals) have largely insignificant coefficients. Finally, the Mills ratio has an insignificant effect on both measures.

Next, we study the effects of subcontracting on other firms in the industry. The idea is to see whether the share of firms with subcontracting arrangements influences the performance of other firms. For this, we use the share of total industry labor force that is employed in subcontracting firms as an independent variable (we also use the share in total sales as an alternative proxy and find similar results). We use a truncated sample of firms – only those that do not have subcontracting arrangements. This leaves us with a panel of 688 observations (Table 4).

We find a positive spillover effect that is for VALUE, but it is only marginally statistically significant in the random-effects specification. The positive coefficient on the share of subcontracting in the VALUE regression may be due to the anticipation of investors that these firms too would be involved in a subcontracting agreement in the future. The coefficient shows that if the share of subcontracting firms doubles in a given sector, market valuation of the firms without subcontracts will go up by 15.8 percentage points. No significant effect is found for the VARCOS measure.

[Table 4 here]

## 6. Conclusions

The results of this simple analysis present some evidence of the positive correlation between subcontracting and knowledge transfer, where the latter results in increased firm efficiency. The effects on other firms in the industry are weak. Our findings suggest that investors value subcontracting and even the possibility of future subcontracting arrangements. Subcontracting also enhances the cost efficiency of recipient firms, while it does not affect the unit costs for competitor firms.

The findings in this paper should be treated with caution, and their robustness should be tested in emerging economies which have recently allowed the possibility of cooperation with foreign firms. It will also be useful to extend this analysis of Czech firms to later years, when partnerships between Czech and foreign firms would have matured and their effect would likely be larger. The present study suggests that subcontracting is a major conduit for knowledge transfer and that future theoretical models should take this into account.

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**Table 1: Descriptive Statistics, 1996** (mean, std. deviation, median)

| Sector | No. of firms | No. of subcontracts | VALUE | VARCOS | SIZE |
|---|---|---|---|---|---|
| Food | 49 | 13 | 0.909 | 0.896 | 548.44 |
| | | | (0.451) | (0.072) | (1014.39) |
| | | | 0.905 | 0.907 | 212.00 |
| Textiles | 33 | 20 | 0.578 | 0.894 | 1137.24 |
| | | | (0.243) | (0.066) | (948.51) |
| | | | 0.544 | 0.892 | 851.00 |
| Clothing | 6 | 4 | 0.478 | 0.864 | 1337.16 |
| | | | (0.162) | (0.097) | (791.23) |
| | | | 0.479 | 0.867 | 1157.00 |
| Lumber and Furniture | 12 | 9 | 0.701 | 0.992 | 716.92 |
| | | | (0.663) | (0.215) | (767.96) |
| | | | 0.536 | 0.936 | 555.00 |
| Paper and Printing | 14 | 8 | 0.799 | 0.873 | 2130.00 |
| | | | (0.702) | (0.071) | (4587.12) |
| | | | 0.598 | 0.882 | 640.00 |
| Chemicals | 27 | 19 | 0.804 | 0.857 | 1651.82 |
| | | | (0.425) | (0.074) | (1817.26) |
| | | | 0.708 | 0.852 | 1215.00 |
| Leather | 5 | 1 | 0.444 | 0.913 | 2056.11 |
| | | | (0.371) | (0.067) | (2976.35) |
| | | | 0.287 | 0.914 | 1198.00 |
| Stone, ceramics | 31 | 15 | 0.772 | 0.797 | 2005.19 |
| | | | (0.508) | (0.101) | (3051.27) |
| | | | 0.637 | 0.804 | 618.00 |
| Base metals | 12 | 5 | 0.598 | 0.924 | 3902.75 |
| | | | (0.254) | (0.079) | (6422.56) |
| | | | 0.605 | 0.918 | 912.00 |
| Metal products | 41 | 18 | 0.604 | 0.876 | 1508.24 |
| | | | (0.296) | (0.086) | (5275.31) |
| | | | 0.557 | 0.885 | 429.00 |
| Nonelectrical | 98 | 62 | 0.745 | 0.896 | 1071.69 |
| | | | (0.472) | (0.175) | (2016.45) |
| | | | 0.628 | 0.894 | 569.00 |
| Electric machinery | 25 | 12 | 0.668 | 0.978 | 775.64 |
| | | | (0.501) | (0.596) | (691.95) |
| | | | 0.526 | 0.876 | 750.00 |
| Transport equipment | 5 | 3 | 1.042 | 0.923 | 4039.20 |
| | | | (0.564) | (0.041) | (2451.63) |
| | | | 0.857 | 0.912 | 3105.00 |
| Other | 15 | 12 | 0.687 | 0.849 | 514.66 |
| | | | (0.412) | (0.099) | (348.51) |
| | | | 0.576 | 0.827 | 444.00 |
| Total | 373 | 201 | 0.726 | 0.887 | 1311.35 |
| | | | (0.454) | (0.193) | (2823.51) |
| | | | 0.627 | 0.885 | 565.00 |

## Table 2: Qualitative Survey Statistics

(Mean, Standard Deviation, Median)

| Variable | Subcontracting | No Subcontracting | t-Statistics |
|---|---|---|---|
| | 201 Firms | 172 Firms | |
| Training | 62% | 27% | 7.524* |
| Skilled Labor Loss | 17% | 29% | -2.798* |
| Product Mix | | | |
| a. same as before | 68% | | |
| b. similar | 18% | | |
| c. substantially new | 14% | | |
| Price per Unit | | | |
| a. same as before | 43% | | |
| b. decreased somewhat | 22% | | |
| c. decreased substantially | 0% | | |
| d. increased somewhat | 31% | | |
| e. increased substantially | 4% | | |

Definitions: Training: 1 if the general manager answered affirmatively to the question "Have (some of) your workers undergone new training in the past two years?," 0 otherwise. Skilled Labor Loss: 1 if the general manager answered affirmatively to the question "Have you lost skilled workers to your competitors?," 0 otherwise. Also, to look at the effect of subcontracting on changing the product mix and on the pricing by the local firm, the following question was addressed to subcontractors: "If you are engaged in a subcontracting arrangement, are the products you participate with a) The same as what you were producing in the absence of subcontracting; b) Similar but not identical to what you produced in the absence of subcontracting; c) New products for your company, produced specifically for this contract?" If the answer to this question was (a) we asked "If the products you participate with in the subcontracting arrangements are the same as what you were producing in the absence of subcontracting, has the price you receive for each unit a) Remained about the same; b) Decreased somewhat; c) Decreased substantially; d) Increased somewhat; e) Increased substantially?" The last column uses comparison of means to establish the statistical significance of the differences between the two groups. * signifies significance at the 1% level.

**Table 3: Estimation Results on Increased Efficiency of Subcontractors**

The sample consists of 373 firms over 4 years for a total of 1,492 observations. Standard errors are corrected for heteroskedasticity using the White method. Absolute values of t-statistics in parentheses. *, **, and *** signify statistical significance at the 1%, 5%, and 10% level, respectively.

| Independent Variable | VALUE | | VARCOS | |
|---|---|---|---|---|
| | Fixed-Effects | Random-Effects | Fixed-Effects | Random-Effects |
| Constant | | 0.726* | | 0.938* |
| | | (7.285) | | (36.174) |
| Subcontracting | 0.122* | 0.116* | -0.057* | -0.028*** |
| | (2.570) | (2.830) | (5.149) | (1.889) |
| Mills Ratio | | -0.052 | | 0.008 |
| | | (1.536) | | (0.758) |
| Sector Dummies Included | Yes | Yes | Yes | Yes |
| Year93 | 0.063* | 0.064* | 0.023* | 0.025* |
| | (3.247) | (3.245) | (4.146) | (3.319) |
| Year95 | -0.046* | -0.045** | -0.013* | -0.016** |
| | (2.924) | (2.328) | (2.784) | (1.982) |
| Year96 | -0.081* | -0.080* | -0.060* | -0.062* |
| | (4.092) | (4.092) | (6.683) | (8.275) |
| Adjusted $R^2$ | 0.653 | 0.536 | 0.436 | 0.254 |

**Table 4: Effects on Other Firms in the Industry**

The sample consists of 172 firms over 4 years for a total of 688 observations. Standard errors are corrected for heteroskedasticity using the White method. Absolute values of t-statistics are in parentheses. *, **, and *** signify statistical significance at the 1%, 5%, and 10% levels, respectively.

| Independent Variable | VALUE | | VARCOS | |
|---|---|---|---|---|
| | Fixed-Effects | Random-Effects | Fixed-Effects | Random-Effects |
| Constant | | 0.918* | | 0.932* |
| | | (11.245) | | (17.025) |
| SHARE | 0.079 | 0.158*** | -0.145 | -0.065 |
| | (0.254) | (1.662) | (1.132) | (1.294) |
| Year93 | 0.109* | 0.114* | 0.017 | 0.017 |
| | (3.524) | (3.942) | (1.802) | (1.324) |
| Year95 | -0.069* | -0.073* | -0.022** | -0.022 |
| | (2.443) | (2.381) | (2.154) | (1.583) |
| Year96 | -0.143* | -0.154* | -0.060* | -0.057* |
| | (3.501) | (4.629) | (3.712) | (3.914) |
| Adjusted $R^2$ | 0.629 | 0.482 | 0.344 | 0.246 |

**Notes**

[1] The phenomenon of manager migration eastward was especially evident in the former East Germany where the majority of managers came from their parent West German companies, lured by higher pay and opportunities for fast promotion. For a description, see Dyck (1997).

[2] The omitted variable is the ratio of the value of the standard normal density function to the value of the standard normal cumulative distribution function (the inverse Mills ratio). Amemiya (1974) generalized the Heckman approach to include all observations in the second step (the OLS estimation) by developing a measure of the inverse Mills ratio for zero observations, i.e., for firms without subcontracting arrangements in our case.