

**Knowledge Transfer Under Subcontracting:
Evidence from Czech Firms^{*}**

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ABSTRACT

We investigate the significance of subcontracting arrangements as a source of knowledge transfer and increased firm efficiency for Czech firms during the initial post-reform period (1992-96). We draw on detailed enterprise surveys and interviews with the managers of 373 manufacturing firms in the Prague region. The results suggest that there is a positive correlation between employee training on the one hand and subcontracting on the other. In particular, the probability of being trained triples if a worker is employed in a subcontracting firm. Subcontracting is also associated with a reduction in variable costs and price premia on the capital market. The effect of subcontracting on other firms in the same industry is mixed. The variable cost share of these firms increases since they have to compete in the market for material inputs and skilled workers. A high share of subcontracting activity in a particular industry is, however, associated with increased market valuation for firms without foreign partners as investors anticipate further cooperation.

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I. 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 (non-equity-type 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 looked into North-North markets, where subcontracting is not a traditional method of cross-border cooperation. It is more common in North-South (or West-East) cross-border 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 graduate by turning into joint ventures.

In this paper we explore the significance of sub-contracting as a source of knowledge transfer and increased efficiency for Czech firms during the initial post-reform period (1992-96). We draw on detailed enterprise surveys and interviews with the managers of 373 manufacturing firms in the Prague region. The dataset 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 at the time of the survey.

The results suggest that there is a positive correlation between employee training on the one hand and subcontracting on the other. In particular, the probability of being trained triples if a worker is employed in a subcontracting firm. Sub-contracting is also associated with a reduction in variable costs and price premia on the capital market. The effect of subcontracting on other firms in the same industry is mixed. The variable cost share of these firms increases since they have to compete in the market for material inputs and skilled workers. A high share of subcontracting activity in a particular industry is, however, associated with increased market valuation for firms without foreign partners as investors anticipate further cooperation. The latter results are largely consistent with previous studies (Haddad and Harrison, (1996); Aitken and Harrison (1997)) on the sector-specific spillover effects of foreign direct investment.

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

II. Cross-Border Partnerships and 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, or indeed through 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, 1995), while Blomstrom and Kokko (1997) 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. His findings are robust to several empirical specifications. However the difficulty of getting data on capital-goods imports prevented him from doing his analysis for more than one year, and others have also been unable to extend his analysis because of lack of data.

Coe and Helpman (1995) use more accessible 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; they simply use as a proxy the weighted average of each foreign country's knowledge stock with domestic import shares as weights. Furthermore, the study covers only industrialized countries – twenty-one OECD countries and Israel – although Coe et al. (1996) extends the analysis to seventy-seven developing countries using country-level data. In another extension, Lichtenberg and van Pottelsberghe (1996) repeat Coe and Helpman's technique, then use foreign direct investment (FDI) as weights, and find that only outward FDI is associated with knowledge acquisition (by buying foreign firms in order to acquire their proprietary knowledge).

Keller (1997) criticizes the Coe and Helpman technique, however. He finds that import shares are not robust weights, since if the weights are randomly generated by switching import shares across countries, the results still hold. His conclusion is that if knowledge transfer occurs, it is not correlated with the volume of trade between countries.

A related strand of the empirical literature studies the effect of increased variety of imported intermediate inputs, either through arms-length trade, or within formal cooperative arrangements (Ethier, 1982; Rivera-Batiz and Romer, 1991). Feenstra (1994) tests this theory using industry-level data. He finds that productivity increases in industries which import more

varieties (proxied by the volume of imports) and attributes this to the “better fit” of input that such industries find for their existing technologies. In this paradigm, there needn’t be any transfer of knowledge to see increased efficiency. Instead, the choice of more differentiated material inputs itself improves the underlying technology.

A third set of recent papers has shown that productivity increases with import competition. This may be because of increased competition in the local market or because of knowledge transfer, as local producers copy existing technologies by simple observation or reverse engineering. The two competing hypotheses are observationally equivalent. Thus Levinsohn (1993) takes the improvement in the efficiency of Turkish firms after liberalization as a sign of increased market discipline and not as a sign of knowledge transfer taking place.

Finally, little evidence is found of spillover effects from FDI to other firms in the same industry in semi-industrialized countries. 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 (1997) 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. 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, however, Blomstrom and Wolff (1989) generally 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.

To the best of our knowledge, 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 (see Markusen (1995) for a survey), which is based on formal linkages (FDI, joint ventures), assumes that there exist an advantage for the foreign subsidiary to enter a new market, and 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 evidence from Eastern Europe provide some answers to this question. A recent study by Djankov and Pohl (1998) finds that managers of Slovak 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. Another possibility is for the local government to subsidize the local firm’s output to induce foreign partners to transfer knowledge even in the presence of high labor turnover (Glass and Saggi, 1997).

III. Conceptual Framework

We see the subcontracting process as being analogous to what firms do when they provide on-the-job training for their workers. Indeed, such on-the-job training of workers must be part of the process here as well, as Western firms first provide such training to Eastern firms, who in turn provide it to their workers.

A problem, in both contexts, 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 our West/East context, and perhaps also within Eastern economies, these constraints will not work.¹ The answer then is to make sure that the information cannot be used to the trainer's disadvantage. That, we suggest, 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 Czech subcontractors to replace them, but only to feed into them.

We will be only slightly formal in fleshing out this theoretical story. Suppose that all workers possess characteristics, and these include all that they know about production as well as their knowledge of how to respond to incentives, be on time, pay attention to quality, etc. Technology is therefore embodied in both people and machines, and workers can not use a technology without possessing some aspects of it, so that they can run the machines. If workers possess that knowledge, that is a worker characteristic. Production of a finished good requires a series of many steps, for each of which the semi-processed good is an input. Other inputs of materials, machines, and labor work with the semi-processed good and send it along as an output that is in turn an input to the next stage. Each of these steps 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. Training itself is another technology, but it consists primarily of workers that do have the characteristics conveying these characteristics somehow to those who do not. It is a process that takes time and the presence of workers both with and without the characteristics. (Books, instruction manuals, etc., just don't do it, we suppose, in part since few are translated in Czech.)

¹ Some of the Central and East European (CEE) countries have, however, adopted legislation which is intended to prevent managers from leaving companies and establishing their own companies in the *same sector* for a certain period. For a more detailed discussion in the case of Bulgaria, see Hoekman and Djankov (1997).

A firm, which already has some workers with the needed characteristics (where they came from initially is not at issue here, being part of the process of entrepreneurship and innovation), acquires new workers, for expansion or to replace workers lost to turnover, by searching the labor market for new workers that will serve its purpose. It must balance the difficulty of finding workers with exactly all of the characteristics that it requires for a given step in the production process against the cost of training the workers itself to give them any characteristics that they lack.

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. It seems obvious that such theory exists, since our observation would be that every firm provides at least a little on-the-job training, and a lot of that is valuable to the workers (which is why their previous jobs appear on their resumé). Indeed, Salop (1979) and Stiglitz (1974) develop models where efficiency wages reduce employee turnover and raise enterprise profits due to savings in additional training and hiring. Aitken et al., (1995) use data for Mexico, Venezuela, and the United States to show that the activity of multinationals is associated with higher wages in their local subsidiaries. More importantly, they do not find evidence of higher wages paid by domestic firms in the same industries.

Turn now to the East-West 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). That abundance in turn will reflect the costs of transmitting those characteristics from workers who have them to others who do not – training costs, on the job or otherwise. Wages will also reflect to a lesser extent how critical certain characteristics are to particular 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. Ability in math, for example, may be abundant, while the ability to monitor product quality, or to keep regular hours, may be scarce, all at the same time that an overall scarcity of capital makes average wages low.

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, Czech 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, or the difficulty of finding workers that have these 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. With time, there may be ways that Eastern entrepreneurs will be able to develop Western technology on their own, by imitating and somehow instilling the needed knowledge and other characteristics into their workers, but the process is bound to be hard, almost as hard as developing new technologies from scratch.

It is here, then, that some sort of cooperation between a Western and an Eastern firm can be beneficial, and therefore 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.² Western workers too can be transported, but they will not be willing to work for lower wages in the East than at home. On the contrary, they will probably require a wage premium to do so. But by working with the untrained Eastern workers for a period of time, they can transmit their own characteristics to them and then return home.³ 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.⁴

² During our enterprise visits we have seen cases where entire German plants were moved to the Czech Republic in an attempt to cut labor costs.

³ 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.

⁴ Evidence for such behavior of foreign firms was documented in studies on South Korea. For a summary, see the East Asian Miracle, (1995).

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, we suggest, not only for the Eastern firm and its workers but for the Eastern economy at large, is the fact that the characteristics that must be transmitted to Eastern workers in these arrangements include not only firm- and product-specific knowledge, but also many other characteristics that also raise the productivity of workers in other contexts. With normal turnover of workers, some of those trained in the Eastern firm will spill out into the economy, raising the availability of those characteristics to other industries as well. Gradually 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 (and associated international trade) 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.⁵

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 the first of these hypotheses, asking whether and to what extent subcontracting arrangements are associated with worker training and later increases in productivity and market valuation of the firms involved. 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.

IV. 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 1992-96. The questionnaire was prepared by the authors and delivered by a local private consulting firms. Since a pilot study

⁵ For example, Benhabib and Spiegel (1994) present empirical cross-country evidence supporting the notion that countries that accumulate human capital increase the rate of adoption of advanced technology.

revealed that managers are sensitive to the confidentiality of the data, all questionnaires had the World Bank logo on the front page, which explained that the results of this survey will only be used in an aggregated form in cross-country studies on the development of the private sector in Central and Eastern Europe. At the time of the interview, managers were also presented with copies of an earlier study by the authors (Pohl et al, 1997) using similar surveys to analyze the effects of privatization in seven transition economies. Managers could retain this copy and see that the data were not used by the Czech government or their potential competitors.

The financial data include detailed information on output produced, firm expenditures, and employment. Data on sales, subsidies,⁶ and inventory changes are also provided. The latter allows revenue numbers to be adjusted for “production for the warehouse.” Firm-specific output prices are 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 1992-96 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 variable SUB is a binary variable for each firm and year, 1992 through 1997, taking the value 1 if the firm is participating in one or more subcontracting arrangements in that year, 0 otherwise.

Since we also want to address the issue of knowledge transfer, several additional questions were asked of all firms. On the basis on these questions we construct the following variables, each of which is 1 if the general manager answered affirmatively to the indicated question and 0 otherwise:

Variable	Question
TRAINING	“Have (some of) your workers undergone new training in the past two years”
WAGE INCREASE	“Do you use increases in wages as a means to keep skilled workers from leaving”
SKILLED LABOR LOSS	“Have you lost skilled workers to your competitors”
DEFAULT	“Are you likely to default on your cooperation if approached by another foreign partner”

⁶ Note that subsidies may need to be included as revenues if a firm operates in a sector where price controls are still in place. In such cases (for example, in the utility sector), subsidies counterbalance the lower prices that firms are forced to charge consumers. Since we investigate only firms in manufacturing sectors where all price controls were removed in 1991, this is not a problem here.

Interestingly, only a quarter (27%) of subcontractors say they would consider breaking a contract with a current partner in order to entertain an alternative offer. In the majority of cases this is due to the implicit (or explicit) expectation that the cooperation will turn into a joint venture if the trial period is successfully completed.

Following the first survey, a second survey was sent to 35% of all subcontractors to look further at the effect of subcontracting on changing the product mix and on the pricing by the local firm. This survey attempted to see whether the appearance of increased efficiency may be due to price increases, rather than to enhanced productivity. The following main question was addressed to firms already identified as 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.”

Two additional questions were included to test the degree of cooperation between the partners. First, “How does your foreign partner ensure that your products meet quality standards? 1. By continuous presence in your company; 2. Using external (third party) inspection; 3. By administering random tests.” Second, “What penalty is imposed if your products do not meet quality standards? 1. A pre-determined fine; 2. Price reductions for future shipments; 3. Return shipments that do not meet quality requirements; 4. May break the contract.” These questions are used in the last section of our analysis.

The sample has the following selection characteristics. First, all firms were listed on the Prague Stock Exchange (PSE), following their privatization in 1993. This probably 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 – small firms were not listed on the capital market. The selection of firms is biased away from enterprises in the former military complex, which were not privatized until later in the transition. Within the group of privatized firms, however, no bias exists, as all firms were required to report to the survey firm; compliance is mandatory as part of their capital market requirements.

To study the possible effects of subcontracting on other firms in the industry, 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. In particular, there are no tax holidays or customs duties that apply to those firms in the Czech Republic. For 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, although in fact it is due to tax provisions.

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 (IAS) were adopted for all Czech firms in 1994. The main difference of the old Czech income-statement accounting from the IAS was in treating production for inventory as sales revenue. Since we have information on inventory levels and changes in inventory, the conversion to IAS income statements for 1993 requires little tinkering with the data.

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 1993-1996. In particular, we study whether stocks of firms with subcontracts trade for higher ratios of market to replacement value, and also whether those firms have larger negative 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 such 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 firm performance.

The variable VARCOS is defined as labor costs and material expenses as a fraction of total sales revenues. Table 1 reports summary statistics. 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). We also use a variable representing Tobin's Q (TOBQ). To calculate it, we use the secondary market prices for firms traded on the PSE 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 TOBQ as the sum of market valuation and total debt outstanding, divided by the firm's replacement value (net fixed assets plus inventory).⁷ In table 1, the last column reports summary statistics. The median TOBQ across all firms is 0.627. There is a decline in mean TOBQ over the years, as the aggregate stock market went down after the initial surge in 1993 (not reported). Typically, firms in high-skill intensive

⁷ We use the face value of debt as market values of debt are not available. We do not think this introduces a bias in the regressions for three reasons. First, since all debt is floating interest rate—all fixed interest-rate debt was transferred from firms to a special agency in 1990—par and market values are close. Second, while (the risk of) non-payment could lower market values below par values, this would bias TOBQ downward for low Q-firms as these are more likely to risk repayment problems. This would mean that the slope-coefficients would be underestimated. Third, we also tested the relationships between the ratio of market value of equity to the book value of equity only—thus not including the value of debt—and subcontracting and control variables, and found similar results.

sectors and with valuable intangible assets will have high TOBQs, while firms in physical-capital intensive industries and/or industries where the output prices are regulated will have low TOBQs. The sectoral dispersion of Czech firms' TOBQs is consistent with this: the Food sector has the highest median TOBQ (0.905), while Clothing has the lowest (0.479). The TOBQs of most firms are stable over time: eight firms are in the top ten over the whole period. The values of TOBQ in 1996 vary between 3.02 and 0.13.

[Table 1 here]

As control variables, we use the firm's size, as well as year and sector dummies (regional dummies are not significant). We define SIZE as the number of employees. The average (median) size of firms in the sample was 1,311 (565) workers in 1996. The food sector had the smallest median size (211), while Transport Equipment had the largest (3,105). Our use of SIZE as a control variable in the regression analysis follows Estrin and Takla (1995). Sector dummies ($DSEC_i$) 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. Finally, year dummies ($DYEAR_t$) are included to correct for changes in the institutional environment, as well as economy wide shocks. To correct for possible endogeneity in the data, we also use information on pre-subcontracting (1991) variable costs (VARCOS:91) and size (SIZE:91).

V. Evidence

We perform the empirical analysis in three parts. First, we study the simple correlations between our dependent variables and the main independent variable (SUB). We also test whether there have been increases in wages in firms that have signed subcontracting agreements. The latter is a necessary condition in explaining how those firms reduce employee turnover once their workers have gone through training. We then turn to a two-step regression analysis to measure the effect of subcontracting arrangements on firm performance. Finally, we test for the presence of indirect effects from subcontracting on other firms in the industry.

Simple Tests

In this section we look at the correlations between several key variables. If the main hypothesis is correct, we would expect to find some preliminary evidence for the positive effect of subcontracting in the raw correlation matrix (Table 2, Panel A). The correlation coefficients between SUB and the dependent variables in 1995 and 1996 show the expected signs. Interestingly, those coefficients have the opposite signs for the first half of the sample period (1993-94). Thus subcontracting was associated with higher variable costs and lower market valuation at the time of the actual signing of contracts – as mentioned earlier, most of the arrangements were made in the 1993-94 period. Are foreign partners attracted to less restructured firms because of cheaper labor costs? Or is it that the more efficient firms do not get involved in such contracts because they do not expect any gains? We control for these possibilities in the multivariate analysis. Some indication is already provided in Table 2, Panel

B. Subcontractors start with relatively worse initial indicators but improve (particularly on stock prices which, although they fall absolutely, rise relative to those of non-subcontractors) during the period. Note that employees in subcontracting firms are more than twice as likely to get additional training as their colleagues in other firms. As hypothesized earlier, relatively little turnover of skilled workers happened during the sample period. In fact, subcontractors lost fewer skilled workers than non-subcontracting firms, even though fewer subcontractors raised their wages as a preemptive device.

[Table 2 here]

Estimation Results

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 profitability and size on subsequent subcontracts. The hypothesis here is that the firms most likely to sign subcontracts were relatively profitable (a proxy for efficient) 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.

The approach we use is an alternative to 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 past performance. The second step involves an OLS estimation, using only the firms with subcontracting agreements, and results in sample selection bias, defined as the omitted variable problem. The 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 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) and is computed directly as part of the TSP econometric package we use. 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.

We use Amemiya's approach to calculate the inverse Mills ratio from the probit estimation and employ it as an instrument in the second-step estimation. It instruments for the unobserved (by the econometrician) impacts on the subcontracting decisions. In particular, for nonzero observations for subcontracting, the inverse Mills ratio is calculated as

$$\text{MILLS} = \frac{\psi(\beta'x)}{\phi(\beta'x)}$$

where $\psi(\cdot)$ represents the density function, $\phi(\cdot)$ denotes the cumulative distribution function, x denotes a vector of explanatory variables in the probit regression, and β is the set of corresponding parameter estimates of the explanatory variables.

The results from the first step estimation are reported in Table 3. As expected, there exists a positive relation between subcontracts signed on the one hand, and VARCOS:91 and SIZE:91 on the other. We also compute the inverse Mills ratio for each firm (MILLS) that we use as a separate independent variable in the second-step regressions to correct for endogeneity.

[Table 3 here]

We estimate second-step regressions using 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. Although F-tests reject the hypothesis that a common constant term across firms is appropriate, the OLS estimates are nevertheless reported to provide a benchmark for comparisons. We also ran cross-section OLS regressions for every year separately to investigate the behavior of the parameters over time (not reported).

The Hausman-specification tests indicate that either the fixed or random effects model can be used. Following Mundlak (1978) we choose the random effects model. From a practical standpoint, fixed effects estimation is costly in terms of degrees of freedom, and in a longitudinal dataset 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. This would probably be stretching the reality of the Czech firms' behavior.

[Table 4 here]

The coefficients on SUB all have the expected signs with the exception of the VARCOS OLS coefficients which is positive but statistically insignificant (Table 4). The results have a ready economic interpretation. The presence of subcontracting is associated with an increase of 0.116 in the mean value of TOBQ, which is a 16% premium compared to the average value of TOBQ of all firms in the sample 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 significant support for the theory.

As discussed earlier, this result may be spurious, i.e., the increase in efficiency may be due to price increases rather than productivity enhancement. The current data do not allow us to test these two competing hypotheses. This is where we expect the second survey to help, but we have not been able to analyze the results from it yet.

Indirect Effects of Subcontracting

In this section we study the effects of subcontracting on other firms in the industry. We follow the estimation procedure as detailed in Aitken and Harrison (1997). 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 (we also use the share in the total number of firms, and total sales as alternative proxies) as a separate independent variable. We use a truncated sample of firms – only those that do not have subcontracting arrangements. This leaves us with a total of 758 observations (firms that did not have subcontracting a particular year). The results are reported in Table 5. Standard errors are corrected for heteroskedasticity using the White method. As shown in Table 2, Panel B, it is too early to observe direct effects from knowledge spillovers.

We find a significant positive spillover effect that is robust to both specifications for TOBQ, but negative effects for cost reductions (VARCOS should be decreasing in SHARE to get a positive effect). The coefficients show that if the share of subcontracting firms doubles in a given sector, variable costs will increase by 0.015, while the market valuation of the firms will go up by 0.009. What explains these mixed results? The positive coefficient on SHARE in the VARCOS regressions may be due to the argument advanced by Harrison – the cooperation between foreign and local firms results in higher market share for the local subcontractors. Other firms in the sector decrease production which results in higher fixed costs per unit. The positive coefficient on SHARE in the TOBQ regression may be due to the anticipation of investors that these firms too would be involved in a subcontracting agreement in the future.

[Table 5 here]

VI. Conclusions

The results of the analysis suggest that there is a statistically significant positive correlation between subcontracting on the one hand and knowledge transfer on the other. Subcontracting – under which there is interaction between Czech firms and foreign buyers, but no formal cooperation – triples the probability of being trained, and is associated with a reduction in variable costs and an increase in prices on the stock exchange. The indirect effects on other firms in the industry are mixed. A high share of subcontracting activity in a particular industry is associated with increased variable cost share of these firms. Their market valuation also increases, however, suggesting anticipation on the part of investors of future partnerships with foreign firms.

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Table 1: Descriptive statistics
(mean, std. deviation, median)

Sector	No. of firms	No. of subcontracts	SIZE:96	VARCOS:96	TOBQ:96
Food	49	13	548.44 (1014.39) 212.00	0.896 (0.072) 0.907	0.909 (0.451) 0.905
Textiles	33	20	1137.24 (948.51) 851.00	0.894 (0.066) 0.892	0.578 (0.243) 0.544
Clothing	6	4	1337.16 (791.23) 1157.00	0.864 (0.097) 0.867	0.478 (0.162) 0.479
Lumber and Furniture	12	9	716.92 (767.96) 555.00	0.992 (0.215) 0.936	0.701 (0.663) 0.536
Paper and Printing	14	8	2130.00 (4587.12) 640.00	0.873 (0.071) 0.882	0.799 (0.702) 0.598
Chemicals	27	19	1651.82 (1817.26) 1215.00	0.857 (0.074) 0.852	0.804 (0.425) 0.708
Leather	5	1	2056.11 (2976.35) 1198.00	0.913 (0.067) 0.914	0.444 (0.371) 0.287
Stone, ceramics	31	15	2005.19 (3051.27) 618.00	0.797 (0.101) 0.804	0.772 (0.508) 0.637
Base metals	12	5	3902.75 (6422.56) 912.00	0.924 (0.079) 0.918	0.598 (0.254) 0.605
Metal products	41	18	1508.24 (5275.31) 429.00	0.876 (0.086) 0.885	0.604 (0.296) 0.557
Nonelectrical	98	62	1071.69 (2016.45) 569.00	0.896 (0.175) 0.894	0.745 (0.472) 0.628
Electric machinery	25	12	775.64 (691.95) 750.00	0.978 (0.596) 0.876	0.668 (0.501) 0.526
Transport eq.	5	3	4039.20 (2451.63) 3105.00	0.923 (0.041) 0.912	1.042 (0.564) 0.857
Other	15	12	514.66 (348.51) 444.00	0.849 (0.099) 0.827	0.687 (0.412) 0.576
Total	373	201	1311.35 (2823.51) 565.00	0.887 (0.193) 0.885	0.726 (0.454) 0.627

Table 2: Raw Data Comparisons**Panel A: Correlation Matrix**

	SUB95	VARCOS93	VARCOS94	VARCOS95	VARCOS96	TOBQ93	TOBQ94	TOBQ95	TOBQ96
SUB95	1.000								
VARCOS93	0.092	1.000							
VARCOS94	0.002	0.729	1.000						
VARCOS95	-0.006	0.618	0.816	1.000					
VARCOS96	-0.078	0.248	0.374	0.385	1.000				
TOBQ93	-0.145	-0.078	-0.125	-0.116	-0.093	1.000			
TOBQ94	-0.023	0.052	-0.043	-0.046	-0.076	0.769	1.000		
TOBQ95	0.036	0.003	-0.075	-0.079	-0.087	0.668	0.775	1.000	
TOBQ96	0.097	0.061	0.049	0.034	-0.009	0.495	0.564	0.726	1.000

Panel B: Subcontractors vs. Other Firms

(Mean, Standard Deviation, Median)

Variable	Subcontracting	No Subcontracting
	201 Firms	172 Firms
TRAINING	62%	27%
WAGE INCREASE	71%	80%
SKILLED LABOR LOSS	17%	29%
VARCOS93	0.987 (0.094) 0.994	0.966 (0.131) 0.983
VARCOS94	0.952 (0.090) 0.953	0.951 (0.109) 0.965
VARCOS95	0.935 (0.086) 0.946	0.936 (0.096) 0.953
VARCOS96	0.874 (0.085) 0.882	0.904 (0.089) 0.893
TOBQ93	0.788 (0.435) 0.675	0.936 (0.562) 0.778
TOBQ94	0.792 (0.376) 0.715	0.821 (0.452) 0.714
TOBQ95	0.773 (0.411) 0.679	0.743 (0.415) 0.669
TOBQ96	0.766 (0.475) 0.635	0.678 (0.425) 0.588

Notes: 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. WAGE INCREASE: 1 if the general manager answered affirmatively to the question “Do you use increases in wages as a means to keep skilled workers from leaving,” 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.

Table 3: Probit Estimates (First Step)

Independent Variable	Coefficient (t-Statistics)
Constant	-0.961 (1.752)
VARCOS:91	1.023 (1.849)
SIZE:91	0.002 (1.928)
Observations	373
Adjusted R ²	0.02

Note: The sample consists of 373 firms over 4 years for a total of 1,492 observations.

Table 4: Estimation Results (Second Step)

Independent Variable	TOBQ		VARCOS	
	OLS	Random-effects	OLS	Random-effects
Constant	0.743 (11.436)	0.726 (7.285)	0.927 (59.085)	0.938 (36.174)
SUB	0.091 (1.847)	0.116 (2.830)	0.011 (0.795)	-0.028 (1.889)
MILLS	-0.038 (1.195)	-0.052 (1.536)	-0.014 (1.465)	0.008 (0.758)
Food	0.196 (2.854)	0.194 (1.745)	0.039 (2.394)	0.038 (1.359)
Textiles	-0.128 (2.114)	-0.126 (1.092)	0.043 (2.806)	0.041 (1.385)
Clothing	-0.134 (1.940)	-0.136 (0.754)	-0.004 (0.198)	-0.009 (0.268)
Lumber and Furniture	-0.254 (3.264)	-0.248 (1.739)	0.081 (3.805)	0.076 (2.149)
Paper and Printing	-0.024 (0.248)	-0.020 (0.146)	0.036 (1.887)	0.034 (0.997)
Chemicals	0.112 (1.608)	0.113 (0.948)	0.003 (0.218)	0.002 (0.058)
Leather	0.026 (0.267)	0.025 (0.134)	0.084 (3.987)	0.085 (1.739)
Stone, ceramics	0.135 (1.768)	0.133 (1.149)	-0.049 (2.754)	-0.051 (1.709)
Base Metals	0.011 (0.163)	-0.007 (0.098)	0.051 (2.465)	0.045 (1.248)
Metal Products	-0.009 (0.138)	-0.008 (0.068)	0.025 (1.557)	0.022 (0.805)
Nonelectrical	-0.027 (0.459)	-0.027 (0.267)	0.037 (2.395)	0.035 (1.428)
Electric Machinery	-0.015 (0.209)	-0.012 (0.103)	0.032 (0.998)	0.028 (0.952)
Transport Equipment	0.208 (2.016)	0.205 (1.068)	0.105 (4.885)	0.108 (2.265)
Year93	0.062 (1.885)	0.064 (3.245)	0.026 (3.438)	0.025 (3.319)
Year95	-0.042 (1.485)	-0.045 (2.328)	-0.016 (2.496)	-0.016 (1.982)
Year96	-0.078 (2.485)	-0.080 (4.092)	-0.064 (5.867)	-0.062 (8.275)
Adjusted R ²	0.071	0.536	0.099	0.254

Table 5: Effects on Other Firms in the Industry

Independent Variable	TOBQ		VARCOS	
	OLS	Random-effects	OLS	Random-Effects
Constant	1.268 (3.241)	1.368 (2.158)	0.365 (1.287)	0.451 (1.115)
SHARE	0.011 (7.256)	0.009 (5.512)	0.017 (23.468)	0.015 (14.524)
Food	0.529 (8.086)	0.532 (5.741)	0.664 (40.391)	0.666 (23.714)
Textiles	-0.258 (2.058)	-0.254 (1.402)	0.256 (8.394)	0.259 (4.758)
Clothing	-0.387 (2.509)	-0.425 (1.628)	0.159 (3.094)	0.157 (1.957)
Lumber and Furniture	-0.442 (2.068)	-0.525 (2.048)	-0.117 (2.157)	-0.126 (1.618)
Paper and Printing	-0.218 (1.698)	-0.197 (0.958)	0.301 (9.096)	0.301 (4.905)
Chemicals	0.098 (0.639)	0.095 (0.425)	-0.085 (2.315)	-0.091 (1.394)
Leather	0.436 (4.869)	0.442 (2.296)	0.771 (36.154)	0.770 (13.514)
Stone, ceramics	0.238 (1.968)	0.215 (1.399)	-0.302 (10.251)	-0.309 (6.768)
Base Metals	0.165 (1.568)	0.152 (0.945)	0.504 (18.217)	0.497 (10.128)
Metal Products	0.187 (1.785)	0.189 (1.378)	0.456 (19.148)	0.453 (11.234)
Nonelectrical	-0.224 (1.728)	-0.228 (1.298)	-0.224 (6.708)	-0.224 (4.261)
Electric Machinery	-0.054 (1.287)	-0.051 (0.335)	-0.431 (7.465)	-0.427 (9.095)
Transport Equipment	0.245 (1.118)	0.249 (0.859)	0.305 (8.215)	0.300 (3.351)
Year93	0.112 (2.374)	0.110 (3.774)	0.019 (1.678)	0.017 (1.315)
Year95	-0.051 (1.284)	-0.064 (2.062)	-0.021 (2.118)	-0.019 (1.374)
Year96	-0.122 (2.778)	-0.136 (4.329)	-0.054 (2.497)	-0.051 (3.656)
Adjusted R ²	0.105	0.415	0.049	0.057

Note: The sample consists of 172 firms over 4 years for a total of 688 observations.