ABSTRACT

Title of dissertation: TO *LOHN* OR NOT TO *LOHN*-A PUZZLE IN SUBCONTRACTING ARRANGEMENTS: THEORY AND EVIDENCE

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The dramatic increase in outsourcing has led to a burgeoning theoretical literature that tries to explain the associated organization of production. So far, however, the literature has focused solely on analyzing the determinants of decisions by outsourcing firms, but has ignored the firms to which production is outsourced. This dissertation bridges this gap in the literature by studying outsourcing decisions not from the point of view of the outsourcing firm alone, but as a joint process that actively involves the manufacturer to which production is outsourced.

In the theoretical part of the dissertation we focus on a particular form of international outsourcing, also known as the *lohn* system, in which the outsourcing firm provides the manufacturer with all the inputs needed to produce and then re-imports the final goods. We use an incomplete contracts framework to show that the *lohn* system is

more likely to be adopted the lower the manufacturer's ability to find low-cost inputs; the lower the bargaining power of the manufacturer; and the lower the degree of relationship-specificity.

In the empirical part of the dissertation we test the above predictions of the model. We exploit two unique firm-level databases from the National Institute of Statistics in Romania that provide information on physical production and balance sheet items for a large number of firms in Romania, collected monthly for the years 2005 and 2006. We use the data sources to construct two different datasets, one at the firm level and the other one at the firm-product level. We present firm-level results for cross-sections for the years 2005 and 2006, while at the firm-product-level we provide results for both cross-section and panel data.

Our empirical findings support the main predictions of the theoretical model. For instance, measuring the bargaining power of the manufacturer as the ratio of domestic to export sales, we obtain that the lower this ratio is, the more likely it is that the manufacturer will adopt the *lohn* system. Similarly, consistent with our theoretical model, we find that the lower the firm or product specificity, the higher the likelihood of adoption and the extent of usage of the *lohn* system. Using firm age as a measure of its ability to obtain the low-cost input provides mixed evidence for our theoretical prediction. Our results are robust to the use of different estimation procedures, measures, and samples.

TO *LOHN* OR NOT TO *LOHN*-A PUZZLE IN SUBCONTRACTING ARRANGEMENTS: THEORY AND EVIDENCE

by

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DEDICATION

To my parents

and

to my husband

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Simona C. Andrei

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CHAPTER 1

Introduction and Motivation

In the last two decades a large and growing part of production has become global either through foreign direct investment (FDI), or through international outsourcing. While initially a lot of attention was devoted to documenting and explaining the dramatic increase in FDI, in recent years, interest regarding international outsourcing has been growing both in academic circles and outside.[1] Helpman [2006] argues that an understanding of what drives decisions involving outsourcing is essential for understanding the recent trends in the world economy.[2]

A widely-used form of international outsourcing is the one in which the outsourcing firm provides the manufacturer with the inputs necessary for production. Under this arrangement the inputs are purchased by the outsourcing firm, imported into

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[1] Rising interest in outsourcing can be gauged from the fact that in 2004 there were 2,634 articles in US newspapers on service outsourcing alone (Amiti and Wei [2005]). This figure is especially interesting given the fact that service outsourcing constitutes a relatively small fraction of the total GDP for almost all countries around the world, as well as a relatively small fraction of outsourcing (Amiti and Wei [2005]).

[2] Recent years have seen a dramatic increase in international outsourcing. The most common type of outsourcing is material outsourcing, which has also increased steadily in the last decades, as evidenced by the growing trade in intermediate inputs. For instance, Feenstra and Hanson [1996] estimate that in US manufacturing there was an increase in total imported intermediate inputs from 5.3 percent to 11.6 percent between 1972 and 1990. Similarly, Hummels, Ishii and Yi [2001] and Yeats [2001] show evidence of increasing trade in components relative to trade in final goods.

the country where the manufacturer is located, processed there and transformed into goods that are exported to the outsourcing firm, which then sells them under its own brand name. This type of subcontracting arrangement has traditionally been used in the apparel, footwear, and textiles industries across the world (see Musiolek [2002]). Apart from these industries, this production arrangement can also be seen in Indian IT service outsourcing in recent years. In China alone almost 20% of its total exports were produced under this subcontracting arrangement in recent years,[3] while a substantial portion of the production of garments in Central and Eastern Europe is carried out under this subcontracting arrangement, which is known in the region as the *lohn* system.[4] In Romania, currently EU's largest apparel producer, around 70% of the output in the apparel industry is produced under the *lohn* system.

Despite the widespread use of this production arrangement in the real world, there does not exist any theoretical literature on why firms choose to adopt it instead of other arrangements. In particular, it has not been explained why firms choose to use the *lohn* system instead of a standard arm's length transaction, in which the purchase of inputs is controlled by the manufacturer. Since both kinds of production arrangements are used in practice, but there is little knowledge as to how the choice between the two arrangements is made, in Chapter 2 we propose a theoretical model that identifies the necessary and sufficient conditions under which one versus the other production arrangement would be adopted. We build on the work by Feenstra and Hanson [2005] to develop a model of

[3] According to Feenstra and Hanson [2003], processing exports in China alone accounted for a total of $128.55 billion per year on average between 1997 and 2002, which represents approximately 55% of China's average total exports over the same period of time. Out of this, according to the same source, as much as 30% was produced under the subcontracting arrangement that we study.

[4] This is the regional name of this production arrangement (*lohn* means *wage* in German), which is commonly used in Central and Eastern Europe. Another name for this production system is *ishleme* (Turkish for *embroidery*) (see Musiolek [2002]).

relationship-specific investments and incomplete contracts that uses property rights theory in the vein of Grossman and Hart [1986] and Hart and Moore [1990].

We find that the *lohn* system is more likely to be adopted when the manufacturer has relatively low ability to find low-cost inputs, whereas an arm's length transaction is more likely when the manufacturer's ability to find low-cost inputs is high. This is intuitive because allowing the more efficient agent to be responsible for the input supplies increases the size of the surplus to be divided between the two agents. We also find that the *lohn* system is more likely to be adopted instead of an arm's length transaction when relationship specificity is low. This is in line with the Grossman-Hart-Moore property rights literature in that when the holdup problem is less severe (i.e. specificity is low), ownership and control should be given to different parties. In our case the manufacturer owns the processing facility, whereas the outsourcing firm controls the input purchase (*lohn* system). Finally, we find that when the manufacturer has low bargaining power the *lohn* system is more likely to be preferred to an arm's length transaction.

In the empirical part of the dissertation we test the predictions of the theoretical model using data at the firm and firm-product level from two groups of manufacturing industries in Romania: apparel, textiles, and footwear on the one hand, and food, tobacco, and chemicals on the other hand. We show that our model applies to both groups, even though with some differences. We exploit two excellent data sources from the National Institute of Statistics in Romania: the monthly survey IND TS at the firm-product-level and firms' annual balance sheets, which we were able to obtain and use for the first time in an econometric estimation. The IND TS survey allows us to identify, for each firm, which products are produced under the *lohn* system each month, a feature that is crucial for our analysis and not available elsewhere. The balance sheets provide important additional characteristics for each firm. Using firm identifiers we were able to match the entries in the two databases and to construct two unique datasets, one at the firm level and the other one at the firm-product level. Details about the data sources and the construction of the datasets are provided in Chapter 3 of the dissertation.

Chapters 3 and 4 both bring empirical evidence in support of the predictions of the theoretical model. Chapter 3 is devoted to the analysis of firm-level data and applies the theory in Chapter 2 under the assumption that all firms are single product firms. We show that, measuring the bargaining power of the manufacturer as the ratio of domestic to export sales, we obtain that the lower this ratio is, the more likely it is that the manufacturer will adopt the *lohn* system. Also, consistent with our theoretical model, we find that the lower the firm specificity, the higher the likelihood of adoption or the extent of usage of the *lohn* system. While our conclusions hold for both groups of industries that are analyzed, specificity shows up stronger in the apparel, textile, and footwear industry, while bargaining power has a stronger effect in the food, tobacco, and chemicals group. This suggests that the different technologies in different industries might matter. Finally, using a firm's age as a measure of its ability to obtain the low-cost input, we obtain mixed evidence that younger firms are more likely to adopt the *lohn* system. We believe that this result illustrates the fact that firm age also picks up other firm characteristics.

In Chapter 4 we use the cross-section and panel data at the firm-product level to test the theoretical model under the assumption that multi-product firms make independent production decisions for each good they produce. The cross-section results are in excellent agreement with the results in Chapter 3. The analysis of the panel-data for the years 2005 and 2006 brings further evidence in support of the predictions that the use of the *lohn* system by a firm to produce a certain good is higher when the manufacturer's bargaining power is low and when there are a lot of other firms that also produce that good (i.e. specificity is low).

In order to test the validity of our results we perform several sensitivity and robustness exercises. We show that the results are robust to alternative specifications, alternative measures of key variables, to sample size, and to outliers.

This dissertation contributes to the literature in various ways. First of all, this research belongs to the group of works that try to explain the decisions regarding outsourcing and the new forms of the organization of production. Within this branch of literature, our work belongs to the small, but growing trend of incorporating insights from the industrial organizational literature to explain how firms sort into different organizational forms. One of the main contributions of this dissertation is to analyze the decision about what organizational form to adopt, not from the point of view of the outsourcing firm alone, as in the existing literature, but as a joint process, in which the firm outsourcing goes to is also actively involved. Doing so enables us to answer the important question of why a particular organizational form of production is chosen by all parties.

To our knowledge, this is also the first work that attempts to explain the adoption of the form of international outsourcing in which the outsourcing firm provides the manufacturer with the inputs necessary for production. This is an important research question given the widespread use of this production arrangement in various industries traditionally and in light of the fact that we see it starting to be adopted in new industries such as the IT service industry in India. Given the lack of studies addressing this research question in the literature, this contribution is especially important and timely. In addition to constructing a theoretical framework to explain the choice between *lohn* and a standard arm's length transaction, we are also able to find two excellent data sources and to use them for the first time for econometric estimation by compiling two unique datasets for our analysis.

Apart from the above contributions, as with any new topic of research, this dissertation also raises a number of interesting and exciting questions to be pursued in future work, some of which we discuss at the end of each chapter.

CHAPTER 2

Theoretical Model

2.1 Introduction and Literature Review

This chapter introduces the theoretical framework that we use to study the choice between the *lohn* system, the form of international outsourcing in which the outsourcing firm provides the manufacturer with the inputs necessary for production, and a standard arm's length transaction, in which the manufacturer controls the purchase of these inputs.

As mentioned in Chapter 1, this is one of the few works to date that study the outsourcing decisions not from the point of view of the outsourcing firm alone, but as a joint process, in which the firm to which production is outsourced is also actively involved. Our approach is different from that of the vast majority of the existing theoretical models of the "new organization of production," which consider the decisions of firms in the outsourcing country, but ignore their counterparts in the countries where production is being outsourced. For example, Antras [2005], Antras and Helpman [2004], Grossman and Helpman [2004] make notable contributions in terms of explaining how firms choose between international outsourcing and FDI and the effects of these choices on the economy of the country that engages in outsourcing and FDI, but they analyze these issues entirely from the point of view of the firms in the outsourcing countries.

In order to explain outsourcing and the organizational forms associated with it, it is necessary to move away from traditional trade models and to include insights from the industrial organization literature, such as relationship-specific investments and incomplete contracts (Spencer [2005]). Progress has already been made towards understanding these new and increasingly important organizational forms. Earlier work on property-rights theory by Grossman and Hart [1986] and Hart and Moore [1990], as well as the incentive-system framework of Holmstrom and Milgrom [1994] have been incorporated into recent models of trade to explain determinants of firms' sorting into organizational forms (see Spencer [2005] for a recent review of this literature).

The paper that is closest in spirit to the present research is Feenstra and Hanson's work on "Ownership and Control in Outsourcing to China: Estimating the Property Rights Theory of the Firm." Feenstra and Hanson [2005] use a framework of incomplete contracts to explain the form of export processing that is most common in China: FDI with manufacturer's control over input purchases, i.e. the processing facility is owned by the outsourcing firm. We extend the Feenstra and Hanson [2005] model to account for the existence of the *lohn* system, in which the manufacturer owns the processing facility and the outsourcing firm provides the inputs necessary for production. To that end we allow for the possibility that there is a difference in the relative ability of the two agents to find the low-cost inputs. We also determine the necessary and sufficient conditions under which the outsourcing firm and the manufacturer adopt the *lohn* system versus a standard arm's length transaction.

The remainder of this chapter is organized as follows: Section 2.2 details the setup of the model, which is solved through backwards induction in Section 2.3. The results and the testable implications of the model are presented in Section 2.4. Section 2.5 concludes.

2.2 Setup

We consider the case of a manufacturer engaged in export processing for an outsourcing firm located in a different country. Following recent trade literature, the framework we use to model the interaction between the manufacturer and the outsourcing firm is based on a model of international outsourcing developed in Feenstra and Hanson [2005]. This model uses the property-rights theory from Grossman and Hart [1986] and Hart and Moore [1990], in which contracts are assumed to be incomplete and parties use Nash bargaining to alleviate hold-up problems. Feenstra and Hanson use their model to explain the organizational form most common in export-processing in China: factory ownership and Chinese control over input purchases.

We use the Feenstra and Hanson [2005] approach to develop a model that explains the opposite organizational form, which they do not look into: domestic ownership of the export-processing factory and foreign control over input purchases. As mentioned in Chapter 1, this production arrangement is widespread in many industries worldwide, for example textiles, apparel, and footwear. Most of the production of garments from Central and Eastern Europe takes place under this production arrangement, known in the region as the *lohn* system.

Let R be the manufacturer involved in export processing and let F be the outsourcing firm. The manufacturer uses imported[5] inputs to produce the final good for the outsourcing firm, who then takes care of retail and distribution. The timing of the game is as follows: in period zero the two agents decide jointly who controls input purchase decisions, based on net payoffs in equilibrium. In period one they make preparations for production, in the form of effort investments aimed at increasing their combined profits. Effort investments are costly, relationship-specific, and they are observable, but not verifiable, which leads to a standard hold-up problem. After investments have been made the two parties bargain according to the generalized Nash bargaining solution. In the second and last period of the game inputs are bought, the good is produced and sold, and payoffs are realized. There is no re-negotiation at this stage. In the following we describe the setup of the model more formally.

As already mentioned, in period one the two agents undertake investments to increase the value of total *ex post* gains. Following Feenstra and Hanson [2005], we assume that the following types of investments are made: to decrease the cost of inputs purchase, to prepare the factory for production, and to market the good. Efforts investments are denoted by e_1, e_2, and e_3, respectively. Hence e_1, $0 \le e_1 \le 1$, is the effort to look for a cheap input and is exerted by the agent who controls the input purchase decision. Recall that input purchases can be made by the manufacturer (standard arm's

[5] While in reality inputs used for production under the *lohn* system are imported, our model can also be applied to the case when inputs are domestically produced. All our results, in terms of the conditions under which agents would adopt the *lohn* system versus a standard arm's length transaction would remain unchanged in that case.

length transaction) or by the outsourcing firm (*lohn* system), depending on the form of production arrangement adopted. The effort level e_2, $0 \le e_2 \le 1$, is exerted by the manager of the processing facility R and represents effort to prepare the factory to produce. We can think of e_2 as being investment in productivity-enhancing technology. Finally e_3, $0 \le e_3 \le 1$, is the effort investment by the outsourcing firm F to market the final good, and could be thought of as the investment in a marketing campaign.

Combined period profits at the end of period 2 are given by:

$$\pi = \underbrace{B(1+\lambda e_2 + e_3)}_{Sales\ Revenue} - \underbrace{A\left(1-e_2\right)}_{Cost\ of\ input\ processing} - \underbrace{P\left[1-e_1\left(1-\delta+a\delta\right)\right]}_{Cost\ of\ input\ purchase} \tag{2.1}$$

The indicator variable δ shows the production arrangement, and takes the value 0 if inputs are purchased by the outsourcing firm F (*lohn* system) and the value 1 if the manufacturer R controls the inputs purchase decisions (arm's length transaction).

Note that the revenue from the sale of R's output is increasing in e_3, the effort by the outsourcing firm F to market the final good. Following the existing literature (Grossman and Helpman [2004], Feenstra and Hanson [2005]), we also assume that sales revenues are increasing in e_2. For instance, the manufacturer's effort to prepare the factory for production by acquiring the latest technology available on the market could result in higher quality products, which can bring in higher revenues. Assuming linearity of the sales revenue function in the levels of effort, we can write it as: $B\left(1+\lambda e_2 + e_3\right)$, where $B > 0$ is the level of revenues from sales that can be obtained in the absence of effort to increase firm productivity and to market the R's output, and λ, where $0 < \lambda \leq 1$ represents the marginal increase in sales revenue due to effort e_2 exerted by R to prepare factory for production, relative to the increase due to effort e_3 exerted by the outsourcing firm to market the final good.[6]

Note that our results are not specific to the particular functional forms that we use for computational simplicity. In *Appendix 1* at the end of this chapter we present an alternative specification of the model, in which effort levels e_2 and e_3 enter multiplicatively in the formula for sales revenues. This specification yields the same necessary and sufficient conditions under which the *lohn* system is used instead of a standard arm's length transaction. Moreover, under this specification, sales revenues are equal to zero if either $e_2 = 0$ or $e_3 = 0$, which means that the manufacturer's investment to prepare the factory for production, as well as the outsourcing firm's effort to market the final good are indispensable. See *Appendix 1* for a more formal treatment of this extension.

The cost of input processing, on the other hand, is decreasing in e_2, the effort by R to prepare the factory for production. For computational simplicity, we assume that the cost of input processing is a linear, decreasing function of e_2 and it is given by:

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[6] In the paper I follow Feenstra and Hanson [2005] and Holmstrom and Milgrom [1994] and assume that λ lies between zero and one. This assumption implies that the marginal contribution of marketing effort to sales revenues exceeds the contribution of efforts to prepare factory for production. Note however that the results of my model also hold for values of λ greater than one, as long as λ is not too high, so as to result in positive net profit for any levels of effort.

$A(1-e_2)$, where $A>0$ is the cost of processing the inputs in the absence of any effort to reduce this cost.

The cost of input purchase is decreasing in e_1, the level of effort spent to look for a lower-cost producer. We assume that there is a continuum of input-suppliers of the perfectly homogeneous input that R needs to be able to produce, and that each of them is able to supply one unit of the input. These suppliers have different costs of producing the input. Let $P>0$ be the price charged by the highest-cost input supplier. F or R, depending on who is responsible for purchasing the input, can choose to buy from the highest-cost supplier or search for lower-cost suppliers, who charge a lower price for the input. In view of the above, when F exerts the effort level e_1, it is able to buy the input at the price $P(1-e_1)$. Hence, the higher the effort e_1, the lower the cost of input purchase.

An important departure from the Feenstra and Hanson [2005] model is that we allow the two agents to differ in their ability to look for the cheaper input. Let $a\geq 0$ be the relative efficiency of the manufacturer R in finding the cheap input. It follows that, if the manufacturer controls the input purchase decision and exerts effort level e_1 to look for the cheap input, the price he expects to pay for the good is $P(1-ae_1)$. Recall that the inputs needed for production are imported into the country where the manufacturer is located. Depending on where inputs are being imported from, as well as on individual firm characteristics of the manufacturer and the outsourcing firm, it can be that one firm or the other is more efficient in getting the low-cost input.

As mentioned before, exerting effort is costly to the agents; let C_F and C_R be the cost of expending effort to F and R, respectively. We assume that these cost functions are increasing and convex. For simplicity, let them be quadratic in the levels of effort exerted by the two parties. We further assume that the effort costs incurred are proportional to agent F and R's respective disutility of effort, γ_F and γ_R, where $\gamma_F > 0, \gamma_R > 0$. Using these notations and the afore-mentioned assumptions, we write the cost of exerting effort to the two parties as

$$C_F = \frac{\gamma_f}{2}\left[(1-\delta)e_1^2 + e_3^2\right] \tag{2.2}$$

and

$$C_R = \frac{\gamma_r}{2}(\delta e_1^2 + e_2^2)\,. \tag{2.3}$$

2.3 Equilibrium Levels of Effort Investment

Recall that the timing of the game is as follows: in period zero the decision about who should control the purchase of inputs is made. In period one effort investments are made simultaneously by the two parties. In period two inputs are bought and processed, and the final goods are sold.

Following the Grossman-Hart-Moore property-rights theory, we assume a framework of incomplete contracts. The manufacturer and the outsourcing firm cannot sign *ex ante* enforceable contracts, in which to specify binding levels of investment effort e_1, e_2, and e_3. Hence, investments are observable, but not verifiable, and agents can only bargain over the surplus from the relationship after the effort investments have been made. We model the ex post bargaining as a generalized Nash bargaining game in which the outsourcing firm F obtains a fraction θ of the *ex post* gains from the relationship, where $0 \le \theta \le 1$. Note that I allow θ to take on the extreme values 0 and 1, when one agent makes a take-it-or-leave-it-offer to the other agent.

As shown before, when the manufacturer R and the outsourcing firm F agree, the surplus that is obtained from the relationship is given by π from equation (2.1). Let $\hat{\pi}_F$ and $\hat{\pi}_R$ be the disagreement payoffs to F and R, respectively, i.e. agents' payoffs when Nash bargaining breaks down. Let ψ be the parameter that describes the degree of the hold-up problem or of relationship specificity. If the two parties fail to agree, then F can find another export processing plant to work with, but the return on his effort is reduced by a fraction ψ, where $0 < \psi < 1$. It follows that:

$$\hat{\pi}_F = (1-\psi)\left[Be_3 + (1-\delta)Pe_1\right]. \qquad (2.4)$$

Meanwhile, the manufacturer R can use the factory to process the input for another firm if the agreement with F falls through. In this case, R is entitled to the residual profits of the firm, but loses a fraction ψ from the returns on his investment in joint-production. The underlying assumption here is that, if the manufacturer R has to work with a different outsourcing firm and R does not control the decision over input purchases, the price paid for the input is P. On the other hand, if the manufacturer R controls the purchase of the input, the price at which the input is bought is $P(1-ae_1)$. Hence, R's disagreement payoff is:

$$\hat{\pi}_R = (1-\psi)\lambda Be_2 - A(1-e_2) - P(1-\delta ae_1). \qquad (2.5)$$

Using the above notations, we can write F and R's *ex post* profits, which are denoted by π_F and π_R, respectively. The *ex post* profits are given by the generalized

Nash bargaining solution, in which each party receives its disagreement payoff plus a fraction of the surplus from agreeing versus disagreeing, as follows:

$$\pi_F = \hat{\pi}_F + \theta\left(\pi - \hat{\pi}_R - \hat{\pi}_F\right) = \theta\left(\pi - \hat{\pi}_R\right) + \left(1-\theta\right)\hat{\pi}_F \qquad (2.6)$$

and

$$\pi_R = \hat{\pi}_R + \left(1-\theta\right)\left(\pi - \hat{\pi}_R - \hat{\pi}_F\right) = \left(1-\theta\right)\left(\pi - \hat{\pi}_F\right) + \theta\hat{\pi}_R . \qquad (2.7)$$

Since contracts are not *ex ante* enforceable, in period one the two parties choose investment efforts e_1, e_2, e_3 non-cooperatively and seek to maximize their individual net payoffs. Maximizations need to be performed for the two possible scenarios, one in which the outsourcing firm F controls the decision about input purchases, and the other one, when the manufacturer R does, i.e. for $\delta = 0$ and $\delta = 1$, respectively.

The outsourcing firm F maximizes $\tilde{\pi}_F = \pi_F - C_F$, the difference between his *ex post* payoff and the cost of making effort investments. Using equations (2.2), (2.4), (2.5), (2.6), and (2.7) F's maximization problem can be re-written as:

$$\max_{e_1, e_3}\left\{\theta\left[B\left(1+e_3+\lambda\psi e_2\right)+Pe_1\right]+\left(1-\theta\right)\left(1-\psi\right)\left(Be_3+Pe_1\right)-\right.$$

$$\left.\frac{\gamma_F}{2}\left(e_1^2+e_3^2\right)\right\}, \text{ for } \delta = 0 \qquad (2.8)$$

and as

$$\max_{e_3}\left\{\theta B\left(1+e_3+\lambda\psi e_2\right)+\left(1-\theta\right)\left(1-\psi\right)Be_3-\frac{\gamma_F}{2}e_3^2\right\}, \text{ for } \delta = 1 . \qquad (2.9)$$

Similarly, the manufacturer R maximizes his net payoff $\tilde{\pi}_R = \pi_R - C_R$, which we can re-write using equations (2.3), (2.4), (2.5), (2.6), and (2.8) as

$$\max_{e_2}\left\{\left(1-\theta\right)\left[B(1+\lambda e_2)-A\left(1-e_2\right)-P+\psi\left(Be_3+Pe_1\right)\right]+\right.$$

$$+\theta\Big[\big(1-\psi\big)\lambda Be_2 - A(1-e_2) - P\Big] - \frac{\gamma_R}{2}e_2^2\Big\}, \text{ for } \delta = 0 \qquad (2.10)$$

and as

$$\max_{e_1,e_2}\Big\{\big(1-\theta\big)\Big[B(1+\lambda e_2+\psi e_3) - A\big(1-e_2\big) - P\big(1-ae_1\big)\Big] +$$

$$\theta\Big[\big(1-\psi\big)\lambda Be_2 - A(1-e_2) - P\big(1-ae_1\big)\Big] - \frac{\gamma_R}{2}(e_1^2+e_2^2)\Big\}, \text{ for } \delta = 1. \qquad (2.11)$$

For $\delta = 0$, i.e. when the outsourcing firm F makes input purchase decisions, take first order conditions in equations (2.8) and (2.10) and solve the resulting system of equations to obtain the following equilibrium levels of effort:

$$e_1 = \frac{P\big(1-\psi+\psi\theta\big)}{\gamma_F}, e_2 = \frac{B\lambda + A - B\theta\lambda\psi}{\gamma_R}, e_3 = \frac{B\big(1-\psi+\psi\theta\big)}{\gamma_F}. \qquad (2.12)$$

For $\delta = 1$, i.e. when the manufacturer controls the input purchase decisions, solve the first order conditions for equations (2.9) and (2.11) for e_1, e_2, and e_3 to obtain the following equilibrium levels of effort:

$$e_1 = \frac{Pa}{\gamma_R},\ e_2 = \frac{B\lambda + A - B\theta\lambda\psi}{\gamma_R},\ e_3 = \frac{B\big(1-\psi+\psi\theta\big)}{\gamma_F}. \qquad (2.13)$$

2.4 Results

In this section we show how the decision about the choice of production arrangement is made based on the net payoffs obtained in equilibrium. The equilibrium values of e_1, e_2, and e_3 as given by equation (2.13) are plugged into equation (2.11) to obtain the maximum net payoff available to the manufacturer R when it controls input purchase decisions. Similarly, the values of e_1, e_2, and e_3 from (2.12) are plugged into equation (2.10) to obtain the maximum net payoff available to the manufacturer when the outsourcing firm F provides the input. Let $\Delta_R = \tilde{\pi}_R |_{\delta=1} - \tilde{\pi}_R |_{\delta=0}$ be the difference between the maximum net payoffs available to the manufacturer R when it controls the input purchase decision ($\delta = 1$) versus when the outsourcing firm F buys the input ($\delta = 0$). The following expression is obtained for Δ_R:

$$\Delta_R = P^2 \frac{2\gamma_R \psi \left[\psi\theta^2 - 2\psi\theta + \psi + \theta - 1 \right] + \gamma_F a^2}{2\gamma_F \gamma_R}. \tag{2.14}$$

Note that, for different values of the parameters involved, Δ_R can take on both positive and negative values. In other words, depending on the degree of relationship specificity, on the ability to find the low cost input etc, the manufacturer R some times prefers to control the input purchase decision, while other times he prefers to let the outsourcing firm F supply the input necessary for production.

Similarly, we calculate the maximum net payoffs available to the outsourcing firm F under the two possible scenarios, by plugging the equilibrium values of e_1, e_2, and e_3 as given by equation (2.13) into equation (2.11) and those from (2.12) into equation (2.10), respectively. Let $\Delta_F = \tilde{\pi}_F |_{\delta=1} - \tilde{\pi}_F |_{\delta=0}$ be the difference between the maximum net payoffs of the outsourcing firm F when the manufacturer controls the input purchase decision ($\delta = 1$) versus when F himself buys the input ($\delta = 0$), which can be expressed as:

$$\Delta_F = -\frac{1}{2} \frac{P^2 \left[1 - \psi(1-\theta) \right]^2}{\gamma_F}. \tag{2.15}$$

It is easy to see that $\Delta_F \leq 0$ for any parameter values allowed in the model, as specified in Section 2.2. Hence, the outsourcing firm F always prefers to control the input purchase decision, rather than let the manufacturer exercise that control. The explanation for this result has to do with the incentive mechanism in our problem. Since the manufacturer R owns the processing facility and is the sole residual claimant, the outsourcing F does not have the incentive to exert first-best levels of investment effort. However, by giving the outsourcing firm control over inputs, his incentives improve and he exerts effort at levels closer to the first-best. At the same time, note that the Nash-bargaining solution guarantees that the manufacturer and the outsourcing firm will prefer working together to not dealing with each other at all, even when their rankings of the two production arrangements differ.

The following decision rule is used to determine what arrangement to use: a given production system is adopted if it yields higher net payoffs to both agents in equilibrium. In the case where the two agents differ in terms of the choice of production system, in equilibrium the system in place would be the one preferred by the agent who gains the most. This could come about through a system of non-distorting transfer payments whereby the agent who gains more makes a transfer payment to the other agent so as to have his preferred system in place.[7] In reality such a transfer might be used to alleviate concerns one party might have about the quality of inputs used for production. Suppose for instance that we are under the scenario in which the outsourcing firm prefers to control the purchase of inputs, but the manufacturer would rather he did, since that would

[7] While in the paper we assume for simplicity that the outcome is decided through a transfer payment, in reality this could take place through various alternative mechanisms that we abstract from. For example, under an alternative scenario the two parties can bid for the low cost input supplier and the one with the higher valuation would win the bid.

yield him higher payoffs in equilibrium. However, the outsourcing firm is concerned that the manufacturer will not be able to buy the high quality inputs that he would like to be used in the production process. Then, if the gain to him from buying the better inputs at a higher price exceeds the loss to the manufacturer from not buying the cheapest inputs, the outsourcing firm may choose to make a transfer payment to the manufacturer for his agreement to have the outsourcing firm control the input purchase decision.

In light of the notations introduced, the decision rule for the adoption of the *lohn* system can be formulated as follows: if $\Delta_R < 0$, then the *lohn* system is adopted, since it is optimal for both agents. If $\Delta_R > 0$, then cases need to be considered:

1) if $\Delta_R + \Delta_F > 0$, then the manufacturer R makes a transfer payment to the outsourcing firm F and the *non-lohn*-system is adopted, i.e. the agents engage in an arm's length transaction;
2) if $\Delta_R + \Delta_F < 0$, then the outsourcing firm F makes a transfer payment to the manufacturer R to compensate him for not having his preferred system in place and the *lohn*-system is adopted.
3) If $\Delta_R + \Delta_F = 0$, the two agents are indifferent between the two production arrangements.

Given that Δ_F is always negative, the decision rule simplifies and becomes: *lohn*-system is adopted if and only if $\Delta_R + \Delta_F > 0$ and *non-lohn* system is adopted if and only if $\Delta_R + \Delta_F < 0$. We re-write the expression for $\Delta_R + \Delta_F$ with Δ_F and Δ_R replaced by their expressions from equations (2.14) and (2.15) and, after some manipulations and setting $P = 1$, we obtain the following necessary and sufficient condition for the adoption of the *lohn* system:

$$\eta < \frac{1-\psi^2\left(1-\theta\right)^2}{a^2}, \qquad (2.16)$$

where $\eta = \frac{\gamma_F}{\gamma_R}$ denotes the relative disutility of effort for the outsourcing firm F relative to the manufacturer R. Note that the conditions under which the *lohn-system* will be adopted are captured in one formula that has very intuitive interpretation.

Four propositions follow immediately from expression (2.16). See *Appendix 2* for a graphical illustration of the following results:

Proposition 1**:** The lohn-system will be adopted for values of the relative disutility of effort $\eta < \frac{1-\psi^2\left(1-\theta\right)^2}{a^2}$. For values of the relative disutility of effort $\eta > \frac{1-\psi^2\left(1-\theta\right)^2}{a^2}$, a standard arm's length transaction is used.

Proposition 2**:** The *lohn-system* will be adopted for values of the relative efficiency in getting low cost inputs $a < \sqrt{\frac{1-\psi^2\left(1-\theta\right)^2}{\eta}}$. For $a > \sqrt{\frac{1-\psi^2\left(1-\theta\right)^2}{\eta}}$, a standard arm's length transaction is used.

Proposition 3**:** For values of the fraction of the *ex post* gains obtained by the manufacturer (i.e. the lower the bargaining power of the manufacturer R) $1-\theta < \frac{\sqrt{1-\eta a^2}}{\psi}$, the *lohn*-system is adopted. For $1-\theta > \frac{\sqrt{1-\eta a^2}}{\psi}$ a standard arm's length transaction is used.

***Proposition 4*:** For values of the degree of relationship specificity $\psi < \frac{\sqrt{1-\eta a^2}}{1-\theta}$, the *lohn*-system is adopted. A standard arm's length transaction is used if $\psi > \frac{\sqrt{1-\eta a^2}}{1-\theta}$.

To summarize, we show that the *lohn* system is more likely to be adopted: the lower the relative disutility of effort (η) for the outsourcing firm F relative to the manufacturer R; the lower the manufacturer's efficiency in finding low-cost inputs (a); the lower the fraction of the *ex post* gains obtained by the manufacturer (i.e. the lower R's bargaining power); and the lower the degree of relationship-specificity (ψ).

When providing an interpretation for the above-stated results, it is useful to group *Propositions 1 and 2* together, and *Propositions 3 and 4* together. *Propositions 1* and *2* are intuitive because allowing the agent who has a lower disutility of effort or who is more efficient in finding the low-cost input be responsible for the purchase of input supplies increases the size of the surplus to be divided between the two agents. *Propositions 3* and *4,* on the other hand, summarize results pertaining to the bargaining between the two agents. In these cases, shared ownership and control of the factory and inputs (i.e. the *lohn* system) comes about because it provides the non-residual claimant (the outsourcing firm F) with better incentives to exert effort. In particular, the result that the *lohn* system is more likely to be adopted instead of an arm's length transaction when relationship specificity is low is in line with the Grossman-Hart-Moore property rights literature. According to results in this literature, when the holdup problem is less severe (i.e. specificity is low), the ownership and control should be given to different parties. In our case the manufacturer owns the processing facility, whereas the outsourcing firm controls the input purchase (*lohn* system).

2.5 Conclusions

In this chapter we develop the first model that explains why firms engaged in export processing choose to adopt the subcontracting arrangement known as the *lohn* system, in which the outsourcing firm provides the manufacturer with the inputs needed to produce. It is surprising that despite a vast and growing literature on international outsourcing, this important aspect of the choice of production arrangement has not been looked into. Our model builds on the Feenstra and Hanson [2005] model of international outsourcing in an incomplete-contracts setting, which we extend to be able to explain a form of production arrangement that they do not investigate.

We are able to provide necessary and sufficient conditions under which the *lohn* system is adopted instead of a standard arm's length transaction and vice-versa. Specifically, we show that it is optimal to adopt the *lohn* system when the ability of the manufacturer to find the low cost input provider (a) is low, when the relative disutility of effort for the outsourcing firm (η) is low, when the manufacturer's bargaining power ($1-\theta$) is low, and when the degree of relationship-specificity (ψ) is low. The opposite is true for the cases when an arm's length transaction would be preferred. We show that these results are robust to alternative parameter specifications, including the extreme cases when one agent has the ability to make a take-it-or-leave-it offer to the other agent at the stage when surplus is divided.

The model we use in this chapter explains why some firms choose to adopt the *lohn* system while others do not. This leads to a natural extension exploring the impact of this production arrangement on firm performance over time. Does the *lohn* system make the firms that adopt it more (less) productive? Does it cause these firms to grow faster (slower) than the others firms? These are interesting questions particularly in view of their policy implications about the *lohn* system's being a short-run versus long-run strategy. These issues are already debated in the manufacturing sector in Romania. Some argue that firms who adopt the *lohn* system come to rely on the outsourcing firms for their inputs and hence do not invest in their own input production technology or make investments to reduce input procurement costs. Use of the *lohn* system is not likely to be an optimal long-run strategy for the local firm under these circumstances. The analysis of this issue, given its essentially dynamic nature constitutes a possible extension of the theoretical model presented here.

Another possible extension of the present theoretical model is to take into account the market structure in both the market for the goods whose production is being outsourced, as well as that in the market for inputs. In the textile and apparel industries for instance, where the *lohn* system is widely used, both the input and the product markets have a market structure that can be characterized as monopolistically competitive. Hence, it would be very interesting to see how our results change once we account for the market structure.

Appendices to Chapter 2

Appendix 1

Below we present an alternative specification of the model, in which the manufacturer's effort to prepare the factory for production (e_2) and the outsourcing firm's effort to market the final good (e_3) enter multiplicatively in the formula for sales revenues:

$$\pi = \begin{cases} Be_2e_3 - A(1-e_2) - P\left[1-e_1\left(1-\delta+a\delta\right)\right], & \text{if } \mathrm{e}_2\mathrm{e}_3 \neq 0 \\ 0 & \text{otherwise} \end{cases} \tag{2.17}$$

The rest of the terms are kept exactly as introduced in Section 2.2. We solve the model in the same way as described in Section 2.3 and obtain the following equilibrium levels of effort investment.

For $\delta = 1$, i.e. when the manufacturer controls the input purchase decisions:

$$e_1 = \frac{Pa}{\gamma_R}, \quad e_2 = \frac{B^2\left[\theta^2 + 2\theta - 1 + \psi\left(1-\theta\right)^2\right] + \gamma_F\left[A + B\theta\lambda\left(1-\psi\right)\right]}{\gamma_F\gamma_R - B^2\theta\left(1-\theta\right)},$$
$$e_3 = B\frac{\theta\left[A + \theta B\lambda\left(1-\psi\right)\right] + \gamma_R\left(1-\theta\right)\left(1-\psi\right)}{\gamma_F\gamma_R - B^2\theta\left(1-\theta\right)}. \tag{2.18}$$

For $\delta = 0$, i.e. when the inputs necessary for production are provided by the outsourcing firm (the *lohn* system):

$$e_1 = \frac{P(1-\psi+\psi\theta)}{\gamma_F},\ e_2 = \frac{B^2(1-\theta)^2(1-\psi)+\gamma_F\left[A+B\theta\lambda(1-\psi)\right]}{\gamma_F\gamma_R - B^2\theta(1-\theta)},$$

$$e_3 = B\frac{\theta\left[A+\theta B\lambda(1-\psi)\right]+\gamma_R(1-\theta)(1-\psi)}{\gamma_F\gamma_R - B^2\theta(1-\theta)}. \tag{2.19}$$

Note that the expressions for e_2 and e_3 are different under the new specification than under the initial one, where they were given by equations (2.12) and (2.13). However, when we solve for Δ_F and Δ_R, we obtain the same expressions as the ones given by equations (2.14) and (2.15) and consequently, the same conditions under which the *lohn* system is preferred to a standard arm's length transaction and vice-versa.

As noted before, this specification has the advantage that it makes investment efforts e_2 and e_3, the effort to prepare the factory for production and to market the final good, respectively, indispensable for obtaining gains from trade. In addition, this specification supports the claim that the results we obtain are not driven by the particular functional forms that we use in the text.

Appendix 2

Figure 2.1 below illustrates the results stated in *Proposition 1* and *Proposition 2*. The boundary between the *lohn* and the arm's length transaction regions is given by the equation: $\eta a^2 + \psi^2 (\theta - 1)^2 - 1 = 0$.

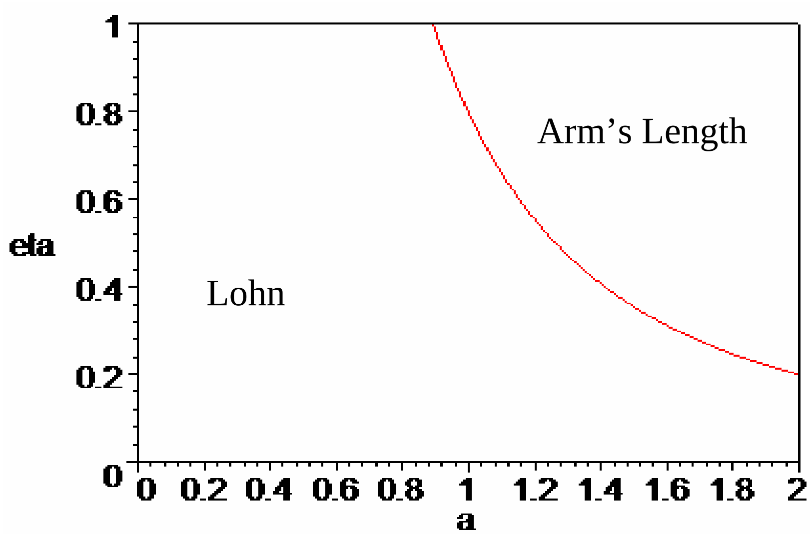

Figure 2.1: *Lohn* vs Arm's length transaction region as a function of a and η, computed for $\psi = 0.5$ and $\theta = 0.1$

Figure 2.2 illustrates the results stated in *Proposition 3* and *Proposition 4*. Again, the boundary between the *lohn* and the arm's length transaction regions is given by the equation: $\eta a^2 + \psi^2(\theta - 1)^2 - 1 = 0$.

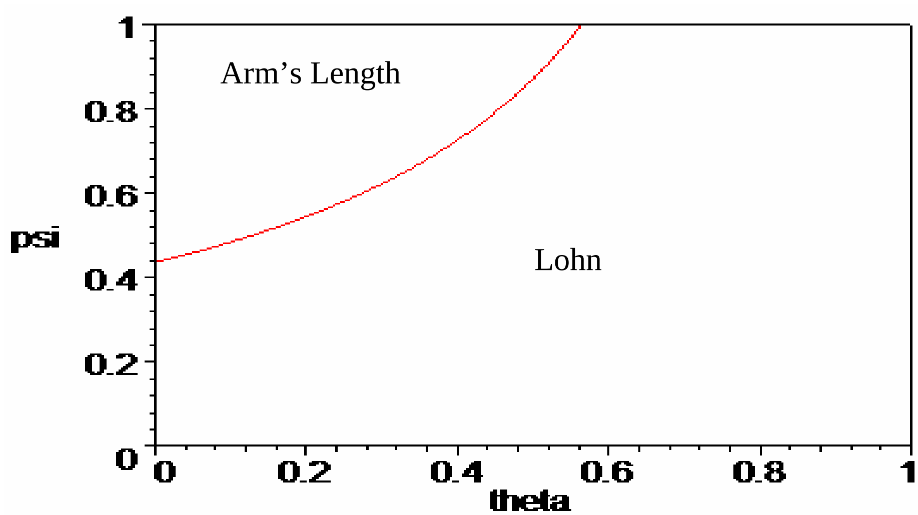

Figure 2.2: *Lohn* vs Non-*Lohn* region as a function of θ and ψ, computed for $a = 0.9$ and $\eta = 1$

Figure 2.3 summarizes the results of *Propositions 1* through *4*, and shows the *lohn* and non-*lohn* regions as functions of a, θ, ψ, for $\eta = 1$. Note that the arm's length region lies above the surface that has the equation $\eta a^2 + \psi^2 (\theta - 1)^2 - 1 = 0$, while the *lohn*-region lies below that surface.

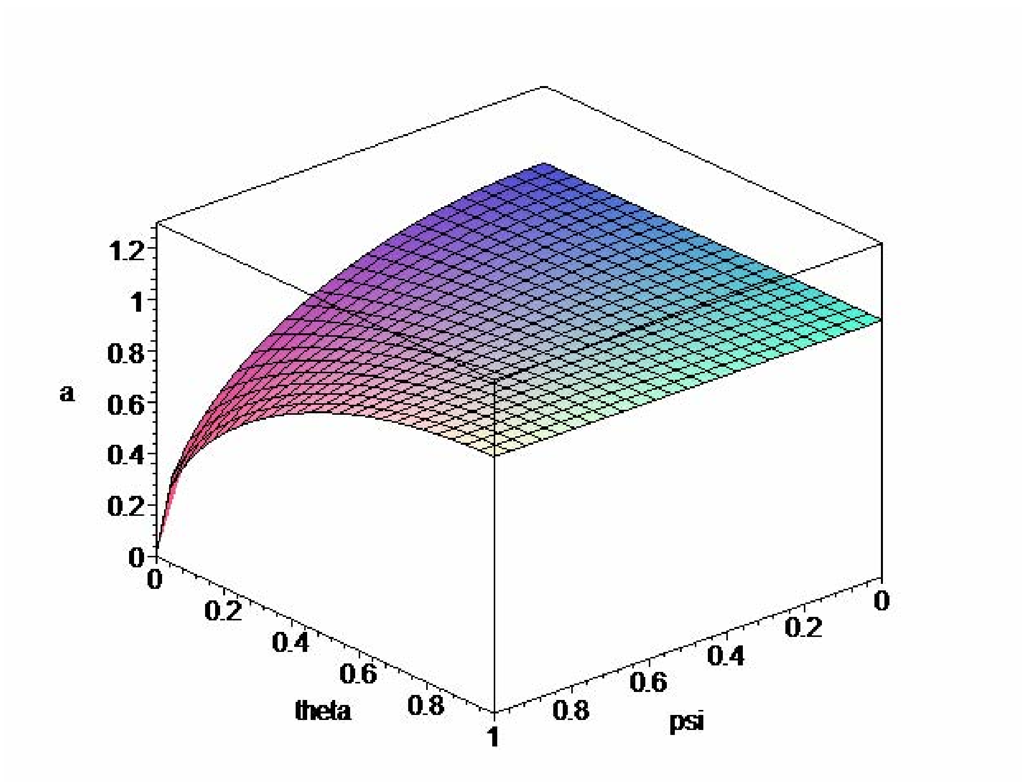

Figure 2.3: *Lohn* vs. arm's length regions as a function of a, θ, ψ, for $\eta = 1$

CHAPTER 3

Evidence Using Firm-Level Data

3.1 Introduction

This chapter offers the first pieces of empirical evidence in support of the predictions of the theoretical model presented in Chapter 2. There we found that a manufacturer is more likely to adopt the production arrangement called *lohn* (the form of international outsourcing in which the outsourcing firm provides the manufacturer with inputs necessary for production) over a standard arm's length transaction when his ability to find low cost inputs is low, his bargaining power is low, or when transaction specificity is low.

In the present chapter we use cross-section data at the firm level to show that, measuring the bargaining power of the manufacturer measured as the ratio of domestic sales to export sales, the manufacturer is more likely to adopt the *lohn* system when this ratio is low than when it is high. Also, consistent with our theoretical model, we find that the lower the index of firm specificity, the higher the likelihood of adoption or the extent of usage of the *lohn* system. We find mixed evidence that, using a firm's number of years in existence as a measure of its ability to get a low-cost input, younger firms are more likely to adopt the *lohn* system.

The empirical analysis in this chapter uses a firm-level dataset that we construct using two unique data sources from the National Institute of Statistics in Romania. These two data sources are also exploited to put together a second dataset, at the firm-product level, which we use for the empirical analysis presented in Chapter 4. Section 3.2 describes the data that were available to us, as well as how both datasets were constructed. We then use the implications from our theory and the data available to construct the empirical variables and arrive at our empirical specification; this step is detailed in Section 3.3.

Section 3.4 presents the results of the empirical analysis using cross-section data at the firm level for the years 2005 and 2006. We show that our results are robust to the use of different estimation procedures (the linear probability model, logit, Tobit) and samples (for different industries, different years, etc). Section 3.5 concludes.

3.2 Data

The data used in this dissertation come from two separate databases at the National Institute of Statistics in Romania: the *Short-Term Indicators Survey* (the IND TS survey) and firms’ annual balance sheets.

In order to measure usage of the *lohn* system we use firm-level data for the years 2005 and 2006 from the IND TS survey conducted by the National Institute of Statistics in Romania. This unique data source allows us to identify, for each firm in the sample, the quantity of each item produced under the *lohn* system each month. This information is essential for our analysis and is not available in other data sources from Romania or other countries. To our best knowledge, this is the first time this data source is used for econometric estimation in general, and in particular, to estimate the determinants of the *lohn* system in Romania.

The following monthly data from the IND TS survey[8] are also available at the firm-product level and are used to construct measures for the determinants of the *lohn* system (our right-hand side variables): inventory at the beginning and at the end of each month, quantity produced in the current month, quantity sold domestically and abroad in the current month, and value of total quantity sold, which is reported in Romanian currency (Leu--code RON[9]). Section 3.3.2 contains a description of how the data was used to construct the variables for the empirical model.

The IND TS survey covers all industries in Romania; however, the data we use is for the following six manufacturing sectors: apparel, textiles, leather goods and footwear, food and beverages, tobacco, and chemicals, chemical products, and man-made fibers.[10] The first three industries on the list are the ones in which the *lohn* production system has been heavily used. The other three industries are used for comparison and include two light industries: food and beverages and tobacco, and one heavy industry: chemicals,

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[8] Additional background information and the sample design for this survey are provided in Appendix 1.
[9] In July 2005 Romania introduced its new redenominated currency, the new leu (code: **RON**), which was valued at 10,000 old leu (code: **ROL**).
[10] Industries are classified according to the NACE (French: Nomenclature Générale des Activités Économiques dans les Communautés Européennes), the European Union industry standard classification. The first four digits of NACE codes are the same for all countries in the EU. For a complete list of NACE codes, see
http://ec.europa.eu/comm/competition/mergers/cases/index/nace_all.html

chemical products, and man-made fibers. Table 3.1 shows that the six industries that are the focus of our analysis account for a significant percentage of output in manufacturing.

In addition to data from the IND TS survey we have information from firm annual balance sheets, which provide important additional characteristics of each firm. These data were released by the National Institute of Statistics in Romania, which collects the information from the Department of Public Finance to whom firms in Romania have the obligation to report annually. We have the following information from the database with annual balance sheets: firm location (at the county level), form of ownership (whether state-owned or private, Romanian or foreign etc, as described in Table 3.2), year of establishment, total revenue (in RON), number of employees, and NACE industry codes at the 2 and 4-digit levels. We use these data to construct measures for the determinants of the *lohn* system (as described in Section 3.3.2), and also for our vector of controls (for details see Section 3.3.3).

Using firm identifiers we matched the records from the two databases and created an annual firm-level dataset that we use to test the predictions of our theoretical model. Details about how the dataset was constructed are provided in Appendix 2. In each year, only firms with Romanian ownership that engaged in export activities in the current year were kept for the purpose of our analysis. In terms of the classification by type of ownership outlined in Table 3.2, we kept only firms with ownership codes 10 and 21 (Romanian, at least 50% state owned), 26 and 31 (Romanian, at least 50% privately owned), and 40 (Romanian cooperative ownership). Also, we eliminated outliers from our sample,[11] i.e. firms with fewer than five employees and those with an annual *TotalRevenue* of over 2 billion RON. Finally, we kept in the sample only the observations for which all the variables were non-missing. Thus, 889 firm-level observations were left in the sample for the year 2005 out of the initial 2,132 for firms with Romanian ownership. Of these, 743 observations are for firms in the textiles, apparel, and footwear industries, while the remaining 146 are for firms in the food processing, tobacco, and chemical products industries. Our firm-level sample for the year 2006 contains 888 observations out of the initial 1,805 for firms with Romanian ownership: 771 of these firms are in the textile-apparel-footwear group, while 117 are firms in the food-tobacco-chemicals group.

3.3 Using the Theory to Develop an Empirical Strategy

3.3.1 Implications of Theory for Empirical Analysis

In the theoretical part of this dissertation we developed a model that analyzes the conditions under which the form of international outsourcing known as the *lohn* system (in which the outsourcing firm provides the manufacturer with the inputs necessary for production) is preferred to a standard arm's length transaction. Simply put, the decision under investigation is over who should control the purchase of inputs. If the outsourcing firm (denoted by F) controls the input purchase decision, the production arrangement is

[11] Note that the results we obtain are robust to the inclusion of outliers, as shown in Table 3.10 and Table 3.11.

called *lohn*. If the manufacturer (R) controls the inputs used for production, then the arrangement is a standard arm's length transaction.

The decision rule is the following: a given production system is adopted if it yields higher net payoffs to both agents in equilibrium or if the agent who gains more pays the other agent to have its preferred system in place. For the outsourcing firm F the difference between the maximum net payoffs available under the two alternative productive arrangements is denoted by Δ_F and is given by:

$$\Delta_F = -\frac{1}{2}\frac{P^2\left[1-\psi\left(1-\theta\right)\right]}{\gamma_F}, \tag{3.1}$$

where $P > 0$ represents the maximum price at which the input is available for purchase on the market; ψ ($0 \le \psi \le 1$) is the parameter for relationship-specificity (i.e. the fraction from the return on investment that the agents lose if the deal falls through and they have to find other agents to work with); θ ($0 \le \theta \le 1$) represents the fraction of *ex post* gains from the relationship obtained by F; and γ_F ($\gamma_F > 0$) represents the disutility of effort for agent F.[12] Note that $\Delta_F \le 0$ for any parameter values in the specified ranges, hence, the outsourcing firm always prefers to control the input purchase decision over allowing the manufacturer to have control over it.

For the manufacturer R the difference between the maximum net payoffs available under a standard arm's length transaction vs. *lohn* is denoted by Δ_R and it is given by:

$$\Delta_R = P^2\,\frac{2\gamma_R\psi\left(\psi\theta^2 - 2\psi\theta + \psi + \theta - 1\right) + \psi_F a^2}{2\gamma_F\gamma_R}, \tag{3.2}$$

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[12] See Section 2.4 for the explanation of how equation (3.1), as well as (3.2) and (3.3) are derived.

where a ($a \geq 0$) represents the relative ability of the manufacturer R to find the low-cost input; γ_R ($\gamma_R > 0$) represents the disutility of effort for agent R; and P, ψ, θ, γ_F have the same meaning as before. Note that, for parameters within the specified range, the sign of Δ_R is ambiguous.

As shown in Section 2.4, the rule simplifies to the following: the *lohn*-system is adopted if and only if $\Delta_R + \Delta_F > 0$ and a standard arm's length transaction is adopted if and only if $\Delta_R + \Delta_F < 0$. In the case $\Delta_R + \Delta_F = 0$, the two agents are indifferent between the two production arrangements. After further manipulations we obtain the following necessary and sufficient condition for the adoption of the *lohn* system:

$$\eta < \frac{1 - \psi^2 \left(1 - \theta\right)^2}{a^2}, \tag{3.3}$$

where $\eta = \frac{\gamma_F}{\gamma_R}$ denotes the relative disutility of effort for F vs. R. This expression of the conditions under which the *lohn*-system is adopted has a relatively straight-forward interpretation, which will make the transition to empirical estimation relatively smooth.

The following implications of the theoretical model can be drawn immediately from expression (3.3):

1. The lower the relative disutility of effort (η) of the foreign buyer F vs. the domestic producer R, the more likely it is that *lohn* will be adopted.
2. The lower the manufacturer's ability to find the low-cost input (a), the more likely it is that the *lohn*-system will be adopted.

3. The lower the fraction of *ex post* gains obtained by the manufacturer (i.e. the lower R's bargaining power $1-\theta$), the more likely it is that the *lohn*-system will be adopted.
4. The lower the relationship-specificity (ψ), the more likely it is that the *lohn*-system will be adopted.

Given the constraints of the data that were available, only implications 2, 3, and 4 are testable empirically and these will be the focus of our analysis from now on. We assume for simplicity that $\eta = 1$, i.e. the two agents have the same disutility of effort. The necessary and sufficient condition for the adoption of the *lohn* system can be re-written as:

$$a^2 + \psi^2 (1-\theta)^2 < 1, \qquad (3.4)$$

where a, θ, η have the meaning explained previously.

3.3.2 Constructing the Empirical Variables Corresponding to the Theoretical Model

In order to test the predictions of the theoretical model the following variables need to be identified: the dependent variable that indicates whether a given firm uses the *lohn* system in a given year and to what extent; the bargaining power of the domestic manufacturer (1-θ, where $0 \le \theta \le 1$); the relative ability of the domestic manufacturer to find the low-cost input (a, where $a \ge 0$); and the parameter for relationship-specificity (ψ, where $0 \le \psi \le 1$, i.e., the fraction of return on investment that the agents lose if the deal falls through and they have to find other agents to work with).

The **dependent variable** is defined in two different ways: binary and continuous. As a binary variable, the left-hand side term captures the decision of the manufacturer to adopt the *lohn* system versus not adopting it. Upon estimation, this measure provides us with the probability that a firm would adopt the *lohn* system in a given year. Alternatively, the dependent variable is defined in a continuous fashion as the fraction of sales under the *lohn* system, exploiting the variation across firms of the share of sales under the *lohn* system. The specific measures constructed for the firm-level dataset are presented in Appendix 3.

Our measure of the **bargaining power of the manufacturer** is based on the interpretation of bargaining power as **patience**, according to the non-cooperative foundations of the Nash bargaining framework. Everything else being the same, the more **patient** player, who can bear the cost of delays in reaching an agreement, has a higher bargaining power. Hence, from here on we call the parameter $(1-\theta)$ **patience** and we devise measures to capture **patience**.

For instance, the manufacturer would be more patient in negotiations with an outsourcing firm if he produced mostly for the domestic market and would not depend much on sales abroad. This situation would be reflected in a high ratio of domestic sales to export sales for the respective company. We use this ratio as a proxy for the manufacturer's patience and implicitly, for the firm's bargaining power.

Another situation in which the manufacturer would be more patient in negotiations with an outsourcing firm would occur if he had a lot of inventory relative to output produced in the previous period. In this case he would want to sell the inventory to generate income before he produces more, so he would be more patient in negotiations about future production. Hence, a higher ratio of inventory to output will make the manufacturer more patient in negotiations with the outsourcing firm. We use this ratio as an alternative measure for the manufacturer's bargaining power. Appendix 3 presents in detail how we construct both the domestic sales to export sales ratio and the inventory to output ratio at the firm level in. The Davidson-MacKinnon J-test for non-nested alternatives that we conducted to determine which of the two variables was more appropriate for our analysis failed to reject either of the two measures. For reasons of exposition, in the text we will present the results obtained by using the domestics sales to export sales ratio as a measure for bargaining power, while the baseline results using the inventory to output ratio are presented in Table 3.13-Table 3.14.

To measure a, the relative **ability of the domestic manufacturer** to find a low-cost input supplier, we use the number of years in operation (*FirmAge*). Everything else being the same, the higher the number of years a firm has been in operation, the greater its reputation and the existing network, and the higher the ability to find a low-cost input supplier. See Appendix 3 for a detailed description of the measures for a.

Finally, the parameter for **relationship specificity** (ψ) is defined in terms of the specificity of the assets and skills involved in production. This in turn is reflected in the number of firms producing that good.[13] Consider for instance what it takes to manufacture men's shirts versus sophisticated embroidered women's tops that require

[13] In his paper on "Credible Commitments: Using Hostages to Support Exchange" (*American Economic Review*, September 1983, 73,5 19-40.),Williamson identifies four distinct sources of specificity (p.526): 1. human capital specificity; 2. physical asset specificity; 3 site specificity; and 4. dedicated assets specificity. The relevance of each of these sources to our discussion can be inferred from the characteristics of the manufacturing industries that are the focus of our analysis. Site specificity is not important because goods produced by most manufacturing industries can be relocated at relatively low costs. This is especially the case in the industries that we analyze. Our measure allows for other sources of hold-up, be it physical assets, human capital investments, or dedicated assets. As explained in the text, we argue that all of these are inversely related to the number of firms that use those assets or those workers.

special embroidering machines or workers specially trained to embroider manually. Since it is much more complicated to manufacture the latter versus the former, there will be many more firms producing men's shirts than women's embroidered blouses. Hence, specificity is related to the size of the production market for any given product manufactured by a firm. The more firms produce a certain product, using the same technology, the more likely it is that the assets and the skills involved are not very specific. The measure for specificity is described in detail in Appendix 3.

3.3.3 Estimation Equation

The qualitative predictions of the theoretical model we want to test are that the *lohn* system is more likely to be used when the ability of the manufacturer to find low cost inputs (a) is low, when his bargaining power ($1-\theta$) is low, and when relationship specificity (ψ) is low. One way to test these predictions using cross-section data is to use a linear model of the form:

$$y_j = \beta_0 + \beta_1 a_j + \beta_2 \psi_j + \beta_3 \left(1-\theta_j\right) + \beta_4 X_j + \varepsilon_j \, , \qquad (3.5)$$

in which j is the subscript for an individual firm; a, θ, η have the same interpretation as above; and X_j represents a vector of controls that we discuss in detail later on in this section. The dependent variable is defined in two different ways: as a binary variable, y_j takes the value one if firm j uses the *lohn* system, and zero otherwise. Alternatively, y_j is defined as a continuous variable that represents firm j's fraction of sales under the *lohn* system. We use these two measures to capture *lohn* system usage in the absence of contract-level data.

Before continuing our discussion of estimation based on the linear model proposed by equation (3.5), we consider whether this model captures the correct relationship between the dependent and the observed explanatory variables. Indeed, the analytical condition for the adoption of the *lohn* system given by expression (3.4) seems to suggest that there might be room for exploiting the functional forms in that expression to arrive at an empirical specification. In particular, expression (3.4) seems to indicate that y_{jt} might depend on $a, 1-\theta$ and/or ψ in a quadratic fashion, or that the model might contain an interaction term between the manufacturer's bargaining power $1-\theta$ and relationship specificity ψ. We have experimented with various model specifications that include these features and have conducted tests for functional form misspecification using the J-test proposed by Davidson and MacKinnon [1981] for non-nested alternative models with the same dependent variable. In general we are not able to conclusively reject the linear model. In particular, when we test the linear model given by equation (3.5) against the following model that uses the functional form in equation (3.4):

$$y_j = \gamma_0 + \gamma_1 a_j^2 + \gamma_2 \psi_j^2 \left(1-\theta_j\right)^2 + u_j, \qquad (3.6)$$

we are able to reject the latter, but not the former[14]. Hence, in the following we will use the linear model captured by equation (3.5) as the main empirical specification and our empirical results will be derived by estimating this equation using different techniques.

Note that in the estimation equation given by (3.5) we control for ownership and location-specific factors that might affect the usage of the *lohn*-system at the firm level.

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[14] See Table 3.9 in the Appendix to Chapter 3 for details.

We do that by putting ownership and county fixed effects into the regression equation, which becomes

$$y_j = \beta_0 + \alpha_j + \delta_j + \beta_1 a_j + \beta_2 \psi_j + \beta_3 \left(1-\theta_j\right) + \beta_4 X_j + \varepsilon_j . \qquad (3.7)$$

Here α_j and δ_j are ownership and county fixed effects. Vector x_j includes other controls for firm size, such as the number of employees (*NumberEmployees*) and the revenue (*TotalRevenue*).

The parameters of interest in equation (3.7) are: β_1, the coefficient on the manufacturer's ability to find low cost inputs (a_j); β_2, the coefficient on relationship specificity (ψ_j), and β_3, the coefficient on the manufacturer's bargaining power ($1-\theta_j$). Based on the theory, the expected signs for these coefficients are: $\beta_1 < 0$; $\beta_2 < 0$; $\beta_3 < 0$.

We use various techniques to estimate Equation (3.7). When the left-hand side variable is binary, we employ both a linear probability model and the binary response model logit. Alternatively, when the dependent variable is the percentage of output produced under *lohn*, i.e. a continuous variable censured at 0 and 1, we use the linear probability and Tobit models to test our predictions. The results of our estimation are presented in Section 3.4.

3.4 Results

3.4.1 Summary Statistics

Table 3.3 presents summary statistics for our main variables at the firm level, for cross-section data in years 2005 and 2006. The statistics are consistent across the two years. On average, over 89% of the surveyed firms from the textiles, apparel, and footwear industries used the *lohn* system in 2005; the same is true for the year 2006. In the other manufacturing group, which includes the food-processing, tobacco, and chemical industries, *lohn* is also used, albeit less, with around 37% of the firms adopting it in each of the two years. As we would expect based on the theory, firms in the textiles, apparel and footwear industries have, on average, domestic sales to export sales ratios and firm specificity a few times lower than firms in the food, tobacco, and chemicals group, in each of the two years.

It is also worth pointing out that both in the industries where *lohn* is widely used, and in the ones in which it is used less, there are firms that produce their entire output in *lohn* (i.e. *PercentageLohnFirm* = 1), but also some that do not use *lohn* at all (i.e. PercentageLohnFirm = 0). Indeed, it is fairly common, particularly for smaller firms with few products, to either produce all their output using the *lohn* system or opt out of it altogether.

Finally, the two groups of industries differ, on average, in terms of total revenue and number of employees. On average, firms in the food processing, tobacco, and chemical industries have about four times the total revenue and double the number of employees that firms in the textiles, apparel, and footwear group do. This reflects the difference in technologies between the two groups of industries and the fact that the latter is much more capital intensive than the former. In the following sections we discuss how these differences can explain the results we obtain when the theoretical model is applied to one group of industries versus the other.

3.4.2 Baseline Results

Table 3.4 presents baseline results for the estimation of equation (3.7) using cross-section data at the firm level for the year 2005. The sample includes only the observations for the textiles, apparel, and footwear industries. The manufacturer's ability to find low cost inputs is measured by the number of years a firm has operated (*FirmAge*). The manufacturer's bargaining power is measured by the weighted average of the firm's domestic sales to export sales, using the shares of the different products in the firm's total output as weights (*HomeSalesToExportSalesRatio2*). *FirmSpecificity* measures the coefficient of relationship specificity. The construction of all the measures is explained in Appendix 3. Each specification includes the controls for firm size mentioned in Section 3.3.3, as well as ownership and county dummies. Heteroskedasticity-robust standard errors are given in brackets.

Columns 1 and 2, where the dependent variable *LohnFirm* is binary, look at the impact of the explanatory variables on the probability that the firm adopts the *lohn* system. Column 1 of Table 3.4 shows the results of ordinary least squares estimation. As expected, all the coefficients of interest are negative and the coefficient on *FirmSpecificity* is statistically significant at the 5% level. In column 2 of the table we present the results of estimating the same specification using logit instead of OLS. When estimating the logit model Stata dropped the observations for which only one value of a predictor variable was associated with only one value of the response variable (a situation known as *perfect prediction*)[15]. In this way the sample was reduced from 743 to 639 observations. For the sake of consistency and in order to be able to compare the magnitude of estimates across specifications, we used the reduced sample in all the other estimations[16]. The logit estimates reported are marginal effects, not regression coefficients. All the estimates keep the correct sign, but the coefficient on *FirmSpecificity* is now significant only at the 10% level. Note also that the scaled estimates for logit (obtained by dividing the logit estimates by 4) are larger in magnitude than the OLS estimates for all the variables of interest. For instance, the scaled estimate of *FirmAge* is -0.01, which is higher than the OLS coefficient of -0.003. Similarly, for the coefficient on *FirmSpecificity*, the scaled logit estimate is -0.502, which is higher than the OLS estimate of -0.279.

We use predicted probabilities to interpret the results of logit estimation. Table 3.8(b) shows that the predicted probability of a firm's adopting the *lohn* system is 0.684, if the parameter for firm specificity is equal to one, whereas if that parameter is very low, the probability goes up to 0.941 (while the other regressors are held constant at their mean value). The firm's domestic sales to export sales ratio seems to have a weaker effect on the probability that a firm in the apparel, textiles, or footwear industry will adopt the *lohn* system, For very high values of the domestic sales to export sales ratio, which in our interpretation corresponds to high bargaining power of the domestic manufacturer, the predicted probability of adopting the *lohn* system is 0.888 and it increases to 0.934 when

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[15] For instance, if all the firms in textiles, apparel, and footwear, located in the same county used the *lohn* system in 2005, or if none of them did, Stata dropped the corresponding observations from the sample before running the logit model.

[16] Note, however, that the results we obtain are robust to the inclusion of the observations dropped by logit. Table 3.12 presents the results for OLS and Tobit for the sample that includes all 743 observations, for the year 2005.

this ratio is very low, i.e. when the bargaining power of the domestic manufacturer is low (see Table 3.8(c)). Finally, firm age seems to have little impact on the probability that a firm in the apparel, textiles, or footwear industry will adopt the *lohn* system: the probability of adoption is 0.954 for new starters, and 0.922 for firms that have been operating for 14 years.

Columns 3 and 4 of Table 3.4 present the results of estimating the effect of the explanatory variables on the extent to which the *lohn* system is used, i.e. on the share of exports under the *lohn* system (continuous dependent variable *PercentageLohnFirm*). The rest of the specification is identical to the one in the first two columns. The estimation techniques used in this case are ordinary least squares and Tobit, which is appropriate given the continuous nature of our dependent variable, bounded between 0 and 1. The Tobit estimates reported are marginal effects, not regression coefficients. As predicted by the theoretical model, all the estimates of interest have negative sign, meaning that the extent to which *lohn* is used is higher when the manufacturer's ability to find low cost inputs (a_j) is low, when his bargaining power ($1-\theta$) is low, and when relationship specificity (ψ_j) is low. The coefficient on *FirmSpecificity* is now statistically significant at the 1% level. Note also that, just as logit estimation implied greater impact of the independent variables on the left-hand side variable than OLS estimation did, marginal effects after Tobit in column 4 are higher than OLS estimates in column 3 for all the variables of interest.

The four models used for estimation in Table 3.4 are also used to analyze the sample for the food, tobacco, and chemicals industry for the year 2005 and the results are reported in Table 3.5. The first aspect to note is that the coefficients on the firm domestic sales to export sales ratio and on firm specificity have the expected negative sign. This indicates that the predictions of the theoretical model hold for this group of industries as well, albeit with some differences. For the food, tobacco, and chemicals industry, the measure for bargaining power is highly statistically significant across specifications, while the measure for specificity is significant at the 10% level or better only in 2 out of the 4 models. This result is different from what we found for the textile, apparel, and footwear industries, where the measure for firm specificity was highly statistically significant, while the measure for bargaining power was not.

In interpreting the above results it is useful to recall the implications of the theoretical model. Specificity matters directly for determining the disagreement-payoff. Our results seem to indicate that the disagreement payoff affects the apparel, textiles, and footwear industry more than the food, tobacco, and chemicals group. Bargaining power, on the other hand, matters directly in determining the division of the surplus, which seems to affect the food, tobacco, and chemicals industry, but not so much apparel, textiles, and footwear.

Finally, the coefficient on firm age is positive, though insignificant, across specifications in Table 3.5, indicating that older firms in these industries are more likely to adopt the *lohn* system. We believe that this result reflects the fact that *FirmAge* captures many other firm characteristics in addition to the manufacturer's ability to find low cost inputs that we want to measure.

In view of the above we conclude that our baseline results offer support for our intuition and the predictions of our theoretical model. Our results indicate that low specificity and bargaining power make firms in all industries analyzed more likely to use the *lohn* system, However, specificity shows up stronger in the apparel, textile, and footwear industry, while bargaining power has a stronger effect in the food, tobacco, and chemicals group. Our results also indicate that younger firms are more likely to adopt the *lohn* system in the apparel, textiles, and footwear industry, but not in the food, tobacco, and chemicals industry. We believe that this result illustrates the fact that the age of the firm captures many other characteristics apart from its ability to find low-cost inputs.

3.4.3 Robustness Checks

We test the robustness of our results by conducting the empirical analysis on data from 2006. Table 3.6 and Table 3.7 report the findings of the estimations using cross-section data at the firm level for the year 2006[17]. We find a remarkable similarity with the results obtained for the year 2005, which provides additional validation for the theory, as well as for the empirical approach used to test it. Table 3.6 is the equivalent of Table 3.4 for the year 2006, using the corresponding sample for the textile, apparel, and footwear industries. Just like in Table 3.4, all coefficients of interest have the expected sign across all specifications. Moreover, the coefficients on *FirmSpecificity* are statistically significant at the 1% level, while the coefficients on the ratio of domestic sales to export sales are not statistically significant. Unlike in Table 3.4, the coefficient on firm age is statistically significant at the 5% level or better in 3 of the 4 specifications.

Table 3.7 is the equivalent of Table 3.5 and the results are very similar to the ones obtained for the year 2005: the coefficient on firm age is positive, but not

[17] We do not show the results of panel data analysis using the firm-level dataset because firm fixed effects use up too many degrees of freedom. However, the analysis using panel data at the firm-product level for the years 2005 and 2006 supports our predictions based on the theoretical model. See Chapter 4 for details.

statistically significant, across specifications. The coefficient on domestic sales to export sales ratio is negative and statistically significant at the 5% level or better in three of the four specifications. Finally, the coefficient on *FirmSpecificity* is negative and statistically significant at the 10% level in two of the four specifications. Note that, just like in the analysis for the year 2005, specificity, and through it, the disagreement payoffs, seem to matter more in the apparel, textiles, and footwear industries, while the division of surplus has a stronger impact in the food, tobacco, and chemical industries.

3.5 Conclusions

In this chapter we present the empirical strategy and the data used to test the theoretical model developed in Chapter 2 and perform analysis using cross-section data at the firm-level. We start by describing the unique data that we were able to obtain from the National Institute of Statistics in Romania. These data include firm-level information on physical production and balance sheet items for a large number of firms in Romania, collected monthly over several years. We explain how we use these data to construct two datasets (one at the firm-level and one at the firm-product level) for the empirical analysis, as well as the empirical variables corresponding to the theoretical model. For example, firm age is used to measure a manufacturer's ability to find low cost inputs; the ratio of domestic to export sales measures the manufacturer's bargaining power; and the index for relationship specificity is inversely related to the number of firms that produce a certain good.

The remainder of the chapter is dedicated to testing the main predictions of the theoretical model on cross-section data at the firm-level for the years 2005 and 2006.

Analysis using the product-level dataset, for both cross-section and panel data is presented in the next chapter. In general, the results support the predictions of the theoretical model for both groups of industries analyzed. For instance, the probability of adopting the *lohn* system is inversely related to the manufacturer's bargaining power and to specificity. However, the results suggest that the different technologies in the two groups of industries may matter: relationship specificity and the division of surplus seem to have a stronger effect in the apparel, textiles, and footwear industries, while bargaining power affects more the food, tobacco, and chemicals group. Firm age offers partial support to our prediction that firms with a lower ability to find low-cost inputs are more likely to use *lohn*. We obtain that younger firms are more likely to adopt the *lohn*-system in the apparel, textiles, and footwear industries, but that older firms are more likely to do so in the food, tobacco, and chemicals industry. We believe that this result shows that firm age picks up other firm characteristics in addition to the ability to find low cost inputs, which makes the overall effect ambiguous. Our results are robust to the use of various estimation procedures, measures and samples.

Tables

Table 3.1: Percentage of Total Manufacturing Output Corresponding to Industries in the Sample

Industry	Year 2004	Year 2005	Year 2006
Food and beverages	17.24%	17.22%	15.96%
Tobacco products	1.87%	1.72%	1.61%
Textile products	2.86%	2.58%	1.95%
Clothing products	5.02%	4.03%	3.72%
Leather goods and footwear	2.23%	1.88%	1.84%
Chemical substances and products	7.41%	5.87%	5.65%
Total	36.63%	33.30%	30.72%

Note: Percentages were calculated based on annual production figures in value terms.
Source: National Institute of Statistics in Romania website: www.insse.ro.

Table 3.2: Classification of Romanian Firms by Type of Ownership, with Corresponding Codes

Description	Code
Full State Ownership	10
Mixed ownership, more than 50% state-owned	
State+Romanian Private	21
State+Foreign	22
State+Romanian Private+Foreign	23
Mixed ownership, less than 50% state-owned	
State+Romanian Private	26
State+Foreign	27
State+Romanian Private+Foreign	28
Private Ownership (Romanian or Romanian+Foreign)	
Romanian	31
Romanian+Foreign	32
Cooperative Ownership	40
Full Foreign Ownership	60

Source: National Institute of Statistics in Romania

Table 3.3: Summary Statistics at the Firm-Level: Years 2005 and 2006

Variable	Obs	Mean	Std. Dev.	Min	Max
Year 2005					
Textiles&Apparel&Footwear					
LohnFirm	743	0.89	0.31	0.00	1.00
PercentageLohnFirm	743	0.61	0.35	0.00	1.00
FirmAge	743	9.60	4.22	0.00	14.00
FirmHSESRatio1	743	3.83	17.64	0.00	296.13
FirmHSESRatio2	743	2.38	9.34	0.00	119.99
FirmSpecificity	743	0.06	0.14	0.00	1.00
TotalRevenue	743	4.52	9.58	0.01	150.30
NumberEmployees	743	184.44	275.64	5.00	2097.00
Food&Tobacco&Chemicals					
LohnFirm	146	0.38	0.49	0.00	1.00
PercentageLohnFirm	146	0.33	0.46	0.00	1.00
FirmAge	146	11.37	3.94	0.00	14.00
FirmHSESRatio1	146	14.23	44.39	0.00	360.21
FirmHSESRatio2	146	14.37	37.80	0.00	246.92
FirmSpecificity	146	0.17	0.25	0.00	1.00
TotalRevenue	146	45.86	132.04	0.07	1442.07
NumberEmployees	146	309.75	553.47	5.00	5275.00
Year 2006					
Textiles&Apparel&Footwear					
LohnFirm	771	0.90	0.29	0.00	1.00
PercentageLohnFirm	771	0.84	0.33	0.00	1.00
FirmAge	771	9.07	5.32	0.00	15.00
FirmHSESRatio1	771	4.44	29.69	0.00	521.21
FirmHSESRatio2	771	1.79	8.66	0.00	169.23
FirmSpecificity	771	0.05	0.12	0.00	1.00
TotalRevenue	771	4.65	8.87	0.01	106.67
NumberEmployees	771	178.98	241.51	5.00	1919.00
Food&Tobacco&Chemicals					
LohnFirm	117	0.37	0.48	0.00	1.00
PercentageLohnFirm	117	0.33	0.47	0.00	1.00
FirmAge	117	12.09	3.99	0.00	15.00
FirmHSESRatio1	117	10.87	28.67	0.00	175.24
FirmHSESRatio2	117	18.30	77.52	0.00	710.80
FirmSpecificity	117	0.17	0.23	0.00	1.00
TotalRevenue	117	65.32	177.41	0.11	1731.81
NumberEmployees	117	355.23	583.47	6.00	5048.00

Table 3.4: Baseline Results at the Firm Level: Textiles&Apparel&Footwear, 2005

	2005: Textiles&Apparel&Footwear			
	Dep. Var.: **LohnFirm**		Dep. Var.: **PercentageLohnFirm**	
	1	2	3	4
	(OLS)	(LOGIT)	(OLS)	(TOBIT)
FirmAge	**-0.003**	**-0.041**	**-0.005**	**-0.019**
	[0.003]	**[0.042]**	**[0.003]**	**[0.012]**
FirmHSESRatio2	**-0.001**	**-0.005**	**-0.001**	**-0.004**
	[0.001]	**[0.013]**	**[0.002]**	**[0.004]**
FirmSpecificity	**-0.279****	**-2.007***	**-0.539*****	**-0.991*****
	[0.138]	**[0.833]**	**[0.136]**	**[0.271]**
TotalRevenue	-0.021***	-0.220***	-0.020***	-0.074***
	[0.004]	[0.056]	[0.004]	[0.011]
NumberEmployees	0.001***	0.007***	0.001***	0.002***
	[0.000]	[0.002]	[0.000]	[0.000]
Constant	0.783***	-1.416	0.582**	1.109
	[0.250]	[3.551]	[0.227]	[0.703]
Observations	639	639	639	639
R-squared	0.25		0.33	

Table 3.5: Baseline Results at the Firm Level: Food&Tobacco&Chemicals, 2005

	2005: Food&Tobacco&Chemicals			
	Dep. Var.: **LohnFirm**		Dep. Var.:**PercentageLohnFirm**	
	1	2	3	4
	(OLS)	(LOGIT)	(OLS)	(TOBIT)
FirmAge	**0.016**	**0.109**	**0.017**	**0.104***
	[0.014]	**[0.088]**	**[0.014]**	**[0.056]**
FirmHSESRatio2	**-0.003*****	**-0.294*****	**-0.003****	**-0.220*****
	[0.001]	**[0.114]**	**[0.001]**	**[0.083]**
FirmSpecificity	**-0.264**	**-2.848***	**-0.333****	**-2.611**
	[0.185]	**[1.498]**	**[0.132]**	**[1.578]**
TotalRevenue	-0.001	-0.011*	0	-0.008
	[0.001]	[0.006]	[0.001]	[0.005]
NumberEmployees	0	0.002**	0	0.001
	[0.000]	[0.001]	[0.000]	[0.001]
Constant	0.011	-4.154*	0.077	-3.317*
	[0.361]	[2.232]	[0.344]	[1.888]
Observations	89	89	89	89
R-squared	0.36		0.33	

Robust standard errors in brackets

All specifications include ownership and county dummies

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3.6: Robustness to Sample Selection: Textiles&Apparel&Footwear, 2006

	2006: Textiles&Apparel&Footwear			
	Dep. Var.: **LohnFirm**		Dep. Var.:**PercentageLohnFirm**	
	1	2	3	4
	(OLS)	(LOGIT)	(OLS)	(TOBIT)
FirmAge	**-0.008****	**-0.103*****	**-0.007*****	**-0.018**
	[0.003]	**[0.037]**	**[0.003]**	**[0.011]**
FirmHSESRatio2	**-0.003**	**-0.022**	**-0.004**	**-0.011****
	[0.003]	**[0.022]**	**[0.003]**	**[0.005]**
FirmSpecificity	**-0.526*****	**-3.456*****	**-0.744*****	**-2.027*****
	[0.156]	**[0.920]**	**[0.170]**	**[0.370]**
TotalRevenue	-0.011***	-0.120*	-0.015***	-0.055***
	[0.004]	[0.063]	[0.005]	[0.009]
NumberEmployees	0.000***	0.005**	0.000***	0.002***
	[0.000]	[0.002]	[0.000]	[0.000]
Constant	0.736***	-2.041	0.795***	1.133**
	[0.280]	[1.316]	[0.286]	[0.540]
Observations	649	649	649	649
R-squared	0.21		0.31	

Table 3.7: Robustness to Sample Selection: Food&Tobacco&Chemicals, 2006

	2006: Food&Tobacco&Chemicals			
	Dep. Var.: **LohnFirm**		Dep. Var.: **PercentageLohnFirm**	
	1	2	3	4
	(OLS)	(LOGIT)	(OLS)	(TOBIT)
FirmAge	**0.018**	**0.103**	**0.016**	**0.106**
	[0.015]	**[0.099]**	**[0.015]**	**[0.120]**
FirmHSESRatio2	**-0.001*****	**-0.179****	**-0.001*****	**-0.26**
	[0.000]	**[0.081]**	**[0.000]**	**[0.171]**
FirmSpecificity	**-0.643***	**-4.192**	**-0.709***	**-6.051**
	[0.327]	**[3.576]**	**[0.355]**	**[4.593]**
TotalRevenue	-0.001***	-0.023	-0.001	-0.028
	[0.000]	[0.016]	[0.000]	[0.024]
NumberEmployees	-0.000***	0.000	-0.000**	0.000
	[0.000]	[0.002]	[0.000]	[0.002]
Constant	0.163	-0.217	0.123	0.911
	[0.411]	[3.931]	[0.440]	[5.785]
Observations	64	64	64	64
R-squared	0.48		0.43	

Robust standard errors in brackets

All specifications include ownership and county dummies

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3.8(a-c): Predicted Probabilities Year 2005

Table 3.8(a)

FirmAge	Prediction for *LohnFirm*
0	0.954
1	0.953
2	0.951
3	0.949
4	0.947
5	0.945
6	0.942
7	0.940
8	0.938
9	0.935
10	0.933
11	0.930
12	0.928
13	0.925
14	0.922

Table 3.8(b)

FirmSpecificity	Prediction for *LohnFirm*
0.003	0.941
0.010	0.940
0.0714	0.933
0.151	0.922
0.250	0.907
0.333	0.892
0.411	0.876
0.500	0.855
0.542	0.844
0.690	0.801
0.808	0.761
0.940	0.709
0.965	0.699
1	0.684

Table 3.8(c)

FirmHomeSalesExportSaleRatio2	Prediction for *LohnFirm*
0.010	0.934
0.504	0.934
1.022	0.934
7.473	0.932
15.447	0.930
25.199	0.926
36.0254	0.923
59.141	0.914
81.286	0.905
119.986	0.888

Table 3.9: J test for non-nested models

H0: M1	t(2675)	-1.242
H1 : M2	p-val	0.215
H0 : M2	t(2676)	7.871
H1 : M1	p-val	0.000

Note: M1 is the linear model given by equation (3.5), while M2 is the model with quadratic terms from equation (3.6)

Table 3.10: Robustness to Inclusion of Outliers: Year 2005

	2005: Textiles&Apparel&Footwear			
	Dep. Var: **LohnFirm**		Dep. Var: **PercentageLohnFirm**	
	1	2	3	4
	(OLS)	(LOGIT)	(OLS)	(TOBIT)
FirmAge	**0.000**	**-0.005**	**-0.001**	**-0.005**
	[0.002]	**[0.030]**	**[0.003]**	**[0.012]**
FirmHSESRatio2	**0.000**	**-0.005**	**-0.001**	**-0.005**
	[0.001]	**[0.013]**	**[0.002]**	**[0.005]**
FirmSpecificity	**-0.295****	**-2.061****	**-0.552*****	**-1.130*****
	[0.137]	**[0.797]**	**[0.135]**	**[0.307]**
TotalRevenue	-0.017***	-0.213***	-0.019***	-0.081***
	[0.004]	[0.053]	[0.004]	[0.012]
NumberEmployees	0.000***	0.006***	0.000***	0.002***
	[0.000]	[0.002]	[0.000]	[0.000]
Constant	0.903***	-1.03	0.780**	-1.005*
	[0.255]	[1.600]	[0.196]	[0.590]
Observations	771	771	771	771
R-squared	0.18		0.26	

Robust standard errors in brackets
All specifications include ownership and county dummies
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3.11: Robustness to Inclusion of Outliers: Year 2006

	2006: Textiles&Apparel&Footwear			
	Dep. Var: **LohnFirm**		Dep. Var: **PercentageLohnFirm**	
	1	2	3	4
	(OLS)	(LOGIT)	(OLS)	(TOBIT)
FirmAge	**-0.007*** **	**-0.104*** **	**-0.007*** **	**-0.019***
	[0.003]	**[0.036]**	**[0.003]**	**[0.012]**
FirmHSESRatio2	**-0.003**	**-0.022**	**-0.004**	**-0.011** **
	[0.003]	**[0.022]**	**[0.003]**	**[0.005]**
FirmSpecificity	**-0.469*** **	**-3.338*** **	**-0.668*** **	**-1.802*** **
	[0.146]	**[0.870]**	**[0.162]**	**[0.354]**
TotalRevenue	-0.012***	-0.119**	-0.015***	-0.056***
	[0.004]	[0.058]	[0.005]	[0.009]
NumberEmployees	0.000***	0.005***	0.000***	0.002***
	[0.000]	[0.002]	[0.000]	[0.000]
Constant	0.696***	-0.581	0.620***	-0.057
	[0.206]	[1.417]	[0.195]	[0.695]
Observations	658	658	658	658
R-squared	0.20		0.29	

Table 3.12: Robustness to Inclusion of Observations Dropped by Logit: Year 2005

	2005: Textiles&Apparel&Footwear		
	Dep. Var: **LohnFirm**	Dep. Var: **PercentageLohnFirm**	
	1	2	3
	(OLS)	(OLS)	(TOBIT)
FirmAge	**-0.003**	**-0.005**	**-0.019**
	[0.003]	**[0.003]**	**[0.012]**
FirmHSESRatio2	**-0.000**	**-0.001**	**-0.004**
	[0.001]	**[0.002]**	**[0.004]**
FirmSpecificity	**-0.279** **	**-0.539*** **	**-0.991*** **
	[0.138]	**[0.136]**	**[0.271]**
TotalRevenue	-0.017***	-0.020***	-0.074***
	[0.004]	[0.004]	[0.011]
NumberEmployees	0.000***	0.000***	0.002***
	[0.000]	[0.000]	[0.000]
Constant	-0.783***	0.582**	1.109
	[0.250]	[0.227]	[0.703]
Observations	743	743	743
R-squared	0.25	0.33	

Robust standard errors in brackets
All specifications include ownership and county dummies
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3.13: Baseline Results Using the Inventory to Output Ratio: Year 2005

	2005: Textiles&Apparel&Footwear			
	Dep. Var: **LohnFirm**		Dep. Var: **PercentageLohnFirm**	
	1	2	3	4
	(OLS)	(LOGIT)	(OLS)	(TOBIT)
FirmAge	**-0.004**	**-0.044**	**-0.005**	**-0.019**
	[0.003]	**[0.042]**	**[0.003]**	**[0.012]**
FirmIORatio2	**0.001**	**-0.004**	**-0.001**	**-0.005**
	[0.001]	**[0.013]**	**[0.002]**	**[0.004]**
FirmSpecificity	**-0.286****	**-2.073****	**-0.534*****	**-0.976*****
	[0.138]	**[0.850]**	**[0.138]**	**[0.271]**
TotalRevenue	-0.018***	-0.219***	-0.020***	-0.074***
	[0.004]	[0.056]	[0.004]	[0.010]
NumberEmployees	0.000***	0.007***	0.000***	0.002***
	[0.000]	[0.002]	[0.000]	[0.000]
Constant	0.778***	1.497	0.585**	1.106
	[0.249]	[3.511]	[0.228]	[0.702]
Observations	639	639	639	639
R-squared	0.25		0.31	

Table 3.14: Baseline Results Using the Inventory to Output Ratio: Year 2006

	2006: Textiles&Apparel&Footwear			
	Dep. Var: **LohnFirm**		Dep. Var: **PercentageLohnFirm**	
	1	2	3	4
	(OLS)	(LOGIT)	(OLS)	(TOBIT)
FirmAge	**-0.007*****	**-0.108*****	**-0.007*****	**-0.018*****
	[0.003]	**[0.037]**	**[0.003]**	**[0.012]**
FirmIORatio2	**-0.000**	**-0.006**	**-0.003**	**-0.008****
	[0.001]	**[0.008]**	**[0.003]**	**[0.005]**
FirmSpecificity	**-0.533*****	**-3.411*****	**-0.744*****	**-2.033*****
	[0.158]	**[0.942]**	**[0.171]**	**[0.372]**
TotalRevenue	-0.011***	-0.123***	-0.015***	-0.056***
	[0.004]	[0.067]	[0.005]	[0.009]
NumberEmployees	0.000***	0.005***	0.000***	0.002***
	[0.000]	[0.002]	[0.000]	[0.000]
Constant	0.735***	-1.517	0.795***	-0.338
	[0.281]	[1.355]	[0.285]	[0.636]
Observations	649	649	649	649
R-squared	0.20		0.30	

Robust standard errors in brackets

All specifications include ownership and county dummies

* significant at 10%; ** significant at 5%; *** significant at 1%

CHAPTER 4

Evidence Using Firm-Product-Level Data

4.1 Introduction

In this chapter we use the dataset constructed at the firm-product level to test empirically the determinants of the adoption of the *lohn* system. The predictions of the theoretical model from Chapter 2 are now tested under the assumption that the theory applies at the firm-product level and that the decision to adopt a production arrangement is made independently for each good produced by multi-product firms. In reality, it is reasonable to assume that a firm's ability to find low-cost inputs for the production of a given good is affected by the fact that the same firm also produces other goods for which the same input might be used. Along the same lines, it can be argued that a firm's bargaining power and the specificity of the relationship for the production of one good depend on the other goods the firm produces. However, analyzing the effects of these spillovers on the variables of interest is beyond the scope of this work and in the following analysis we ignore any product interdependencies.

The remainder of the chapter is organized as follows. Section 4.2.1 reports the summary statistics for the 2005 cross-section and for the two-year panel at the firm-product level. Section 4.2.2 presents the measures that we use, as well as the empirical specification. Section 4.3.1 reports the results of the empirical analysis using cross-section data at the firm-product level for the year 2005. In general the predictions of the theoretical model are confirmed by the analysis of these data. Section 4.3.2 shows that our results are robust to the selection of different samples (for different industries, different years, etc.) and of a different measure for one of the key variables. The results of the analysis using the two-year panel are presented in Section 4.4. Further evidence is offered in support of the predictions of the theoretical model about the impact of the manufacturer's bargaining power and of relationship specificity on the use of the *lohn* system. Due to the inclusion of firm dummies in the specification *FirmAge* does not add any new information to the model, so we are not able to show conclusively the impact of the ability of the manufacturer to find low cost inputs for the production of a good on the use of *lohn* for that good. Section 4.5 concludes; a few suggestions for possible extensions of the empirical analysis are also included here.

4.2 Summary Statistics, Empirical Variables, and Estimation Equation

4.2.1 Summary Statistics

Summary statistics for the main variables at the firm-product level are presented in Tables 4.1 and 4.2. The cross-section data for the year 2005 is summarized in Table

4.1. The sample contains 2964 observations for the apparel, textiles, and footwear industries and 313 observations for the food, tobacco, and chemicals industry. The statistics are consistent with the ones we observed at the firm-level: the *lohn* system seems to be used in both groups of industries analyzed, but more in the apparel, textiles, and footwear group, than in food, tobacco, and chemicals. On average, about 90% of the products in textiles, apparel, and footwear were produced using the *lohn* system in 2005, while in the food-processing, tobacco, and chemical industries, on average, *lohn* was used to produce about 37% of the goods. Note that in both industry groups there are products that are always produced under *lohn* (i.e. *PercentageLohnProduct*=1), but also products that are never produced under the *lohn* system. Also, as we would expect based on the theory, products in apparel, textiles, and footwear have product inventory-to-output ratio, domestic sales to export sales ratio and product specificity a few times lower than firms in the food, tobacco, and chemicals industries. Finally, products in apparel, textiles, and footwear have lower, on average, total revenue and fewer employees than do products in food, tobacco, and chemicals.

Table 4.2 presents the summary statistics for the two-year panel for the years 2005 and 2006. The sample at the firm-product level contains 5135 observations for the apparel, textiles, and footwear group and 420 observations for the food, tobacco, and chemicals industries. The same observations apply as for the cross-sections. In the apparel, textiles, and footwear industries, on average, 92% of the goods are produced under this production arrangement, compared to 33% in the industries in the food, tobacco, and chemicals industries. Again, the product inventory-to-output ration, the product domestic sales to export sales ratio, product specificity, as well as total revenue and the number of employees are lower for products in apparel, textiles, and footwear, than for products in the food, tobacco and chemicals industries.

4.2.2 Empirical Variables and Estimation Equation

The empirical variables used to measure the variables of interest from the theoretical model with firm-product-level data[18] are often the product-level counterparts of the measures at the firm-level. Specifically, in order to measure the manufacturer's bargaining power we propose two alternative measures: one is based on the ratio of domestic to export sales of a product by a given firm (*ProductHSESRatio*), while the other one uses the inventory to output ratio (*ProductIORatio*). Also, specificity is measured by *ProductSpecificity*, a measure inversely related to the number of firms producing a certain product. Finally, for the manufacturer's ability to find low cost inputs we use the number of years a firm has operated (*FirmAge*). The motivation for choosing these measures conceptually is discussed in Section 3.3.2, while details related to the construction of the measures are provided in Appendix 3.

For the analysis of cross-section data at the firm-product level we use the following regression equation:

$$y_{ji} = \beta_0 + \alpha_j + \delta_j + \beta_1 a_{ji} + \beta_2 \psi_{ji} + \beta_3 \left(1 - \theta_{ji}\right) + \beta_4 X_j + \varepsilon_{ji}, \qquad (4.1)$$

where j is the subscript for firms and i is the subscript for products. α_j and β_j are ownership and county dummies, and the vector of controls includes the number of employees (*NumberEmployees*) and the firm's revenue (*TotalRevenue*). The parameters

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[18] See Appendix 2 for details about how the firm-product-level dataset was constructed.

of interest in this equation are: β_1, the coefficient on the manufacturer's ability to find low cost inputs for the production of good i (a_{ji}); β_2, the coefficient on the specificity of producing good i by firm j (ψ_{ji}), and β_3, the coefficient on the manufacturer's bargaining power in negotiations for the production of good i ($1-\theta_{ji}$). Based on the theory, the expected signs for these coefficients are: $\beta_1 < 0; \beta_2 < 0; \beta_3 < 0$. The results from estimating this equation using various techniques are presented in Section 4.3.

For the analysis of the two-year panel the basic regression equation is:

$$y_{jit} = \beta_0^* + \gamma_j + \beta_1^* a_{jit} + \beta_2^* \psi_{jit} + \beta_3^* \left(1-\theta_{jit}\right) + \beta_4^* X_{jt} + u_{jit}, \qquad (4.2)$$

where t is the time subscript and γ_j is the dummy for firm j. The other variables have the interpretations presented above. Section 4.4 presents results obtained from panel-data estimation.

4.3 Cross-Section Results

4.3.1 Baseline Results

Table 4.3 displays our baseline results from the estimation of equation (4.1) using data at the firm-product level for the year 2005. The sample that was used for these estimations includes only the observations for the textiles, apparel and footwear industries. The first two columns of the table present results obtained for specifications with a binary dependent variable, while in the last two columns the dependent variable is defined in a continuous fashion, as detailed in Section 4.2.2. The ability of the manufacturer to find low-cost inputs is still measured by *FirmAge*, a variable that captures the number of years that the company has operated. *ProductHSESRatio* averages the monthly ratio of domestic to export sales of a good by a given firm over a year and is used to measure the manufacturer's bargaining power. Finally, the parameter of relationship specificity is measured by *ProductSpecificity*, which is defined as the inverse of the number of firms that produce a certain good in a given year. The construction of all the measures is detailed in Appendix 3. In each specification in Table 4.3 we control for each company's annual revenue (*TotalRevenue*) and number of employees (*NumberEmployees*), and we include ownership and county dummies. Robust standard errors are given in brackets.

Column 1 of Table 4.3 presents the results of ordinary least squares estimation to analyze the impact of the right-hand side variables on the probability that the firm uses the *lohn* system for the production of a certain good. The coefficients of interest are all negative, as predicted by the theory. Moreover, the coefficients on the product ratio of domestic sales to export sales and *ProductSpecificity* are statistically significant at the 10% level or better, while the coefficient on *FirmAge* is not statistically significant. These observations hold true when we estimate the same specification using logit instead of OLS, as illustrated in column 2 of Table 4.3. The logit estimates presented in the table are marginal effects, not regression coefficients. In order to interpret the results of logit estimation we calculated predicted probabilities, which are displayed in Table 4.4(a)-(c).

Table 4.4.(c) shows that, on average, if a product is produced by only one company, the probability that it is produced under the *lohn* system is about 76%, compared to 96% if 20 companies produce that good (keeping all the other regressors at their mean values). The product's ratio of domestic sales to export sales seems to have a

smaller impact on the probability of adopting the *lohn* system in the apparel, textiles, and footwear industries. Table 4.4.(b) shows that, on average the predicted probability of adopting the *lohn* system drops from about 95% to about 85% as the ratio of domestic sales to export sales increases. Finally, Table 4.4(a) shows that the number of years a firm has operated has almost no impact on the probability that it will use the *lohn* system for the productions of a given good.

In the specifications for columns 3 and 4 of Table 4.3 the dependent variable is continuous (*PercentageLohnProduct*) and what we estimate is the impact of the explanatory variables on the share of sales of a product under the *lohn* system. We keep the rest of the specification the same as for the first two columns in the table. The new specification is estimated using ordinary least squares and Tobit, for which we report marginal effects. The conclusions from the first two columns also hold for these estimations. As predicted by our theoretical model, we obtain that the extent to which *lohn* is used is negatively related to the manufacturer's ability (as measured by the firm's age) to find low cost inputs a_{ij}, to his bargaining power ($1-\theta$, which we measure as the producer's dependence on exports relative to the domestic market), and to the coefficient for specificity (ψ). Just as before, the coefficients on product specificity and the ratio of domestic sales to export sales are statistically significant, both at the 1% level, while the coefficient on *FirmAge* is not statistically significant.

The four models used for estimation in Table 4.3 are also used to analyze the sample for the food, tobacco, and chemicals industry for the year 2005 and the results are reported in Table 4.5. The coefficients of the measures for bargaining power and relationship specificity are negative across specifications, as we would expect based on the theory. Moreover, the coefficient of the product ratio of domestic sales to export sales is statistically significant at the 1% level in all specification. The coefficient of product specificity is statistically significant at the 1% level in the logit specification, at the 5% level when we use Tobit, and at the 10% level in the OLS estimation with a continuous dependent variable. This coefficient is not statistically significant in the estimation using the linear probability model. The same pattern can be observed as in the analysis using firm-level data: the degree of relationship specificity seems to have a stronger effect on *lohn* adoption and extent of use in the apparel, textiles, and footwear industries. Meanwhile, the way the surplus is divided seems have a stronger effect on that decision in the food, tobacco, and chemicals industries.

The coefficient of firm age is positive across all specifications in Table 4.5, seeming to indicate that in the food, tobacco and chemicals industry, older firms are more likely to adopt and use the *lohn* system. This is the same result we got in the analysis of firm-level data for these industries and we believe the same explanation holds as to why we see this result.

Based on the analysis above, we conclude that in general our baseline results using cross-section data at the firm-product level support our intuition that the predictions of the theoretical model presented in Chapter 2 apply to multi-product firms if we ignore product interdependence. The measures that we use provide strong evidence that relationship specificity and the manufacturer's bargaining power are inversely related to the adoption and extent of usage of the *lohn* system. While specificity seems to matter more in the apparel, textiles, and footwear industries, bargaining power and the division of surplus seem to be more important in the group with food, tobacco, and chemicals industries. We get mixed evidence that the manufacturer's ability to find the low-cost input is inversely related to the probability that a firm will adopt for the production of a certain good. We believe this result is due to the fact that firm age, which is used to measure the manufacturer's ability to find low-cost inputs, also captures many other firm characteristics and we do not have a way to isolate the different effects of these other characteristics on the probability that the *lohn* system will be used.

4.3.2 Robustness Checks

In the following we subject our results to robustness tests and show that they still hold. We start by checking the sensitivity of our results to sample selection. Table 4.6 reports the results of the analysis performed on the 2006 cross-section data from the textiles, apparel, and footwear industries. The results are remarkably similar to the baseline results from Table 4.3. All coefficients of interest have negative sign across specifications, as predicted by the theoretical model. The coefficient of product specificity is statistically significant at the 1% level in all four specifications, while the coefficient of the product ratio of domestic sales to export sales is significant only in the logit specification. Once again we observe that, in the apparel, textiles, and footwear industries, the degree of relationship specificity has a stronger impact on the use of the *lohn* system than does the division of the surplus. Also, the coefficient on firm age is statistically significant at the 1% level across specifications, indicating that younger firms are more likely to use the *lohn* system than older firms.

We have also tested the sensitivity of the results to a different measure for the manufacturer's bargaining power. The sample used for analysis is the 2005 cross-section at the firm-product level from the apparel, textiles, and footwear industries. The results reported in Table 4.7 were obtained by using the ratio of inventory to output (*ProductIORatio*) instead of the ratio of domestic to export sales (*ProductHSESRatio*) to measure the producer's bargaining power. Note that the results obtained here are in excellent agreement with our baseline results from Table 4.3. All the coefficients of interest have the correct sign in all the specifications, showing that *lohn* is more likely to be used when the manufacturer's ability to find low cost inputs is low, when his bargaining power is low, and when the coefficient for relationship specificity is low. The estimates are statistically significant at the 1% for product specificity, at the 10% or better for the measure of bargaining power, and not statistically significant for firm age.

The robustness checks discussed above offer additional evidence in support of the baseline results presented in the previous section. Based on the results reported in both sections we conclude that the predictions of the theoretical model are in general validated by the analysis of cross-section data at the product-firm level. Next, we present some results obtained for the analysis of panel data.

4.4 Panel Data Results

The panel that we use is a two-year panel for the years 2005 and 2006. Table 4.8 reports the results obtained for the sample from the apparel, textiles, and footwear industries using the same models and measures as for the baseline results in Table 4.3. Hence, the ability to find low-cost inputs is measured by *FirmAge*; the manufacturer's bargaining power is measured by the *ProductHSESRatio*, while *ProductSpecificity* measures the degree of relationship specificity[19]. The vector of controls includes firms' annual revenue (*TotalRevenue*) and number of employees (*NumberEmployees*), as well as county and ownership fixed effects. Heteroskedasticity-robust standard errors are included in brackets.

The results are in excellent agreement with the baseline results we used with cross-section data. All coefficients of interest are negative across specifications, as predicted based on the theoretical model. The coefficients of *ProductHSESRatio* and *ProductSpecificityi* are statistically significant at the 5% level or better in all specifications, while the coefficient on *FirmAge* is not statistically significant. We get the same results when we use the two-year panel sample from the food, tobacco, and chemicals industries, as illustrated in Table 4.9.

We also report some results obtained when firm dummies are included in the specification. Note that in these cases we drop ownership and county dummies from the estimation equations, since they become redundant in the presence of firm dummies. Controlling for individual firm characteristics is desirable: models that include firm dummies in the vector of controls explain much more of the variation in the data than similar specifications that control for the type of ownership and location, but not for individual firm characteristics. For instance, the R square for OLS estimation is over 0.74 or better for specifications that include firm dummies, as opposed to less than 0.2 for regressions that include ownership and county dummies instead.

Table 4.10 reports the results of the analysis with firm dummies in, for the sample from apparel, textiles, and footwear industries. Columns 1 and 2 present results of OLS

[19] The construction of all the measures is detailed in Section 3.3.2 and in Appendix 3.

estimation: in the first column the dependent variable is binary, while in the second column it is continuous. For both specifications the estimates for *ProductHSESRatio* and *ProductSpecificity* have the negative sign that we expect from our theory, but the coefficients are not statistically significant. This is because the inclusion of firm dummies eliminates most of the variation in the variables. The coefficient of *FirmAge* is positive and statistically significant at the 1% level. In columns 3 and 4 of Table 4.10 *FirmAge* is dropped from the specifications, otherwise, the models are the same. The estimates for the other coefficients do not change almost at all, and the new R-squares are identical to the ones for the specifications in which *FirmAge* was included. We conclude that *FirmAge* is redundant in the model with firm dummies and cannot be used to measure the manufacturer's ability to find low-cost inputs; hence, we are not able to test this prediction of the theoretical model. However, as discussed above, we are still able to bring some evidence in support of the other two testable predictions of the model.

Note also that our baseline results include OLS estimates, but no results for logit or Tobit estimation. In the case of the logit the reason is that, in the presence of firm dummies, the model drops most of the observations due to perfect prediction (see Footnote 14 for an explanation of this issue) and runs the regression on a very restricted sample (511 observations as compared to the 5,135 that are used for OLS estimation). In the case of Tobit, the model fails to achieve convergence due to severe censoring at 1.

We also present the results of the analysis with firm dummies in using a different measure for one of the key variables. Table 4.11 presents the results obtained when an alternative measure is used for the manufacturer's bargaining power (*ProductIORatio*) and the conclusions of that analysis are exactly the same. The coefficients on

ProductHSESRatio and *ProductSpecificity* are negative, but statistically insignificant across specifications, while the coefficient on *FirmAge*, when included in the specification, has a positive sign. When *FirmAge* is dropped, in columns 3 and 4 of Table 4.11, we again see that *FirmAge* does not add new information to the model in the presence of firm dummies.

We conclude that panel data brings further evidence in support of the predictions of the theoretical model that *lohn* is more likely to be used when the manufacturer's bargaining power is low and when relationship specificity is low. However, due to the limitations of the data available, the analysis of panel-data cannot provide conclusive evidence in support of the prediction that the use of *lohn* is inversely related to the manufacturer's ability to find low cost inputs.

4.5 Conclusions

This chapter brings new insights to understanding the decision to adopt the *lohn* system, by using a firm-product-level dataset to study this decision under the assumption that all firms behave like multi-products firms and ignoring potential product-interdependencies. First we develop an empirical approach similar to the one in Chapter 3 to test the predictions of the theoretical model using cross-section data at the firm-product level for the years 2005 and 2006 and we find that those predictions hold under the assumptions of this chapter. For example, firms are more likely to use *lohn* for the production of goods when the manufacturer's bargaining power (measured as the ratio of domestic to export sales or as the ratio of inventory to output) is low, or when the degree of relationship specificity, measured as a product specificity index, is low. We are not able to obtain conclusive evidence about the prediction that manufacturers with low ability to find low-cost inputs are more likely to use the *lohn* system. This is because firm age, the measure that we use for this theoretical variable, also captures other firm characteristics that we do not control for in this model.

In this chapter we also test the implications of our theory on a two-year panel for 2005 and 2006, in addition to the annual cross-sections for the two years. The results provide additional support for the predictions of the theory about the impact of the manufacturer's bargaining power and of relationship specificity on the use of *lohn*. Again, we do not have conclusive evidence about the relationship between the manufacturer's ability to find low-cost inputs and the adoption of the *lohn* system. We also conduct a series of robustness tests and find that our results are not sensitive, for instance, to sample selection or to the choice of measure for one of the key variables.

Apart from testing the predictions of the model developed in Chapter 2, the data can be exploited further to answer other interesting questions, such as what is the impact of the *lohn* system on a firm's productivity and output. An answer to this question might shed light on whether firms in a given industry should adopt the *lohn* system and whether this production arrangement could be a viable long-term option or just a short-term strategy.

We also plan to extend the empirical analysis conducted in this dissertation. Currently our analysis uses firm and product level datasets from six industries in Romania to test the implications of the theoretical model. However, the broader question of why the *lohn* system is adopted can be tested at the country or industry level by exploiting the variation in the usage of the *lohn* system across countries/industries. For instance, it would be possible to gain some insight into how different institutions may affect outcomes at this micro level by comparing adoption of the *lohn* system by firms in the same industry but in two countries that differ in the institutions affecting the industry in specific ways, and/or that experienced changes in these institutions that could be regarded as exogenous.

Tables

Table 4.1: Summary Statistics for Annual Cross-Sections: Year 2005

Variable	Obs	Mean	Std.Dev.	Min	Max
Textiles&Apparel&Footwear					
LohnProduct	2964	0.90	0.30	0.00	1.00
PercentageLohnProduct	2964	0.87	0.31	0.00	1.00
FirmAge	2964	10.17	4.12	0.00	14.00
ProductIORatio	2964	5.5	51.99	0.00	1614.30
ProductHSESRatio	2964	6.54	53.26	0.00	1624.98
ProductSpecificity	2964	0.05	0.12	0.00	1.00
TotalRevenue	2964	5.93	10.11	0.01	150.30
NumberEmployees	2964	282.30	397.13	5.00	2097.00
Food&Tobbaco&Chemicals					
LohnProduct	313	0.37	0.49	0.00	1.00
PercentageLohnProduct	313	0.34	0.47	0.00	1.00
FirmAge	313	11.49	4.16	0.00	14.00
ProductIORatio	313	8.65	60.10	0.00	938.40
ProductHSESRatio	313	22.37	91.72	0.00	1232.44
ProductSpecificity	313	0.20	0.27	0.00	1.00
TotalRevenue	313	83.98	254.14	0.07	1442.07
NumberEmployees	313	469.40	953.53	5.00	5275.00

Table 4.2: Summary Statistics for Two-Year Panel Data

Variable	Obs	Mean	Std.	Min	Max
Textiles&Apparel&Footwear					
LohnProduct	5135	0.92	0.27	0.00	1
PercentageLohnProduct	5135	0.89	0.29	0.00	1.00
FirmAge	5135	10.11	4.90	0.00	15
ProductIORatio	5135	9.60	73.64	0.00	1682.105
ProductHSESRatio	5135	9.74	79.98	0.00	3295.64
ProductSpecificity	5135	0.05	0.12	0.00	1.00
TotalRevenue	5135	6.60	9.76	0.01	94.69
NumberEmployees	5135	304.43	386.95	5.00	2097.00
Food&Tobbaco&Chemicals					
LohnProduct	420	0.33	0.47	0.00	1
PercentageLohnProduct	420	0.31	0.46	0.00	1.00
FirmAge	420	12.79	3.67	0.00	15
ProductIORatio	420	2.42	10.48	0.00	144.5334
ProductHSESRatio	420	27.39	114.93	0.00	1481.72
ProductSpecificity	420	0.24	0.29	0.00	1.00
TotalRevenue	420	129.06	335.68	0.12	1731.81
NumberEmployees	420	628.86	1097.23	5.00	5275.00

Table 4.3: Baseline Results at the Firm-Product Level: Textile&Apparel&Footwear, Cross-Section, Year 2005

	2005: Textiles&Apparel&Footwear			
	Dep. Var: **LohnFirm**		Dep. Var: **PercentageLohnFirm**	
	1	2	3	4
	(OLS)	(LOGIT)	(OLS)	(TOBIT)
FirmAge	**-0.002**	**-0.025**	**-0.002**	**-0.011**
	[0.002]	**[0.024]**	**[0.002]**	**[0.013]**
ProductHSESRatio	**-0.025***	**-0.323***	**-0.034***	**-0.182***
	[0.015]	**[0.118]**	**[0.012]**	**[0.048]**
ProductSpecificity	**-0.280***	**-1.922***	**-0.405***	**-1.439***
	[0.074]	**[0.426]**	**[0.050]**	**[0.209]**
TotalRevenue	-0.018***	-0.170***	-0.017***	-0.059***
	[0.002]	[0.020]	[0.002]	[0.005]
NumberEmployees	0.004***	0.069***	0.006***	0.017***
	[0.000]	[0.006]	[0.000]	[0.001]
Constant	0.064	-1.773*	0.045	-1.663***
	[0.158]	[0.911]	[0.137]	[0.625]
Observations	2643	2643	2643	2643
R-squared	0.27		0.29	

Robust standard errors in brackets
All specifications include ownership and county dummies
* significant at 10%, ** significant at 5%, ***significant at 1%

Table 4.4: Predicted Probabilities

Table 4.4(a)

FirmAge	Prediction
0	0.962
1	0.961
2	0.960
3	0.959
4	0.958
5	0.957
6	0.956
7	0.955
8	0.954
9	0.953
10	0.952
11	0.951
12	0.950
13	0.949
14	0.947

Table 4.4(b)

ProductHSESRatio	Prediction
.1	0.953
5.522	0.952
10.016	0.951
25.477	0.949
50.104	0.945
99.931	0.937
197.396	0.918
419.713	0.853

Table 4.4(c)

ProductSpecificity	Lohn predicted probability
.005	0.956
.05	0.952
.1	0.947
.2	0.937
.25	0.931
.5	0.892
1	0.756

Table 4.5: Baseline Results at the Firm-Product Level: Food&Tobacco&Chemicals, Cross-Section, Year 2005

	2005: Food&Tobacco&Chemicals			
	Dep. Var: **LohnFirm**		Dep. Var: **PercentageLohnFirm**	
	1	2	3	4
	(OLS)	(LOGIT)	(OLS)	(TOBIT)
FirmAge	**0.007**	**0.109****	**0.009**	**0.159**
	[0.008]	**[0.047]**	**[0.007]**	**[0.072]**
ProductHSESRatio	**-0.170*****	**-34.949*****	**-0.156*****	**-41.666*****
	[0.050]	**[11.036]**	**[0.046]**	**[11.592]**
ProductSpecificity	**-0.114**	**-2.126****	**-0.178***	**-3.091****
	[0.101]	**[1.008]**	**[0.091]**	**[1.513]**
TotalRevenue	-0.007*	-0.019***	0.000	-0.024***
	[0.004]	[0.006]	[0.000]	[0.009]
NumberEmployees	0.010*	0.013*	-0.002**	0.01
	[0.006]	[0.008]	[0.001]	[0.011]
Constant	-1.498**	1.445	0.588**	-0.561
	[0.729]	[1.911]	[0.322]	[2.420]
Observations	246	246	246	246
R-squared	0.35		0.4	

Robust standard errors in brackets
All specifications include ownership and county dummies.
* significant at 10%, ** significant at 5%, ***significant at 1%

Table 4.6: Robustness to Sample Selection: Cross-Section, Year 2006

	2006: Textiles&Apparel&Footwear			
	Dep. Var: **LohnFirm**		Dep. Var: **PercentageLohnFirm**	
	1	2	3	4
	(OLS)	(LOGIT)	(OLS)	(TOBIT)
FirmAge	**-0.004*** **	**-0.070*** **	**-0.004*** **	**-0.027*** **
	[0.001]	**[0.021]**	**[0.001]**	**[0.012]**
ProductHSESRatio	**-0.019**	**-0.266*** **	**-0.020**	**-0.125**
	[0.014]	**[0.112]**	**[0.017]**	**[0.130]**
ProductSpecificity	**-0.425*** **	**-3.313*** **	**-0.442*** **	**-2.256*** **
	[0.080]	**[0.563]**	**[0.083]**	**[0.343]**
TotalRevenue	-0.009***	-0.079***	-0.010***	-0.059***
	[0.002]	[0.018]	[0.002]	[0.007]
NumberEmployees	0.002***	0.032***	0.003***	0.024***
	[0.000]	[0.006]	[0.000]	[0.003]
Constant	0.649**	1.505	0.527*	0.423
	[0.330]	[1.848]	[0.299]	[1.282]
Observations	2416	2416	2416	2416
R-squared	0.19		0.21	

Table 4.7: Robustness to Change in Measure: Cross-Section, Year 2005

	2005: Textiles&Apparel&Footwear			
	Dep. Var: **LohnFirm**		Dep. Var: **PercentageLohnFirm**	
	1	2	3	4
	(OLS)	(LOGIT)	(OLS)	(TOBIT)
FirmAge	**-0.002**	**-0.025**	**-0.002**	**-0.011**
	[0.002]	**[0.024]**	**[0.002]**	**[0.012]**
ProductIORatio	**-0.030***	**-0.297*** **	**-0.042** **	**-0.229** **
	[0.015]	**[0.081]**	**[0.017]**	**[0.066]**
ProductSpecificity	**-0.279*** **	**-1.956*** **	**-0.338*** **	**-1.438*** **
	[0.074]	**[0.477]**	**[0.072]**	**[0.287]**
TotalRevenue	-0.018***	-0.208***	-0.019***	-0.122***
	[0.002]	[0.028]	[0.002]	[0.010]
NumberEmployees	0.004***	0.057***	0.004***	0.028***
	[0.000]	[0.000]	[0.000]	[0.003]
Constant	0.064	2.705	-0.12	2.727***
	[0.158]	[2.100]	[0.154]	[0.840]
Observations	2643	2643	2643	2643
R-squared	0.27		0.30	

Robust standard errors in brackets
All specifications include ownership and county dummies.
* significant at 10%, ** significant at 5%, ***significant at 1%

Table 4.8 Panel Data, No Firm Dummies: Textiles&Apparel&Footwear

	2005-2006: Textiles&Apparel&Footwear			
	LohnProduct	**PercentageLohn**	**LohnProduct**	**PercentageLohn**
	1	2	3	4
	(OLS)	(LOGIT)	(OLS)	(TOBIT)
FirmAge	**-0.001**	**-0.001**		
	[0.001]	**[0.001]**		
ProductHSESRatio	**-0.009****	**-0.011****	**-0.010****	**-0.011****
	[0.005]	**[0.005]**	**[0.005]**	**[0.005]**
ProductSpecificity	**-0.362*****	**-0.393*****	**-0.363*****	**-0.395*****
	[0.055]	**[0.055]**	**[0.055]**	**[0.055]**
TotalRevenue	-0.016***	-0.018***	-0.016***	-0.018***
	[0.001]	[0.001]	[0.001]	[0.001]
NumberEmployees	0.003***	0.004***	0.003***	0.004***
	[0.000]	[0.000]	[0.000]	[0.000]
Constant	0.949***	0.922***	0.944***	0.915***
	[0.008]	[0.009]	[0.005]	[0.005]
Observations	5135	5135	5135	5135
R-squared	0.17		0.17	

Table 4.9: Panel Data, No Firm Dummies: Food&Tobacco&Chemicals

	2005-2006: Food&Tobacco&Chemicals			
	LohnProduct	**PercentageLohn**	**LohnProduct**	**PercentageLohn**
	1	2	3	4
	(OLS)	(LOGIT)	(OLS)	(TOBIT)
FirmAge	**-0.004**	**-0.001**		
	[0.007]	**[0.007]**		
ProductHSESRatio	**-0.073*****	**-0.066*****	**-0.074*****	**-0.067*****
	[0.022]	**[0.020]**	**[0.022]**	**[0.020]**
ProductSpecificity	**-0.334*****	**-0.331*****	**-0.334*****	**-0.331*****
	[0.069]	**[0.065]**	**[0.069]**	**[0.065]**
TotalRevenue	0.000	0.000	0.000	0.000
	[0.001]	[0.001]	[0.001]	[0.001]
NumberEmployees	0.000	-0.001***	0.000	-0.001***
	[0.001]	[0.000]	[0.001]	[0.000]
Constant	0.507***	0.461***	0.465***	0.450***
	[0.087]	[0.087]	[0.034]	[0.032]
Observations	420	420	420	420
R-squared	0.11		0.11	

Robust standard errors in brackets
All specifications include ownership and county dummies
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4.10: Results for Panel Data, Firm Dummies in: Textiles&Apparel&Footwear

	2005-2006: Textiles&Apparel&Footwear			
	LohnProduct	**PercentageLohn**	**LohnProduct**	**PercentageLohn**
	1	2	3	4
	(OLS)	(OLS)	(OLS)	(OLS)
FirmAge	**0.015*** **	**0.017*** **		
	[0.005]	**[0.006]**		
ProductHSESRatio	**-0.004**	**-0.004**	**-0.004**	**-0.004**
	[0.003]	**[0.003]**	**[0.003]**	**[0.003]**
ProductSpecificity	**-0.046**	**-0.016**	**-0.049**	**-0.011**
	[0.045]	**[0.042]**	**[0.045]**	**[0.042]**
TotalRevenue	-0.001	-0.006***	-0.002	-0.005
	[0.003]	[0.003]	[0.003]	[0.003]
NumberEmployees	0.001***	0.002***	0.001	0.001**
	[0.000]	[0.000]	[0.000]	[0.000]
Constant	0.745***	0.571***	0.991***	0.990***
	[0.080]	[0.081]	[0.006]	[0.005]
Observations	5135	5135	5135	5135
R-squared	0.74	0.77	0.74	0.77

Table 4.11: Robustness to Change in Measure: Panel Data 2005-2006

	2005-2006: Textiles&Apparel&Footwear			
	LohnProduct	**PercentageLohn**	**LohnProduct**	**PercentageLohn**
	1	2	3	4
	(OLS)	(OLS)	(OLS)	(OLS)
FirmAge	**0.015*** **	**0.027*** **		
	[0.005]	**[0.005]**		
ProductIORatio	**-0.005**	**-0.004**	**-0.005**	**-0.005**
	[0.005]	**[0.004]**	**[0.005]**	**[0.004]**
ProductSpecificity	**-0.046**	**0.016**	**-0.049**	**0.011**
	[0.045]	**[0.042]**	**[0.045]**	**[0.042]**
TotalRevenue	0.001	-0.006**	0.002	-0.005
	[0.003]	[0.003]	[0.003]	[0.003]
NumberEmployees	0.001**	0.002***	0.001	0.001**
	[0.000]	[0.000]	[0.000]	[0.000]
Constant	0.756***	0.573***	0.991***	0.991***
	[0.080]	[0.081]	[0.006]	[0.005]
Observations	5135	5135	5135	5135
R-squared	0.74	0.77	0.74	0.77

Robust standard errors in brackets

All specifications include firm dummies

* significant at 10%; ** significant at 5%; *** significant at 1%

APPENDICES

Appendix 1. The Short-term Indicators Survey: Background and Sample Design

The Short-term Indicators Survey (or the IND TS survey) is a monthly industry survey that the National Institute of Statistics in Romania (henceforth referred to as NIS) has conducted without interruption since January 2000. Initially, the data collected through this survey included information on physical production and turnover for a representative sample of firms from all industries in Romania. Since January 2005 the survey has been expanded to include information on several other dimensions: the value of firm contracts signed with domestic and foreign partners, the number of employees, wages, and investments.

In the following we describe the **sample design** for the IND TS survey:

1. For a given year, the pool from which the sample is drawn is made up of all firms, in all industries, which were active two years before. A firm is considered to be active in a given year if the average number of employees or annual turnover is different from zero.

2. Firms from the original pool that have four or fewer employees are dropped, provided that firms left in the pool account for at least 90% of turnover and at least 90% of the number of employees in each industry. For industries in which this criterion is not met, only firms with two or fewer employees are dropped. For the year 2007, after dropping firms from the original pool in this fashion, the firms that were left accounted for 94.47% of turnover and 94.01% of all employees from the original pool.

3. Stratified random sampling with a Neyman allocation is used instead of simple random sampling in this sample design.[20] The principle underlying the Neyman allocation method is that it produces the minimum sample size which will provide an estimate with a fixed sampling variance of turnover.[21] The characteristics used to stratify firms are the NACE code and the employment size class.

4. For the largest employment size class (in our case, 50 or more employees), this allocation procedure places all the firms in those strata in the sample. In other words, all firms with 50 or more workers for all industries are included in the national sample.

5. As employment decreases, smaller proportions of firms are included in the sample according to the Neyman allocation method, so as to obtain the minimum sample size that will provide an estimate of turnover with a fixed sampling variance. From any given stratum firms are drawn randomly, with all firms belonging to the same stratum having the same probability of being included in the sample.

6. The size of the national sample is determined such that, with probability .95, average turnover for firms in the sample differs by at most 3% from average turnover for

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[20] Information on stratified sampling obtained from the *BLS Handbook of Methods* available at http://www.bls.gov/opub/hom/homch9_g.htm

[21] Please refer to http://www.amstat.org/Sections/Srms/Proceedings/papers/1996_033.pdf for more information on the Neyman allocation method.

all firms in all strata. This feature of the sample design also ensures that the sample is representative of the underlying population.

Appendix 2. Construction of the Two Datasets

Recall that the data from the IND TS survey are monthly data at the product level for a number of firms and that most of the data are in physical units. Specifically: inventory at the beginning of the month, quantity produced in the current month, inventory at the end of the month, quantity sold domestically and abroad in the current month, and quantity produced under the *lohn* system in the current month are all in physical units and not in value terms. The only data available in monetary terms is total sales in the month of reporting, which is the sum of sales abroad, sales domestically, and sales of products produced under the *lohn* system. Total sales in the month of reporting are given in the Romanian currency Leu (RON).

We use these data to construct yearly firm-product level and firm-level datasets, which we can merge with the annual data available from firms' balance sheets. First we convert to monetary values all the information that is available in physical units: inventory at the beginning of the month, quantity produced in the current month, quantity sold in the current month (domestically, abroad and under the *lohn* system), and inventory at the end of the month. This is achieved by using the average price per unit sold of each product, which we calculate as follows:

$$Average\ price\ per\ unit = \frac{total\ sales}{\begin{matrix} qty.sold\ to \\ the\ domestic\ market \end{matrix} + \begin{matrix} qty.sold \\ abroad \end{matrix} + \begin{matrix} qty.sold \\ of\ goods\ produced \\ under\ lohn\ system \end{matrix}}$$

The above formula for calculating average price per unit of a product implicitly assumes that the price per unit is the same for units sold domestically, for units sold abroad, as well as for units sold that were produced under the *lohn* system, which seems like a reasonable assumption in this case.

Next, we multiply the average price per unit calculated as above by the amount in physical units to get monthly figures at the firm-product level. We then add up the monthly figures to get annual figures at the firm-product level, then sum over all products for each firm to obtain annual data at the firm level. The results of these manipulations are an annual firm-product level dataset and an annual firm-level dataset in which the production variables are expressed in monetary units.

Appendix 3. Measuring Variables of Interest from the Theoretical Model

A.3.1. The Dependent Variable

a. For the annual firm-product level dataset we construct the following alternative measures of the dependent variable:

- *LohnProduct*: binary variable that takes on the value one if the value of quantity sold of a good produced under *lohn* in a given year is greater than zero, and zero otherwise.

- *Percentage_LohnProduct:* the share of sales under *lohn* system at the firm-product level, calculated as the sales of a product under the *lohn* system divided by total export sales of a product in a given year.

b. For the annual firm-level dataset we construct the following measures of the dependent variable:

- *LohnFirm*: the counterpart of *LohnProduct* in the firm-level dataset, focusing on whether a firm has positive sales of output produced under the *lohn* system for any of its products in a given year. If it does, then the *LohnFirm* variable takes the value one, otherwise, it takes the value zero.
- *Percentage_LohnFirm:* the correspondent of *Percentage_LohnProduct* in the firm-level dataset, calculated as the sales of a product under the *lohn* system summed over all the products the firm produces, divided by the total export sales of all products in a given year.

A.3.2. Bargaining Power of the Manufacturer

a. For the annual firm-product level dataset:

- *ProductHSESRatio*: for each firm-product entry in a given month we measure the numerator as sales to the domestic market that month and the denominator as export sales that month. We then convert this ratio to annual figures by calculating its value for all months in a year, summing up the twelve values and dividing by twelve.
- *ProductIORatio*: for each firm-product entry in a given month we measure the numerator as inventory at the beginning of the current month and the denominator as

output in the previous month. We then convert this ratio to annual figures by calculating its value for all months in a year, summing up the twelve values and dividing by twelve;

b. For the annual firm-level dataset we construct two alternative measures that are the equivalent of the variables described above:

- *FirmHSESRatio*, which we calculate in two different ways. The first one is to take a simple average of the *ProductHSESRatio's* described above for all the products the firm produces. The second way to measure this ratio is to construct a weighted average of the *ProductHSESRatio's* over all the products manufactured by a given firm and use the shares of sales of the products as weights. We construct this measure as follows: 1. we multiply the annual *ProductHSESRatio* for a given product by the share of that product in the firm's total annual sales and 2. we sum over all the products produced by the firm. Note that the weighted average takes into account the share of each product in the total output of the firm, hence giving a higher weight to the products with the higher share. Meanwhile, the simple average gives all products the same weight. Hence, we prefer *FirmHSESRatio*2 and we use the other measure only for consistency checks.

- *FirmIORatio*: we use the same two different ways to calculate this ratio as in the case of the *FirmHSESRatio*. *FirmIORatio1* is calculated by taking a simple average of the *ProductIORatio*'s described above, for all the products produced by a given firm. In order to construct *FirmIORatio2* we calculate a weighted average of the *ProductIORatio*'s over all the products manufactured by a given firm and use the shares of sales of the products as weights. This involves two steps: 1. multiplying the annual *ProductIORatio* for a given product by the share of that product in the firm's total annual sales and 2. summing over all the products of the firm. The same considerations apply as to why the measure based on weighted average should be preferred to the one based on simple averaging.

A.3.3. Ability of the Manufacturer to Find Low-Cost Inputs

a. For the annual firm-product level dataset:

- *TotalSales_Annual*: Value of output or sales of a product in a given year. It is measured in monetary units (Romanian Leu--RON)

b. For the annual firm-level dataset:

- *AnnualRevenue:* the annual variable that we got from the firms' balance sheets. It is measured in monetary units (Romanian Leu--RON)
- *NumberEmployees:* average number of employees as reported in the firm's balance sheet for the current year.
- *FirmAge*: equal to the year of reporting minus the year the firm was established, as reported in the firm's balance sheet.

A.3.4. Parameter for Specificity

a. For the firm-product level dataset we construct the variable *ProductSpecificity* as the inverse of the number of firms which produce a certain product in that year.

b. For the firm-level dataset we construct the variable *FirmSpecificity* as follows: We use a weighted average of the *ProductSpecificity* for all the products produced by any given firm using the share of output in the total firm output as weights.

In order to calculate this measure, we first take the ratio of the output of a given product for any given firm in a year to total output of that firm in that year. Then we multiply that ratio by the inverse of the number of firms in the sample which produce that product in that year. Finally, we sum up the figures obtained in this fashion over all the products sold by the firm in that year. The procedure described above is captured by the formula: $E_{jt} = \sum_{k=1}^{n} s_{jkt} e_{kt}$, where k is one of the n products produced by firm j in year t, $s_{jkt} = \frac{S_{jkt}}{\sum_{k=1}^{n} S_{jkt}}$ is the share of product k in firm's j total sales in year t, and $e_{kt} = \frac{1}{n_{kt}}$ represents the inverse of the number of firms that produce good k in year t.[22]

[22] A similar measure for specificity is used in Gonzalez-Diaz, Manuel, Benito Arrunada and Alberto Fernandez (2000), "Causes of subcontracting: evidence from panel data on construction firms" *Journal of Economic Behavior and Organization*, 42, pp. 167-187.

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