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Entrusted Outsourcing, Productive Performance and Risks.

An Application to French Manufacturing Firms

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Contents

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Abstract

To analyse the relationship between entrusted outsourcing and firms' productive performance, we propose a model with three equations: a selection equation for the status of the contracting firm, an equation of interest for the volume of outsourcing and an equation for performance as a function of the (estimated) amount of outsourcing.

Based on an unbalanced sample of 27,311 French manufacturing firms over the period 1998-2007, our estimates indicate that firms' performance has a positive effect on the probability of being outsourcer. The best-performing firms are also those for which the volume of outsourcing is highest. Outsourcing improves the performance of firms in low and medium technology sectors, while it reduces performance in high and medium-high technology sectors. This reduction is particularly noticeable for the firms that turn most to subcontracting; there is a U-shaped relationship between outsourcing and performance in these sectors. We also observe that firms use outsourcing to externalise cyclical risks, but they prefer to internalise technological risks. Finally, firms do not seem to use outsourcing as a means to minimise their production costs.

Keywords: Outward subcontracting; corporate performance; cyclical risks; technological risks.

JEL Classification: D23; L22.

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Introduction

Since the early 1990s, a trend towards increased use of outsourcing has been observed, although this is not a new phenomenon. In France, industrial outsourcing doubled between 1985 and 2003, growing from 5% of industrial production (expressed in terms of value added) to nearly 10% (SESSI, 2005). This places France in a rather intermediate position in Europe: the countries where the intensity of subcontracting is highest include Portugal (14%) and Poland (11%), while at the other end of the scale are Belgium (6%), the Netherlands (6%) and Romania (5%) (Eurostat, 2008). Germany has a slightly lower rate of outsourcing intensity (7%) than France does.

Over the years, outsourcing has also become more internationally-oriented. Hummels *et al.* (2001) show that for ten OECD countries and four emerging countries, trade in components represents 21% of those countries' exports. Their results also indicate that international outsourcing grew by nearly 30% between 1970 and 1990. More recently, using a sample of five European countries (Germany, Austria, Italy, Finland, the Netherlands), Falk and Wolfmayr (2008) show that the share of materials imports compared to the added value in the manufacturing sector increased from 7.3% in 1995 to 8.9% in 2000.

While, on average, subcontracting has grown significantly over the last twenty years, in both national and international dimensions, this activity is also strongly subject to economic cycles. Hence, in 2003, while industrial activity stagnated and investment declined, the demand for outsourcing (or equivalently, entrusted outsourcing) declined nearly 8% (SESSI, 2005). This downturn is even more marked in 2008 and 2009, after the start of the economic crisis. During that period, the intensity of industrial outsourcing decreased to 8% (from 10% in 2003), accompanied by a fall of 20% in industrial production (Calzada *et al.*, 2012).

Industrial outsourcing is a legal concept that the European Commission defines as follows: a firm, the "contractor" (outsourcer), entrusts, under its instructions, to another company, the "subcontractor" (outsourcee), the manufacture of goods, the supply of services or the

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performance of work to be provided to the contractor or performed on his behalf (Commission Notice of 18 December 1978). Outsourcing is therefore a contractual relationship between a contracting firm and a subcontractor, i.e. an entity that carries out the assignment. Unlike a supplier, a subcontractor manufactures an input specific to the production of the contracting firm. This specificity leads to a more elaborate contractual relationship than is traditionally envisaged between a supplier/provider and a buyer in a given market. In particular, it allows the contracting firm to more closely monitor the subcontractor's production. In fact, it is important for the subcontractor to meet the compatibility and quality standards for the input requested by the contracting firm, in addition to the specified deadlines. Nevertheless, this monitoring can be more difficult to implement – and therefore less effective and more costly – than if the contracting firm had chosen to internalise quality control for the input by producing it in-house via vertical integration of all or part of the production process within a single entity.

A firm has three means to choose between in-house production and purchasing from external sources. The choice among the use of the market, entrusted outsourcing and vertical integration depends on the level of specificity of the commodities to be produced, the specific investments to be made, transaction costs and the completeness of contracts (Williamson, 1985; Grossman and Hart, 1986). Numerous empirical studies have been conducted to test transaction cost theory (Lafontaine and Slade, 2007). However, the arbitrage systematically considered between in-house production (i.e. vertical integration) and outsourcing do not allow differentiation between outsourcing and the use of the market.

At market level, outsourcing may emerge as an equilibrium if two conditions are satisfied: i) the market is sufficiently "thick", i.e. contracting firms and subcontractors are sufficiently numerous and ii) the system of matchmaking between the two types of firm performs well (Grossman and Helpman, 2002). Empirical studies confirm market thickness as a key determinant of the decision to use subcontracting (Diaz-Mora and Triguero-Cano, 2012; Jabbour, 2013).

The choice of outsourcing or vertical integration gives rise to fixed costs that can only be covered by the best-performing firms (Grossman *et al.*, 2005). This theoretical conclusion has already been subjected to empirical studies based on firm data (see Jabbour, 2013; Federico, 2010). It is also appropriate to study the feedback effects of outsourcing on the contracting firms' performance. In this regard, empirical results are rather mixed. Girma and Görg (2004) show that the decision to use outsourcing has a positive impact on performance while Windrum *et al.* (2009) show a negative effect.

The aim of this study is to determine whether entrusted outsourcing, as a mode of productive organisation, is used by the best-performing firms and if this organisational mode, in turn, can increase performance.

To assess the dynamics at work – and contrary to what has been proposed in the literature so far – we propose to integrate both causal relationships in a single model. Our model is based on three equations. The first is a selection equation that determines whether firms turn to outsourcing. The second is an equation of interest explaining the volume of entrusted outsourcing. As this second equation is estimated from the subsample of contracting firms, we must be able to check for a possible selection bias. The third and final equation of our system allows us to explain performance based on the amount of entrusted outsourcing in the past year. To deal with potential problems of endogeneity and with the presence of zero values for some explanatory variables transformed in logarithms, this amount is derived from the estimate of the second equation.

The second contribution of this paper is to consider the use of entrusted outsourcing as a means of risk reduction. Paradoxically, this aspect is rarely considered in the literature. We establish a distinction between technological risks and cyclical risks. As subcontracting seems to primarily concern specific commodities whose development and production may present uncertainties, we must consider the technological risks. The contracting firm may thus be inclined to transfer all or part of these risks to the subcontractor, or, conversely, internalise them to avoid increasing its transaction costs. The contracting firm can also turn to subcontracting as a means to limit the negative effects of cyclical fluctuations, no matter how specific the inputs are.

Entrusted outsourcing may be viewed as a solution for cost minimisation. However, the literature only envisages labour costs; this means capital is considered as a fixed factor. The third contribution of this study is to relax that hypothesis by introducing the user cost of capital into the first two equations of our model. To minimise its costs, a contracting firm may externalise part of its production through outsourcing, but it can also (re)combine capital and labour within its production process.

The database used for our estimates concerns French manufacturing firms in thirteen manufacturing sectors (NA, Nomenclature agrégée, a French classification of business activities) and observed over the period 1998-2007. Jabbour (2013) uses the same French data but over an earlier period (1990-2001). It appears that entrusted outsourcing grew at a very high rate until 1995 (3.6% annual growth rate between 1985 and 1995), while after this date, trends are much less marked (0.66% average annual growth rate) (Thévenot and Valentin, 2004). These evolutions may reflect changes in corporate behaviour concerning the decision to use outsourcing, particularly the rise of externalisation for support activities in the 1980s (e.g. accounting, payroll, human resources, IT). However, they may also indicate that from the mid-1990s, entrusted outsourcing was better measured in France. Despite the richness of the database used for this analysis, the outsourcing measurements available do not allow distinguishing between domestic and international outsourcing.

The main results drawn from this study can be summarised as follows. An initial analysis of descriptive statistics reveals that, in our sample, 86% of firms are contractors. However, the intensity of entrusted outsourcing is somewhat limited since, on average, it represents only 9% of corporate turnover. Firms are less systematically subcontractors, at a rate of 34% and, inversely, the intensity of realised outsourcing is higher, with an average of 25%. A sectorial analysis indicates, in many manufacturing sectors, first order stochastic dominance of contractors relative to subcontractors in terms of their performance, as measured by total factor productivity (TFP).

This last result is confirmed by our model's econometric estimates. It appears that firms' performance has a simultaneous positive effect on their probability to entrust using outsourcing and on its volume. The decision to use a production organisation system based on subcontracting does not have such a clear effect on firms' performance. It depends on the technological level of sectors. Estimates show that entrusted outsourcing provides performance gains in low and medium technology sectors while, on the contrary, there is a significant negative effect in high and medium-high technology sectors.

The estimates also indicate that entrusted outsourcing depends on the risks faced by the contracting firm. Outsourcing is used as a mean to limit cyclical risks. Indeed, higher cyclical risks increase the probability of using outsourcing as well as increasing its volume. Conversely, technological risks have a negative effect, albeit it is less pronounced on the probability of being a contractor.

Minimisation of production costs does not appear to be a real determinant of the decision to use outsourcing, even though the user cost of capital is considered in addition to labour costs. This result is consistent with the findings of previous studies (Girma and Görg, 2004). The only negative effect obtained concerns the user cost of capital in the equation of the volume of outsourcing. This result suggests that contracting firms internalise the production of specific capital that is, *a priori,* the most expensive. However, once the decision has been made to subcontract, the return on a contracting firm's existing capital can lead it to make more intensive use of that capital the most expensive it is, thus leading the firm to subcontract less. However, such arguments depend on the form of contracts between contracting firms and subcontractors and cannot be fully validated here.

This study is structured as follows. The first section is a review of the literature on entrusted outsourcing. In the second section, the database used for the econometric estimates of our model is presented as descriptive statistics on entrusted outsourcing and realised outsourcing. The econometric model is discussed in section 3 and the estimates' results are presented in section 4. Economic policy recommendations are made in the concluding remarks of this study.

I Review of the literature on entrusted outsourcing

The literature displays two main approaches. The first focuses on the determinants of entrusted outsourcing or realised outsourcing; the second concerns the impact of subcontracting on firms' performance. Given the main object of this study, we limit our literature review to studies focusing on entrusted outsourcing.

1.1. The determinants of outsourcing

Amongst the arguments used to explain entrusted outsourcing, this literature review focuses on the performance of contracting firms, reduction of their activity risks and minimisation of their production costs. Other arguments are also considered in the literature, such as the size of the outsourcers, their foreign or domestic origin and the structure of the markets.

1.1.1. *Firms' performance*

Since the seminal paper of Mélitz (2003) on firms' heterogeneity in terms of performance, this argument has become central to explain why firms export but also practice offshoring, i.e. all or part of their production is carried out abroad. The best-performing firms turn to offshoring and in particular to international outsourcing[2]. This argument can be extended to domestic outsourcing[3]. Thus, Grossman and Helpman (2002) assumes that the use of outsourcing involves higher fixed costs than vertical integration. In that case, the best-performing firms will be able to amortise these higher fixed costs. However, a non-monotonic relationship can be established between outsourcing and firms' performance. Grossman and Helpman (2004) show, based on a principal-agent model that the least-productive and most-productive firms choose to outsource; other firms, with an intermediate level of performance, use vertical integration. It is assumed here that the differentiated goods produced by the principal require an input that can only be provided by a qualified agent. To encourage the latter to provide the high level of effort required at both ends of the distribution of performance for contracting firms, the agent should be allowed to remain independent.

Empirical studies generally confirm the positive effect of performance on entrusted outsourcing. In the case of French firms over the period 1990-2001, Jabbour (2013) highlights this effect, given that it is stronger in the service sectors than in manufacturing sectors. Finally, Diaz-Mora and Triguero-Cano (2012) show that over the period 1991-2002, Spanish manufacturing firms were more likely to outsource, they are product-innovative or process-innovative, or if they invested in R&D.

[2] Offshoring also includes production abroad by subsidiaries. In this case, the firm practicing offshoring is considered to be a vertically-integrated multinational.
[3] Hence, Antràs and Helpman (2004) show that the most productive firms become multinational rather than turning to international outsourcing if the fixed costs to set up foreign subsidiaries are higher. This conjecture is verified in the case of Italian manufacturing firms (Federico, 2010). For a survey of the literature on international outsourcing, see Spencer (2005).

1.1.2. *Risks*

Outsourcing can be viewed as an adjustment variable of the market: it allows more flexible management of the firm's activity. By choosing to externalise part of its production, the firm will, at the same time, externalise the economic risks to its suppliers. Following Abraham and Taylor (1996), the decision to use outsourcing is based on a large extent on this notion of economic risk. To specify the content of this notion we focus on two types of risk: business risk and technological risk.

- Cyclical risk

Outsourcing can be viewed as a means for managing cyclical risk: if, to deal with cyclical business fluctuations, a firm chooses to externalise, and therefore to outsource, it protects itself from cyclical risk. By turning to a subcontractor, the contractor does not have to invest in additional machinery to increase production volume. Therefore, if future demand decreases and/or the economic situation deteriorates, it will not bear depreciation costs related to the purchase of new machinery.

- Technological risk

Opposing arguments should be considered in order to establish the effect of technological risk on the decision to use outsourcing. First, we can emphasise that as risk increases for production of technological assets, of a specific nature, firms will be less likely to outsource part of their activity to avoid bearing technological risk. Outsourcing is based on contracts that are, by their nature, incomplete. It is impossible to predict all eventualities given the specificity of the investments to be made; indeed, in case of disputes between contracting parties, courts will have difficulties settling the dispute (Spencer, 2005). When the input has a high degree of specificity, the contracting firm may face a hold-up problem due to *ex post* renegotiation of the contract (i.e. once the input has been assembled) by the subcontractor[4]. The latter can also benefit from the knowledge transfer needed to comply with the technical specifications of the specific input to be produced and capture all or part of the innovation rent of the contractor (Teece, 1986). The contracting firm may also be subject to moral hazards of the subcontractor, to the extent that the latter may be incited not to produce the level of quality required for the input concerned by the transaction. Outsourcing may also require profound technological changes in the organisation, based on a modular approach to address the increasing complexity of producing differentiated products that are more and more innovative (Press and Geipel, 2010). This concerns coordinating the market exchange of compatible sub-products between interdependent firms and the complex and risky management of trade flows of specific inputs[5].

Conversely, since innovation activities are risky by nature, the use of outsourcing can be viewed as a means for contracting firms to avoid all uncertainties. In support of this hypothesis, we found that outsourcing, initially confined to peripheral activities with regard to the contracting firm's core business, has developed in the field of knowledge intensive business services and in new product development (Bengtsson and Dabhilkar, 2009). In this

[4] Conversely, the contracting firm may create a hold-up problem for the subcontractor via changes to payment terms, threats to switch to another subcontractor, etc.
[5] This is the case of the "evanescent hand" (Langlois, 2003), i.e. a "centre of gravity" between the invisible hand of Adam Smith and the visible hand of Chandler, a barycentre whose position depends on the nature of the technologies to be used in the industry (modular products versus "systems integrators," see Frigant, 2005).

view, Bartel *et al.* (2005) show that technological change had a positive effect on the decision to use outsourcing for Spanish manufacturing firms over the period 1990-2002. From these conflicting arguments, it follows that the presence of technological risk has an indeterminate effect on entrusted outsourcing.

- Risks and sunk costs

As in models of real options, the risks related to outsourcing may interact with sunk costs. Outsourcing entails specific investments that are only partially recoverable in case of breach of contract. This results in two periods of inaction. i) Once engaged in outward subcontracting, firms will no longer be incited to change their mode of production organisation (Jabbour, 2013). ii) Firms may wait several years before engaging in this outsourcing relationship, because it is risky and costly.

While it is very difficult, or even impossible, to directly measure the level of risk associated with the completeness of outsourcing contracts, assumed here to be an integral part of the technological risk, the presence of sunk costs is easier to consider in a model of outsourcer status. A usual approach is to consider the outsourcer status of the contractor in the current period depends positively on that same status in the previous period[6] (Diaz-Mora and Triguero-Cano, 2012; Jabbour, 2013).

- Risk measurement

To take business cycles into account in econometric models, the standard procedure is to introduce time dummy variables (Girma and Görg, 2004; Jabbour, 2013). Beyond that, we can assume that cyclical shocks are not symmetric across sectors. Under these conditions, products of time and sector dummy variables are introduced into the models.

However, to obtain a more accurate measurement of cyclical risk, we can use an approach based on an autoregressive model of order $m \geq 1$ on profit per sector, in which we introduce as control variables the current and lagged sector sales and the unemployment rate (Ghosal, 2010). The standard deviation over the previous five years of the remainders obtained from the estimate of this model constitutes a risk proxy. In this autoregressive model, we can also substitute the value added for the variable of profit by sector or for employment, as in Abraham and Taylor (1996). These authors show that cyclical uncertainty positively affects the propensity of American manufacturing firms to use outsourcing, observed over the years 1979, 1983 and 1986/1987. To determine the technological risk, we can use the same type of autoregressive specifications by choosing R&D spending as the variable of interest.

1.1.3. *Cost minimisation*

Subcontracting may be a means for firms to reduce their labour costs. Since international outsourcing and, in a broader sense, offshoring are based on the international division of labour, firms in developed countries leverage the low cost of unskilled labour in developing countries by carrying out labour-intensive production of intermediate goods abroad (Jones *et al.*, 2005). In fact, an argument based on cost reduction can also be used in the case of domestic outsourcing (Abraham and Taylor, 1996). Under these conditions, outsourcing

[6] This approach is based on that used in the literature to test that exporters support sunk costs (Roberts and Tybout, 1997; Bernard and Jensen, 2004).

should enable placing the contracting firms' unskilled labour in competition with the subcontractors' employees. Thus, the higher the wages of unskilled workers, the more firms should turn to entrusted outsourcing. On the other hand, for the high-skilled workers that are involved in contracting firms' core activities, remuneration should have no effect, or a limited positive effect, on the amount of entrusted outsourcing. In their empirical analysis based on an unbalanced panel of British firms from three manufacturing industries (chemicals, precision instruments and electronics), observed over the period 1980-1992, Girma and Görg (2004) select the wage rates (expressed logarithmically) of skilled and unskilled workers to estimate the labour cost savings allowed by the decision to use outsourcing. They also introduce a proxy for the degree of unionisation in their empirical model, with the additional argument that outsourcing is a good means to limit the bargaining power, and therefore the wage demands, of trades unions. None of these studies considers that the cost of capital could have an influence on the contractor status and the amount/intensity of entrusted outsourcing. This hypothesis may appear very restrictive since it involves fixed capital. Just as with the labour factor, firms may use entrusted outsourcing to minimise their cost of capital. However, a high cost of capital may also reflect a high degree of specificity for this production factor and be a hindrance to the use of outsourcing, as in the case of the highest-skilled workers.

1.1.4. *Effects of size, economies of scale (MES) and organisation of vertical relationships*

When economies of scale are present, production costs increase if production is fragmented between many suboptimal plants, all things being equal (Jones *et al.*, 2005). Girma and Görg (2004) therefore consider that larger firms enjoy economies of scale and have no incentive to fragment their production by using outsourcing. This conjecture can be contradicted by examples encountered in the automotive sector, among others. The contracting firms' size allows them to reduce the cost of seeking subcontractors, matchmaking and organisation of vertical relationships. The empirical study by Jabbour (2013) on entrusted outsourcing by French manufacturing firms is more in line with this last hypothesis. The Probit model estimate indicates that the size of contracting firms has a positive effect on the probability to outsource. This positive effect of size is also obtained for Japanese manufacturing firms in 1998 (Tomiura, 2009) and for Spanish manufacturing firms over the period 1991-2002 (Diaz-Mora and Triguero-Cano, 2012).

1.1.5. *Origin (domestic or foreign) of firms*

It seems reasonable to assume that the subsidiaries of a group will have behaviour different from independent domestic firms. More specifically, regarding foreign subsidiaries, Girma and Görg (2004) consider that they will have a greater propensity than domestic firms to use outsourcing. Foreign affiliates can implement local outsourcing, like any other firm, but can also use their multinational network to organise international outsourcing[7]. Hence, belonging to a foreign group (or even to any group) has an expected positive effect on entrusted outsourcing. This expectation is confirmed by the estimates of the two authors. However, the empirical works do not systematically support this positive effect. For example, Diaz-Mora and Triguero-Cano (2012) show that belonging to a group has no significant effect on the probability to use outsourcing while Holl (2008) and Díaz-Mora (2008) show a negative effect.

[7] As available data does not distinguish between subcontracting assigned locally and abroad, it is difficult to go further with this analysis.

1.1.6. *Structure of markets and sectors*

We can consider that the intensity of competition has an impact – possibly non-linear (inverted-u effect) – on the decision to subcontract some activities and the level of entrusted outsourcing. In case of less harsh competition, firms will be increasingly inclined to use outsourcing to improve their competitiveness. However, as the market becomes more concentrated, it becomes less "thick" in the sense that the possibilities for matchmaking between contractors and subcontractors decrease, thus further limiting the opportunities for outsourcing (Grossman and Helpman, 2002). In addition to a traditional measure of market concentration, it is therefore useful to introduce one or more measurements of the market's thickness.

Following the approach of Diaz-Mora and Triguero-Cano (2012) on the size of industries, Jabbour (2013) uses the number of employees of firms other than firm *i*, belonging to the same industry (four-digit classification) as a proxy for market thickness. A variable for the size of the local market is also considered. A similar method is used to build this variable, given that, in addition to being in the same industry, the firms are located in the same region. It appears that the size variable of the local market has a positive effect. Note that it is more pronounced compared to that of the industry size, both concerning the probability to subcontract activities and the intensity of outsourcing, measured here as the ratio of the amount of entrusted outsourcing to intermediate inputs. However, one might question the quality of the variable for the size of the local market proposed by Jabbour (2013). The EAE survey (Enquête annuelle d'entreprise, annual business survey conducted by INSEE) only provides the address of the registered office of each firm, so it is difficult to gain a proper understanding of the true geographical location for multi-site firms. Since our empirical analysis is also based on EAE data, it does not seem desirable to use a variable for the size of the local market.

In light of these arguments, we can construct, as proposed by Jabbour (2013) and also by Tomiura (2009), a Type II Tobit model with a decision equation, i.e. a Probit model that models the probability of using outsourcing, and an equation of interest to explain the amount of entrusted outsourcing, conditioned on the fact that firms decide to use it.

1.2. The effects of outsourcing on outsourcers' performance

Firms use outsourcing with the expectation of increasing their performance. Thus, ten Raa and Wolff (2001) show a positive correlation between the growth of TFP in US manufacturing industries during the 1980s and 1990s and a more intensive use of outsourcing in these industries. Outsourcing is defined here in a broad sense as it covers all purchases of inputs from the same or other industries[8]. In their empirical analysis, Girma and Görg (2004) consider a more explicit sense of causality. They show that the intensity of outsourcing has a positive impact on TFP.

However, other empirical studies provide mitigated results. From a representative panel of 43,000 German firms over the period 1992-2000, although Gorzig and Stephan (2003) show that the outsourcing of material inputs has a positive effect on contracting firms' performance, outsourcing of services not related to production has, conversely, a negative

[8] The other industries are limited here to the service sector.

impact, at least in the short term[9]. Surprisingly, the distinction between short- and long-term effects of outsourcing has received little attention in the literature, while according to Bengtsson and Dabhilkar (2009) it is important to differentiate them because outsourcing has two long-term disadvantages: *i)* contracts involving subcontracting may limit the organisational innovation abilities of the contracting firm and thereby reduce its ability to optimally exploit future profit opportunities*; ii)* inputs produced via subcontracting have a high level of specificity.

Thus, in a bilateral monopoly relationship between contracting firms and subcontractors, the latter are able to gain almost all the bargaining power at the expense of the former. Ultimately, it is not certain that the effect of subcontracting on performance is linear (positive); it seems preferable to consider a non-linear relationship. From a sample of manufacturing firms from the Netherlands, monitored in 1995 and 1998, Kotabe and Mol (2009) show an inverted-U relationship between the two variables, a relationship that persists even with estimates by industry.

Girma and Görg (2004) also show that outsourcing has a positive effect on TFP in the chemical and precision instruments sectors, while it is insignificant in the electronics sector. It therefore appears necessary to differentiate the effects of outsourcing according to the sector's technological level. In fact, these effects are *a priori* ambiguous. Transaction cost theory indicates that innovations are produced more efficiently within firms than via other contractual arrangements such as subcontracting (Williamson, 1985). But, as mentioned above, a significant part of innovation is now the result of co-production with suppliers, rather than in-house production. This finding is confirmed by an empirical analysis by Mol (2005) of 52 manufacturing firms in the Netherlands, in 1993 and 1998. Results indicate that the intensity of R&D in the initial year has a positive effect on the trend in outsourcing between the two periods.

Since the productive organisation of multinational firms is based on an international network, they may have better control of the use of outsourcing. Hence, the effect of outsourcing on productive performance may be higher for subsidiaries of foreign companies, as compared to domestic firms. The empirical results obtained by Girma and Görg (2004) in their sample of British manufacturing firms provide evidence for the validity of this hypothesis. Their results suggest that the distinction according to the nationality of firms is relevant in the chemical and precision equipment sectors, with an effect of outsourcing on TFP that is more pronounced for foreign affiliates than for domestic firms. Conversely, in the electronics sector, there are no significant differences of effect between domestic firms and multinational ones[10].

[9] From a sample of Japanese firms with fewer than 300 employees, surveyed between 1966 and 1987, Kimura (2002) obtains a negative effect on performance, as well.

[10] This positive relationship between international subcontracting and firms' performance seems equally clear in the cases of Ireland (Görg *et al.*, 2008), Austria (Egger *et al.*, 2001), the US (Amiti and Wei, 2009) and Germany (Winkler, 2010).

II Scope and limits of data

2.1. Characteristics of variables in the database

The database used is an unbalanced panel of 27,311 firms established in France. These companies are in manufacturing sectors, including agro-food industries, but excluding energy, and are observed over the period 1998-2007[11]. The database contains a total of 186,836 observations. The data used is fairly representative of manufacturing activity in France. The sum of the value added for firms in our database represents 73.20% of the total value added for the manufacturing sector over the same period.

This database is derived principally from the EAE, conducted by INSEE. The TFP used as a proxy of firm performance is derived from the estimate of a production function. The EAE survey provides information needed to estimate such a function: the value added, proxy of the quantity produced, tangible assets for capital input and year-end headcount for labour input. To use the value added and tangible assets in volume they are deflated by corresponding sectoral and annual price indices (price index of value added and price index of capital).

From the EAE survey, a distinction can be made between entrusted outsourcing and realised outsourcing. Regarding entrusted outsourcing, three accounting items are considered: General outsourcing (item 611), which corresponds to products or services that cannot be incorporated directly into the work or products to which they contribute (definition from AFNOR, Association Française de Normalisation, French standards organisation), Purchases of studies (604) and Purchases of materials (605). The total entrusted outsourcing is the sum of these three items. In addition, concerning materials purchases, it should be noted that we can distinguish between capacity outsourcing and speciality outsourcing. In the first case, the contracting firm and subcontractor produce the same products, while in the second, the contracting firm does not have the ability to produce them, in contrast with its outsourcee. We therefore have detailed information on the nature of the entrusted outsourcing. Less information is available regarding realised outsourcing. In fact, the only information available concerns the turnover of realised outsourcing.

The EAE survey provides detailed information on the characteristics of outsourcing. Unfortunately, information is not available the bilateral relations between contracting firms and subcontractors. Thus, when we know the characteristics of the contracting firm, we do not know what type(s) of firm(s) it has entrusted with the production of input. Therefore, we cannot carry out an integrated analysis of entrusted outsourcing and realised outsourcing. Similarly, it is not possible to determine the geographical origin of subcontractors. In other words, it is not possible to distinguish between domestic outsourcing and international subcontracting; this is a limitation of the analysis.

[11] It is an unbalanced panel of firms observed over a minimum of four successive years. The initial database covers a longer period: from 1990 to 2007. However, information on outsourcing before 1998 appeared to be unreliable, and we have been led to limit the temporal span of our sample. Furthermore, the use of firm data rather than establishment data is quite appropriate in our case because the firm level is the pertinent one to consider.

In addition, we used the LiFi survey (Enquête annuelle sur les liaisons financières, Annual survey of corporate financial links) and the R&D survey (annual survey of resources devoted to R&D). LIFi's utility is to provide information on corporate group membership, and more specifically, on foreign group membership. This allows to test whether the foreign subsidiaries have a specific behaviour to entrusted outsourcing. The R&D survey is used to provide information on internal expenditures on research and development, which are used to determine the measure of the technological risk associated with outsourcing activity.

Firms' performance is measured here by their productive efficiency or, equivalently, total factor productivity (TFP[12]). To construct the TFP, we assume that firms use Cobb-Douglas technology, i.e.:

$$y_{it} = tfp_{it} + \beta_l l_{it} + \beta_k k_{it} + \varepsilon_{it} \quad (1)$$

where:

- y_{it} is the output of firm i operating in the industry j (index j will dropped henceforth for simplicity) in the year t and deflated by the annual price index of value added;
- tfp_{it} is the TFP;
- l_{it} is the labour input measured by the number of employees at each year end;
- and k_{it} is the physical capital proxied by the value of tangible assets at the beginning of each year, deflated by the annual price index of capital.

All these variables are expressed in logarithms. We assume that technologies vary among sectors and require indexing by j of the parameters of the production function (1) ε_{it} is an idiosyncratic error term that captures shocks that are not anticipated by firm i. We assume that $E\left(k_{it}\middle|\varepsilon_{it}\right)=E\left(l_{it}\middle|\varepsilon_{it}\right)=0$.

tfp_{it} is assumed to evolve in response to productivity shocks specific to firms and perfectly anticipated by them but not anticipated by the econometrician. Thus, tfp_{it} may be considered an individual time-varying effect that is less restrictive than the common hypothesis of an individual time invariant effect.

Calculating tfp_{it} requires estimating the production function (1). This function cannot be estimated by ordinary least squares (OLS) because that method generates biased and non-consistent estimate. Since labour is often assumed to be flexible, or equivalently, fully adjustable, it is positively correlated with the productivity shocks. Because of this positive correlation, the estimated coefficient of labour using OLS will be biased upwards. To limit this bias, we use the method proposed by Ackerberg *et al.* (2006) (See Annex 2 for a presentation of the estimator).

To construct the risk series of business ($risq\_conj_{jt-1}$) and technological ($risq\_techno_{jt-1}$), we use the approach proposed by Ghosal (2010). In a first step, the current sectoral value added in volume is regressed on its lagged values and on a time trend. As our complete database covers the period 1990-2007, all available information was used to improve the accuracy of risk measurement. For each sector (NACE, two-digit classification), the

[12] Total Factor Productivity.

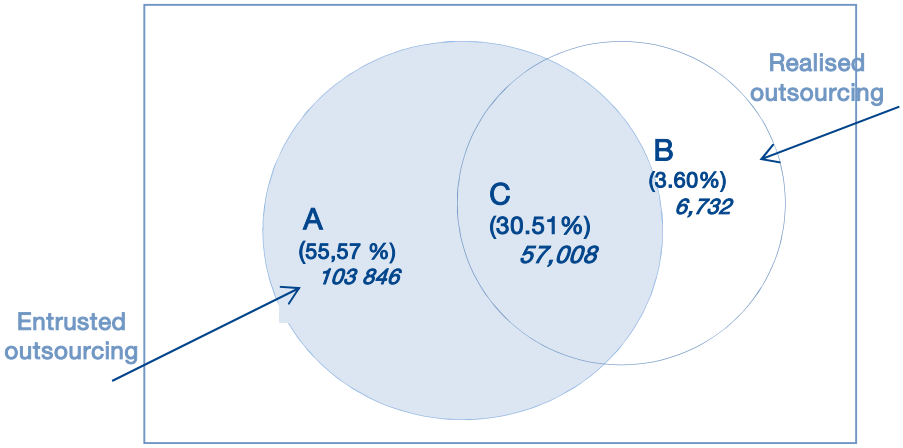
standard deviation over the seven years prior to the current period of remainders is then calculated. The remainders are considered a measure of the non-systematic component of the model predicting the value added. The resulting series of standard deviations constitutes a proxy variable for cyclical risk[13]. The same procedure is used to construct the proxy variable for technological risk. In this case, domestic expenditure on R&D by sector in volume (DERD) is substituted, in the forecasting model, for the value added.

2.2. Descriptive statistical analysis: initial findings on outsourcing in France

Our sample includes four types of firms (Figure 1):

- firms that are exclusively contractors (entrusted outsourcing), 55.57% of our observations (see area A in figure 1);
- firms that are only subcontractors (realised outsourcing) (area B, 3.60% of observations);
- firms that practice both entrusted outsourcing and realised outsourcing (area C, 30.51% of observations);
- firms that have no outsourcing relationships (10.32% of observations).

Figure 1
Level of entrusted and realised outsourcing



Hence, nearly 90% of the sample firms are involved in an outsourcing relationship. This figure covers complex interdependencies between firms since a consequent fraction of them, nearly a third, practice both entrusted outsourcing and realised outsourcing.

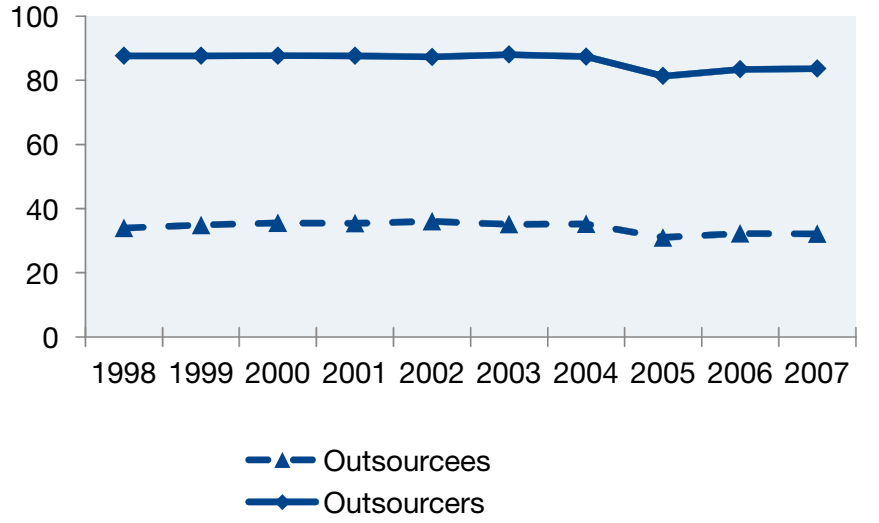
The share of companies using entrusted outsourcing is much higher than that of firms performing realised outsourcing. On average, over the period 1998-2007, contracting firms amounted to 85.16%, while subcontractors amounted to only 34.16%[14] (Chart 1). The observed gap is constant over the period although the decline between 2004 and 2005 is

[13] Since annual data provides a limited number of observations in the time dimension, it is not suitable to use more sophisticated specifications such as ARCH or GARCH models (see, however, O'Brien and Folta, 2009) .

[14] These percentages are in line with those obtained by Thévenot and Valentin (2004) for France over the period 1993-2000. By contrast both authors show, with an average annual increase of 3.56%, significant growth in the intensity of entrusted outsourcing between 1984 and 1992.

significantly more pronounced for subcontractors (-4%) than for contractors (-2.6%). Finally, there was a slight decrease in both outsourcees and outsourcers, with rather similar negative average annual growth rates of -0.53 and -0.46, respectively.

Chart 1
Proportion of outsourcers and outsourcees in the French manufacturing sectors



It appears that in all manufacturing sectors except "Manufacture of basic metals and fabricated metal products, except machinery and equipment," over 50% of firms are exclusively outsourcers since they are not also realising outsourcing (see Table 1). They represent over two thirds of the firms in five out of thirteen sectors. As before, realised outsourcing seems much more limited within each sector, since less than 10% of firms by sector are engaged exclusively in this type of activity. Finally, note that entrusted outsourcing and realised outsourcing are not exclusive. With the exception of the "Manufacture of food products and tobacco products" sector, where no firm simultaneously performs both activities, the percentage of such firms is significant in the other twelve sectors. It reaches a maximum of nearly 54% in the "Manufacture of basic metals and fabricated metal products, except machinery and equipment" sector.

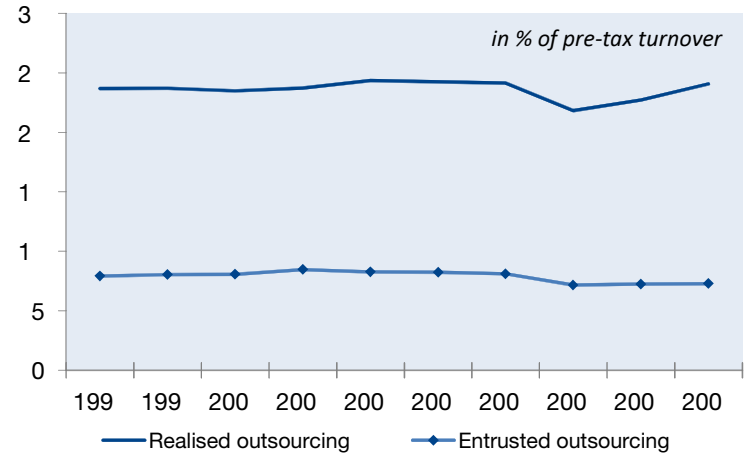
Table 1
Frequency of outsourcers and/or outsourcees in French manufacturing industries (1998-2007)

	Manufacturing sectors	% of outsourcees	% of outsourcers	% of firms simultaneously outsourcees and outsourcers	% of foreign groups
1	Manufacture of food products and tobacco products	0.00	57.09	0.00	14.40
2	Manufacture of textiles, wearing apparel, leather and related products	8.53	57.15	24.76	8.17
3	Manufacture of wood and paper products; printing and reproduction of recorded media	2.14	68.23	16.01	13.56
4	Manufacture of coke and refined petroleum products	3.64	53.50	15.13	38.38
5	Manufacture of chemicals and chemical products	3.14	65.06	19.60	29.18
6	Manufacture of basic pharmaceutical products and pharmaceutical preparations	2.42	59.22	34.56	45.78
7	Manufacture of rubber and plastics products, and other non-metallic mineral products	4.13	52.14	29.00	20.20
8	Manufacture of basic metals and fabricated metal products, except machinery and equipment	3.95	37.84	53.69	11.39
9	Manufacture of computer, electronic and optical products	2.93	61.06	27.66	20.65
10	Manufacture of electrical equipment	1.59	70.07	19.08	24.21
11	Manufacture of machinery and equipment n.e.c.	1.98	66.71	22.14	23.68
12	Manufacture of transport equipment	1.64	72.34	17.65	10.13
13	Other manufacturing; repair and installation of machinery and equipment	0.94	75.24	14.63	14.08

The discrepancy observed between the frequency of contractors and subcontractors may result from a higher dispersion of the former than of the latter across firms. To verify this assumption we must compare the intensity of entrusted outsourcing and realised outsourcing.

Chart 2 tends to confirm this hypothesis since during the period 1998-2007, the intensity of realised outsourcing (annual average across all firms) is higher by almost 16 percentage points against entrusted outsourcing, given that the latter represents a small share of firm turnover, about 9%. As in the case of the frequency for outsourcees and outsourcers, we observe that the two intensities are relatively stable over the period studied. Realised outsourcing increases with an average annual growth rate of 0.16% while the average annual growth rate decreases by 0.8% per year for entrusted outsourcing. In fact, the only significant decreases again concern 2005, with a decrease of 9.6% for the intensity of realised outsourcing and 11.6% for the intensity of realised outsourcing. Although these decreases were substantial in 2005, the trends between 1998 and 2007 bear no relation to what we have observed in terms of growth in entrusted outsourcing during the 1980s and until the early 1990s (Thévenot and Valentin, 2004).

Chart 2
Intensity of outsourcing



An analysis by sector (NACE, two digit codes) also shows that realised outsourcing has a higher intensity (15.22% on average per sector) than realised outsourcing (7.23%) (see Table 2)[15]. The two exceptions are the “Food products industry” and "Other manufacturing" sectors. However, with a coefficient of variation of 0.74 against 0.41 for the intensity of the entrusted outsourcing, the dispersion between sectors is the highest for the intensity of realised outsourcing.

The decomposition of entrusted outsourcing into the three categories as defined by the French accounting system shows that, on average, "Purchases of studies" represents 2.90% of pre-tax turnover, which is the highest intensity within the three categories. The intensity is lowest (0.94% on average) and the most dispersed (coefficient of variation of 0.85) for Purchases of materials, i.e. industrial entrusted outsourcing. Although the intensity

[15] We note that the intensity is measured here as the average share of outsourcing in pretax turnover of each firm.

remains low (under 4%), the two sectors with the greatest use of industrial outsourcing are "Manufacture of transport equipment" and "Other manufacturing; repair and installation of machinery and equipment".

Table 2
Realised and entrusted outsourcing by industry

as average share of corporate turnover, in %

	Manufacturing sectors	Realised outsourcing	Entrusted outsourcing			
			Total	Purchases of studies (604)	Purchases of materials (605)	Other (611)
1	Manufacture of food products and tobacco products	0.00	1.50	0.00	0.00	0.01
2	Manufacture of textiles, wearing apparel, leather and related products	21.43	8.76	4.60	0.55	3.15
3	Manufacture of wood and paper products; printing and reproduction of recorded media	8.85	6.01	3.37	0.66	1.55
4	Manufacture of coke and refined petroleum products	8.99	4.98	1.49	0.12	2.57
5	Manufacture of chemicals and chemical products	11.55	4.94	1.44	0.34	2.20
6	Manufacture of basic pharmaceutical products and pharmaceutical preparations	18.64	8.54	3.04	0.76	3.71
7	Manufacture of rubber and plastics products, and other non-metallic mineral products	22.76	4.68	1.92	0.88	1.46
8	Manufacture of basic metals and fabricated metal products, except machinery and equipment	45.75	9.98	4.53	2.56	2.41
9	Manufacture of computer, electronic and optical products	19.76	7.36	2.99	1.88	1.87
10	Manufacture of electrical equipment	9.89	7.01	2.75	2.05	1.79
11	Manufacture of machinery and equipment n.e.c.	13.76	8.22	2.77	2.73	1.90
12	Manufacture of transport equipment	9.35	8.28	2.83	3.20	1.99
13	Other manufacturing; repair and installation of machinery and equipment	7.12	13.74	5.95	3.87	3.30

It was necessary to determine the ratio of firms' entrusted outsourcing to their pre-tax turnover in order to consistently compare this ratio with that of realised outsourcing. However, since entrusted outsourcing corresponds to purchases from suppliers, it may seem more appropriate to measure the intensity as a function of firms' intermediate consumption (Table 3). The intensity of total entrusted outsourcing is larger previously with

an average value, for all sectors, of 11.35%, and the same applies to Purchases of studies (4.61%) or Purchases of materials/industrial outsourcing (2.26%). Yet, the dispersion between sectors of the intensities for the two types of entrusted outsourcing is not significantly altered. Hence, the coefficient of variation is 0.54 for purchases of studies whereas previously it was 0.53 and it remains the same for industrial outsourcing. The sectors with the highest relative use of "Purchases of studies" are, in descending order, "Other manufacturing," "Manufacture of basic metals and fabricated metal products, except machinery and equipment" and "Manufacture of textiles, wearing apparel, leather and related products." The order is somewhat different in the case of industrial outsourcing," with the "Other manufacturing" sector still having the highest intensity, but now followed by "Manufacture of machinery and equipment n.e.c." and "Manufacture of basic metals and fabricated metal products, except machinery and equipment." We note that the "Manufacture of transport equipment" sector, which includes, in particular, the automotive and aerospace industries, is only in fourth position among thirteen manufacturing sectors.

By decomposing industrial outsourcing into capacity outsourcing (the contracting firm has the resources needed to manufacture the intermediate product) and specialty outsourcing (the contracting firm does not have the technical capacity to produce this product), it appears that the latter is more systematically used than the former. On average, specialty outsourcing represents 83.5% with a low dispersion across sectors (coefficient of variation of 0.08). This suggests that firms use subcontracting as a means to externalise activities upstream of their production process, rather than to outsource horizontal activities. Clearly, this type of externalization is only relative, given the low intensity of industrial outsourcing in manufacturing sectors.

Concerning the other characteristics of the database, we find that 57% of firms are classified as small, 34% medium-sized, 5% intermediate-sized and 4% large-sized (see Table A1.1 in Annex 1). The proportion of firms belonging to a group is nearly 62%; 16% are subsidiaries of foreign multinational firms. Firms in our sample are quite open to international competition since more than 75% of them are exporters (extensive margin). However, while the extensive margin is large, the intensive margin is more limited since the average export rate is only 17%. These values are consistent with figures presented in previous studies (ISGEP, 2008). In addition, the average unit labour cost is €36,360 and TFP is €14,120, corresponding, on average, to 20% of firms' value added.

To provide an initial analysis of differences in productive performance between firms using outsourcing and other firms, it is useful to compare their cumulative distribution functions of performance. This allows us to determine whether there is a first-order stochastic dominance of contractors over other firms on the basis of their respective productive performance[16]. In some sectors, the distribution function of contractors' performance is below that of other firms for a given value of TFP (see Chart A1.1, Annex 1) that indicates the presence of first-order stochastic dominance. However, this presence is less clear in some other sectors: Manufacture of coke and refined petroleum products, Manufacture of chemicals and chemical products, Manufacture of basic pharmaceutical products and pharmaceutical preparations, Manufacture of rubber and plastics products, and other non-

[16] It can be shown that comparing the distribution functions of two sub-populations, in this case the contractors and other firms, is equivalent to comparing the expected values for their productive performance. Under these conditions, to consider that contractors have first-order stochastic dominance is equivalent to verifying that $E(tfp_{donneurs\_ordre}) > E(tfp_{autres})$.

metallic mineral products, and Manufacture of transport equipment. The use of a Kolmogorov-Smirnov (KS) test should allow clarification of this ambiguous figure.

The KS test allows us to determine if the distribution function of contractors' performance $(F(tfp_{donneurs\_d'ordre}))$ is lower than the performance of other firms $(F(tfp_{autres}))$ or equivalently if their difference $(F(tfp_{donneurs\_d'ordre}) - F(tfp_{autres}))$ is significantly negative for a given value of TFP (null hypothesis).

The KS test provides more clear results than those previously obtained. Hence, in the large part of sectors, we can conclude that the performance of contractors has first-order stochastic dominance over other firms. We reject this hypothesis in only two sectors: Manufacture of coke and refined petroleum products and Manufacture of rubber and plastics products, and other non-metallic mineral products.

Table 3
Entrusted outsourcing by industry

Average share of firms' intermediate consumption, in %

	Manufacturing sectors	Total	Other	Purchases of studies (604)	Purchases of materials (605)	Distribution of industrial outsourcing	
						Capacity (%)	Specialty (%)
1	Manufacture of food products and tobacco products	1.99	0.05	0.03	0.01	7.69	92.31
2	Manufacture of textiles, wearing apparel, leather and related products	13.38	4.88	6.96	0.86	22.76	77.24
3	Manufacture of wood and paper products; printing and reproduction of recorded media	10.12	2.63	5.71	1.10	18.70	81.30
4	Manufacture of coke and refined petroleum products	10.57	5.38	3.18	0.23	6.54	93.46
5	Manufacture of chemicals and chemical products	7.52	3.31	2.18	0.56	11.45	88.55
6	Manufacture of basic pharmaceutical products and pharmaceutical preparations	11.26	4.94	4.11	0.92	7.50	92.50
7	Manufacture of rubber and plastics products, and other non-metallic mineral products	7.13	2.25	2.87	1.34	17.34	82.66
8	Manufacture of basic metals and fabricated metal products, except machinery and equipment	17.08	4.21	7.83	4.24	22.80	77.20
9	Manufacture of computer, electronic and optical products	10.61	2.72	4.38	2.71	20.47	79.53
10	Manufacture of electrical equipment	10.66	2.76	4.22	3.08	21.18	78.82
11	Manufacture of machinery and equipment n.e.c.	13.19	3.08	4.57	4.30	22.56	77.44
12	Manufacture of transport equipment	11.56	2.81	4.02	3.99	23.22	76.78
13	Other manufacturing; repair and installation of machinery and equipment	22.58	5.50	9.92	6.08	11.88	88.12

III Econometric model: an integrated analysis for outsourcing and firms' performance

To carry out a complete analysis of the links between entrusted outsourcing and firm performance, we propose to estimate an extended version of the model used in Jabbour (2013) for the effects of entrusted outsourcing on TFP. Our model is formed by three equations. The first two use the approach defined in Jabbour (2013) corresponding to a Type II Tobit model (Amemiya, 1984) with a selection equation that determines whether or not firms become contractors and an equation of interest explaining the volume of entrusted outsourcing. The third equation of our system explains the performance of firms from the amount of entrusted outsourcing.

3.1. Selection equation for outsourcer status

In the selection equation, we consider a dummy variable D_out_{it} that has the value 1 when the amount of entrusted outsourcing is strictly positive for firm *i* in year *t* and 0 otherwise, i.e.:

$$D\_out_{it} = \begin{cases} 1 & \text{if} \quad D\_out_{it}^{*} = \alpha_1' z_{1it} + f_{1i} + u_{1it} > 0 \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

where:

- $D\_out_{it}^{*}$ is the corresponding latent variable,
- z_{1it} a vector of independent variables affecting the entrusted outsourcing,
- f_{1i} an unobserved individual effect and
- u_{1it} an idiosyncratic error term.

The second equation of the system is defined as:

$$out_{it} = \begin{cases} out_{it}^{*} = \alpha_2' z_{2it} + f_{2i} + u_{2it} & \text{if} \quad D\_out_{it} = 1 \\ -\infty & \text{otherwise} \end{cases} \tag{3}$$

where out_{it}^{*} is a latent variable for the volume of outward outsourcing (expressed logarithmically) and as in expression (2), z_{2it} a vector of independent variables affecting the amount of entrusted outsourcing, f_{2i} is an unobserved individual effect and u_{2it} is an error term.

Conditioned on z_{1it} and z_{2it}, the two error terms (u_{1it} and u_{2it}) are assumed to follow distributions with zero mean and variances σ_1^2 and σ_2^2. Equation (2) is a (nonlinear) dynamic model, since to reflect the presence of sunk costs related to subcontracting, D_out_{it-1} is introduced as a regressor. This type of model requires investigating the issue of initial conditions. The trajectory followed by successive values of $D\_out_{i\tau}$ ($\tau = 1.....T$) is very likely to depend on the first observation D_out_{i0}. To resolve this problem, Wooldridge

(2005) proposes to condition the individual effects on the initial conditions and on the individual means of the model's regressors[17]. The individual effects are therefore modelled as follows:

$$f_{1i} = \alpha_{10} + \gamma_1^{'} z_{1i.} + \theta_1 D\_out_{i0} + \upsilon_{1i}$$
$$f_{2i} = \alpha_{20} + \gamma_2^{'} z_{2i.} + \varphi\left(\upsilon_{1i} + u_{1it}\right) + \upsilon_{2i}$$

where:

- α_{10} and α_{20} are constant terms,
- $z_{1i.}$ and $z_{2i.}$ are the vectors of regressors expressed as individual means, in order to take into account a possible correlation between the regressors and the individual effects,
- $\gamma_1^{'}$ and $\gamma_2^{'}$ are the associated coefficients that must be estimated.

The unknown parameter θ_1 with initial value D_out_{i0} must also be estimated, as well as φ the coefficient of $f_{1i} + u_{1it}$. The two error terms υ_{1i} and υ_{2i} are assumed to be independent of the model's regressors.

3.2. Equation of interest for outsourcing

The introduction of $\varphi\left(\upsilon_{1i} + u_{1it}\right)$ allows us to take into account unobserved heterogeneity in the Type II Tobit models of panel data. We use the method proposed by Wooldridge (1995): a simple extension of the initial approach by Heckman (1979).

To estimate the equation of interest (2), we consider that:

$$E\left(out_{it}^{*} \middle| D\_out_{i\tau} = 1\right) = \alpha_2^{'} z_{2it} + E\left(f_{2i} \middle| D\_out_{i\tau} = 1\right) + E\left(u_{2it} \middle| D\_out_{i\tau} = 1\right)$$

where:

$$E\left(f_{2i} \middle| D\_out_{i\tau} = 1\right) = \alpha_{20} + \gamma_2^{'} z + \varphi E\left(\upsilon_{1i} + u_{1it} \middle| D\_out_{i\tau} = 1\right)$$
$$E\left(u_{2it} \middle| D\_out_{i\tau} = 1\right) = \rho E\left(\upsilon_{1i} + u_{1it} \middle| D\_out_{i\tau} = 1\right)$$

To correct for selection bias in the sample, for each firm with a strictly positive amount of outsourcing (or equivalently for $D\_out_{it} = 1$), the inverse Mills ratio ($Mills\_ratio_{it}$), equal to $E\left(\upsilon_{1i} + u_{1it} \middle| D\_out_{i\tau} = 1\right)$, is estimated from the selection equation (2) for each observation. It is then introduced as a regressor into the equation of interest (3) given that the coefficient of

[17] This is an extension of the approach defined in Mundlak (1978) where individual effects are only conditioned on the individual means of the regressors. We can also specify a reduced form model for the initial conditions, which will be estimated simultaneously with the nonlinear dynamic model (Heckman, 1981). The advantage of the method proposed by Wooldridge (2005) is its simplicity. In addition, it provides satisfactory estimates, comparable to other methods such as that of Heckman (1981) for unbalanced panels for which the observation period covers at least ten years (Akay, 2012).

the regressor is $\varphi + \rho$. The selection equation is a Probit model estimated by maximum likelihood and the equation of interest is estimated by the quasi-generalised least squares method (QGLS). In addition, since the two equations include generated regressors[18], 100 bootstrap replications are used to provide a consistent estimate of the standard deviations of the coefficients in the Type II Tobit model.

3.3. Performance equation

The third equation concerning firms' productive performance is as follows:

$$\widehat{tfp}_{it+1} = \alpha_3^{'} z_{3it+1} + f_{3i} + u_{3it} \qquad (4)$$

where $\widehat{tfp}_{it+1}$ is the estimated TFP of firm *i* in year *t* (expressed logarithmically), z_{3it} is a vector of regressors that contain the estimated amount of entrusted outsourcing, f_{3i} is an individual effect and u_{3it} is an error term. The performance equation is also estimated with QGLS and assumes the Mundlak specification. In addition, since the estimated amount of outward outsourcing is a generated regressor, 100 bootstrap replications are used again to estimate the standard deviations of the coefficients of the performance equation. Following the CDM innovation model (Crepon *et al.*, 1998), we introduce the lagged, estimated value for the amount of outward outsourcing ($\widehat{out}_{it}$) rather than its observed current value $t+1$ given the structure of the model. We thereby limit the endogeneity bias of this regressor[19]. Furthermore, since $\widehat{out}_{it}$ is expressed logarithmically, this variable is always defined. The hypothesis chosen in this case is that all firms use outsourcing, even those who report a zero value for their entrusted outsourcing[20].

The z_{1it} vector consists of two subsets of explanatory variables. The first subset includes our interest variables for the decision to use outsourcing; the control variables are in the second subset. Among the interest variables, we have the lagged explanatory variable (D_out_{it-1}), to account for the presence of irrevocable costs related to outsourcing. Futher, we have firms' performance ($\widehat{tfp}_{it-1}$), cyclical risk ($risq\_conj_{jt-1}$) and technological risk ($risq\_techno_{jt-1}$), as well as unit labour cost (w_{it-1}). w_{it-1}, i.e. the labour cost (wages + charges) per employee in each firm[21]. These last three variables are expressed in logarithms. The (user) cost of capital ($Cout\_usage_{jt-1}$) is built according to the method in Hall and

[18] In equation (2), the TFP is the generated regressor, while in equation (3), it is the inverse Mills ratio.
[19] More broadly in order to limit this potential endogeneity bias in our entire system of equations, firms' explanatory variables are systematically lagged by one year.
[20] Setting $\widehat{out}_{it-1} = 0$ for firms that do use to outsourcing would implicitly assume that the amount of entrusted outsourcing is equal to 1. This choice is arbitrary and would make the estimate of that equation dependent on the unit of measure of this amount (euros, or thousands or millions of euros).
[21] Unlike Girma and Görg (2004), we do not have sufficiently precise information to distinguish between skilled and unskilled workers.

Jorgenson, 1967[22]. Unlike the labour cost, the cost of capital was established at sectoral level rather than at firm level due to a lack of sufficient and reliable data in our database.

For control variables, firms' size is considered by means of four dummy variables for size classes ($Small\_size_{it-1}$, $Medium\_size_{it-1}$, $Intermediate\_size_{it-1}$, $Large\_size_{it-1}$)[23] and a proxy variable, in logarithms, for the economies of scale in the sectors (mes_{jt})[24].

We also introduce a measure of market thickness ($epais_{jt}$) as proposed by Jabbour (2013), representing the total employees in industry *j* except those in firm *i* (in logarithms). Concentration in the French markets ($Conc_{jt}$) is considered through a second-degree polynomial. To measure the concentration, we use the Herfindahl-Hirschman index, calculated from the value added of firms at sectoral level (NACE, two-digit classification), i.e.:

$$Conc_{jt} = \sum_{i=1}^{i=N_{it}^{j}} \left(\frac{Y_{it}}{\sum_{i=1}^{i=N_{it}^{j}} Y_{it}} \right)^2$$

The value of this index varies between zero and one, given that a higher value of $Conc_{jt}$ means a more concentrated sector and less-intense competition in the market j. Openness to international competition is also considered via a dummy variable for firms that export (Exp_{it-1}). Dummy variables are introduced when firms belong to a group ($Group_{it-1}$) or belong to a foreign group ($Foreign\_group_{it-1}$). Finally, annual and time dummy variables are added to control for the effects of the economic cycle and other sector-specific characteristics. In equation (3) concerning the amount of outward outsourcing, the vector z_{2it} has the same explanatory variables as z_{1it}. However, to avoid a multicollinearity problem between the regressors of this equation and the inverse Mills ratio ($mills\_ratio_{it}$), the dummy variable Exp_{it-1} is replaced by the ratio of exports to turnover ($Export\_rate_{it-1}$).

[22] $Cout\_usage_{jt-1} = P_{FBCF_{jt-1}}\left(r_{t-1} - \pi_{t-1} + \delta\right)$ where $P_{FBCF_{jt-1}}$ is the price index for gross fixed capital formation for the sector *j* (NA classification) in year *t-1*, $(r_{t-1} - \pi_{t-1})$ is the real interest rate, the difference between the nominal long-term interest rate and the annual inflation rate in France (AMECO European macroeconomic database), and δ is the depreciation rate of capital, fixed at 8%.

[23] These four dummy variables for firm sizes are constructed from the Eurostat classification. Firms with headcounts under 49 are considered small, those with headcounts between 50 and 249 are considered medium, those with headcounts between 250 and 499 are considered intermediate, and those with headcounts over 500 employees are considered large. In econometric estimates, to avoid multicollinearity problems, the dummy variable associated with small firms will be taken as a reference.

[24] The variable mes_{jt} is calculated using the method proposed by Comanor et Wilson (1967). For a given sector, this measure corresponds to the ratio of the average size (value added) of firms exceeding the median value to the total value added of the sector.

The vector z_{3it} in the performance equation (4) consists of the estimated amount of entrusted outsourcing ($\widehat{out}_{it}$) and its square, since entrusted outsourcing is assumed to have a non-linear effect on firms' performance. Concentration, openness to international competition and being a part of a foreign group are introduced into equation (4) as control variables as well as time and sector dummy variables. Contrary to Girma and Görg (2004), capital intensity and intermediate input intensity are not used as regressors in equation (4) because rather than measuring performance through apparent labour productivity, we measure it through TFP.

IV Results of estimates

4.1. Estimate of the production function

Firms' productive efficiency, measured here by TFP (tfp) can easily be determined from (1), once the coefficients of inputs of the Cobb-Douglas production function have been estimated using the method from 'Ackerberg *et al.* (2006). These coefficients are assumed to vary between industries (the thirteen manufacturing sectors of the French NA classification[25] are considered here) to take differences in technology and market structures into account. As our complete database covers the period 1990-2007, all available information is used for the estimates of the production function to improve their precision.

The estimates we carried out produced results in line with expectations (Ackerberg *et al.*, 2006). Thus, the average value for the capital coefficient is 0.241 for the thirteen sectors; it is 0.721 for the labour coefficient (Tables A3.1 and A3.2). In addition, the estimates lead to high significance level for the elasticities of inputs, except for the labour coefficient, significant only at the level of 10% in sector 2, "Manufacture of textiles, wearing apparel, leather and related products." However, significant differences appear among sectors for the elasticities of physical capital, confirming the use of different technologies in various industries. Thus, the coefficient of variation for the elasticity of capital, calculated across all thirteen sectors, is 0.242. These differences concerning technology seem to have less effect on the labour coefficient since its coefficient of variation is three times lower, with a value of 0.080.

4.2. Entrusted outsourcing, performance, cyclical risks and production costs

Columns (1) and (2) of Table 4 show the estimates of selection equation (2) under the assumption that the individual effects are uncorrelated and correlated, respectively. Significant differences for the marginal effects appear between these two columns, suggesting the presence of correlated individual effects. This finding is confirmed by the Wald test, shown at the bottom of column (2), which strongly rejects the hypothesis that individual effects are not correlated with the regressors of the selection equation.

However, our estimates indicate that θ_1 is not significantly different from 0, leading to the conclusion that in this case, the individual effects are not dependent on the initial conditions. The goodness of fit of the probit model can be measured by the area under the ROC (Receiver Operating Characteristics) curve. As the last line of column (2) indicates, the value of this area is significantly greater than 0.8. Consequently, the goodness of fit for the selection equation is very satisfactory.

In the equation of interest (3), the presence of individual effects is also assumed. Again, the Wald test strongly rejects the hypothesis that individual effects are not correlated with the regressors of the equation for the volume of entrusted outsourcing (see the bottom of column (3)). From this equation's estimate, we also derive that the inverse Mills ratio is not significantly different from zero at the 1% level. This result confirms the presence of a

[25] French nomenclature (NA) is compatible with NACE Rev. 2 classification.

selection bias in the subsample of outsourcers and justifies the introduction of the inverse Mills ratio in the equation of interest.

The use of outsourcing exhibits a significant persistence over time. Thus, the status of contractor the previous year increases, by 21%, the probability of keeping that status for the current period, all other things being equal. However, this effect is lower than that obtained by Jabbour (2013), who shows an increase of 33% in the French manufacturing industry. Note that the two observation periods are different, since Jabbour (2013) focuses her analysis on the years 1990-2001, when the measurement of outsourcing was questionable (Thévenot and Valentin, 2004). In any case, the presence of periods of inactivity for contractors suggests the existence of sunk costs related to outsourcing. Firms cannot easily make adjustments because of contractual relations with their subcontractors that could be costly to modify.

As expected, the best-performing firms are the ones that use outsourcing and have the highest volume of entrusted outsourcing. Hence, a 1% increase in TFP increases the probability of using outsourcing by 0.74%. By contrast, Jabbour (2013) obtained an effect three times higher, but as she notes herself, since her measurement of firms' productive performance is calculated, rather than estimated as in our case, there is a high risk of bias. Productive performance also has a significant positive effect on the volume of outsourcing, since a 1% increase in TFP leads to increase of 0.15% in that volume.

Cyclical risk has a positive impact on both the decision to be outsourcer and the volume of outsourcing. Increasing the $risq\_conj_{jt-1}$ variable by 1% leads, respectively, to an increase of 0.6% in the probability to be outsourcer and an increase of 0.10% in the volume of outsourcing. This result confirms the hypothesis that outsourcers use outsourcing as a mean to absorb business shocks. This explanatory factor is at least as important as the productive performance, given the proximity of the values of the estimated coefficients. Conversely, technological risk has a negative effect, although it is lower (in absolute value), on the probability to be outsourcer and a non-significant effect on the volume of outsourcing.

Minimisation of labour costs has no significant effect on the decision to use outsourcing and on the volume of outsourcing, respectively. Hence, the coefficients of the w_{it-1} variable in columns (2) and (3) of Table 4 are not significantly different from 0. We note that Girma and Görg (2004) show very mixed results in the case of the United Kingdom. The two authors obtain no effect of labour costs for skilled and unskilled personnel on the intensity of outsourcing when they take the presence of individual effects into account in their models. Moreover, Jabbour (2013) finds no significant impact of labour costs on the decision to be an outsourcer, or on the intensity of outsourcing, in France. Although these various results converge, it remains difficult to conclude that high labour costs are not a reason to use outsourcing. As we have observed in our sample, a significant number of firms are both outsourcers and outsourcees (30.51% of all observations). For these firms, the presence of high labour costs cannot be a valid argument. Further, the user cost of capital ($Cout\_usage_{jt-1}$) has no significant effect on the probability to be an outsourcer, while it has a negative impact on the volume of outsourcing. This result suggests that contractors prefer to internalise the specific capital that is, *a priori,* the most expensive, rather than transferring it

to their subcontractors. It is consistent with the outsourcers' objective, highlighted above, to minimise technological risks[26].

For the variables of control, we find that firms belonging to a group outsource a larger volume of their activity than independent firms do. However, there are no significant differences in behaviour between the two types of firms as regards their choice to use outsourcing. Subsidiaries of foreign multinational groups use outsourcing less than independent firms do. This result differs from the conclusions of Girma and Görg (2004), but it is consistent with the hypothesis that multinational companies prefer to internalise their productive activities. In addition, exporter status does not seem to affect the probability of using outsourcing, while export intensity has a positive impact on the volume of outsourcing.

Larger firms have a higher probability of using outsourcing and their volume of outsourcing is higher. This result is consistent with the conjecture that outsourcers' size allows them to reduce the transaction costs of outsourcing (costs of seeking subcontractors, matchmaking and organisation of vertical relationships). Conversely, economies of scale (mes_{jt}) appear as an obstacle to the decision to use outsourcing. This result is in line with the expectation that firms prefer to avoid a fragmentation of their productive activities to subcontractors in order to benefit from economies of scale. However, for contracting firms, economies of scale have a positive effect on the volume of outsourcing. The results also indicate a growing relationship between the degree of concentration ($Conc_{jt}$) and the probability to use outsourcing, thus confirming the role of the size effect. The volume of outsourcing has a U-shaped relationship with the degree of concentration.

Despite these satisfactory results, a more direct measure of market thickness to favour matchmaking between contracting firms and subcontractors does not entirely provide the desired effect. In fact, $epais_{ijt}$ has a negative impact on the probability of being an outsourcer but a positive impact on the volume of outsourcing. The negative effect observed here is in contrast to the results of Jabbour (2013). Clearly, the results are quite different and they argue for a better proxy variable for market thickness[27], especially as there are strong suspicions of multicollinearity with sectoral variables. For example, the correlation between $epais_{ijt}$ and mes_{jt} is 0.48 (see Table A1.2 in Annex 1).

[26] However, the lack of effect of user cost on the decision to use outsourcing may also be explained by the fact that this variable is measured at sectoral level, and not at individual level. In fact, part of the effect of the user cost of capital is already captured through sector dummy variables.
[27] For example, in his empirical analysis, Tomiura (2009) introduced a dummy variable for firms' access to the Internet; this variable has a positive effect on the decision to use outsourcing.

Table 4
Estimates of equations for entrusted outsourcing

	Selection equation Uses outward subcontracting (1/0) Marginal effects		Equation of interest Volume of outsourcing (in logarithms)
	Individual uncorrelated effects	Individual correlated effects	
	(1)	(2)	(3)
out_{it-1}	0.2139 (53.271)	0.2107 (51.212)	-
$\widehat{tfp}_{it-1}$	0.0127 (6.852)	0.0074 (2.559)	0.1531 (9.845)
$risq\_conj_{jt-1}$	0.0061 (3.478)	0.0061 (3.438)	0.0990 (10.379)
$risq\_techno_{jt-1}$	-0.0023 (-2.340)	-0.0022 (-2.184)	0.0031 (0.511)
w_{it-1}	0.0271 (7.806)	-0.0075 (-1.380)	-0.0420 (-1.078)
$Cout\_usage_{jt-1}$	0.0005 (0.308)	0.0003 (0.194)	-0.1224 (-14.717)
$Small\_size_{it-1}$	Ref.	Ref.	Ref.
$Medium\_size_{it-1}$	0.0250 (14.285)	0.0072 (1.791)	0.1474 (7.285)
$Intermediate\_size_{it-1}$	0.0484 (10.909)	0.0210 (2.172)	0.4312 (10.139)
$Large\_size_{it-1}$	0.0832 (13.940)	0.0483 (3.145)	0.5980 (8.527)
$epais_{ijt}$	-0.0156 (-2.971)	-0.0154 (-2.913)	0.3377 (5.652)
mes_{jt}	-0.0228 (-4.648)	-0.0220 (-4.460)	0.2701 (5.140)
$Group_{it-1}$	0.0135 (7.982)	0.0119 (6.894)	0.1673 (12.843)
$Foreign\_group_{it-1}$	-0.0040 (-1.519)	-0.0067 (-2.471)	-0.1022 (-5.409)
Exp_{it-1}	0.0180 (10.533)	0.0001 (0.048)	-
$Export\_rate_{it-1}$	-	-	0.0016 (3.788)
$Conc_{jt}$	0.3120 (4.328)	0.2899 (4.096)	-3.2217 (-5.139)

$Conc_{jt}^2$	-0.2384 (-1.370)	-0.1932 (-1.116)	3.3747 (2.094)
$\widehat{mills\_ratio}_{it}$	-	-	-0.4398 (-14.888)
Const	-	-	1.012 (3.35)
# of firms	27299	27299	25261
# of observations	159429	159429	137826
Log likelihood	41367.097	41283.427	-
χ^2 Wald test	-	9.65 (0.022)	3944.13 (0.000)
Area under ROC	0.851	0.852	-
σ (Area under ROC)	(0.002)	(0.002)	

t-student in parentheses.

In column (1), the estimates of the probit model are just provided for comparison because this model is estimated under the restricted assumption that the random effects are uncorrelated with the regressors. In column (2), the probit model is estimated using the method proposed by Wooldridge (2005) to check for a possible correlation between the regressors and the individual effects and to control for a potential effect of the initial conditions on the dependent variable. The results presented in columns (1) and (2) correspond to the average marginal effects. The inverse Mills ratio is derived from the second Probit model and introduced into the equation of interest for which the estimates are presented in column (3). The individual means of the regressors are again introduced to check for a possible correlation with the individual effects. The QGLS method is used to improve the estimates' precision. For equations (2) and (3), a Wald joint hypothesis test is carried out to verify that all of the regressors are correlated with the individual effects (H_0). The probability of accepting H_0 is shown in parentheses. All three models incorporate time and sector dummy variables. Thirteen manufacturing sectors were selected from the French NA classification. To facilitate reading the results in Table 4, the estimated coefficients of time and sector dummy variables, as well as intra-individual averages and out_{i0}, are not reported. As $\widehat{tfp}_{it-1}$ and $\widehat{mills\_ratio}_{it}$ are generated regressors, the standard deviations are calculated using 100 bootstrap replications.

4.3. Increased performance and entrusted outsourcing

While the best-performing firms have the highest probability of being outsourcers and also outsourcing a large volume of activity, entrusted outsourcing in turn increases firms' productive performance (see column 1 of Table 5). In addition, and contrary to the findings of Kotabe and Mol (2009), the relationship is (log-) linear since the quadratic term $\widehat{out}_{it}^2$ has no significant effect on the performance variable $\widehat{tfp}_{t+1}$. This result tends to be more robust than those of Girma and Görg (2004). When correlated individual effects are introduced in their specifications, the impact of outsourcing on firms' performance is systematically insignificant in the three manufacturing sectors studied (Chemicals, Precision instruments and Electronics). However, the estimated value of the $\widehat{out}_{it}$ parameter in our performance equation is very low. Hence, a 1% increase in the volume of outsourcing only induces an increase of 3×10^{-3} % in TFP.

The performances of (foreign) group-affiliated firms are lower than those of independent firms, once we check for the volume of outsourcing. Furthermore, the coefficient of the $Export\_rate_{it}$ variable is not significant. The increase in the intensive margin does not seem to give rise to a learning effect for exporters in foreign markets and does not allow them to increase their productive performance[28]. As in the two previous equations, the concentration effect is non-linear, showing an inverted-U relationship. However, with a turning point $Conc = 0,30$, this non-linear relationship applies only to the Manufacture of coke and refined petroleum products sector. For other sectors, the concentration effect on corporate performance is linear and increasing.

Relationships considered through our performance model may depend on intrinsic characteristics of sectors, in particular the technological level as suggested by the literature and by Table 3. Using Eurostat/OECD classification for the technological level of sectors, we re-estimated equation (4) from two sub-samples. The first corresponds to high and medium-high technology sectors; the second to medium and low technology sectors. Estimates indicate that in high and medium-high technology sectors, the volume of outsourcing does not improve firm performance. On the contrary, it reduces firm performance because the elasticity equals $-0,0114 - 2 \times 0,0032 \times \widehat{out}_{it}$. Nevertheless, the effect is not very noticeable, since the estimated elasticity at the average point of the sample is -0.03. Thus, a 1% increase in the volume of outsourcing leads to a reduction of 0.03% in TFP. However, since the elasticity at the tenth decile is -0.37, the effect of outsourcing on firms' performance is now much stronger. In low and medium technology sectors, the positive relationship between outward subcontracting and firms' productive performance is still present, and its estimated elasticity remains low. These results suggest that in sectors with high technological intensity, and unlike other industries, the firms who most use outsourcing would be better off by internalising their activities.

[28] This result differs from the conclusions generally obtained in the literature. Generally, the literature shows a positive effect of export intensity on firms' performance (for a comparison of fourteen countries on the basis of enterprise data, see (ISGEP, 2008). One possible explanation for this observed difference is that the learning effect is largely mediated by trade flows created by international subcontracting.

Table 5
Estimates of the Performance equation ($\widehat{tfp}_{t+1}$)

	Overall (1)	High and medium-high technology sectors (2)	Medium and low technology sectors (3)
$\widehat{out}_{it}$	0.0031 (1.901)	-0.0114 (-3.483)	0.0041 (1.852)
$\widehat{out}_{it}^{2}$	-0.0008 (-1.466)	-0.0030 (5.095)	0.0006 (0.714)
$Group_{it}$	-0.0011 (0.242)	-0.0078 (0.805)	0.0052 (0.910)
$Foreign\_group_{it}$	-0.0182 (2.345)	-0.0346 (-2.814)	-0.0128 (1.723)
$Export\_rate_{it}$	-0.0000 (-0.104)	-0.0004 (-1.906)	0.0001 (0.824)
$Conc_{jt}$	3.6117 (16.950)	7.3647 (23.185)	-1.9286 (-3.822)
$Conc_{jt}^{2}$	-5.9672 (-5.9633)	-33.1393 (-14.289)	3.9202 (3.517)
Constant	-2.397 (-158.57)	-1.513 (-46.41)	-2.400 (-151.24)
# of firms	25268	6996	18568
# of observations	132145	38194	93951
χ^2 Wald test	1122.74 (0.000)	390.49 (0.000)	931.04 (0.000)

t-student in parentheses.

The individual means of the regressors are introduced in the three equations to control for a possible correlation between regressors and individual effects. The QGLS method is used to improve the estimates' precision in all three cases. A Wald joint hypothesis test was carried out to verify that all regressors are correlated with the individual effects (H_0). The probability of accepting H_0 is shown in parentheses. All three models incorporate time and sector dummy variables.

Thirteen manufacturing sectors were selected from the French NA classification. For an easier reading of the results in Table 5, the estimated coefficients of time and sector dummy variables, as well as individual means, are not reported. As $\widehat{out}_{it}$ and $\widehat{out}_{it}^{2}$ are generated regressors, the standard deviations are calculated using 100 bootstrap replications.

Conclusion

This working paper has analysed the relationships between entrusted outsourcing and firms' productive performance. Insofar as the relationships are bidirectional, a dynamic three-equation model is proposed. The first equation refers to the probability of having the status of outsourcer, the second concerns the volume of entrusted outsourcing and the third is a performance function for the (estimated) amount of outward subcontracting. Estimates of this model were made from an unbalanced sample of 27,311 French manufacturing firms observed over the period 1998-2007.

From the results, we derive that as firms' performance increases, so does their probability of being an outward subcontractor. The best-performing firms are also those for which the volume of outsourcing is highest. In addition, outsourcing improves firms' performance in medium and low technology sectors, but to a small extent. Conversely, outsourcing reduces firms' performance in high and medium-high technology sectors; this effect is particularly significant for contracting firms that rely heavily on outsourcing.

The results also exhibit that contracting firms use outsourcing as a means to externalise cyclical risks. Conversely, outsourcers seem to internalise technological risks. Minimisation of production costs does not appear to be an objective for contracting firms.

For the control variables, among the most noticeable results is that firms' size has a positive effect on the probability of being a contracting firm and on the volume of entrusted outsourcing. Group affiliation only has a positive effect on the probability of being an outsourcer, while subsidiaries of foreign multinational firms use less outsourcing than domestic firms do. The presence of economies of scale reduces the probability of being an outsourcer; market concentration has an inverted-U effect on this probability.

In view of these results, one might be tempted to encourage the development of outsourcing in medium and low technology sectors and, on the contrary, to limit its scope in high and medium-high technology sectors, to avoid reducing the performance of outsourcers. However, public intervention in this regard could only be considered if it also takes into account the impact of outsourcing on the productive performance of the subcontractors themselves. Our analysis should be completed by determining whether this mode of organisation for productive activities actually has an overall positive effect on performance in each sector.

It would also be useful to distinguish between two types of outsourcing: capacity outsourcing (when the contracting firm has the resources necessary to manufacture the intermediate product) and specialty outsourcing (when the contracting firm lacks the technical ability to produce the outsourced product). Depending on the case, the logic underlying the decision to use outsourcing is different for the contracting firm. In particular, the risks to be considered are not of the same nature. Capacity subcontracting provides the contractor additional flexibility to manage cyclical risk; specialty outsourcing allows the contractor to minimise the risks and costs inherent in the production of innovation.

Annex 1

Additional descriptive statistics

Table A1.1
Characteristics of variables (except outsourcing)

Sample size: 186,836 observations

Variable	Mean	SD	Minimum	Maximum
TFP (in thousands of euros)	14.12	16.30	0.13	1855.35
cyclic_risk (in logarithms)	103.97	91.51	7.54	359.60
technological_risk (in logarithms)	29.06	24.01	0.45	110.72
W (in thousands of euros)	36.36	12.94	6.31	480.75
User cost (price index)	10.490	1.01	9.500	15.223
Small_size (in %)	56.88	-	-	-
Medium_size (in %)	34.15	-	-	-
Intermediate_size (in %)	4.97	-	-	-
Large_size (in %)	3.99			
Thickness (in logarithms)	12.08	0.84	6.75	13.25
Ex (in %)	75.60	-	-	-
Export_rate (in %)	17.32	23.93	0.00	100.00
Group (in %)	61.55	-	-	-
Foreign_group (in %)	16.03	-	-	-
Conc	0.02	0.02	0.00	0.56
MES (in logarithms)	0.001	0.002	0.00	0.09

Table A1.2
Correlation matrix

	TFP	Cycl_risk	Technological_risk	W	User_cost	Small_size	Medium_size	Intermediate_size	Large_size	Thickness	Ex	Export_rate	Group	Foreign_group	Conc	MES
TFP	1.00															
Cycl_risk	-0.05	1.00														
Technological_risk	-0.07	0.50	1.00													
W	0.23	-0.07	0.07	1.00												
User_cost	-0.01	0.24	0.19	-0.13	1.00											
Small_size	0.00	0.07	-0.02	-0.07	-0.04	1.00										
Medium_size	-0.02	-0.04	0.01	-0.03	0.02	-0.83	1.00									
Intermediate_size	0.01	-0.04	0.00	0.07	0.02	-0.26	-0.16	1.00								
Large_size	0.03	-0.04	0.02	0.16	0.03	-0.23	-0.15	-0.05	1.00							
Thickness	-0.15	0.48	0.58	0.04	0.07	-0.01	-0.00	0.00	0.02	1.00						
Ex	0.05	-0.04	0.03	0.13	0.04	-0.20	0.13	0.09	0.10	0.01	1.00					
Export_rate	0.07	-0.00	0.05	0.18	0.04	-0.23	0.12	0.13	0.17	0.01	0.41	1.00				
Group	0.06	-0.14	0.01	0.18	-0.06	-0.35	0.23	0.16	0.16	-0.00	0.14	0.17	1.00			
Foreign_group	0.03	-0.07	0.03	0.21	0.00	-0.28	0.12	0.19	0.19	0.04	0.15	0.27	0.35	1.00		
Conc	-0.02	-0.26	-0.06	0.06	0.01	-0.07	0.03	0.04	0.07	-0.12	0.06	0.07	0.06	0.08	1.00	
MES	0.05	-0.23	-0.20	0.05	-0.00	-0.04	0.01	0.02	0.04	-0.48	0.02	0.02	0.04	0.04	0.58	1.00

Table A1.3
Results of Kolmogorov-Smirnov test
Performances of outsourcers versus performances of non outsourcers

Manufacturing industries from the French NA nomenclature		Test statistic (p-value)
1	Manufacture of food products and tobacco products	-0.0065 (0.894)
2	Manufacture of textiles, wearing apparel, leather and related products	-0.0006 (0.998)
3	Manufacture of wood and paper products; printing and reproduction of recorded media	-0.001 (0.995)
4	Manufacture of coke and refined petroleum products	-0.2086 *** (0.002)
5	Manufacture of chemicals and chemical products	-0.047 (0.063)
6	Manufacture of basic pharmaceutical products and pharmaceutical preparations	-0.0491 (0.650)
7	Manufacture of rubber and plastics products, and other non-metallic mineral products	-0.0281 ** (0.011)
8	Manufacture of basic metals and fabricated metal products, except machinery and equipment	-0.0005 (0.999)
9	Manufacture of computer, electronic and optical products	-0.0227 (0.291)
10	Manufacture of electrical equipment	-0.001 (0.999)
11	Manufacture of machinery and equipment n.e.c.	-0.0064 (0.865)
12	Manufacture of transport equipment	-0.0098 (0.943)
13	Other manufacturing; repair and installation of machinery and equipment	-0.0126 (0.817)

The number of asterisks (*) indicates the significant level of the Kolmogorov-Smirnov test statistic: **: 5%; ***: 1%.

Chart A1.1
Distribution functions of productive performance for outsourcers and non-outsourcers, by sector (French NA classification)

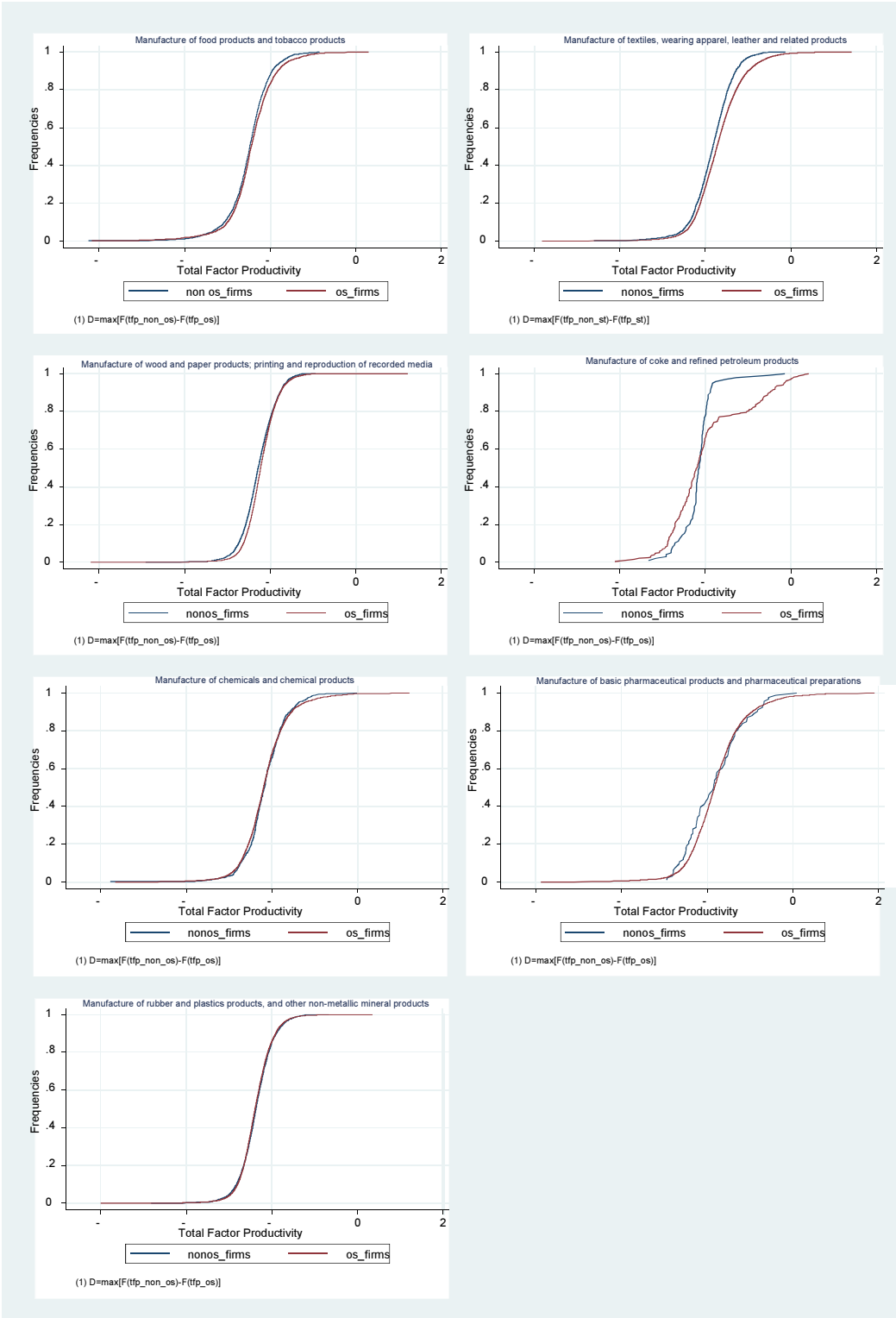
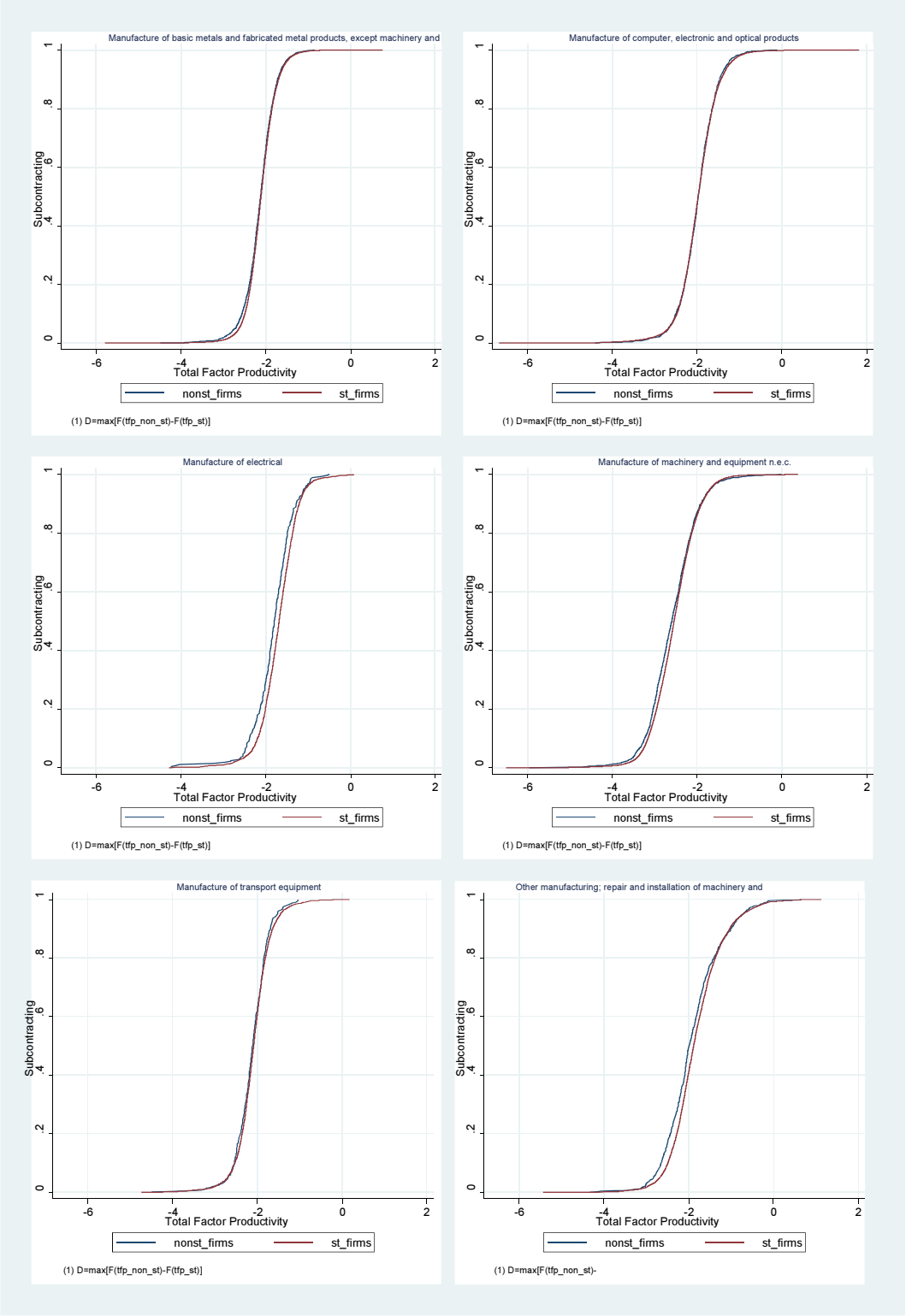


Chart A1.1 (continued)



Annex 2

Ackerberg, Caves and Frazer method for estimating the Cobb-Douglas production function

Under this approach, it is assumed that tfp_{it} can be represented by a nonlinear function of the capital stock (k_{it}), the quantity of labour (l_{it}), the intermediate inputs (m_{it}) (a proxy used for identification), such that for any industry *j,* the production function is:

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + h(l_{it}, c_{it}, k_{it}, m_{it}) + \varepsilon_{it}$$ [29] (6)

The procedure consists of two steps. In the first step, the non-linear expression (6) is estimated at each sector level in order to capture the potential differences in technology. As the inputs of the production function are no more correlated with the error term ε_{it}, we can consistently estimate (6) by using OLS. However, given the non-linear form of (6), it is not possible to identify the inputs' coefficients.

Using the d'Olley and Pakes (1996) approach, we assume that tfp_{it} follows a first order Markov process, such as:

$$tfp_{it} = E\left(tfp_{it} \mid tfp_{it-1}\right) + \xi_{it} \quad (7)$$

where ξ_{it} is an unanticipated productivity shock.

In the second step, the coefficients of capital and labour can be identified. To do this, we assume that the physical capital stock used in the current process is fixed at the end of the previous period. Consequently, the capital stock is not correlated with ξ_{it}. In addition, we consider that the labour factor is not perfectly flexible, since labour demand adjusts with time. We therefore assume that l_{it-1} is also independent of ξ_{it}. In practice, for fixed values of β_l and β_k, we can estimate the expression (6) and thereby derive $\widehat{tfp_{it}}$. From the OLS regression of $\widehat{tfp_{it}}$ on a fourth order polynomial in $\widehat{tfp_{it-1}}$, we can calculate $\hat{\xi}_{it}$. Lastly, we evaluate the sample analogue to the moment conditions used to identify the production function parameters, i.e.

$$\frac{1}{N}\frac{1}{T}\sum_t\sum_i \hat{\xi}_{it}\begin{pmatrix} k_{it-1} \\ l_{it-1} \end{pmatrix} \quad (8)$$

The procedure is repeated for different values of the parameters. To minimise expression (8), we use a genetic algorithm, which is a stochastic optimisation algorithm substantially faster than the grid search method used by Ackerberg *et al.* (2006) to estimate the production functions.

[29] The function $h(.)$ is always defined, on the condition that the proxy variable m_{it} is always positive (Olley and Pakes, 1996).

Annex 3

Estimates of the production function by manufacturing sector

Table A3.1
Estimates of input coefficients by the ACF method[1]

French NA nomenclature - 13 manufacturing sectors [2]

	Manufacture of food products, beverages and tobacco products	Manufacture of textiles, wearing apparel, leather and related products	Manufacture of wood and paper products; printing and reproduction of recorded media	Manufacture of coke and refined petroleum products	Manufacture of chemicals and chemical products	Manufacture of basic pharmaceutical products and pharmaceutical preparations
$\log K_{-1}$ [3]	0.303 (9.847)	0.181 (11.181)	0.228 (53.181)	0.389 (2.774)	0.267 (7.236)	0.167 (6.740)
$\log L$	0.750 (7.716)	0.573 (1.770)	0.720 (76.736)	0.747 (4.791)	0.761 (13.119)	0.771 (22.779)
# of observations	36718	39404	36122	631	9797	4188
# of firms	3611	4177	3713	53	949	404

t-student in parentheses.

[1] ACF is a two-step method. Since the coefficients for physical capital and labour are estimated during the second step, their standard deviations are biased. Therefore, the standard deviations are calculated using 100 bootstrap replications.
[2] 13 manufacturing sectors were selected. They are derived from the French NA classification, compatible with European NACE Rev. 2 classification.
[3] To be consistent with the assumptions of the ACF method, the physical capital stock lagged by one year is used as a regressor.

Tableau A3.2
Estimates of input coefficients by the ACF method[1]

French NA nomenclature - 13 manufacturing sectors [2]

	Manufacture of rubber and plastics products, and other non-metallic mineral products	Manufacture of basic metals and fabricated metal products except machinery and equipment	Manufacture of computer, electronic and optical products	Manufacture of electrical equipment	Manufacture of machinery and equipment n.e.c.	Manufacture of transport equipment	Other manufacturing; repair and installation of machinery and equipment
$\log K_{-1}$ [2]	0.239 (14.763)	0.224 (35.935)	0.260 (7.681)	0.238 (7.800)	0.235 (21.896)	0.218 (10.211)	0.180 (12.686)
$\log L$	0.753 (27.242)	0.719 (62.571)	0.7132 (12.549)	0.652 (9.362)	0.795 (39.117)	0.690 (20.411)	0.733 (12.686)
# of observations	37977	82679	26412	5165	36040	6621	12673
# of firms	3599	8022	2645	500	3442	639	1396

t-student in parentheses.
[1] ACF is a two-step method. Since the coefficients for physical capital and labour are estimated during the second step, their standard deviations are biased. Therefore, the standard deviations are calculated using 100 bootstrap replications.
[2] 13 manufacturing sectors were selected. They are derived from the French NA classification, compatible with European NACE Rev. 2 classification.
[3] To be consistent with the assumptions of the ACF method, the physical capital stock lagged by one year is used as a regressor.

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