

# **MEDIATION EFFECTS OF TRUST AND CONTRACTS ON KNOWLEDGE-SHARING AND PRODUCT-INNOVATION: EVIDENCE FROM THE EUROPEAN MACHINE TOOL INDUSTRY**

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**Purpose**

This paper analyzes the mediating role of contracts and trust on the generation of product innovations stemming from buyer-supplier knowledge-sharing among the members of the supply chain. Together with the individual effects of trust and contracts, their joint effect is examined in order to determine whether these are complementary or alternative mechanisms of safeguarding and control.

**Design/Methodology/Approach**

Drawing on a survey of 202 European machine tool firms acting as buyers and sellers, we propose and evaluate a structural equation model.

**Findings**

Results confirm that there is a positive relation between contracts and trust with respect to buyer-supplier knowledge-sharing, and of the latter with respect to innovation performance. They also show that firms in which both the levels of trust and contract use are high reinforce their product-innovation capability based on buyer-supplier interaction (complementarity thesis). However, results also show that, contrary to trust, contracts by themselves do not act as a stimulus for product innovation.

**Limitations/Implications**

Establishing contracts seems to be a highly recommended action in a buyer-supplier relationship focused on increasing innovation capacity. This does not go against engendering trust in a relationship. Both trust with a degree of formalization, in different ways, help to increase the effect of sharing valuable knowledge on innovation capacity.

**Originality/Value**

To our best knowledge, no prior study has delved into differentiating the use of contracts and trust as mechanisms in mediating the effect originated from knowledge-sharing on product innovation performance with two different samples formed by buying and selling firms.

**KEYWORDS**

Trust; Contracts; Knowledge-sharing; Innovation; Supply chain; Machine tool industry

**JEL CODES**

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# **MEDIATION EFFECTS OF TRUST AND CONTRACTS ON KNOWLEDGE-SHARING AND PRODUCT INNOVATION: EVIDENCE FROM THE EUROPEAN MACHINE TOOL INDUSTRY**

## **1. INTRODUCTION**

A firm's buyers and suppliers are important sources for the identification of strategic challenges and the knowledge required to meet them: in other words, to innovate.

Relationships with suppliers in particular can have a considerably positive influence on buyers' innovative capacity and their ability to offer high quality and added-value products down the supply chain (Dyer & Nobeoka 2000, Bessant 2004, Wagner 2006). Collaborative relationships with buyer firms can also be a source of creativity and new ideas, as well as an effective way of ensuring loyalty to the seller. In this connection, there is a need to establish and maintain long-term relationships (Anderson & Narus 1990; Bidault & Castello 2009; Gila 2009; Grönroos 1983; Jap & Ganesan 2000; Noordevier et al. 1990) and to find mechanisms for effective diffusion of needs and knowledge among buyers and suppliers.

Various studies have brought to light the positive relationship between knowledge-sharing and innovation performance for the members of the supply chain (Li et al. 2009; Lin et al. 2012; Tsai 2009). This has led to the conclusion that firms sharing more knowledge tend to benefit from more valuable innovations. Sharing information can also bring risks, however, to the extent that it can lead to a loss of exclusive knowledge that is fundamental for the firm. Especially important, therefore, are the means available for ensuring that buyer-supplier knowledge-sharing (KS) does help the organization to gain a competitive edge without precipitating any opportunistic actions from competitors. The existence of formal contracts and the presence of trust are two well-recognized instruments of guarantee and control to this end (Williamson 1985, Dyer & Singh 1998, Wang et al, 2011, Cao and Lumineau, 2015). However, current research in the field has not reached a consensus on whether trust or a formal contract is more useful for the purpose of engendering innovation in the buyer-supplier realm, or with respect to how they should be employed. This is information that managers need in order to focus their efforts on the most adequate tool for the improvement of their innovation capability.

Therefore, the principal aim of this paper is the analysis of the mediating role of contracts and trust on the generation of product innovations stemming from buyer-supplier KS among the members of the supply chain, and thus to give an answer to some practical questions for management: Will increasing the formalization of the contract have a significant effect on innovation performance? Would an increase in mutual trust have a comparable effect? Will those two factors be mutually exclusive with respect to the improvement of innovation performance, or reinforcing it? And how does the combination of the two mediate the effect of buyer-supplier KS on innovation?

Data for analysis were gathered from 202 European firms in the machine tool industry, which is characterized by buyers and providers being the main drivers of innovation (Carlsson 1995; Chuma 2001; Lissoni 2001; Lissoni & Pagani 2003; Chen 2006; Otero 2010). Those same buyers and suppliers are also a conduit for potential knowledge spill-over to competitors (Chen 2006; Chuma 2001; Lissoni & Pagani 2003; Otero 2010; Wengel & Shapira 2004). This industry is therefore a particularly interesting setting for the study of exchange governance mechanisms.

Our paper is organized as follows. The introduction is followed by a review of the literature on trust and contracts, and their impact on buyer-supplier KS and innovation, which forms the basis of a four-part hypothesis for empirical testing. The third section explains the methodology of our study, and describes the main results. A fourth section presents our conclusions and then examines the theoretical and practical implications of the study. We finally identify and discuss the limitations of the research and the avenues that remain open for further research.

## **2. CONCEPTUAL FRAMEWORK AND RESEARCH HYPOTHESIS**

### **2.1. Knowledge-sharing routines and innovation**

Dyer & Singh (1998, p. 665) define knowledge-sharing routines among firms as “regular patterns of inter-firm relations that permit the transfer, recombination and creation of specialized knowledge”.

The delivery of complex products and services, when valuable knowledge is recognized, shared and absorbed from partners, can generate improvements in the selling firm’s cognitive capacity and information-processing capabilities from a

condition of bounded rationality to one of expert rationality (Gulati & Sytch, 2007; Uzzi, 1997). Intense information and knowledge-sharing between buyers and suppliers increases the probability of generating new ideas early in the process and of discovering new ways to enhance performance (Dyer 1997) and thus, be a key factor in product innovation performance (Lin 2007; MacDuffie & Helper 1997).

Sharing and exploiting knowledge are linked to the conditions needed for its transfer, requiring efforts and resources such as smooth and easy communication; parties to the transfer who request or provide information; access to technical information available for transfer from the employees of one firm to those of the other; or technical communication resources that are compatible with the other party's (Charterina and Landeta, 2013). The following hypothesis, in line with two previous studies from Charterina and Landeta (2010 y 2013), links the efforts to share information and gain knowledge with superior performance in product innovation. Thus:

H<sub>1</sub>. A great knowledge-sharing effort in the buyer-supplier relationship is positively related to superior product innovation performance.

## **2.2. Trust, knowledge-sharing and product innovation performance**

The literature on business-to-business relationships discusses numerous ways in which trust enhances buyers' and suppliers' performance in exchange relationships. Given the goal of our research study, this sub-section will focus on the literature linking trust, buyer-supplier KS and product innovation.

Trust between buyer and supplier can be defined as the expectation that the other party can be relied upon to fulfill its obligations, to behave predictably, and to act and negotiate fairly even when opportunism is possible (Zaheer, McEvily & Perrone 1998), whether or not the behavior of said party can be monitored or controlled (Mayer et al. 1995; Joshi & Stump 1999; Krishnan, Geysenks & Steenkamp 2016)

When buyers and suppliers trust each other, they are more willing to engage in open communication and share information (Jap 1999; Morgan & Hunt 1994; Villena et al. 2011; Zaheer et al. 1998). In their meta-analytic review of 75 studies van Wijk *et al.* (2008, 840) found strongly significant medium to large effect sizes of trust on

knowledge transfer, concluding that trust and tie strength were the most important drivers of organizational knowledge transfer across organizations. Effective learning between partners is thereby facilitated (Gulati 1995; Lane et al. 2001; Selnes & Sallis 2003) and innovation performance enhanced (Wang et al. 2011).

Trust influences not only how much knowledge is shared between parties, but also the type that is transferred. When buyers and suppliers believe they will not be harmed or placed at risk by the other party's actions, they are more likely to share tacit knowledge that is specific and valuable (Dyer & Singh 1998; Uzzi 1997) and even organization-specific, proprietary and sensitive information (Uzzi 1997; Zaheer et al. 1998; Carey et al. 2011; Selnes & Sallis 2003). Trust can also help to evaluate and better understand knowledge-sharing between buyers and suppliers (Lane et al. 2001), in that "social relationship imbues information with veracity and meaning beyond its face value" (Uzzi 1997, p. 46).

In long-term relationships, such as those between the buyers and suppliers in our research sample, there are high levels of uncertainty and risk in terms of resources committed and final outcomes. Trust plays a critical role in the development of such long-term relationships, covering expectations about what the other party will do in circumstances that are very difficult to specify in a written contract (Blomqvist et al. 2005). In addition, disagreements might occur at different junctures in long-term relationships. High levels of trust enable both parties to find joint problem-solving solutions and sort out problems 'on the run' (Uzzi 1997), and to have the freedom to disagree, find productive resolutions to disagreements and produce novel insights from shared ideas (Moorman et al. 1992; Morgan & Hunt 1994).

Researchers have found a strong positive relationship between inter-organizational trust, business performance and innovativeness (Wang et al. 2011, Zaheer et al. 1998), suggesting that such trust paves the way towards inter-firm negotiations by lowering transaction costs (Zaheer et al. 1998) and increasing innovation (Molina-Morales et al. 2011). If the environment is extremely uncertain, mutual trust rather than formal contracts is the most effective mechanism for managing the supply chain relationship (Wang et al. 2011). When the high level of uncertainty is related to partner firms' behavior, trust has been found to have a particularly positive effect on performance (Krishnan, Martin and Noorderhaven (2006).

The role of trust as either an antecedent or mediator in buyer-supplier KS has been widely discussed in business-to-business literature. However, few previous studies have focused on its mediating effect in the direction *from* knowledge sharing *to* innovation. Trust can develop from knowledge mutually gained in the relationship, exercised by means of what Ballantyne (2004) has called “iterative cycles of dialogue”. In the supplier-manufacturer relationship, the establishment of embedded ties enables the creation of informal coordination mechanisms with the consequent elements of trust, commitment or joint problem-solving (Huang and Chang 2008). Pre-existing levels of trust between incumbent firms and potential buyers of disruptive technologies affect the former’s intention to adopt a new, disruptive technology (Obal 2013).

In long-term buyer-seller arrangements characterized by a high level of servicing, it is plausible to expect a relationship in which trust not only enhances buyer-supplier KS but that the relationship, in turn, also acts positively on trust. Therefore, we hypothesize that:

H<sub>2a</sub>. In a buyer-supplier relationship, greater knowledge-sharing routines are positively associated with a higher degree of trust.

Reflecting on the extensive work published on trust as a variable that is positively linked to product-innovation performance, we also propose:

H<sub>2b</sub>. In a buyer-supplier relationship, greater trust is associated with a higher degree of product innovation performance.

The linkage of these two sub-hypotheses allows us to account for the mediation effect (Baron and Kenny 1986; Cheung 2007; Hayes 2013) of trust in the relationship between buyer-supplier KS and product innovation performance. We therefore further hypothesize that:

H<sub>2c</sub>. Trust positively mediates the effect of buyer-supplier KS routines on product innovation performance.

### **2.3 Contracts, knowledge-sharing and product innovation performance**

Empirical evidence on indication of linkages between contracts, buyer-supplier KS and product innovation has not been conclusive. On the one hand, contracts can delineate the rights and obligations of buyers and suppliers and thereby reduce the risk of

opportunism. Specifically, there is empirical evidence that they: improve partners' coordination and commitment (Jap and Ganesan 2000); enhance the level of cooperation (Sivadas and Dwyer 2000); encourage the discussion and articulation of unspoken assumptions (Cannon et al. 2000); make exchange of information transparent (Noordhoff et al. 2011) and clarify expectations and obligations relating to innovation performance (Wang, Yeung and Zhang 2011). These points enhance buyer firms' innovation performance and cost control (Carey et al. 2011); and, as an overall consequence, facilitate knowledge transfer and improve product innovation performance (Wang et al. 2011).

According to Noordhoff et al. (2011), contracts between firms typically envisage and establish communication activities to be completed at key future points in the innovation process, and set them up. This means that valuable information which may have been overlooked in a less formalized relationship is included and that it is more structured and refined when shared. It should also reduce trivial and repetitive informal information flows that feed redundancy. In addition, contracts provide a way to manage conflict during knowledge transfer. Thus, the risks associated with spillover from buyer-supplier KS and collaborative innovation across the supply chain are lower, and the corresponding transaction costs reduced (Wang et al. 2011).

On the other hand, contracts between buyers and suppliers that are too detailed and complex can be as harmful to the knowledge transfer process as those containing too little information (Wang et al., 2011). The former may provide little flexibility to both parties (Jap and Ganesan 2000), hinder information sharing between a manufacturer and its suppliers in a limited area because of clear, contractual specification of what is and what is not allowed (Wang et al. 2011), and limit informal buyer-supplier KS (Noordhoff et al. 2011). Furthermore, as explicit contracts can signal a lack of trust on the buyer's part to the supplier, resulting in wariness from the latter, this is likely to bring about lower levels of commitment (Jap and Ganesan 2000) and sharing of tacit knowledge (Wang et al. 2011). The use of complex and detailed contracts in a manufacturer-supplier relationship may thus hinder knowledge transfer and collaborative innovation.

In fact, a study by Wang et al. (2011) highlighted that a contract with too many specifications can be as harmful as one with too little detail, despite a positive link



between a well-specified contract and a firm's innovation performance, (forming an inverted U-shaped relationship)

The research discussed in this sub-section has focused on explanation of how formal contracts affect buyer-supplier KS. Though the chronology of the factors and effects might imply causation, it will not be clear-cut in the case of long-lasting and reiterative relationships or those entailing the sale of a complex product demanding continuous revision of contract clauses. Given that positive effects are more frequent than negative ones according to the literature, and that the latter are more often a consequence of inadequate administration of contracts than actually using them, we hypothesize the links between contracts and buyer-supplier KS as follow:

H<sub>3a</sub>. A more intensive level of knowledge-sharing is linked to a greater use of contracts setting out the terms of the relationship between buyers and suppliers.

H<sub>3b</sub>. Intensity in the use of contracts is linked to a higher level of product innovation performance.

H<sub>3c</sub>. Contracts positively mediate the effect of knowledge-sharing routines on product innovation performance.

#### **2.4. Do contracts and trust substitute or complement each other?**

The literature has approached the relationship between trust and contracts as one in which either factor substitutes the other or the two complement each another. The substitution view argues that trust reduces the need for formal contracts (Gulati 1995; Ghoshal & Moran 1996; Dyer & Singh 1998; Uzzi 1997; Zaheer et al. 1998; Adler 2001; Wuyts & Geyskens 2005; Yang et al. 2011; Wang et al. 2011). Proponents of the substitution argument assert that firms should not attempt to build trust and construct formal contracts simultaneously, since both strategies are costly in terms of time and effort (Wuyts and Geyskens 2005), and that one of two strategies serving the same goal of reducing opportunistic behavior may prove to be redundant (Dyer & Singh 1998). Thus, when there are high levels of trust between buyers and suppliers, it is unnecessary to specify or monitor contractual clauses (Dyer & Singh 1998) and it is possible to reduce transaction costs by “replacing contracts with handshakes” (Adler 2001). It has also been argued that exchange partners exhibit “bilateral expectations of willingness to make adaptations” (Heide & John 1992) to their contractual obligations in response to

changes in their operational environments, rather than strictly adhering to the original terms.

Some researchers have further suggested that contracts and trust are not only redundant but in fact counteract their respective effects. Trying to reduce opportunistic behavior by drafting unduly detailed contracts containing coercive terms, clauses and sanctions, may be interpreted as a signal of distrust (Jap & Ganesan 2000). That distrust may, in turn, breed more distrust, causing the relationship between the controlling and controlled parties to degenerate into “pathological spiraling relationships” (Ghoshal & Moran 1996). Paradoxically, high levels of trust and cooperation between buyers and suppliers can actually undermine the effectiveness of explicit contracts, because of reluctance to obey severely enforced contractual details (Antia & Frazier 2001).

The alternative complementary analysis of the relationship was proposed by Ring & Van de Ven (1994), Cannon et al. (2000), Poppo & Zenger (2002), Luo (2002), Reuer & Ariño (2007), Liu et al. (2009), and Carey et al. (2011). Given that contracts specify a long-term commitment to buyer-supplier KS, reduce the risk of opportunistic behavior and promote expectations that the other party will behave cooperatively, they contribute to the development of trust. However, in a reverse complementary relation, trust facilitates the refinement of contracts (Poppo and Zenger 2002). It has also been found that the co-existence of trust and contracts has a complementary effect: the higher the levels of trust and previous collaboration, the easier it is to adapt the contract to unforeseen changes of circumstance and complete it with new clauses and conditions, thereby nurturing continuing cooperation (Luo 2002). When both contracts and trust are present, ‘relationship performance’ improves more significantly and opportunism is more effectively restrained than when only one of the variables is present (Liu 2009). Furthermore, there is empirical evidence that contractual agreements help ensure the continuity of the exchange when buyers and suppliers share ‘relational norms’ by virtue of clarifying the obligations and expectations of the parties (Cannon et al. 2000). Lastly, it has been found that enforcement of contract terms helps to ease buyers’ transition into exchanges with new sellers, thereby reducing the hazards, particularly in situations of high uncertainty about finding optimal partners (Lazzarini et al. 2008)

Contradictory empirical studies that support opposing explanations of the mutual effect of contracts and trust are largely explained by the fact that the two factors play different roles and are not equally effective in regulating business relationships in all the

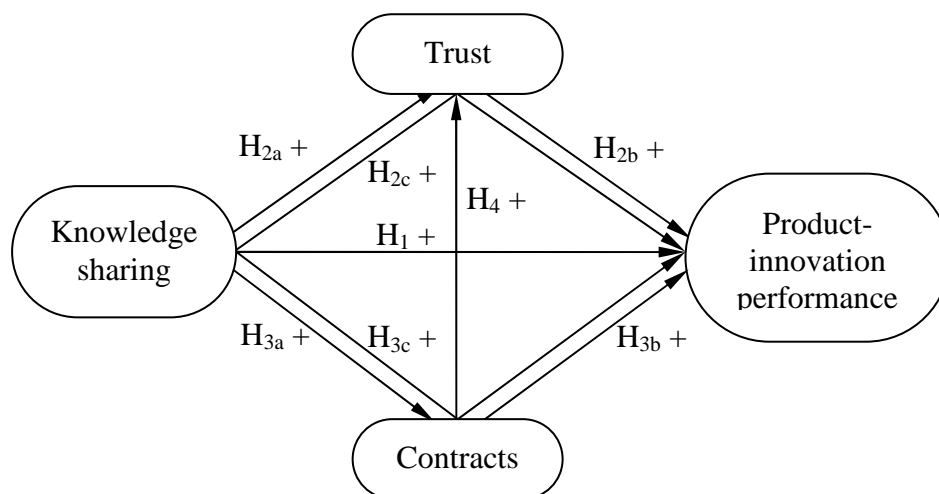
industries and regions in which research was conducted. For example, Yang et al. (2011) and Wang et al. (2011) warn that they could not generalize the results of their study which supported the substitution view, given that said results were influenced by Chinese culture and China's rather ineffective legal system. We assume that the economic, cultural, political, legal, and business contexts in which buyers and suppliers are embedded, and that these influence the effectiveness of trust and contracts as governance mechanisms. Thus, we argue that research to test for complementarity or substitution should focus on key industry sectors in a variety of countries and regions in order to form a basis for the future generalization of findings.

To sum up, there seem to be different but equally logical arguments for interpreting the contradictions that have been found with regard to the mutual effects of contracts and trust, namely the complexity of contractual provisions and factors related to regionality and industry sectors. In this sense, the characteristics of the machine tool industry, on which we base the empirical study, its focus on stable buyer-seller relationships, and its geographical location in Europe, lead us to formulate our hypothesis on positive relation:

H<sub>4</sub>. The use of contracts is significantly related to a higher level of trust.

Figure 1 shows the research hypotheses schematically in a general conceptual framework for the study.

**Figure 1. Conceptual framework**



As well as the formal research hypotheses, the figure depicts the indirect effects linked to trust and the use of contracts as mediators in the relationship between buyer-supplier KS and product innovation performance. It also shows trust as a mediator in the path from contracts to product innovation performance, which was not hypothesized.

### **3. THE STUDY**

#### **3.1 Sample selection**

The data for this empirical study were gathered from a sample of European companies in Divisions 28.4 and 28.9 of the European Commission's *NACE Rev.2 Statistical Classification of Economic activities in the European Community*, which are respectively 'Manufacture of metal forming machinery and machine tools' and 'Manufacture of other special-purpose machinery' (Eurostat 2008). Telephone interviews were conducted with 202 managers in the sales, production, and management departments between May and July 2010 by a specially commissioned professional interviewing organization. These represent the successfully completed interviews from a number of 632 initially contacted firms. The firms comprising the sampling frame were 9,112 companies. These were selected from the NACE lists by reference to the AMADEUS searchable database of company information and business intelligence relating to 14 million companies in 43 European countries including the Russian Federation (Bureau van Dijk 2014). A sampling quota was constructed on the basis of the relative shares of the total machine tool industry in the European Union member states plus Switzerland.

From a sampling frame of 9,112 companies, a quota sampling process dividing the population of firms in terms of country of origin, and size was followed. Proportions from countries were: 37% from Germany, 19.7% from Italy, 8.2% from Spain, 6.9% from France, 7.6% from Switzerland, and 20.7% from the rest of countries. In terms of size, an equal proportion distribution was formed dividing companies in two groups: those of less than 100 employees, and those having more than this number.

Average response rate from these telephone interviews in all the considered sub-groups was of approximately 32% until completion of the required sample of 202 complete valid interviews. The questionnaire was administered in English.

The following table shows some of the basic descriptive values as obtained from the final sample:

**Table 1. Used sample**

Variable			
<b>Size of firm</b>	Selling firms	Buying firms	
	< 100 workers	45	50
	≥ 100 workers	52	55
<b>Relationship with buyer/seller</b>	Since 2008	5.0%	
	Since 2006-2007	4.5%	
	Since 2003-2005	11.3%	
	Since 2000-2002	17.3%	
	Since before 2000	61.9%	
<b>Industries involved</b>	Industrial equipment	35.3%	
	Motor and motor parts	11.3%	
	Dies and moulds	6.0%	
	Food	5.3%	
	Textile	4.0%	
	Aero-space	2.3%	
	Wood	2.3%	
	Plastic materials	1.3%	
	Other	32.2%	

In order to attain the highest possible level of robustness in the model and to minimize variance in measurements and results between the supply and the distribution channels, the total sample was divided into two subsamples, formed by firms buying (n = 105) and selling (n = 97) the specified machinery and machine tools. The division of the sample into buyers and sellers in order to test the proposed measurement and causal models implies its inclusion as a control variable. Due to the reduced sizes of said subsamples, no other control variables were taken for the analysis. However, we used company unit data on their nationality and size, in order not to depart significantly from population quotas.

The criterion for selection of respondents was that they should be: in the case of the buying firms, the most senior production executive or, failing that, a plant manager or the CEO. In the case of the selling firms, they were preferably a sales manager or else the CEO. Respondents were asked to focus on a particular relationship with counterparts in a selling or buying firm, preferably during a recent buying or selling operation. The relationship was to have involved the sale and purchase of machinery, machine parts or complete installations which featured an innovation of some sort, *which had originated, at least in part, from the relationship with that particular buyer or supplier.*

### 3.2 Questionnaire design

To collect data measuring *product innovation performance*, we constructed a scale based on those in studies by Gemünden, Ritter & Heydebreck (1996), Ritter &

Gemünden (2004) and Salomo, Weise & Gemünden (2007). The scale used for responses relating to *buyer-supplier KS routines* drew on the original ideas of Dyer & Singh (1998) and Dyer & Nobeoka (2000), two seminal works which did not themselves propose measurement scales. On this basis, with the collaboration of 26 teaching staff and doctoral students at a Spanish and German university, an initial list of items was drawn up. It was in turn subjected to the judgments of two other research teams from our own department who had contributed to the study, allowing us finally to refine the list to six and five items for the cases of product-innovation performance and buyer-supplier KS routines, respectively.

Following the testing of the measurement model, additionally to the restriction of eliminating poor values in terms of reliability and validity, we had to reduce the number or admitted items per construct to only those that also guarantee the condition of measurement invariance across the two studied sub-samples (explained below). Thus, the items shown in Table 2 are those that finally complied with this condition: 2 from the initial number of 5, for *product innovation performance*, 3 from 5 in *knowledge-sharing*, all (i.e. 3) of the considered from *contracts*, and 2 from 3 initially considered for *trust*. These scales were comprised of two and three items, respectively (shown in Table 2).

With respect to the trust factor, there are relevant works showing how it has to be measured (see for example: Seppanen et al., 2007; Jones et al., 2010; Whipple et al., 2013). In our case, respondents answered on the ‘beliefs in interpersonal trustworthiness’ scale developed by Jap (1999). Although the original scale from this author contained five items, the invariance tests for both subsamples (explained below) obliged us to reduce this scales to two (see in Table 2).

For measurement of the *contracts* construct, the scale was derived from the ‘legal bonds’ factor in the work of Cannon et al. (2000), with a total of three items (see Table 2).

We used 7 point Likert scales. The measurement scales were devised for interpretation depending on whether the respondent’s firm was the buyer or seller in a machine tool sales transaction. Individual evaluations furthermore focused either on the sales or purchasing functions in a respondent’s own firm or on the buyer-seller relationship as a whole.

### **3.3 Testing the measurement model**

Table 2 presents translations of respondents' verbatim comments relating to the ten measurement items finally included in the measurement model, with the corresponding reliability in each case. Factor loadings, Cronbach's Alpha, average variance extracted (AVE) and construct reliability measures demonstrate average-to-good values, depending on the factor measured. In the case of the buyer-supplier KS factor, the test measures did not reach the minimum recommended values of 0.70 for Cronbach's alpha (Nunnally & Bernstein 1994) or 0.50 for the AVE (Fornell & Larcker 1981). However, composite reliability measures between 0.6 and 0.7 may be considered acceptable if the estimates of the model validity are good (Malhotra et al. 2012, p.876). In particular, the chi-square test result (Anderson & Gerbing 1988) confirmed discriminant validity among the factors, as general convergence results obtained from setting the highest correlation to 1 yielded an adjusted result inferior to that from the obtained correlation.

**Table 2. Reliability testing**

	Standardized loadings	Cronbach's alpha	AVE	Composite reliability
<b>Innovation performance</b>				
<b>INP1:</b> Thanks to the incorporated innovations, the product sold to this customer (or purchased from this supplier) allows us to attain exceptional quality or competitive advantage in the sector.	0.723			
<b>INP2:</b> Thanks to incorporated innovations, the machine sold (or purchased) provides us with a significant competitive edge.	0.852	0.763	0.624	0.768
<b>Knowledge-sharing routines</b>				
<b>KSR1:</b> Our technical experts provided our customer (or supplier) with a lot of information and specific knowledge, which was a very useful input to the development of our product.	0.632			
<b>KSR2:</b> We believe that good innovative ideas have derived from the suggestions or demands that we make or have made on our customer (or supplier).	0.579			
<b>KSR3:</b> We have or have had frequent discussions with this customer (or supplier) at which we put forward worthwhile information for improvement of the machine we sold (or purchased).	0.673	0.663	0.396	0.662
<b>Contracts</b>				
<b>CO1:</b> We have or have had written agreements detailing the obligations of both parties.	0.963			
<b>CO2:</b> We have detailed written agreements with this customer (or supplier).	0.960			
<b>CO3:</b> We have or have had a detailed contract with this customer (or supplier), specifying the innovation that the product is or was to feature.	0.757	0.919	0.807	0.854
<b>Trust</b>				

<b>TR1:</b> Both the customer (or supplier) and our company try to help each other mutually.	0.643			
<b>TR2:</b> Both companies trust each other.	0.766	0.677	0.500	0.665

Notes:

Base: 202 responses

MAXIMUM LIKELIHOOD MEASURES:  $\chi^2 = 46.097$  ;  $p = 0.02295$ ; 29 d.f. ; Standardized Root Mean Square Error of Approximation (RMSEA) = 0.056; 90% Confidence Interval of RMSEA (0.021, 0.086); Standardized Root Mean Square Residual (SRMR) = 0.043 ; Comparative Fit Index (CFI) = 0.981

ROBUST MEASURES: Satorra Bentler  $\chi^2 = 37.099$ ;  $p = 0.14372$ ; 29 d.f.; Bentler-Bonett Normed Fit Index = 0.955; Bentler-Bonett Non-Normed Fit Index = 0.984; CFI = 0.989; Bollen's Incremental Fit Index = 0.990; RMSEA = 0.039; 90% Confidence Interval of RMSEA (0.000, 0.072).

The obtained means, standard deviations and paired Pearson correlations of the used items are represented in table 3. We obtained a Confirmatory Factor Analysis (CFA) from these items grouped into the above defined constructs of our model using Structural Equation Modelling (Bollen 1989).

**Table 3. Means, standard deviations and Pearson correlations of the model items for the whole sample**

Item	Mean	Std. Dev.	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)INP1	5.72	1.036									
(2)INP2	5.61	1.028	0.616**								
(3) KS1	5.58	1.259	0.252**	0.294**							
(4) KS2	5.39	1.055	0.322**	0.272**	0.408**						
(5) KS3	5.27	1.347	0.324**	0.321**	0.402**	0.387**					
(6) CO1	5.06	1.889	0.142*	0.279**	0.134	0.094	0.236**				
(7) CO2	4.97	1.851	0.206**	0.290**	0.202**	0.125	0.314**	0.924**			
(8)MCO3	4.79	1.892	0.173*	0.250**	0.143*	0.091	0.254**	0.720**	0.725**		
(9) TR1	5.63	1.192	0.290**	0.334**	0.237**	0.130	0.204**	0.463**	0.427**	0.368**	
(10) TR2	5.86	0.957	0.365**	0.498**	0.252**	0.240**	0.370**	0.391**	0.433**	0.349**	0.524**

\*  $p < 0.05$ ; \*\*  $p < 0.01$

For its part, Table 4 shows that the confidence interval for each of the bivariate factor correlations did not include the value of 1 in any confidence interval. Finally, the square roots of all AVE values obtained are higher than any correlation in their corresponding row or column. Convergent and discriminant validity among the five factors is therefore demonstrated by the tests applied.



**Table 4. Test of discriminant validity**

	<b>Innovation performance</b>	<b>Knowledge-sharing routines</b>	<b>Contracts</b>	<b>Trust</b>
<b>Innovation performance</b>	<b>0.790</b>	0.622***	0.312***	0.690***
<b>Knowledge-sharing routines</b>	(0.446; 0.818)	<b>0.629</b>	0.383***	0.624***
<b>Contracts</b>	(0.145; 0.479)	(0.193;0.573)	<b>0.899</b>	0.620***
<b>Trust</b>	(0.535; 0.845)	(0.434;0.814)	(0.491;0.749)	<b>0.707</b>

Notes:

\*p , 0.05; \*\*p , 0.01; \*\*\*p , 0.001. Diagonal values represent the square root of the AVE. Those above the diagonal are factor correlations; those below are the confidence intervals of factor correlations.

According to the literature, in a cross-section study, common method variance can be lowered by means of a series of *ex ante* practical decisions, and *ex post* tests (Chang, Van Witteloostuijn, & Eden 2010, Nimon & Astakhova 2015, Simmering, Fuller, Richardson, Ocal, & Atinc 2015). The *ex ante* decisions involved the introduction of dependent and independent variables in different sections of the questionnaire, a guarantee of anonymity of interviewees, and an accurate selection of respondents (MacKenzie & Podsakoff, 2012). These measures described above were put in practice in the enclosed empirical study.

With respect to *ex post* measurement common method variance can be ascertained by means of a number of procedures (Podsakoff and Organ 1986, Lindell and Whitney 2001, Podsakoff et al. 2003). A first test is the Harman's one factor procedure using Principal Component Analysis (Podsakoff and Organ 1986). From this test, the obtained non-rotated single factor solution rendered a proportion of total variance equal to 40.46%, less than the limit threshold of 50%.

However, nowadays this test is not regarded in the literature as one giving sufficient accuracy of method variance. Thus, following Lindell and Whitney's (2001) increased marker variable factor, we employed a seemingly unrelated construct containing three reflective items and named *dependence*. This construct had been considered in the empirical study but finally was not included in our model. The results obtained show that the added factor did not give a significant increased effect in the general adjusted valued Chi-square values ( $\Delta\chi^2 = 23.702$  for  $\Delta df=26$ , from the accepted CFA model). Thus, from these results we can conclude that the measurement scale do not reach a critical level of common method variance.

To assess the extent to which the outcome of our study was a robust and generally applicable model, we applied it both to a buyer firm's view of its relationships with suppliers and to a supplier firm's view of its relationships with buyer firms. If a

measurement scale is to be used in different subsets of a sampling universe, as in this case, the observed variables or scales must be invariant across the whole research population (Mellenbergh 1989; Meredith 1993) at one of three levels labeled by Meredith as ‘weak’, ‘strong’ or ‘strict’.

Measurement invariance is held to be weak if equality of factor loadings is found for at least two items per factor (Byrne 1989; Byrne 2006, p.241-246; Hair et al. 2006, p.823; Muthén & Christofferson 1981). Table 5 shows that, in the case of the scales used in our study, the incremental chi-square values obtained demonstrate the non-significance of the value for the general adjustment, due to the restriction of equal factor loadings between seller and buyer firms. Thus, the measurement invariance between the buyer and seller subsamples was found to be weak.

**Table 5. Tests of measurement invariance**

	$\chi^2$ †	$\chi^2_{S-B}$ ††	<i>df</i>	$\Delta \chi^2$	$\Delta df$	<i>p</i>	$\Delta \chi^2_{S-B}$	<i>p</i> S-B	RMSEA (90% CI)	SRMR	CFI	TLI (NNFI)
Single groups:												
Buyers (n=95) ( <i>p</i> )	45.937 (0.024)	33.265 (0.267)	29						0.081 (0.030, 0.123)	0.067	0.967	0.948
Sellers (n=97) ( <i>p</i> )	50.944 (0.007)	37.281 (0.139)	29						0.093 (0.048, 0.134)	0.059	0.943	0.912
Measurement invariance:												
Equal form ( <i>p</i> )	96.882 (0.001)	70.529 (0.125)	58						0.087 (0.055, 0.116)	0.063	0.957	0.933
Equal factor loadings ( <i>p</i> )	99.896 (0.003)	74.105 (0.182)	64	3.014	6	0.807	2.739	0.841	0.080 (0.047, 0.108)	0.067	0.960	0.944

Notes:

Base: 202 responses

90%CI = 90% confidence interval for RMSEA (Root Mean Square Error of Approximation); SRMR = standardized root mean square residual; CFI = comparative fit index; TLI (NNFI) = Tucker-Lewis Index (Bentler-Bonett non-normed fit index)

† Maximum-Likelihood adjusted chi-square values

†† Satorra-Bentler adjusted chi-square values

### 3.4 Results

Structural equation modeling was used to test the eight hypotheses comprising the proposed model of the impact of trust and contracts on buyer-supplier knowledge-sharing and their effect on innovation, as set out schematically in Figure 1. The results are presented in Table 6.

Hypotheses H<sub>1</sub> to H<sub>2b</sub>, H<sub>3a</sub>, H<sub>3b</sub> and H<sub>4</sub> were assessed by means of the decomposition of total effects into the direct effects of their respective antecedent over the consequent. The rows of the table relating to H<sub>2c</sub> and H<sub>3c</sub>, and those captioned (1), (2) and (3) contain all the possible indirect effects existing among the factors in the model. However, an important limitation of this procedure is the possibility of non-linear effects among factors (Wang et al. 2011), such as the case of an inverted U-shaped relationship between the use of contracts and innovation performance, in which both too few or too detailed contractual terms correspond to low levels of innovation performance. The same could apply to the level of use of contracts with respect to buyer-supplier KS. We did in fact examine the effect of any possible quadratic effect of factor contracts, or a non-linear relation of these with buyer-supplier KS or with trust, finding no significant effects. These results are not shown here for the sake of brevity.

**Table 6. Regression Coefficients, *t* values and Model Summary Information**

	Total	Total sample‡		Multi-sample model ‡•					
		Std Coeff	<i>t</i>	Buyers		Sellers		Δ Std Coeff	Two-tailed <i>t</i>
	Direct and indirect effects			Std Coeff	<i>t</i>	Std Coeff	<i>t</i>		
H <sub>1</sub>	KS→IP	0.311	2.379**	0.487	3.493***	0.460	3.493***	0.027	0.983
H <sub>2a</sub>	KS→T	0.585	4.397***	0.557	3.837***	0.393	3.411***	0.055	0.965
H <sub>2b</sub>	T→PIP	0.616	3.149***	0.510	2.045*	0.345	2.149*	0.165	0.896
H <sub>2c</sub>	KS→T→PIP	0.266	2.546**	0.229	1.762	0.136	2.546*	0.093	0.941
H <sub>3a</sub>	KS→C	0.318	2.996**	0.182	1.907	0.212	1.907	-0.030	0.981
H <sub>3b</sub>	C→PIP	-0.170	-1.591	-0.041	-0.217	-0.048	-0.358	0.007	0.996
H <sub>3c</sub>	KS→C→PIP	-0.054	-1.348	-0.008	-0.196	-0.010	-0.318	0.003	0.998
H <sub>4</sub>	C→T	0.482	4.558***	0.595	4.453***	0.479	3.411***	0.116	0.926
(1)	C→T→PIP	0.297	3.031	0.304	1.914	0.165	1.805	0.139	0.912
(2)	KS→C→T	0.154	2.335*	0.108	1.680	0.101	1.531	0.007	0.996
(3)	KS→T→C→PIP	0.094	2.063*	0.055	1.330	0.035	1.317	0.020	0.987

Notes:

KS = knowledge sharing; PIP = product-innovation performance; T = trust; C = contracts

‡  $\chi^2_{S-B}$  (df=29) = 37.099 ( $p = 0.144$ ); RMSEA= 0.039 (0.000, 0.072); CFI = 0.989; TLI = 0.984

‡•  $\chi^2_{S-B}$  (df=67) = 75.885 ( $p = 0.214$ ); RMSEA= 0.039 (0.000, 0.076); CFI = 0.990; TLI = 0.987

\*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$

Overall, the regression coefficients relating to the hypotheses do not vary from the total sample to the buyer and seller subsamples. The details of the results show, first of all, that there is a positive and significant direct relationship between buyer-supplier KS and product innovation performance, supporting hypothesis H<sub>1</sub>. A significant positive relationship was also found between buyer-supplier KS and mutual trust and between trust and product innovation performance, meaning that hypotheses H<sub>2a</sub> and H<sub>2b</sub> are supported.

The proposed model also shows the full extent of the mediation effects of both trust and the use of contracts in the relationship between buyer-supplier KS and product innovation performance. An interesting interpretation of these relationships emerges from analysis of the mediating role of trust, formalized in hypothesis H<sub>2c</sub>. In the cases of the total sample and the selling companies subsample in particular, this mediation effect is significantly positive, meaning that inter-firm trust accounts at least partially for the positive relationship existing between buyer-supplier KS and product innovation performance. This positive sign in the mediation effect was also found in the buying firms subsample, but only at a weak significance level of 8.1%.

Contrary to the propositions in hypothesis H<sub>3b</sub>, the use of contracts does not seem to have any significant effect, positive or negative, on product innovation performance in any of the subsamples. They are therefore rejected. On the contrary, a more intensive level of buyer-supplier KS seems to be positively related to greater use of contracts, as posited in hypothesis H<sub>3a</sub>. This result holds only in the case of the whole sample, though it is almost statistically significant at 5% in the cases of the buyer and seller subsamples.

A more complete view of this relationship is to be found in the mediation role of contracts between buyer-supplier KS and trust, as shown in the row of Table 5 labeled (2). Again, the regression slope of this indirect effect is significantly positive in the case of the total sample, meaning that a significant portion of the positive effect of buyer-supplier KS on trust is attributable to the use of contracts. However, their mediating role in the relation between buyer-supplier KS and product innovation performance is negative, albeit non-significant. It seems that the use of contracts has a dual role, positively related to trust and buyer-supplier KS on the one hand, but with a non-significant negative effect on product innovation performance on the other.

Lastly, these results show a significant positive relation between trust and contracts. This supports hypothesis H<sub>4</sub>, sustaining a complementary relation between these two measures of guarantee and control.

#### **4. DISCUSSION**

The results of our study support the view of the majority of works in the relevant literature, stressing the importance of knowledge-sharing between buyers and their suppliers, and the relevant role of trust in order to achieve this.

However, the role of contracts is more controversial. Contracts seem necessary for buyer-supplier KS to take place, such as Jap and Ganesan 2000, Sivadas and Dwyer 2000, Noordhoff et al. 2011, and Wang et al. 2011 advocated. However, contracts alone do not act as an antecedent factor contributing directly to innovation performance. The proposal from Wang (2011) that the relation between the formalization of norms in a contract and innovation performance is not linear, and forms an inverted ‘U’ shaped effect may explain this apparent lack of relation.

Secondly, the findings of our study do not seem to support the notion of contracts and trust as alternative governance mechanisms in the buyer-supplier transaction. On the contrary, they are consistent with the literature linking those phenomena in a complementary relationship (Ring and Van de Ven 1994; Cannon et al. 2000; Poppo and Zenger 2002; Luo 2002; Reuer and Ariño 2007; Liu et al. 2009; Carey et al. 2011). Each performs a different role within the general objective of achieving the required level of relationship governance. On the basis of our results, it is plausible, on the one hand, to assert that contracts are a necessary ingredient for the development of trust. On the other hand, it is only trust that exerts a positive influence on product innovation performance. Specification of the mutual obligations in the relationship, under a contract, favors mutual trust and relates positively to the exchange of knowledge between the parties, although, as we have previously indicated, they hold no direct influence on innovation performance. For said cause-and-effect relationship to occur, mutual trust must be bolstered in the relationship.

Furthermore, it must be considered that the high level of correlation between trust and contracts could have led us to posit, instead of a series of mediation effects, an interaction effect (Baron & Kenny 1986; Hayes 2013): specifically, a positive

interaction between trust and contracts acting in combination on product innovation performance. To be clear, that possibility was empirically checked and discarded, although those results are not presented here, for the sake of brevity.

## **5. CONCLUSIONS**

This study tests, from a double set of machine tools buyers and suppliers, the mediating role of contracts and trust on the generation of product innovation as a consequence of their efforts to share knowledge.

Results back the relevant role of buyer-supplier KS on innovation performance, and show the mutual interaction between trust and contracts and their individual and combined mediation effects on the causal linkage between buyer-supplier KS and product innovation performance. These results confirm the positive relationship between trust and the use of contracts with respect to buyer-supplier KS, and that there is a significant and positive interaction between these two variables. It is also evidenced that trust within the relationship mediates the linear effect from buyer-supplier KS to product innovation performance partially although in a significantly positive manner. However, contracts alone do not act as a direct stimulus for product innovation.

These results bring important implications for management: buyers and suppliers who seek to improve their innovative capacity based on their relationship must act to share knowledge valid for this purpose, improving the technical resources that facilitate the exchange, its frequency, content and quality. In order that this can take place, the mediation effects from the use of contracts and trust seem to be relevant: specification of contracts stating the agreements, expectations and obligations of the parties guarantees the initial point of exchanges. This evolving relationship helps to generate trust between the parties, as long as their mutual behavior reveals to be based on good faith and not opportunism. This increased confidence prompts sharing more valuable knowledge and continuously improves innovative capacity. Therefore, entering into contracts with a degree of formalization that increases confidence (without detracting from it) and does not defraud the other party's expectations through opportunistic behavior seem to be two highly recommended actions in the buyer-supplier relationship oriented to the improvement of innovative capacity.

Lastly, we highlight that these implications are valid for both sides within the buyer-supplier dyadic relationship. This was obtained from equivalence in the cases of both buying firms with respect to their sellers and selling firms with respect to their buyers. Previous research has been conducted from the perspective of either one or the other. To the best of our knowledge, no other empirical study reported in the literature has confirmed the hypothesized relationships among the factors investigated here by collecting data simultaneously from subsamples of selling and buying firms.

## **6. LIMITATIONS AND IMPLICATIONS FOR FUTURE RESEARCH**

A methodological limitation of our study, affecting the scope for generalization, is that the sample from which the data for analysis were collected was drawn from a frame containing only companies in the machine tool and related industries. Said sector is particularly characterized by very long-standing buyer-supplier relationships. They often span the working life of the product or installation between companies consuming or producing complex custom-built products for which servicing becomes vital. The context is distinctive in its constituent web of relationships, in the form of ‘weak ties’ (Granovetter 1973) downwards in the value-adding process, upwards along the supply chain, and horizontally with other companies in the same location (Marshall 1890). In this context, not only trust but also other elements contributing to the governance of the relationship, such as reputation or word-of-mouth, become very relevant. Future studies should incorporate these effects, comparatively, among different industries.

Another limitation was encountered during the process of validating the measurement scales. The condition of weak measurement invariance across the two analyzed populations obliged us to discard a number of items (Mellenbergh 1989; Meredith 1993), resulting in a minimum of two in the case of the innovation-performance and trust constructs (see Table 1).

Future studies may also include more fine-grained measures of, for example, knowledge exchange, a phenomenon hard to capture. Multiple measures used in some studies that were not considered by us before conducting this survey (Cummings and Teng, 2003, 61-63; Du et al., 2007, 41; Li, 2012, 5406-07) can be very helpful for this purpose. Likewise, while our study has been focused on buyer-supplier relations in the machine tool industry, we think that it could be interesting to also measure the mediation effects

of trust on the relationship between knowledge exchange and product innovation between NPD teams within firms. In recent years, many machine tool firms have grown internationally via mergers and acquisitions of foreign firms, and we think that it could be interesting to research what kind of barriers those firms found for the knowledge transfer between NPD teams of the parent companies and their affiliates and subsidiaries. For this purpose, the literature review conducted by Frank et al. (2014) could be highly valuable as a starting point.

Finally, it must be recognized that the interrelations among the factors analyzed here, and others that were discarded, will usually evolve dynamically over a number of years. A cross-sectional study such as ours can only show some of these relationships in a very limited and static manner. The direction of causality in some of those in the model is an important aspect that we think cannot be fully ascertained in a cross-sectional empirical analysis of what are, in fact, long-standing buyer-seller relations. In our study in particular, we assumed that it would become difficult to distinguish the direction of causality between buyer-supplier KS and the use of contracts after a long period of time, or between contracts and trust. We nevertheless did obtain significant slopes, exclusively in the form of recursive effects. A longitudinal empirical analysis could shed more light on the true nature of the interrelationships among these factors.



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