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Trust in Manufacturing Engineering Project Systems

An Evolutionary Perspective

Michel Leseure

University of Chichester Business School

E-Mail: m.leseure@chi.ac.uk

Structured Abstract

Purpose: The purpose of this paper is to explore the robustness of the emerging body of knowledge about collaborative supply chains in the context of Engineered-to-Order manufacturing engineering project systems.

Design/methodology/approach: This paper uses an evolutionary classification technique to build an evolutionary history for an industry case study: the French Engineered to Order machine design industry.

Findings: The evolutionary history shows that collaborative forms of governance have been used in this industry after an era of failed transactional market-based governance. The industry, however, has abandoned collaborative forms of governance to return to its historical roots towards more vertical integration.

Research limitations/implications: Findings are only relevant in the context of the investigated industry.

Practical implications: In certain industrial settings managers should consider the promise of collaboration and trust with cautious.

Originality/value: The data set supports Williamson's (1993) rejection of trust as a mode of governance and calls for a more careful delineation of the conditions of recourse to trust in managerial situations.

Keywords

Supply chain management, project management, ETO, collaboration, dependence, cladistics, trust.

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Introduction

A key issue in complex design and build engineering projects is to balance the search for efficiency (usually derived from comparative advantage effects along the supply chain) with the management of the vulnerability creating by depending on others. For example, Berger *et al*. (2004) and Berger and Zeng (2005) use decision analysis to find the optimal number of suppliers to work with in order to balance the trade-off between the operating costs of multiple suppliers and the financial losses associated with excessive dependence. Similarly, research dealing with supplier switching decisions (e.g., Wagner and Friedl, 2007) concerns itself with discovering when dependence has led to poor efficiency. The key managerial challenge is to find the right supply chain configuration and governance regime so that increasing one's exposure to vulnerability from a supplier's doing does result in increased performance (Barringer and Harrison, 2000).

Embedded in the search for a solution to this trade-off is a question about the role of collaboration and trust as mechanisms to deal with dependence. This topic was first the subject of a rich conceptual literature promoting trust and collaboration within supply chains in order to improve performance (Barratt, 2004; Sahay, 2003; Handfield and Bechtel, 2002; Simtupang and Sridham, 2004; Skott-Larson *et al*., 2003), and captured by Chen and Paulraj's (2004) conclusion that '*relationships based on cooperation and trust are more likely to survive in the marketplace*'. These conceptual papers led to a large numbers of empirical studies investigating the benefits of collaborative versus transactional relationships (Whipple *et al*., 2010), power and trust as antecedents to collaboration/commitment (Johnston *et al*., 2004; Benton and Maloni, 2005; Zhao *et al*., 2008). This body of literature can be summarised by stating that support is found for

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nurturing supply chain relationship capital in order to improve corporate performance. However, authors acknowledge that these findings are based on large scale cross-sectional surveys when the phenomena under study are actually highly contingent (e.g. Johnson *et al*., 2004). This weakness is explored in conceptual or qualitative research papers where the theory of supply chain as relational advantage is being challenged (Spekman and Carraway, 2006; Emberson and Story, 2006). For example, McCutcheon and Stuart (2000) state that *'supplier alliances have been widely touted but there are probably a limited number of situations when they are applicable'*.

Most empirical work in supply chain management research is typically about supply chain serving consumers markets and including several manufacturing facilities best characterised as mass production facilities, i.e. repetitive manufacturing systems. The repetitive or platform-based nature of the work which is performed means that there are ample opportunities for learning curves and fine-tuning the organisational processes at stake (demand management, manufacturing, multi-echelon inventory management, and distribution). Not all manufacturing systems can be described through these specifications though.

This paper focuses on manufacturing systems laying at the opposite end of the product-process matrix, an industry commonly referred to as Engineered-to-Order (ETO, Hicks *et al*., 2000). Work typically starts with the innovative design of a one-of-a-kind complex product system and is followed by the manufacturing, assembly, testing and fine-tuning of the product before delivery. This industry involves discrete rather than flowline manufacturing processes, it operates in business-to-business rather than business-to-consumer markets, and it typically involves a short and broad supply chain network (managed through project management) rather than a long and narrow supply chain involving simpler transactions.

Many ETO organisations have embraced the lessons regarding the role of collaboration and trust in inter-organisational systems even though these lessons were formulated in a very different context. The purposes of this paper are to observe the evolutionary history of how a specific industry has managed its supply chain in terms of governance regimes and to answer the following questions: To what extent, and when, was a recourse to the concepts of collaboration and trust made? How successful have been the different governance regimes and what are the lessons that can be drawn from the history of this industry?

Methodology

This paper uses a cladistics methodology. Initially used in linguistics and evolutionary biology, cladistics has previously been applied to the study of the evolution of manufacturing systems (McCarthy and Tsinopoulos, 2003; Leseure, 2002; Leseure, 2000; McCarthy *et al*., 2000) and more recently to supply chains (Rose-Anderssen *et al*., 2009). It is important to note that in the field of organisational systematics (McKelvey, 1978), a cladistics methodology is a general classification (a taxonomy) rather than a special classification (a typology). In special classifications, the objective is to observe the diversity of occurrences of a single or very few classificatory variables. For example, one could study trust within supply chains and produce a typology of how different groups of firms perceive and use the concept of trust. In contrast, a general classification, or taxonomy, is based on a large list of classificatory variables and is concerned with the discovery of patterns and structure, i.e. commonly occurring archetypes of specimens presenting the same characteristics. This is why in an organisational research context, cladistics as a classification technique is suitable for contingency theory research, as the outcome of the classifications, the 'species', are akin to organisational configurations (Leseure, 2000).

In terms of analysis, and although based on an classification algorithm, a cladistic classification remains based on the principle of likelihood (i.e. the classification is the most likely given the dataset; Leseure, 2000) and thus, it is best described as a qualitative research methodology based on interpretation.

Finally, from a methodological viewpoint, it is important to clearly define the scope of an evolutionary classification. It is a general longitudinal classification whose scope is to study diversity: in this case the evolution over time of the mechanisms and arrangements through which transactions and relations with suppliers are handled.

Although the role of trust and collaboration were highlighted in the introduction, no hypotheses nor propositions are made regarding these concepts. They will be used as classification variables, amongst others, to build an evolutionary history. As such this paper inscribes itself in Williamson's call for research: '*more microanalytic attention to the processes through which trading relationships evolve is indeed a rewarding research enterprise*' (Williamson, 1993, p. 474). In terms of methodological process, a classification is a research phase that precedes theory development, i.e. hypothesis or propositions can only be formulated once classification results are available, not before.

Unit of Analysis

The ETO industry was described briefly in the introduction. The data used in this paper focuses on the French customised machine design industry ("*Machines Spéciales*").

The unit of analysis are supply chain project configurations, defined as commonly observable archetypes of organisational characteristics displayed by the project organisation undertaking a machine design project. A typical project organisation, or organisational breakdown structure (Turner, 2000), is likely to include different legal forms of organisations working together towards the completion of the project's product. In other words, the supply chain project configurations under study are based on the view of '*projects as organisations*' (Van Donk and Molloy, 2008) and therefore they will be referred to as project organisations in the rest of this paper.

These project organisations typically involve:

- A final customer which is a production facility ordering a machine with unique and new features. The level of technological risk and product complexity are high to very high.
- A machine designer, whose function is to design the machine, to draw blueprints and to prepare a bill of materials and all the machine documentation.
- An automation designer, whose function is to design, document, install, and program the control system of the machine.
- An assembler, involved with the assembly of the different components.
- A system integrator or project management team, with the responsibility of tuning the machine to production specifications (testing, overhaul, improvements).
- Technology providers that supply standardised components or modules such as feeding devices, robotic systems, vision systems, etc.
- Other suppliers of standards parts: materials, parts, motors, etc.

Data Collection and Analysis

The data was collected through a mix of observations and interviews (structured and unstructured). The author worked full time in this industry for 3 years but has generally been involved with it for 10 years. Therefore, a fair portion of the data used is based on work experience, and discussions and unstructured interviews that took place during or after working in this industry. It is important to remember that the ETO industry works on the basis of discrete projects and thus the data collection process may be described as compiling project histories, a process which includes speaking and interacting with the different stakeholders in a project. The dataset is composed of 29 projects, and overall, the data collected spans more than 20 years of industry history.

The data collection and analysis process was based on McCarthy *et al.* (2000, p. 83) suggested steps for building an evolutionary classification with cladistics:

1. Select the manufacturing clade.
2. Determine the characters.
3. Code characters.
4. Establish character polarity.
5. Construct conceptual classification.
6. Construct factual classification.
7. Taxa nomenclature.

As stated earlier, the objective of the procedure is to extract the most likely evolutionary structure given the data set; yet most of the procedure is about constructing the data set itself.

This is why in practical terms, the procedure shown above is not a linear step wise process but is more similar to the spiral model of software design. This means that the procedure is applied once to produce a conceptual 'first draft' classification (this was mostly based on the author's personal knowledge of the industry). Once this prototype classification is finished, the actual project histories were compiled (this is the stage at which project managers were asked to fill in questionnaires about the characteristics and performance of their projects). This data is then used to produce the factual classification and the differences between the factual and conceptual classification structures are analysed. At this point, more data may be needed or data may have to recoded. This is when unstructured interviews with project managers took place.

For a full account of the cladistics methodology, see McCarthy *et al*. (2000, pp. 83-89). In the interest of space, only key steps in the process of discussed here. The process used to select and code the characters is discussed in the next section. All classification work was done with the PHYLogeny Inference Package (PHYLIP) software (Felsenstein, 2013). The analysis itself was done through a multiple character states Wagner parsimony algorithm. The purpose of this algorithm is to suggest an evolutionary history which is the most parsimonious in terms of the number of capabilities acquisition steps that it requires. In other words, it makes the assumption that firms evolve efficiently toward fitter states. Each of the 29 project histories were then allocated to the different configurations suggested by the cladistics configuration at the stage of reconciliation between the conceptual and factual classification.

In this paper, the traditional construction of an evolutionary history of the industry according to the procedure shown above was followed by a comparative performance analysis of the different configuration. For each project, data about project performance, equity (fair sharing of profits between project partners), trust (was the project done in a climate of trust?), learning (were significant and valuable lessons learned through the execution of the project?), and risk was collected. All projects were scored by key personnel (project managers, top managers) and averages for all projects within a configuration are computed to compare performance.

Character Selection and Coding

The list of characters, shown in table 1, was built by extracting key variables from the supply chain management literature dealing with relational advantage and supply chain performance.

In order to model the traits of different project organisations the most logical starting point is transaction cost economics (Williamson, 1985; 1991). Transaction cost economics focuses on the identification of the best mode of governance (character 1 in table 1) so that the cost of managing transactions between firms is minimised. Transaction cost theory is concerned with two key behavioural variables: bounded rationality and opportunism (Williamson, 1993). Bounded rationality means that there are natural cognitive limits to the ability of managers to make rational decisions. Opportunism is concerned with an arm’s length party's propensity to seek their own self-interest. Williamson proposes three governance modes, which in cladistics' terminology are the *character states* for character 1: hierarchical control (internalising the activity and controlling operations through a traditional hierarchical power structure), relying on markets (and contracts), or relying on hybrid organisational modes. The hybrid organisational mode tries to capture the strengths of internalisation whilst avoiding the costs/commitments associated with it. Research in transaction cost economics has shown that in practice, hybrid organisational forms can take many forms (e.g. partnerships, franchising, complex contracting forms; Shelanski and Klein, 1995).

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Characters	**States**	**Comments**	**Relevant Concepts and Literature**
1- Governance Mode	0- Hierarchical control	Control of supply is achieved through internalization.	Transaction cost theory (Williamson, 1993, 2008; Kwon and Suh, 2004, Wu *et al*., 2012) and hybrid governance mode (Shelanski and Klein, 1995)
	1- Market Control	Market mechanisms are used to control and obtain the best supply. Use of bidding process, supplier's audit, learning from previous orders, switching real options.	
	2- Hybrid control	Control is achieved both through market mechanisms, relational capital, and normative values.	
2- Contract Management	0-Internal orders	Can easily be reviewed and updated in internal meetings.	Contracting (Williamson, 1993, 2008; Handfield and Bechtel, 2002) and transactional supply chain relations (Whipple *et al*., 2010)
	1- Formal contracts	Are used to manage the relationship and to set expected product specifications.	
	2- Very formal contracts.	Contracts are extremely exhaustive. Their preparation is expensive, and so is complying to them. Specifications can reach up to 500 pages.	
3- Power Basis	0- Legitimate	Natural exploitation of human capital and know-who in a firm. Based on legitimate forms of coercive power.	Power bases to supply chain relationships (Whipple *et al*., 2010; McCutcheon and Stuart, 2000; Zhao *et al*., 2008) Trust-power climate (Ireland and Webb, 2007). Bargaining power (Crook and Combs, 2007)
	1- Legal	Procedure driven and documented in process/project documentation. Activities are controlled through legal forms of coercive power.	
	2- Non coercive	Activities are controlled through expert, referent, or rewarding forms of power.	
4- Experience Curves	0- Application focused	Experience is accumulated about automation of processes in a specific industrial sector.	Experience curves (Johnston and Chambers, 2000) Focused differentiation strategy (Porter, 1985) Supply chain learning (Bessant *et al*., 2003) Customer focus (Spekman and Carraway, 2006) Relational advantage (Chen and Paulraj, 2004) and history of positive interactions (McCutcheon and Stuart, 2000). Technological aspects of transaction (McCutcheon and Stuart, 2000). Trust as the enabler of relational transactions (Spekman and Carraway, 2006; Handfield and Bechtel, 2002; Johnston *et al*., 2004)
	1- Generic	Experience is about machine design, and can be deployed in a broad range of industries.	
	2- System Integration	Experience is about integrated machine design (co-ordinating the key design functions)	
	3a- Relational (trust based)	Experience about system integration is supplemented by relational ability as different parties need to transfer key product/process knowledge.	
	3b- Technology focused	Integration experience is focused on a specific technological domain, which is a core competency of the system integrator. *(Note: 3a and 3b are mutually exclusive)*	

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Characters	**States**	**Comments**	**Relevant Concepts and Literature**
5- Communication	0 - Internal	Internal communication channels	Communication, information sharing, and other forms of co-ordination as standard variables to model supply chain management processes (Whipple *et al*., 2010, Spekman and Carraway, 2006, Nyaga *et al*., 2010). Processes as a transition driver (Spekman and Carraway, 2006)
	1-Formal	Formal and hierarchical	
	2- Cross lateral	Cross lateral communication allow cross lateral co-ordination.	
6 - Socialisation	0- High	Naturally occurring in project teams.	Formal and informal socialisation processes (Cousins *et al*., 2006)
	1- Difficult	Formality and potential tension in the relationship hampers inter-organisational socialization.	
	2- Encouraged	Through initiatives such as outplacement and workers exchanges.	
7 – Commitment of first tier	0- Internalized	There are no first tier suppliers.	Collaborative forms of supply chain work lead to commitment (Nyaga *et al*., 2010) Commitment to relationships (Kwon and Suh, 2004,2005) Site specific asset and human specific assets (Handfield and Bechtel, 2002) Instrumental vs. normative commitment (Zhao *et al*., 2008) Cooperative relationship behaviours (Johnston *et al*., 2004) Conflict resolution (Benton and Maloni, 2005)
	1- Contractual	First tier suppliers perform the terms of a contract	
	2- Collaborative	First tier is committed to relationship and engage wilfully in collaboration	
8- Commitment of second tier	0 - Internalized	Same as character 7.	
	1-Contractual		
	2- Collaborative		
9- Commitment of third tier	0- Contractual		
	1- Collaborative		
10- Risk	0 – Concentrated on a unique echelon (client)	Maps and allocates a project's risks onto the different members of a supply chain configuration (see figure 2).	Dynamism of input technology, hostages, forecasted technological discontinuities (McCutcheon and Stuart, 2000). Reward/cost sharing (Whipple *et al*., 2010) Fear of opportunism (Ireland and Webb, 2007) Vulnerability (Handfield and Nichols, 2002) Buyer dependence (Handfield and Bechtel, 2002)
	1 – Concentrated on a unique echelon (system integrator)		
	2- Distributed along the supply chain		

Table 1. List of Characters

In relation to the collaborative supply chain literature, markets are what Whipple *et al.* (2010) refer to a transactional relationships whereas hybrid are referred to as collaborative relationships. The next step in a cladistics analysis is to code the polarity of the character states, i.e. to indicate whether a character is ancestral or derived. The industry's history shows that historically the production of the ETO machines were handled in house and it is only with the outsourcing wave of the 1980/90s that the market mode started to be used. Therefore, the hierarchical mode is coded as the ancestral state (state 1-0) and market and hybrid are coded as derived ones (states 1-1 and 1-2). Note that in table 1 and in the multiple character states Wagner parsimony algorithm used to analyse the data, no further evolutionary constraints are specified. In other words an ancestral configuration possessing state 1-0 can stay in this state or can evolve into either 1-1 or 1-2, and both 1-1 and 1-2 can evolve into each other or revert back to the ancestral state.

Transaction cost theory is often described as the science of contracting as contracts are the prime mechanism for co-ordination in the market mode. This is why character 2 observes the types of contracts which are used within the project organisation.

Whilst characters 1 and 2 are tangible and objective characteristics of the project organisations the collaborative supply chain literature uses more abstract concepts to predict the performance of supply chain. One such abstract variable is the distribution of power across different members of a supply chain (character 3; Whipple *et al*., 2010; McCutcheon and Stuart, 2000; Zhao *et al*., 2008). Often the research literature is either about trust or power, but Ireland and Webb (2007) and Blomviqst *et al.* (2005) suggest that trust and power can co-exist as governance levers.

Trust is a second common abstract research variable in supply chain performance research and is reported to be an enabler of relational transactions (Spekman and Carraway, 2006; Handfield and Bechtel, 2002; Johnston *et al*., 2004). Trust can be defined as the *'actor's expectation of the other party's capability, goodwill and self-reference in future situations involving risk and vulnerability'* (Blomqvist et al., 2005, p. 500).

In transaction cost theory, trust is not conceptualised as a sustainable governance construct (Williamson, 1993). This exclusion of trust has been one of the main source of criticisms of transaction cost theory (Grover and Malohtra, 2003; Nooteboom, 2009), and this, despite Williamson's insistent conclusion that *'[...] it is redundant at best and can be misleading to use the term "trust" to describe commercial exchange*' (Williamson, 1993, p. 463). It is for this reason that trust was not coded as a separate character in table 1 but instead only as a character state of a more general character observing the existence of organisational-level learning curves or experience curves (character 4, Chambers and Johnston, 2000) with a supply chain learning context (Bessant *et al*., 2003; Spekman *et al*., 2002).

The ancestral state of character 4 is a project organisation benefiting from application-specific experience curves, e.g. specialising in the design and building of assembly machines for automotive electrical connectors (state 4-0). A project organisation may decide that it has also accumulated generic machine design skills and seek new markets where these skills can be deployed. If this is done successfully, the project organisations is benefiting from further learning curve effects from different industries (state 4-1). This state is however exposing the project organisation to risk every time it ventures in new sectors. The response of project organisations to this challenge is to capitalise on their learning curves and to rationalise their contractual promises by promoting themselves as systems' integrators (state 4-2), i.e. as possessing the ability to lead a project to a successful completion through superior business processes. In other words, whereas the evolution from 4-0 to 4-1 was about the scope of the underlying technical domain, the evolution from 4-1 to 4-2 is about management capability. Character 10, which looks at the organisational distribution of risks, provides further information about the practical impact of this evolutionary step on the allocation of risks within the project organisation.

The fact that learning within project organisations is taking place along two dimensions, the technical/product and process domains, is further captured by an additional set of evolutionary steps with character states 4-3a and 4-3b. 4-3a is about organisations that decide to adopt a focused differentiation strategy (Porter, 1985) to better exploit and commercialise their system's integrator knowledge. 4-3b is about organisations that chose not to follow this specialisation route and decide to face the risks of one-off innovative projects by using trust to completely rely on their partners to cope with unforeseen project issues, i.e. organisations seeking a genuine 'relational advantage' (Chen and Paulraj, 2004). This coding of trust is consistent with Nooteboom (2009) who reaches the conclusions that trust is an essential condition for the processes of learning, adaption, and innovation to take place.

A third key abstract variable of supply chain performance literature is commitment, which is frequently causally associated with trust through Morgan and Hunt's (1994) trust-commitment theory positing that trust is an antecedent to commitment to a cooperative relationship behaviour resulting in increased performance (Kwon and Suh, 2004, 2005; Johnston *et al*., 2004, Wu *et al*., 2012). Characters 7 to 9 describes the level of commitment of different tiers of the supply chain within the project organisations.

Character 5 observes communication practices in the project organisations consistently with the literature highlighting the importance of this variable (Whipple *et al*., 2010, Spekman and Carraway, 2006; Nyaga *et al*., 2010) and character 6 describes the extent to which socialisation takes place within the project organisation (Cousins *et al*., 2006).

Evolutionary History

Figure 1 presents an evolutionary history of supply chain configurations in the French machine design industry. The bottom line represents the six key configurations which have been, or are still in use, in this industry. The horizontal numbered bars on the tree represents the different capabilities which are needed to move from one configuration to another.

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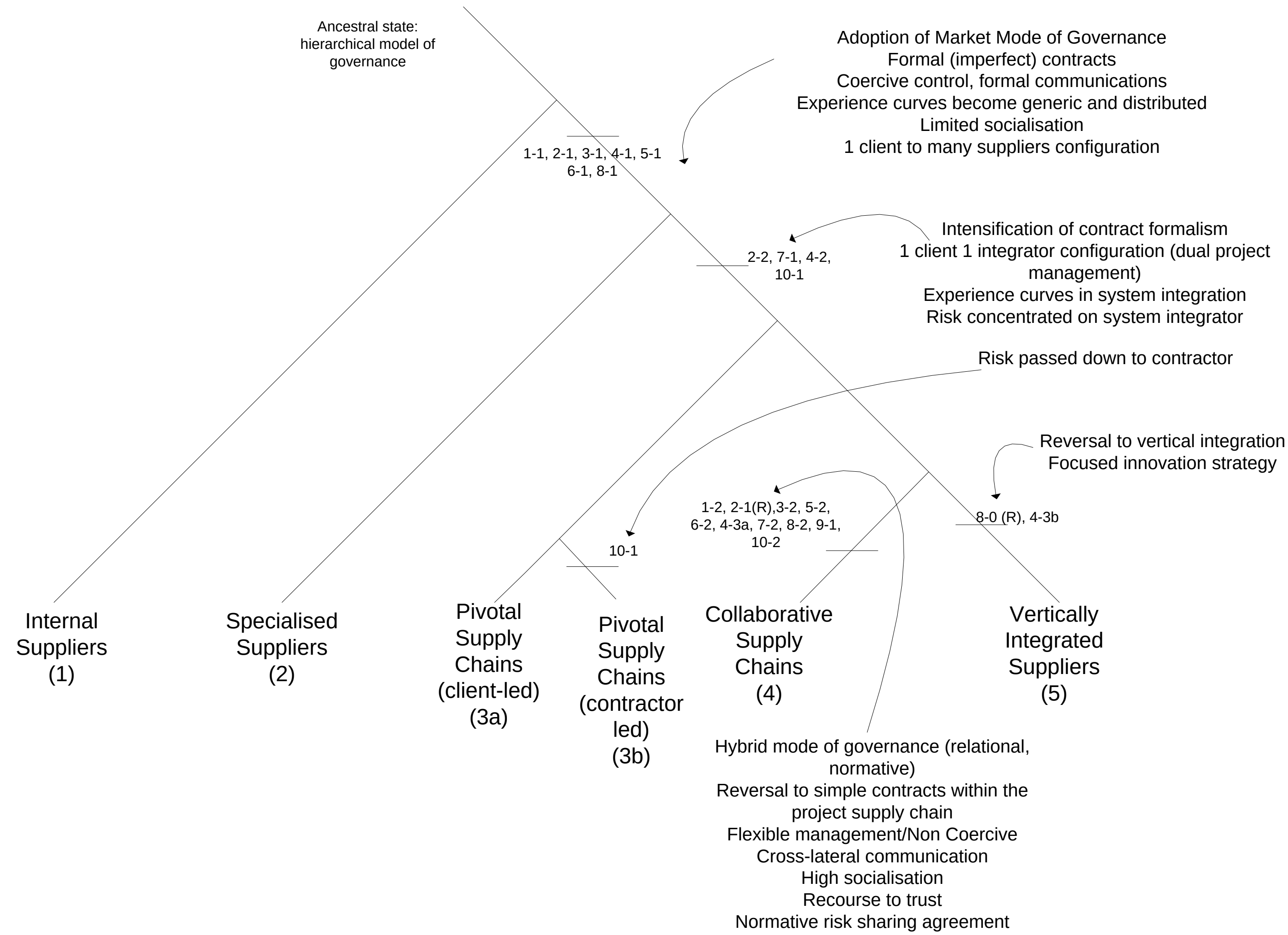

Figure 1 – Evolutionary History of the ‘Machines Spéciales’ Industry

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When asked where the special machine industry originated, individuals with a long experience in the industry associate its existence with a move away from vertical integration. Thus, the ancestral species of the tree, *Internal Suppliers* (1), means that customers have an internal division in charge of the design and manufacture of their production machines. Control is hierarchical and co-ordination straightforward to implement (assuming no divisional rifts or interfacing problems). These internal suppliers exhibit good application-specific experience curves, but suffer from a lack of cognitive distance when compared to firms operating on several types of applications. The major problem of these *Internal Suppliers* is capacity management. *Internal Suppliers* made a high investment in fixed costs and skilled workforce, but their demand is extremely volatile. Thus, their capacity tends to be alternatively under- and over-utilised.

It is the high cost of these divisions and the desire to focus on core competencies which drove firms to seek other modes of working. In the 1980s, firms moved to the *Specialised Suppliers* (2) configuration. The practice exhibited at this time was a perfect illustration of the market mode of governance. Take the example of a firm specialising in designing and manufacturing electronics connectors. These firms would make the decision to keep connector design as a core competency. However, machine design for assembly purposes is not a core competency and is a costly activity: it should be outsourced. The design of a machine should be subcontracted to a design office. The controls side should be subcontracted to another specialist, and so on.

By the 1990s nearly but not all end users had switched from the first configuration to the second. The supporting capabilities in configuration (2) are to rely on market control mechanisms, the use of formal contract and project specifications, procedure-driven processes and co-ordination, and the ability to tap into a very diverse knowledge base.

There are few firms which still operate along these lines today. This can simply be explained by the fact that too often, firms failed to obtain working machinery at the end of the project! These firms learned at their expenses that too much dependence on a supplier could have dramatic financial consequences, as when overall supply chain efficiency collapsed, it was them, the final customer, who bore the highest risk consequence. For example, in one of the projects in the dataset, a customer subcontracted the design and building phases to two different firms. The blueprints were delivered to the customer and then passed onto the builder. The assembled machine was delivered but was unable to produce any parts. The builder blamed a poor design, and the designer a poor quality of built. Due to the cost of production delays and penalties imposed by the customer's customer, and to fears of a long and unsuccessful litigation process, the customer decided to subcontract the modification of the machine to another independent supplier, a solution which brought a significant and unplanned cost to the project.

The demographic demise of configuration (2) shows that in an attempt to reduce production costs, transaction costs crept up due to project vulnerability. The co-ordination of a large set of suppliers required more capabilities than client firms currently had. This was addressed by switching orders away from multiple suppliers to a unique first-tier supplier which would act as a system integrator. Project management and cross-functional integration are the key core competencies of this integrator. Firms that never experimented with configuration (2) evolved into configuration (3a): in these, the client retained responsibility for the project but subcontracted all operations to a system builder, that took responsibility for co-ordinating the second tier of suppliers. Customers who had relied on market mechanisms to access cheaper design and assembly services (configuration 2) now relied on the market to access system integration expertise. An important consequence of this new configuration, *Pivotal Supply Chains* (3b), is that the risk of failure had been passed down to the first-tier. Any penalty or cost incurred by the customer due to a project failure could be passed down the supply chain by detailed contractual agreements. This third configuration became the dominant mode of business, and many companies still operate today in this configuration. Needless to say, the price of this co-ordination service is not cheap as the level of risk assumed is extremely high. One of the features that explain the success of the configuration is the fact that for the first time, a central pivot became a repository of knowledge about both the technical and co-ordination aspects of the project. Thus, previous solutions (technological or managerial) could be reused with another customer. This learning capability provided *Pivotal Supply Chains* with a knowledge base and insight that could not be matched by *Specialised Suppliers*.

The existence of two additional configurations, which have been increasingly used since the late 1990s, shows that there was yet more progress to be made in terms of improving the overall efficiency of supply chains in this industry. The common characteristic of configurations 4 and 5 in figure 1 is the collective acknowledgement that in a supply chain, it is a suboptimal practice to concentrate all the risks on one single echelon. If this is case, this simply means that transaction costs increase as litigations in this industry are long, complex, and expensive matters. Thus, configurations 4 and 5 are based on the principle that as all echelons can contribute to problems in a supply chain, each should be held accountable for their wrong-doing. However, 4 and 5 display a bifurcation point in evolutionary history, i.e. two mutually exclusive solutions to the same problem.

The first alternative, *Collaborative Supply Chains* (4), make the implicit assumption that transferring all the risk to the supply pivot is an inadequate management decision. These supply chains believe that collaborative work practices are the way to better control and collectively manage risk, and thus to diffuse it. Examples of collaborative work practices which were observed in the case studies are:

- Outplacement of designers: from suppliers to the customer sites, or vice versa.
- Rotating project management across partners,
- Strategic alliances,
- Open-book and/or profit sharing agreement within operations network,
- Joint planning, control, and scheduling,
- Joint reception of technical component, including joint test runs.

This configuration is also characterised by the fact that deadlines and budgets are inherently more flexible, as it is most likely that the joint recognition of mutual errors will create a positive ground for work plan revisions.

The second alternative is borne precisely from a general distrust about the feasibility of collaboration in a business environment and about the feasibility of controlling the equity of distribution of benefits along the supply chain. *Vertically Integrated Suppliers* (5) handle the level of risks which is passed down from configuration 2 to 3 by vertically integrating their own first tier suppliers. Thus, the risk from poor communications and poor interfaces is greatly reduced as it is contained to the interfaces with the customers and third-tier suppliers. However

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it should be noted that *Vertically Integrated Suppliers* tend to restrict their product and service offerings to generic applications or technologies. This focused innovation strategy means that they have also reduced the technological and transaction risk that their firms face. *Vertically Integrated Suppliers* used their strategic focus, experience, and accurate control systems to face litigious customers when needed. This stands at odds with the industry custom, where generally, suppliers complain from the opposite practice, i.e. large customers taking them to litigation battles. *Vertically Integrated Suppliers* provide some unique instances of the suppliers taking the customer to court and winning the case. Figure 2 summarises the key characteristics of the different configurations.

Discussion

A short summary of the evolutionary history of the industry is that originally vertically integrated operations in configuration 1 were outsourced to project managers (configuration 3b) who had to vertically integrate their own suppliers in order to operate sustainably (configuration 5).

The evolutionary history of this industry further reveals that trust was at once viewed as the central ingredient towards a new way of managing project in configuration 4. The adoption of collaborative practices, the will to turn around often adversarial relationships, and the diminished emphasis on formal contracts were all consistent with the supply chain management literature positive view of trust. In the context of the ETO industry discussed in this paper, trust as a management value became increasingly viewed critically by managers.

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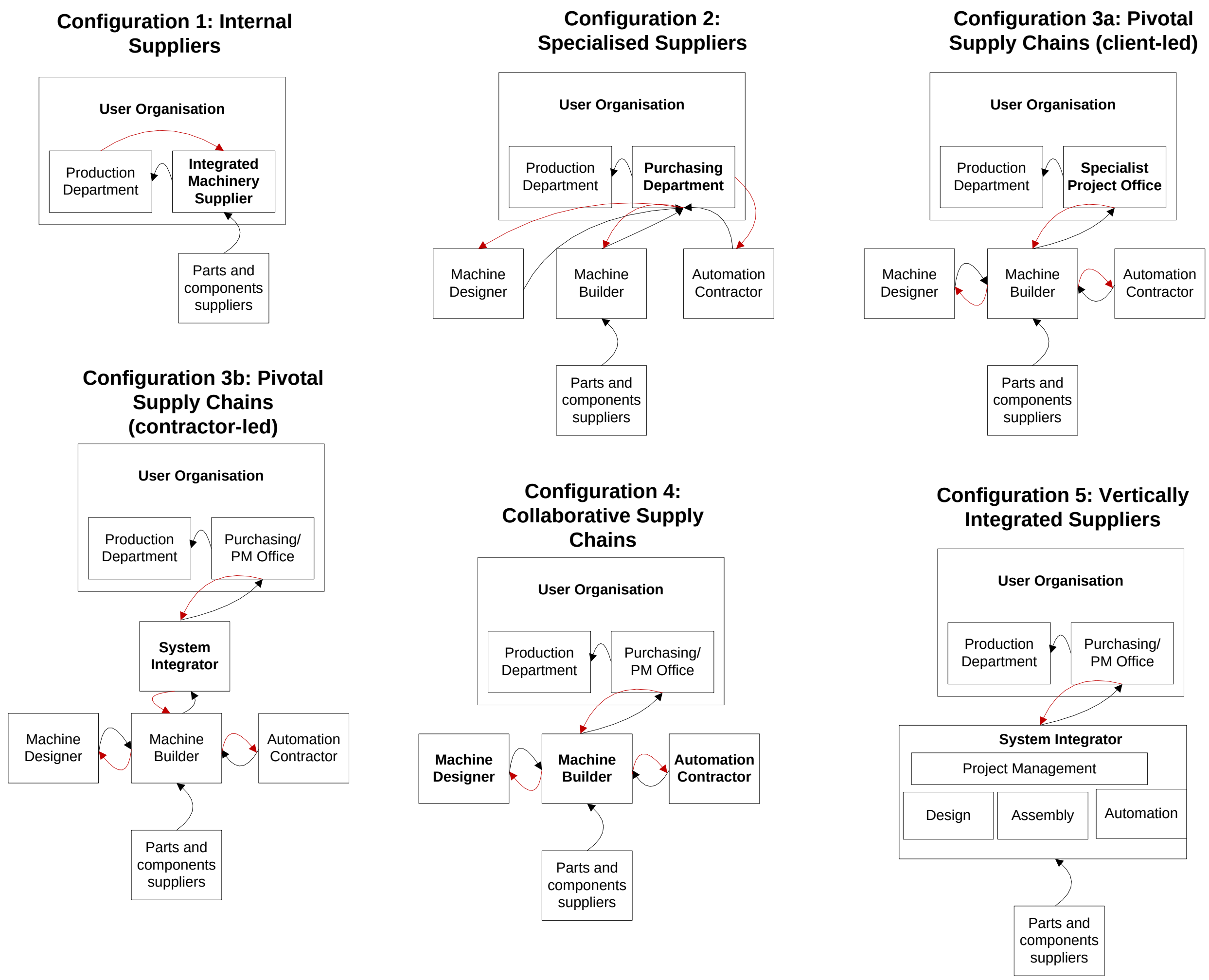

Figure 2: The Different Configurations.
Black arrows represent the flow of products and red arrows the flow of orders/complex contracts. The echelon fully responsible for the project is shown in bold.

The fact that configuration 4, *Collaborative Supply Chains*, was a tentative governance practice that was eventually rejected by industry is confirmed when interviewing managers who acknowledge that abandoning this configuration was a conscious choice. The projects that make up configuration 4 are often good examples of the costs and risks associated with excess trust and 'overembeddedeness' (Ireland and Webb, 2007). This confirms the view of Spekman and Carraway (2006) who state that '*we do not advocate collaborative relationships in all buyer-*

seller relationships' and Emberson and Storey's (2006) critique of the normative buyer-supplier literature. Emberson and Storey (2006) argue that this literature fails to take into account the complex and dispersed nature of collaboration within an organisational context. In other words, respondents to surveys may accept the normative elegance of concepts such as trust and collaboration, but their ability to exploit these sustainably in a complex and dynamic organisational context may be impaired for a variety of organisational and behavioural reasons.

The conclusion about the cost of over-embeddedness experienced by configuration 4 answers the cost side of Williamson's (2008) question about the role of trust in supply chains: *'Transaction cost economics eschews appeal to user-friendly concepts such as the illusive concept of trust. What benefits accrue to the more widespread use of trust amongst SCM practitioners? What are the costs?*'.

Further analysis of the different projects within each species provides a tentative answer to the benefit part of Williamson's question as occasionally more was learned in projects explicitly based on trust. This is shown in table 2 when considering not only the learning scores but their standard deviation (in other words, projects in configuration 4 were either learning success or outright failures when things went wrong).

The fact that the average learning score of configuration 4 is lower than configuration 5 should be mitigated by putting these projects in their historical context. In the data set, the time at which some firms designed their project according to configuration 4 more or less always followed a desired to grow activities away from configuration 3b.

Configuration	Project performance	Equity	Trust	Risk	Learning
(2) Specialised Suppliers	45	47	48	54	46
(3a) Client-led pivotal supply chains	74	70	56	24	56
(3b) Contractor-led pivotal supply chain	75	50	44	68	53
(4) Collaborative supply chains	47	44	32	83	61 (σ=33)
(5) Vertically integrated suppliers	73	64	53	64	69 (σ=17)

Table 2. Managers' Perception of Different Configurations' Characteristics (all score on a 100 points scale)

Configuration 3b is a market-based supply chain, and thus fast growth would only be possible by working with more subcontractors. It would be difficult to cope with the resulting increase in governance costs though. Thus configuration 4 was an attempt at stimulating growth whilst avoiding both the high investment required in configuration 5 and transaction costs of 3b. Almost invariably, firms expanded their customer base aggressively in order to fuel growth. This resulted in riskier than normal projects being taken on board (and the highest average risk score in table 2). Many failed and resulted in bitter disputes within the trust-based configurations. In some of the projects in the dataset, the legal liability incurred when not being able to deliver a technically satisfactory product when trust led to overembeddeness resulted in several firms filing for bankruptcy. The difficulty in establishing returns from trust is consistent with the observation that 'familiarity breeds trust' (Gulati, 1995). Routine and familiarity are not common characteristics of ETO industries, especially when aggressive growth programmes are adopted.

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Conclusion

The persistent scholarly tradition of promoting trust and collaboration in supply chains and project management systems can be explained by two factors: (1) trust is a positive concept associated with an intuitively elegant and appealing way of running operations and (2) the fact that the literature on supply chain management tends to be based on routine, long, shallow, and mostly linear supply chains where 'familiarity breeds trust'.

This paper investigates trust in complex and high risk manufacturing engineering projects. The supply chains that are involved are fundamentally different than those that are traditionally researched. The conclusion is that in the ETO context, or more specifically in the industry researched in this paper, managers take exception to the literature and not only view trust as a misleading but also as a potential dangerous governance lever. Both the evolutionary data set used in this paper and the opinions expressed by the respondents provide strong support for Williamson's thesis (1993) that the recourse to trust in commercial transaction unnecessarily distorts one's perception of effective governance modes. This paper provides supporting evidence that collaborative relationships based on trust are not a sustainable solution for all supply chains (McCutcheon and Stuart, 2000; Emberson and Storey, 2006; Spekman and Carraway, 2006) and provides an actual example of firms that have experienced the disadvantages of excess trust (Ireland and Webb, 2007). These findings highlight the contingent nature of the effectiveness of trust for both researchers and practitioners. More research documenting the contexts and situations in which trust works, or does not work, is needed to provide managers with more robust recommendations for the management of their supply chains.

Research Implications

This paper inscribes itself in a debate between the empirical trust-performance supply chain literature (Benton and Maloni, 2005; Cousins *et al*., 2006; Johnston *et al*., 2004; Nyaga *et al*., 2010; Whipple *et al*., 2010), which concludes that trust and collaboration lead to higher levels of supply chain performance and the critical conceptual literature disagreeing with this notion (McCutcheon and Stuart, 2000; Emberson and Storey, 2006; Spekman and Carraway, 2006). The first contribution of this paper is to present a counter-example to the conclusions of the first school and to therefore provide support for the second school. The second contribution of this paper is to highlight the difference between research asking (1) how does trust lead to higher supply chain performance from (2) in which contexts does trust work as an hybrid governance mode? This difference is akin to that between functional science and systematics (the science of diversity). McKelvey (1982, p. 19) states that *'systematics is prerequisite to good scientific method because it directly affects an investigator's ability to [attain high quality knowledge]'*. It is only through a better understanding of *when and where* trust works in supply chains (question 2 above, the locus of this paper) that we can perform functional studies of *how* trust works (question 1 above).

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