

# THE ADOPTION RATE OF E-COMMERCE IN THE U.S. AND ITALIAN CONSTRUCTION MARKETS: SOME REASONS FOR ITS VARIABILITY

SUBMITTED: June 2005

REVISED: December 2005

PUBLISHED: April 2006 at <http://itcon.org/2006/08/>

EDITOR: K. Ruikar

*Nicola Costantino, Professor  
Politecnico di Bari, Bari, Italy  
email: costantino@poliba.it*

*Roberto Pietroforte, Dr. Professor  
Worcester Polytechnic Institute, Worcester, USA  
email: roberto@wpi.edu*

**SUMMARY:** *There is evidence that the adoption rate of e-commerce applications in the US construction market varies widely, notwithstanding their potential benefits. This paper focuses on some of the reasons behind the varying approaches of construction firms to adopting a set of these technologies. The study first addresses two main determinants of the production arrangements by firms: the cost of production inputs and the cost related to their coordination, namely the exchange of their information and knowledge content. Then, it illustrates the main tasks that encompass the purchasing process of production inputs. Successively, three main hypotheses concerning the possible use and impact of e-commerce applications on the operations of firms are proposed. In the hypotheses the construction industry's varying approaches to these technologies is explained according to variables such as the nature of the business transaction under consideration, the size of the buying firm, and type of market situation. The hypotheses are tested through a questionnaire survey that was administered to three large samples of US and Italian contractors. The samples included large, medium and small firms that operate in building and non-building construction. The results of the survey appear to confirm the initial hypotheses. The adoption rate of e-commerce applications varies according to the nature and phases of the transaction process, type of production inputs as well as size and type of construction firm.*

**KEYWORDS:** *e-commerce, transaction costs, purchasing, subcontracting.*

## 1. INTRODUCTION

The operations of the construction industry are highly fragmented. Many independent firms, in fact, cooperate in the various phases of a construction project. This cooperation is based on an array of contractual transactions and the exchange of a significant amount of information. The execution of each transaction entails information costs for the search and identification of the contractual party (e.g., a supplier or subcontractor), the negotiation and drafting of the contractual agreement and, ultimately, the administration of the contract itself. The use of IT, particularly Internet-based applications, offers potential benefits in terms of improved information processing capabilities and reduced transaction costs. By offering many buyers and sellers, an Internet-based market enjoys continuous offers and consummated transactions, thus achieving "liquidity benefits" (Eisenman, 2000) or more transparency, because buyers have better information about suppliers, prices, product availability and/or product selection. Some years ago the capabilities of Internet-based applications were perceived as a big booster of e-commerce growth in construction. A 2000 survey of the UK construction industry forecasted that about 50% of business transactions would have been based on e-commerce applications in 2005 (Construction, 2000). Such "unrealistic expectations" were lowered to 22% one year later (Construction, 2001), a figure that is still too optimistic considering current market trends. Similar disillusion could be observed in the US and European markets. Overall the use of e-commerce in construction has been lower than expected. This paper aims at explaining some of the reasons behind the different adoption rates of a set of these applications. The paper first illustrates how construction firms make or buy their production inputs within the framework of the transaction cost theory. Decisions about production arrangements are also influenced by the information and knowledge

content of the service or product that is transacted. After having addressed the various tasks of a typical transaction process, three hypotheses of the possible use extent of e-commerce applications are proposed. These hypotheses are verified by administering a questionnaire survey to three samples of US and Italian construction firms. The survey results appear to confirm the proposed hypotheses.

## 2. TRANSACTION COSTS IN CONSTRUCTION PROCUREMENT

The transaction cost theory builds upon the issue of the boundary of the firm that was addressed by Coase (1937). The internal and external transactions of a firm must be governed and give rise to costs that vary according to a given firm's organization and its relationship with other firms. As Williamson (1981) remarked, "the transaction cost approach to the study of organizations has been applied at three levels of analysis. The first is the overall structure of the enterprise... The second or middle level focuses on the operating parts and asks which activities should be performed within the firm, which outside, and why... The third level of analysis is concerned with the manner in which human assets are organized." At any of these three levels, each contract is necessarily incomplete, given the bounded rationality and opportunistic behavior of the transacting parties (Williamson, 1975 and 1979). It can be concluded that "transaction cost economics studies how trading partners protect themselves from the hazards associated with exchange relationships" (Shelanski and Klein, 1995). This last definition appears to be particularly suitable for addressing the type of transactions considered in this study: the purchase of construction supplies and services by general contractors. Construction firms, in fact, buy materials and components in case of self-performed work or/and, more often, rely on the services of specialized trade contractors. As pointed out by Eccles (1981a), the high rate of subcontracting in construction is driven by the small diversification degree by firms, the complexity and non repetition of projects, and demand uncertainty. Differently, the internalization of some production operations can be explained in terms of asset specificity, another important factor that characterizes the governance mode of transactions (Williamson, 1981; Joskow, 1988; Ekstrom *et al.* 2003). According to Williamson (1985), an input used by a firm is highly asset specific if it cannot be used by other firms because of the site specificity, physical asset specificity, human specificity and temporal specificity. As the asset specificity of a production input grows, so does the propensity of the firm to internalize such an input or to outsource it through established and proven suppliers. By internalizing (make option) or externalizing (buy option) portions (or the entirety) of production, the contractor establishes the boundary of his firm, so as to control its "technical core" (Thompson, 1967). US statistical data and past survey results (US Bureau, 2000; Costantino and Pietroforte, 2004) show that the boundary of firms varies, depending on the type of construction market in which they operate. In building construction the rate of subcontracting is significantly higher than in that of non-building construction. This difference can be explained in terms of diverse technical cores set by building and non-building contractors.

The establishment of the technical core results from the optimization of two types of costs: those related to the chosen production arrangement (make or buy) and those related to its coordination. To illustrate these costs, Table 1 shows the range of possible options that a general contractor faces in the construction of a building facade. A similar range of options can be found in the other composing parts of a building or facility. The production of each facade input can be externalized or internalized. Either choice is driven by its direct cost and also by the cost of coordinating its execution. This last type of cost relates to the amount of information and knowledge that must be exchanged for the successful transaction of each input, as will be illustrated in the following section.

TABLE 1: Range of inputs for the construction of a building facade

	Design	Fabrication	Assembly	Delivery	Erection	
Tools/machinery				X	X	Crane, scaffolding
Base material				X	X	Mortar, caulking
Standard component			X	X	X	Brick, standard window
Customized component	X	X	X	X	X	Wall panel, customized window
System	X	X	X	X	X	Curtain wall

### 3. INFORMATION AND KNOWLEDGE CONTENT OF CONSTRUCTION TRANSACTIONS

It should be noted that the information flows (and therefore transaction costs) that are related to the various production situations, as shown in Table 1, vary in terms of quantity of information processing and codification level, that is, the description complexity of the product or work to be transacted. The higher the required craftsmanship of a category of work to be purchased, the more its transaction needs the exchange and sharing of uncodified (or less codified) knowledge and information. Differently, the object of the transaction may be a standard brick that requires the exchange of little codified information because its technical specifications and purchasing criteria are widely known. These different transactional situations, in terms of required information quantity and codification, are shown in Fig. 1 through the example of a building facade. The successful transmission and sharing of uncodified information presents obvious difficulties that can be alleviated through repetitive business transactions between the same parties over time.

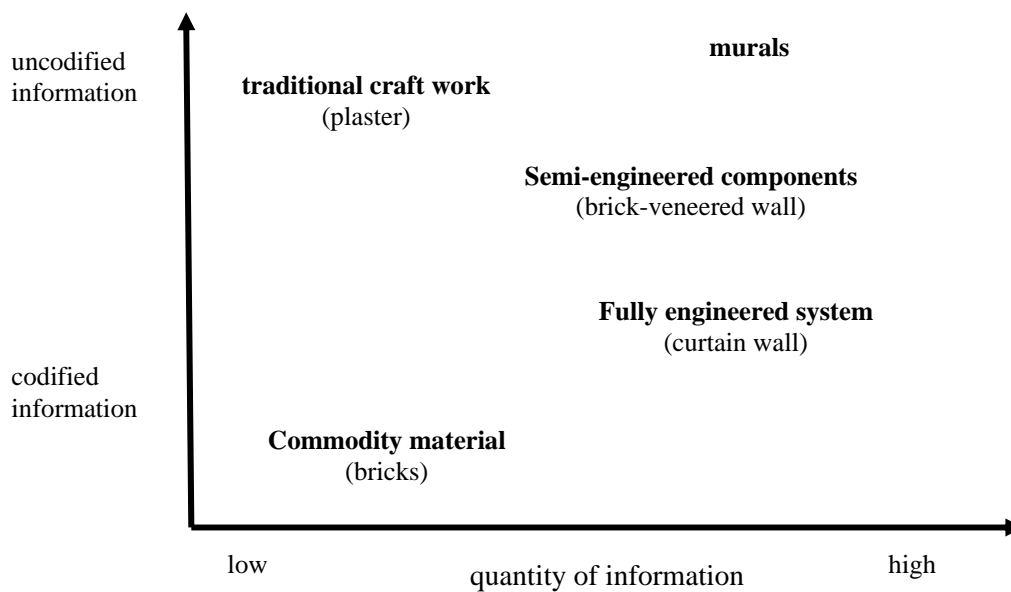


FIG. 1: Different information requirements of the construction of a building facade

Long-term business relationships, in fact, foster the development of trust, mutual understanding and common language between firms that aim at coping with these difficulties. The common language shared within a small group has unique and personal features and is called “idiolect” in semantic terms (Eco, 1968). Generally it is not understandable to outsiders. A typical example is the idiolect that expresses the tacit knowledge of the craftsman that can be communicated only through its application, as in the case of murals and plastering work shown in Fig. 1. According to Nonaka and Konno (1998) “tacit knowledge is highly personal and hard to formalize, making it difficult to communicate or share with others.” Lack of information codification, in addition, gives rise to ambiguity and therefore leads to possible opportunistic behavior and information asymmetries in spot transactions, a hazardous situation that is lessened only with repetitive business transactions between the same parties. The need for a shared idiolect and risk of opportunistic behavior are two of the main determinants of the phenomenon of the quasi-firm (Eccles, 1981b) and macrofirm (Dioguardi, 1983). These semi-integrated forms of organization are composed of independent firms bound together by stable business relationships. In subcontracting, particularly in building construction, long-term business relationships are needed for protecting general contractors from the hazards associated with exchange relationships.

### 4. THE MANAGEMENT OF THE PURCHASING PROCESS

The process of managing the purchase of supplies or subcontracting services in construction generally encompasses seven specific steps (Withee, 2003), as shown in Figure 2. The undertaking of each step entails the generation, transmission and management of information whose quantity and level of codification varies significantly according to what is transacted. Each information process results in costs that can have a

deterministic nature, such as those incurred for product identification or payment, or a probabilistic nature, such as those incurred for quality control and acceptance, as they relate to “quality shortfalls, ex-post bargaining over surplus, litigation, hold-up costs and wasted investments”(Ekstrom *et al.*, 2003).

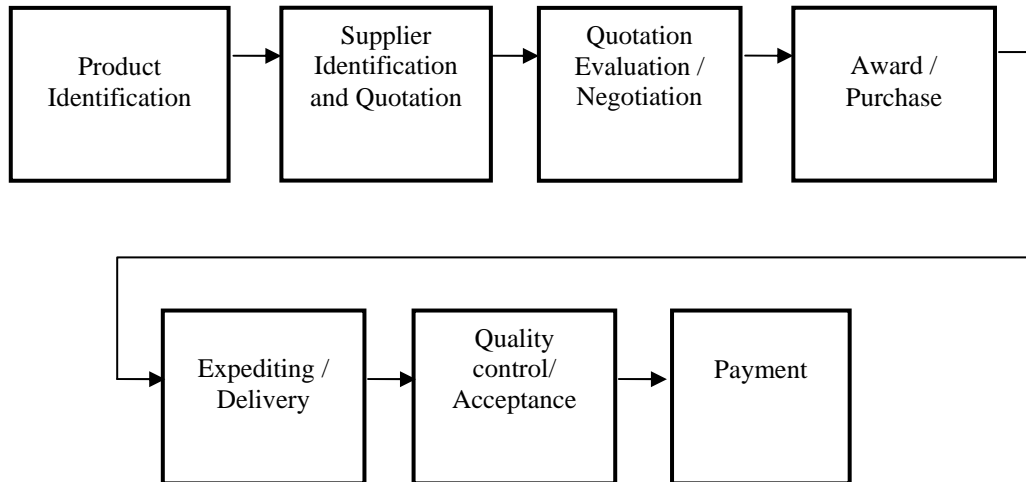


FIG. 2: The steps of the purchasing process

When commodities (e.g., base materials or standard components) are considered, their purchasing process is characterized by a reduced amount of information flows with high levels of codification. In this case, Internet-based applications can lower transaction costs significantly. Another characteristic of purchasing commodities is the decreased risk of contractual hazards (for the small amount of exchanged information and its highly codified nature) and, therefore, of opportunistic behavior (also for the existence of many sellers of base materials and standard components). When subcontracting or customized components are considered, their purchasing process is characterized by:

- An increased amount of information flows with varying extents of codification. In this case, Internet-based applications offer opportunities for lowering the cost of the information process (considering also its high volume), provided that the latter is based on shared idiolects.
- An increased risk of contractual hazards and opportunistic behavior. The need for decreasing this type of risk leads contractors to use proven and known subcontractors or suppliers frequently, independently of the possible advantages of shared idiolects.

## 5. THREE HYPOTHESES ABOUT THE POTENTIAL IMPACT OF INTERNET APPLICATIONS

E-commerce applications can impact any of the seven steps of the purchasing process shown in Figure 2. According to Ronchi (2003), “the Internet could streamline an inefficient procurement process by removing the manual, paper-based, administrative and bureaucratic elements inherent in traditional purchasing systems.” The possible impact of these technologies on purchasing process and procedures varies. We can hypothesize three main scenarios and related intermediate situations. These scenarios are used as hypotheses to be verified with the presented empirical study.

1. The first scenario encompasses the use of Internet-based technologies (e.g., e-mail and on-line catalogues) for identifying and contacting possible suppliers/subcontractors (with whom a contractor may have long standing or new business relationships, depending on the risk of exchange hazard) and exchanging information that is codified into a shared idiolect. For example, when the purchase of craft based work is considered, a buyer may use Internet technologies to locate and solicit proposals, finalize the purchase order and process payments, while at the same time the traditional in-house protocols for proposal evaluation and quality control/acceptance

remain the same. In practice the Internet technologies are simply a new tool for managing existing established information protocols. This scenario probably applies to any type of firm with Internet connection that plans to buy products and services of varying complexity.

2. The second scenario encompasses the use of Internet-based technologies, as integrated into an Enterprise Resource Planning (ERP) or existing in-house IT purchasing procedures. In this case, all information flows have been codified into language shared with potential (and generally usual, depending of the risk of opportunistic behavior) suppliers. The traditional purchasing procedures are modified and integrated into the in-house ERP or other accounting protocols. This approach is often complemented by the use of private portals, i.e., directly controlled by a (typically large) construction firm. The Internet technologies are still a tool for improving the efficiency of purchasing efforts. This scenario is probably applicable only to large firms given the significant IT investments.
3. The third scenario encompasses the use of Internet-based technologies such as on-line catalogues, reverse auction and public market places for purchasing products and/or services. The latter typically are commodities or basic materials or sometimes services with univocally defined scope and content. The purchasing process is almost completely delegated to the portal. In the case of reverse auction, the choice of the supplier is generally left to and managed by the portal software (usually on the lowest price below a given monetary threshold). The reduced risk of incomplete contracts and of consequent opportunistic behavior facilitates the achievement of liquidity benefits, for the increased number of possible (even if little known) suppliers. In this case, the purchasing protocol is completely modified, similarly to what happens when an air ticket is bought through the services of Travelocity or Expedia.

These three scenarios of the possible impact of Internet-based technologies on the purchasing procedures by contracting firms are shown in Fig. 3.

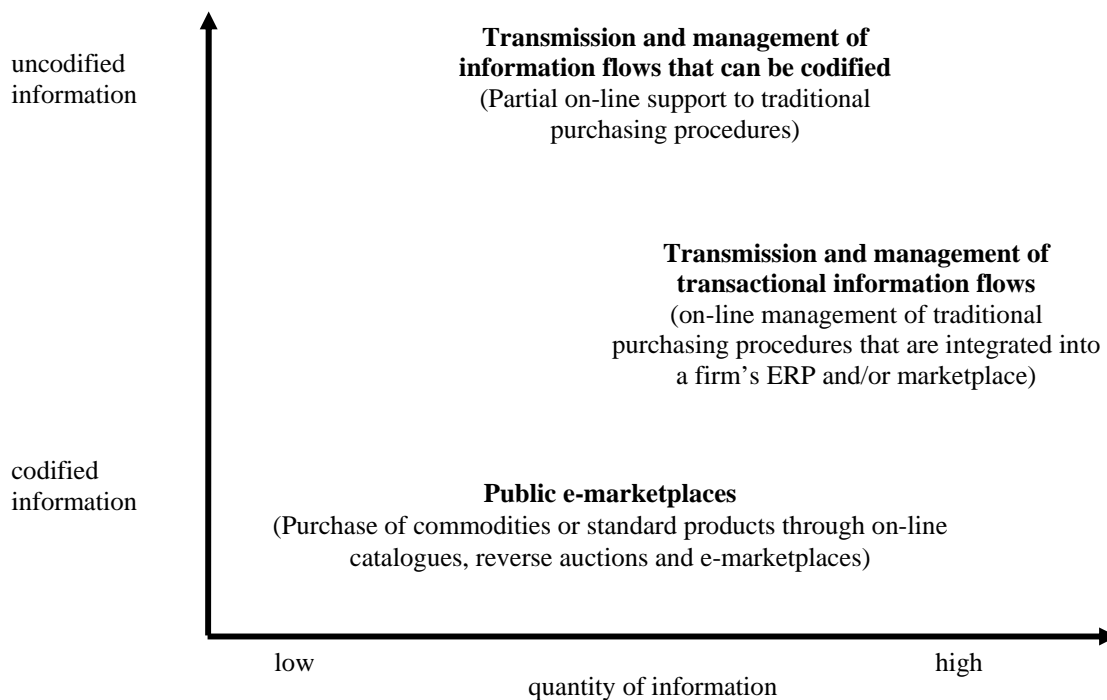


FIG. 3: Possible impact of Internet-based technologies

## 6. QUESTIONNAIRE SURVEY

To verify the above-mentioned scenarios, a questionnaire survey was designed and administered to three different sets of general contracting firms, as follows.

- A sample of 460 US firms that includes the top 400 (>US100 million of yearly sales) according to the 2002 *Engineering News Record* ranking.
- A sample of 111 Italian firms that includes the Top 100 (>US 50 million of yearly sales) according to the 2003 ranking by the magazine *Il Nuovo Cantiere*.
- A sample of 98 firms that operate in the region of Bari, in Southern Italy and make up the local association of contractors. In terms of yearly sales, these firms are much smaller than those of the two other samples. These firms were considered to verify whether firm size matters in the use of the considered applications.

The survey contained 32 questions, broken down into three sets of concerns. The first set encompassed questions aimed at gathering the main characteristics of the surveyed firms such as size, type of construction market and extent of subcontracting. The second set addressed e-commerce applications outlined in the above-proposed hypotheses, namely their adoption rate (current and planned use) by the considered firms, as following.

- Use of e-mail and on-line catalogues to search possible suppliers and exchange information until the issuance of purchase orders.
- Use of on-line purchasing protocols and whether they were integrated into a firm's ERP.
- Purchasing through on-line catalogues.
- Purchasing through reverse auctions and e-marketplaces.

The above-considered applications were taken into account in relation to the purchasing of products and subcontracting services of varying complexity.

The third set of questions addressed the major obstacles to the adoption of e-commerce, as perceived by the surveyed firm. The most relevant issues (for the hypotheses to be verified) pertained to the following.

- Reluctance or inability of e-commerce or e-business among subcontractors.
- Lack of e-commerce or e-business software that meets the needs of the construction industry (i.e., to accommodate the procurement of services).
- Prefer proven suppliers and subcontractors.
- Current e-procurement systems are not suitable for purchasing custom designed components.

These issues were presented in a five-point Likert scale (in terms of level of importance) to respondent contractors.

## 7. SURVEY RESULTS

The characteristics of the surveyed firms are shown in Table 2. The sample includes building and non-building construction firms (e.g., civil engineering). Non-building contractors tend to be larger than building contractors and usually self-perform more work, as observed in all the samples. Non-building contractors therefore, and differently from building contractors, purchase more basic materials and components (i.e., commodities) to be installed by their in-house workforce.

TABLE 2: Characteristics of the surveyed firms

	USA	Italy	Bari
Sample	460	111	98
Respondents	56	37	32
2003 sales <sup>1</sup>	\$ 626.000.000	\$ 339.000.000	\$ 4.100.000
% building firms	71%	65%	69%
% non building firms	29%	35%	31%
2003 yearly sales (building) <sup>1</sup>	\$ 447.000.000	\$ 153.000.000	\$ 3.500.000
2003 yearly sales (non-building) <sup>1</sup>	\$1.074.000.000	\$ 678.000.000	\$ 5.400.000
% subcontracting (building)	76%	65%	62%
% subcontracting (non-building)	29%	48%	30%

<sup>1</sup> 2001 for US sample

Table 3 illustrates the rate of adoption of the four considered applications. The first two samples of surveyed firms show similar orientation in using these applications. As hypothesized earlier in the paper, a lower rate of adoption or interest in the most advanced Internet-based technologies characterizes both US and Italian (second sample) contractors. E-mail is frequently used or planned for use (65-74% of cases) for exchanging information with suppliers. There is significant integration of these information flows into existing corporate management information systems (planning and in use: 51-59%). The use of on-line purchasing is substantial (planning and in use: 38-40%), while that of reverse auctions and e-marketplaces (planning and in use: 28%) is still a limited one. The adoption rate of the four considered technologies appears to be significantly affected by the size of firms, as can be seen in the responses by small firms (Bari region) and medium-large firms (USA and Italy). As far as purchasing through online catalogues is concerned, this practice is adopted (or planned for use) more often for standard products or commodities (48-50%) than for engineered components or subcontracting (33-35%).

TABLE 3. Use extent of the considered e-commerce applications

		USA	Italy	Bari
Use extent of e-mail for communications with suppliers	Planning	16%	16%	6%
	In use	49%	58%	12%
Use extent of integrated management of information (ERP and similar applications)	Planning	27%	12%	7%
	In use	32%	39%	4%
Use extent of on-line purchasing (overall )	Planning	6%	22%	3%
	In use	34%	16%	19%
Use extent of on-line purchasing of commodities	Planning	5%	24%	10%
	In use	45%	24%	19%
Use extent of on-line purchasing of engineered products and subcontracting	Planning	6%	21%	0%
	In use	29%	12%	19%
Use extent of reverse auctions and e-marketplaces	Planning	10%	10%	0%
	In use	18%	18%	0%

The higher rate of self-performed work by non-building contractors is reflected in their more frequent recourse to reverse auction and e-marketplaces, as shown in Table 4. The table does not address the sample of Bari's region, because those small firms currently do not use these applications.

TABLE 4: Use extent of reverse auctions and e-marketplaces

		USA (B)	USA (NB)	Italy (B)	Italy (NB)
Use extent of reverse auctions and e-marketplaces by building (B) and non-building (NB) contractors	Planning	10%	10%	9%	11%
	In use	11%	37%	15%	22%

Some of the reasons for the varying approaches to the considered applications can be found in the perceived adoption obstacles by the surveyed contractors, as shown in Table 5.

TABLE 5: Most perceived obstacles to the adoption of e-commerce

	USA	Italy	Bari	Average
Current e-procurement systems are not suitable for purchasing custom-designed components	3,6	4,4	3,3	3,7
Reluctance or inability of e-commerce/e-business among subcontractors	3,5	3,8	3,8	3,7
Prefer proven suppliers and subcontractors	3,0	3,0	4,0	3,3
Lack of e-commerce/e-business software that meets needs of construction industry	2,8	3,0	3,3	3,0

As the complexity of a business transaction increases (e.g., the purchase of customized components or subcontracting services), so less useful are the capabilities of reverse auctions and e-marketplaces perceived to be. In this regard, the surveyed contractors indicated that the inability of current e-commerce software in meeting the procurement needs of customized components or subcontracting was perceived as the major obstacle to the adoption of these technologies (on a Likert scale: 3.6 USA; 4.4 Italy; 3.3 Bari). On the same scale, the following further reasons were ranked as most important by respondents:

1. Reluctance among subcontractors and suppliers (3.5 USA; 3. Italy; 3.8 Bari). This result was expected, considering the generally small size of specialized trade firms.
2. Preference for proven subcontractors and suppliers (3.0 USA; 3.0 Italy; 4.0 Bari). This orientation confirms that as the complexity and need for processing large amounts of uncodified information increase in a business transaction so does its asset specificity. The possible liquidity benefits are not as convenient as the benefits of long-term collaboration, e.g., reduced risk of hazards associated with exchange relationships with unproven partners.
3. Lack of e-commerce/e-business software that meets the needs of the construction industry (2.8 USA; 3.0 Italy; 3.3 Bari). This last indicator confirms that the surveyed contractors deem current applications not yet suitable for coping with the complexity and intricacies of client/supplier relationships. The simultaneous consideration of the content of Tables 3, 4 and 5 suggests that these contractors are indeed interested in the opportunities offered by Internet-based applications, but for the time being, they prefer to maintain the strategically more important possibility of relying on their usual network of suppliers and subcontractors as well as maintaining their long standing business relationships, in a way similar to the semi-integrated organizational form of the quasifirm. When dealing with established suppliers and subcontractors, purchasing decisions by general contractors are driven by many other factors (e.g., past common experience, workload, new jobs expectation, etc), in addition to price. Differently in the case of commodity-like products, price is often the main and only input to decision making.

## 8. CONCLUSIONS

This study has addressed some of the reasons behind the varying adoption rate of a selected number of e-commerce applications by a sample of US and Italian contractors. Initially three hypotheses of the possible impact of these applications on the purchasing procedures of construction firms were proposed. In this regard the authors argued that the varying use extent of these applications was influenced by the nature and phase of the transaction process, type of transacted production input as well as the size and type of construction firm. These hypotheses were verified through the administration of three questionnaire surveys whose results appear to confirm the original arguments of the study. More specifically the findings suggest the following considerations:

- The use of the Internet (i.e., e-mail) for the information handling of some tasks of the purchasing process is quite diffused, because it offers savings in terms of transaction costs and it does not alter existing purchasing procedures.
- The integration of e-commerce procedures into corporate ERPs is not diffused. Only large firms can afford the significant investments of changing purchasing and accounting procedures, IT systems and personnel training.
- Online purchasing is practiced for the procurement of basic materials and products rather than for engineered or more complex products.
- The use of reverse auctions or e-marketplaces is still a marginal phenomenon. These applications tend to be used by non-building contractors that self-perform a large portion of their work and purchase commodity-like products.
- The procurement of complex products and subcontracting is a transaction that induces contractors “to invest” in repetitive or continuous business relations with proven partners. This type of transaction is characterized by a high level of asset specificity, given the challenge of exchanging a large amount of (often) uncodified information successfully and the possibility of opportunistic behavior.

## 9. REFERENCES

- Construction Products Association (2000), *E-commerce in the construction industry: e-construction.*, C.P.A., London.
- Construction Products Association (2001), *E-construction. Where are we now?*, C.P.A., London.
- Coase R.H. (1937), The nature of the firm, *Economica*, 4, 386-405.
- Costantino N., Pietroforte R. (2002), Subcontracting practices in USA homebuilding: an empirical verification of Eccles's findings twenty years later, *European Journal of Purchasing and Supply Management*, 8, 15-27.



- Costantino N., Pietroforte R. (2004), Production arrangements by US building and non-building contractors: an update, *Construction Management and Economics*, 22, 231-235.
- Dioguardi G.F. (1983), Macrofirm: Construction firms for the computer age, *Journal of Construction Engineering and Management*, ASCE, 109, 13-24.
- Eccles R.G. (1981a), Bureaucratic versus craft administration: the relationship of market structure to the construction firm, *Administrative Science Quarterly*, 26, 449-469.
- Eccles R.G. (1981b), The quasi-firm in the construction industry, *Journal of Economic Behavior and Organization*, 2, 52-529.
- Eco U. (1968), *La struttura assente*, Bompiani & C, Milano.
- Eisenmann T. (2000), *eBricks*, Harvard Business School Publishing, Boston.
- Ekstrom M.A., Bjornsson H.C., Kunz J.C., Levitt R.E. and Nass C.I. (2003), *The impact of rating systems on subcontracting decisions. A transaction cost analysis*, CIFE Technical Report # 135, Stanford University.
- Joskow P.L. (1988), Asset specificity and the structure of vertical relationships: empirical evidence, *Journal of Law, Economics, and Organization*, 4, 95-117.
- Nonaka I., Konno N. (1998), The concept of “Ba”: building a foundation for knowledge creation, *California Management Review*, 40 (3), 40-54.
- Ronchi S. (2003), *The Internet and the Customer-Supplier Relationship*, Ashgate, Aldershot (U.K.).
- Shelanski H.S., Klein P.G. (1995), Empirical research in transaction cost economics: a review and assessment, *The Journal of Law, Economics & Organization*, 11, 335-361.
- Thompson J.D. (1967), *Organization in action*, McGraw-Hill, New York.
- US Bureau of Census (2000), *1997 Economic Census – Construction*, US Department of Commerce, Washington, DC.
- Williamson O.E. (1975), *Markets and Hierarchies: Analysis and Antitrust Implications*, The Free Press, New York.
- Williamson O.E. (1979), Transaction Cost Economics: The Governance of Contractual Relations, *Journal of Law and Economics*, 22, 233-261.
- Williamson O.E. (1981), The economics of organization: the transaction cost approach, *American Journal of Sociology*, 87, 548-577.
- Withee T. (2003), “Use of electronic purchasing applications in the construction industry”, Major Qualifying Project, Department of Civil and Environmental Engineering, Worcester Polytechnic Institute, USA, December 2003.