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Article *in* Total Quality Management and Business Excellence · February 2014
DOI: 10.1080/14783363.2012.728848

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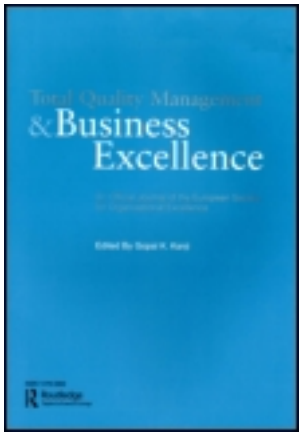

Total Quality Management & Business Excellence

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/ctqm20

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Published online: 08 Oct 2012.

To cite this article: Javier García-Bernal & Nieves García-Casarejos (2014) Economic analysis of TQM adoption in the construction sector, Total Quality Management & Business Excellence, 25:3-4, 209-221, DOI: 10.1080/14783363.2012.728848

To link to this article: http://dx.doi.org/10.1080/14783363.2012.728848

Total Quality Management, 2014
Vol. 25, No. 3, 209–221, http://dx.doi.org/10.1080/14783363.2012.728848

Economic analysis of TQM adoption in the construction sector

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Researchers have dedicated considerable efforts to examining and explaining the capacity of total quality management (TQM) to generate wealth, from the conceptual framework of the resource-based view. From this approach, TQM is basically an inimitable resource that generates competitive advantages. This analytical perspective can help justify and explain the behaviour of the firms that have adopted TQM, but not that of the firms that do not intend to adopt this management approach in the future. In the current work, we aim to make progress in this direction. We offer arguments, from an economic and organisational perspective, that help explain how TQM's capacity to generate wealth is not uniform in all firms but is contingent on variables such as the firm's size and subsector. The results of the empirical analysis, involving a sample of Spanish construction firms, provide support for two hypotheses postulating relations between the firm's optimum level of TQM adoption and its size and subsector.

Keywords: total quality management; construction sector; transaction cost theory; determinants of level of TQM adoption

1. Introduction

Total quality management (TQM) has become very popular among firms in recent years. Empirical evidence seems to suggest that a positive relation exists between TQM adoption and improvements in the performance of a firm. A large amount of research has examined and explained TQM's capacity to generate wealth from the conceptual framework of the resource-based view (RBV). From this analytical perspective, TQM is basically an inimitable resource (Powell, 1995) that generates competitive advantages for its adopters (Savolainen, 2000). Researchers can use the RBV to justify and explain the behaviour of firms that have adopted TQM, but not that of firms that do not intend to adopt TQM in the future. According to the RBV perspective, these latter firms would be behaving irrationally because they would be renouncing the potential benefits available from adopting TQM.

Consequently, there is a need for alternative arguments that help explain the uneven diffusion of TQM in the population of firms. Such arguments can be found by means of a broader and deeper analysis of TQM's capacity to generate wealth taking the theoretical and conceptual framework of Transaction Cost Theory (Williamson, 1975, 1985) as reference. Researchers can use this approach to analyse how TQM can increase organisational efficiency – in terms of wealth generation – only in firms sharing a number of specific characteristics. In this work, we adopt the conceptual delimitation of TQM as an organisational design option that allows firms to efficiently manage their information and coordination problems (Wruck & Jensen, 1994, 1998; Brickley, Smith, & Zimmerman, 2004; García-Bernal & Ramírez-Alesón, 2010) by allocating responsibilities to the people

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possessing the relevant information for each particular decision. This promotes the creation and effective use of specific knowledge dispersed among the different hierarchical levels of the organisation.

Thus we identify and analyse two specific elements that provide arguments capable of explaining the different levels of TQM adoption observable among firms today. On the one hand, and as we have said, TQM helps firms to efficiently manage their information and coordination problems. Consequently, the higher the volume of such costs in a firm, the greater will be TQM's potential to generate wealth in that firm, and hence the stronger the firm's incentive to adopt TQM. On the other hand, we have also said that TQM allows firms to efficiently manage the creation and use of specific knowledge dispersed in different hierarchical levels of the organisation. Consequently, the greater the presence of and need for such specific knowledge for the firm to carry out its normal activities, the greater will be TQM's potential to generate wealth, and hence the stronger the firm's incentive to adopt TQM. Thus each firm's optimum level of TQM adoption will be the one that allows the firm to minimise its total transaction costs, or in other words the level at which the firm can create the most wealth.

Developing the different arguments allows us to formulate two hypotheses – one involving the firm's size and the other its subsector – which we subsequently test empirically using a sample of construction firms from the region of Aragon, in northern Spain. The findings of this work show that the largest firms have the highest levels of TQM adoption. In these firms the potential benefits from adopting TQM exceed the greater direct costs of adoption, so that their optimum levels of TQM adoption are relatively high. The same applies to the firms in the subsectors of the construction sector that are most intensive in the generation and use of specific knowledge. The potential benefits of TQM adoption are higher in these subsectors, and they exceed the greater direct costs of adoption, so the firms present a higher level of TQM adoption.

The rest of this work is structured as follows. In Section 2 we look at the economic nature of TQM and analyse how certain characteristics of the firm can help explain the different levels of TQM adoption observable among firms. Section 3 presents the sample and variables used to test the hypotheses, and then reports the main results of the empirical analysis. Section 4 ends by discussing the main contributions of the work as well as its implications for managers.

2. TQM and the determinants of its adoption

The literature has generated a considerable amount of research examining TQM's capacity to generate wealth from the conceptual framework of the RBV. From this analytical perspective, TQM is basically an inimitable resource (Powell, 1995) that potentially offers firms competitive advantages (Savolainen, 2000). Reed et al. (2000) argue that these competitive advantages are sustainable because TQM can, on its own, raise barriers to imitation. Moreover, adopting TQM also allows firms to develop a series of competencies that improve their organisational performance (Escrig-Tena & Bou-Llusar, 2005). All these arguments help justify and explain TQM's capacity to generate wealth, but they cannot explain why some firms choose not to adopt TQM or why a relatively high number of organisations do not even envisage adopting this management approach in the future.

In view of the RBV's inability to explain the different levels of TQM adoption among firms, in this work we adopt the conceptual delimitation of TQM as an organisational

design option (Wruck & Jensen, 1994, 1998; Brickley et al., 2004; García-Bernal & Ramírez-Alesón, 2010). We can then examine the economic nature of TQM and its capacity to resolve two types of problem that can afflict firms: information or coordination problems; and motivation or incentive problems (Milgrom & Roberts, 1992). Thus from an economic and organisational perspective, Wruck and Jensen (1994, 1998) define TQM as 'a science-based, non-hierarchical, and non-market-oriented organizing technology'. In other words, TQM is an organisational innovation that enables an increase in the productivity of the labour and capital factors. These authors describe TQM as science-based because people at all levels of the organisation are trained to use the scientific method in decision-making. This training, together with the diffusion of team working, encourages the creation of specific knowledge. TQM is non-hierarchical because it offers a process for attributing decision rights in ways that ignore the traditional firm hierarchy. In particular, decision rights are assigned to the people possessing the relevant information for the particular decision in question. Finally, TQM is non-market-oriented because it does not resort to prices or formal exchange mechanisms to motivate cooperation or the transfer of decision rights.

In short, TQM is an organisational design option that improves the management of the firm's information problems via the allocation of decision rights to the people with the relevant information for the particular decision being made. Hayek (1945) establishes that the organisation's performance depends on bringing together decision-making power and the knowledge that is relevant to take each particular decision. But such knowledge initially tends to be dispersed among the different members of the organisation, regardless of their hierarchical levels. In this context, information problems fundamentally mean the transaction costs that need to be incurred when identifying and gathering together all the information necessary to determine an efficient plan of action and communicate it to all the people responsible for its implementation (Milgrom & Roberts, 1992). These costs are not just the direct costs of gathering together and transmitting information but also the costs as a result of the delays that occur both in the stage of designing the action plan and in the stage of its communication. Moreover, because information can never be perfect, implementing and carrying out the action plan have their costs because the people responsible for taking decisions possess insufficient or inadequate information (ex-post residual efficiency losses).

In any case, two ways of bringing together relevant knowledge and decision-making power exist: move the information to those who have the power of decision, or move the power of decision to those who have the knowledge. Jensen and Meckling (1995) prefer the second option, because if the decision-making is located in a single person or group of experts the residual efficiency losses tend to increase. This is because they do not receive all the relevant information and/or cannot process the information efficiently due to the limited capacity of the human mind.

Thus TQM, via the delegation of decision rights to the people with the relevant information or knowledge (or failing this, the people who can acquire such knowledge at least cost), allows the firm to base its decision-making on all the relevant knowledge. It can then reduce the residual losses (RLs) deriving from the existence of information problems. And the more intensely TQM is implemented, the greater the reduction in the RLs.

On the other hand, the firm has to incur some explicit costs directly linked to TQM (e.g. buying specialist TQM consultancy services, training courses and information sessions to familiarise workers with the main concepts and elements of TQM, resources dedicated to install systems to obtain and systematise information, etc.). Clearly, these costs grow with the level of implementation and extension of TQM in the firm. Thus a firm's

optimum level of TQM adoption in efficiency terms depends on a trade-off between the RL derived from the information problems and the direct and explicit costs directly linked to TQM adoption (TQM DC). Each firm has an optimum level of TQM adoption (TQM*) that minimises the total costs (TC) from the two sources (see Figure 1).

The optimum level of TQM adoption will depend on the firm's cost functions. However, these cost functions are determined by a number of characteristics of the firm. In the current work, we focus on two specific elements that are directly related to the evolution and magnitude of the information costs in the firm and hence determine a higher or lower optimum level of TQM adoption. These two elements are the firm's size and its subsector.

With regard to the firm size, the determining element is fundamentally the number of workers. Information problems that hinder coordination between the organisation's members grow with the number of workers because the number of communication channels for transmitting information between them grows at a faster rate than the number of people. One immediate consequence is that the residual efficiency losses due to the inefficient management of the information problems will also – logically – grow. Graphically analysing the effect of an increase in the number of workers on the optimum level of TQM adoption (see Figure 2), an increase in the number of employees translates into an increase in the cost function measuring the efficiency losses due to an inefficient management of the information problems. In other words, that curve shifts to the right (from RL1 to RL2). Clearly, an increase in the function measuring the efficiency losses leads to an increase in the TC function derived from the existence of information problems, so that curve also shifts to the right (from TC1 to TC2). Thus an increase in the number of employees means that the minimum of the new total transaction cost function (TC2) due to the existence of information problems corresponds to a higher level of TQM adoption (TQM*2 rather than TQM*1). In short, in a specific firm the higher the number of workers, the higher the optimum level of TQM adoption. With the above, we propose our first hypothesis:

H1: The optimum level of TQM adoption in a firm rises with the number of workers (firm size).

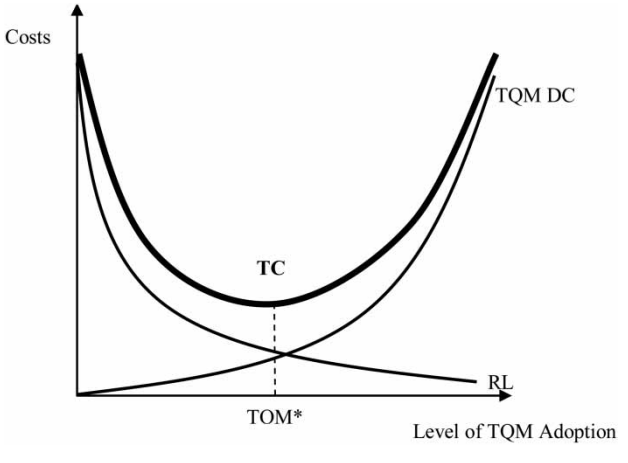

Figure 1. Optimum level of TQM adoption. Source: The authors.

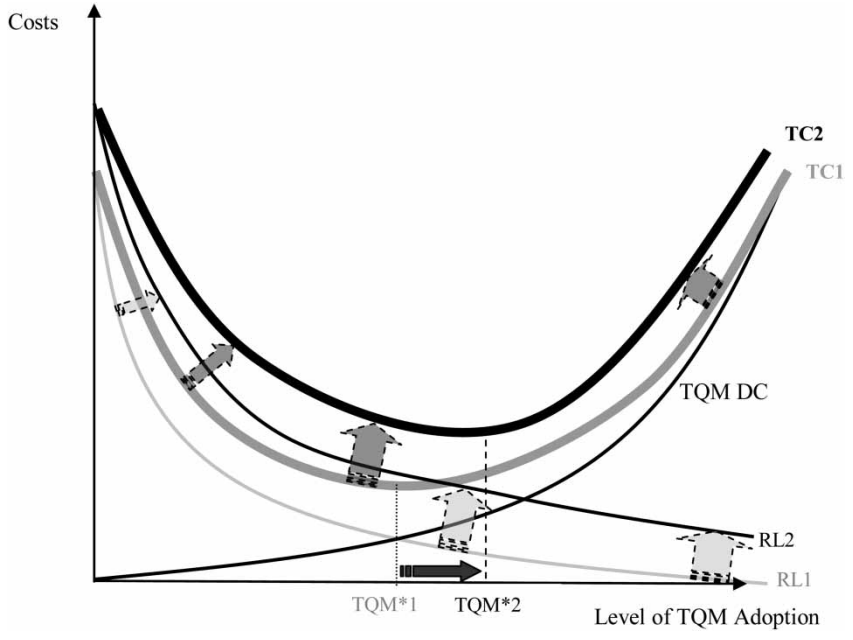

Figure 2. Effect of firm size on optimum level of TQM adoption. Source: The authors.

The second determinant of the optimum level of TQM adoption in each firm is the subsector. The critical element in this case is the level of the need to use and generate specific knowledge to carry out the firm's normal activities, which is to a large extent determined by its sector. The volume of specific knowledge necessary is an important aspect since TQM's capacity to generate wealth lies in its capacity to encourage the creation and efficient use of valuable specific knowledge at all levels of the organisation (Wruck & Jensen, 1998). Thus the greater the need to generate and efficiently manage this specific knowledge, the greater TQM's capacity to generate wealth. The knowledge is specific because it comes linked to a transmission cost between the agents, unlike general knowledge, which transmits without cost (Jensen & Meckling, 1995). The cost of transmitting knowledge depends on factors like the nature of the information, the organisational environment and technology. Transmission in this sense means effective transmission, not just communication. In other words, the receiver of the knowledge must understand the message well enough to be able to use the knowledge. The fact that specific knowledge bears transmission costs means that to be able to use it efficiently the managers must decentralise the decision-making process.

In this context, adopting TQM may allow firms to manage specific knowledge efficiently and improve the overall efficiency in terms of wealth generation, via a reduction in the RL as the level of TQM adoption rises. But the function measuring the evolution in the RLs in function of the level of TQM adoption depends on the nature of the information that the firm uses to carry out its daily activities. This is directly linked to the sector in which the firm operates. Looking at Figure 3, if a firm moves to a new sector with a greater need to generate and use specific knowledge, the function measuring RLs shifts to the right (from RL3 to RL4). This reflects an increase in the RLs. Clearly, this increase in the RLs function leads to a simultaneous increase in the total transaction cost function (from TC3 to TC4). Consequently, the optimum level of TQM adoption

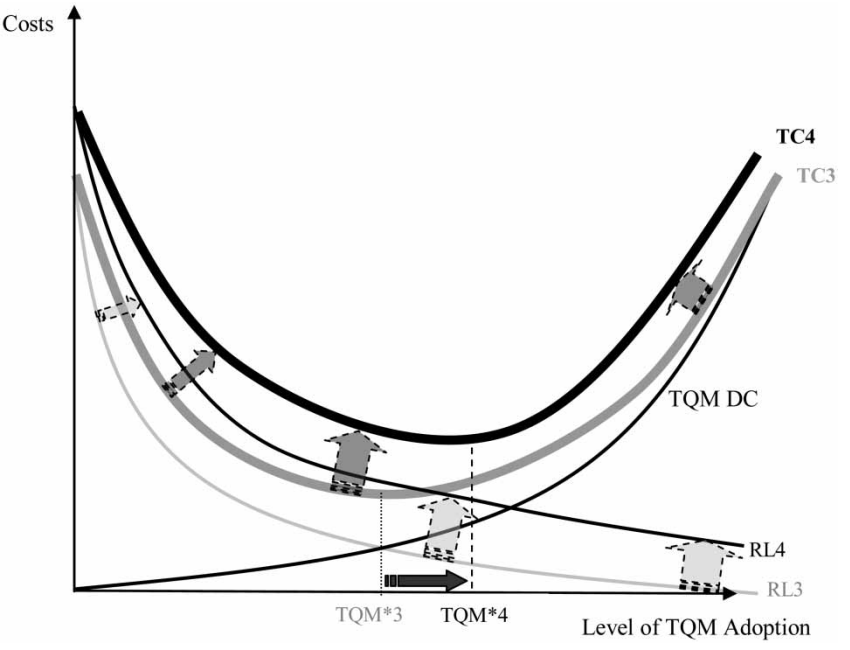

Figure 3. Effect of sector on optimum level of TQM adoption. Source: The authors.

also increases (from TQM*3 to TQM*4). Evidently, the more specific the knowledge generally relevant for the decision-making, the higher the optimum level of TQM adoption. This is a consequence of TQM's greater capacity to generate wealth in such firms, which in turn, compensates the increase in the explicit costs due to the higher TQM adoption level. Thus we can propose our second hypothesis:

H2: The optimum level of TQM adoption in a firm depends on the need to generate and use specific knowledge in its subsector.

3. Empirical analysis

3.1 *Description of sample*

To test our research hypotheses we collected information from a sample of construction firms in the northern Spanish region of Aragon. We opted for primary information because of the lack of detailed secondary information and data on the level of TQM adoption in the construction sector in this region. We chose this sector because it was one of the main engines of economic growth in Spain until the outbreak of the current economic crisis, making it an interesting sector in which to examine TQM adoption. The sector represented almost 11% of the region's GDP and employed more than 80,000 people before the crisis. According to the latest report prepared for INAEM, the Aragonese Employment Agency (Fundación Laboral de la Construcción en Aragón, 2010), growth in the construction sector began to slow in early 2007 and employment dropped sharply by over 14,000 workers the following year.

To obtain the information we needed to achieve our research objectives, we designed a questionnaire in collaboration with consultants specialised in TQM and the European foundation for quality management (EFQM) Excellence Model.[1] After it was designed the questionnaire was validated by a group of experts unconnected with the research.

The questionnaires were initially sent by post; after an insufficient response rate more questionnaires were completed in personal and telephone interviews. We eventually obtained detailed information from 293 construction firms from Aragon, and this sample, stratified by size and province, is representative of the population.[2] The data collection took place throughout the second half of 2008. Table 1 summarises the technical specifications of the study.

The sample firms have the following distribution among the region's three provinces: 68.9% are located in Zaragoza, approximately 21.5% in Huesca, and 9.6% in Teruel. With regard to the distribution by size, and following the European Commission's classification of firm size according to the number of workers,[3] 2% of the sample firms are large firms. The rest are SMEs (15.4% medium-sized firms and 82.6% small firms). This study ignores microfirms because of TQM's limited capacity to generate wealth in them. The potential negative consequences of information or coordination problems are practically non-existent in firms with a small number of employees.

At the national level, the sector is very fragmented in terms of production value, according to the industry observatory (Observatorio Industrial de la Construcción, 2012). The structure is the same in the region of Aragon. Thus we can assume the competitive market hypothesis, since the sector's concentration indicators will be low.

Looking now at the specific subsector in which each firm concentrates its activities, almost 40% of the firms specialise in Building construction, a little over 21% in Specialised construction activities, and 13% specialise in civil engineering. Only just over 7% specialise in the Complementary activities subsector. The remaining firms work in two or more subsectors, although more than 80% of these do at least some work in the Building construction subsector.

Finally, approximately 95% of the firms declare a high level of independence or autonomy in their management, while the rest recognise constraints on some of their decision-making, being largely subsidiaries of other firms.

3.2 *Level of TQM adoption*

With regard to the level of TQM adoption, practically 50% of the sample firms say that they do not intend to adopt TQM, while just over 38% say they have adopted TQM. Table 2 reports the data at various levels of aggregation.

Table 1. Technical specifications.

Name	Questionnaire on TQM adoption among Aragonese construction firms
Scope	Autonomous Region of Aragon (Spain)
Universe	Construction firms operating in Aragon region and employing at least 10 workers
Population (size)	1156 firms
Data collection instrument	Questionnaire sent by post or completed in personal or telephone interview
Period of fieldwork	1 July–23 December 2008
Questionnaires completed	295
Response rate	25.5%
Valid questionnaires	293
Confidence level	95.5%, with $p = q = 0.5$
Sampling error	$\pm 4.9\%$

Source: The authors.

Table 2. Level of TQM adoption.

	N	%	*N*	%	
Do not intend to adopt	146	49.8	146	49.8	Do not intend to adopt
Intend to adopt in long term	13	4.4	34	11.6	Intend to adopt in future
Intend to adopt in medium term	14	4.8			
Intend to adopt in short term	7	2.4			
In process of implementation	8	2.7	113	38.6	Implemented or in process of implementation
Implemented but not certified	1	0.3			
Implemented and certified	104	35.5			
Total			293	100	

Source: The authors.

Almost 36% of the sample firms possess recognition or certification linked to quality management. Specifically, approximately 20% have ISO 9001 certification and rather less than 3%, ISO 14001. A relatively high percentage of firms (15%) have ISO certification but in a now-obsolete version (ISO 9000 and/or ISO 14000). Finally, barely 2% of the sample firms belong to a quality-related association (e.g. Club Excelencia en Gestión, Asociación Española para la Calidad, Club Empresa 400, etc.).

3.3 *Empirical results*

The two hypotheses proposed in the theoretical section postulate that the firm characteristics firm size and subsector condition the optimum level of TQM adoption.

Table 3 shows the relation between firm size and level of TQM adoption. The data show that the majority of the large firms have initiated the process of implementing TQM, while the only large firm that has not yet done so intends to adopt TQM in the future. In contrast, over 50% of the small firms say they do not intend to adopt TQM, while only a third have started implementation, less than half the figure for the medium-sized firms. The lower level of TQM adoption among the small firms is

Table 3. TQM adoption in function of firm size.

	Level of TQM adoption			
	Do not intend to adopt	Intend to adopt	Implemented or in process of implementation	Total
Size				
Small firms	**139**	**26**	**77**	**242**
	57.4%	10.7%	31.8%	100.0%
	95.2%	*76.5%*	*68.1%*	*82.6%*
Medium	7	7	**31**	**45**
firms	15.6%	15.6%	68.9%	100.0%
	4.8%	*20.6%*	*27.4%*	*15.4%*
Large firms	**0**	**1**	**5**	**6**
	–	16.7%	83.3%	100.0%
	–	*2.9%*	*4.4%*	*2.0%*
Total	146	34	113	293

Note: Total firms are in bold; percentage of row total in roman; percentage of column total in italic.
Source: The authors.

a consequence of TQM's capacity to create wealth. As we mentioned above, TQM is an organisational design option that allows firms to improve their management of information problems by allocating decision rights to the people with the relevant information to take each particular decision. Consequently, the larger the firm, the greater TQM's potential to generate wealth, since information or coordination problems grow with the number of agents (employees) involved. Thus the ex-ante incentives for adopting TQM are greater for larger firms and the greater benefits from adopting TQM compensate to a greater extent the direct costs the firm must incur in intensifying the level of adoption.

In order to test empirically whether a dependence relation exists between firm size and the optimum level of TQM adoption (*H1*), we carried out an association-independence test between both variables. This test uses the Pearson statistic and the Likelihood ratio, and the results follow a chi-square distribution with 4 degrees of freedom (see Table 4). At a significance level greater than 99% the null hypothesis of non-existence of association or dependence between firm size and optimum level of TQM adoption is rejected. Thus a relation does exist between the different categories of firm size – measured by number of employees – and optimum level of TQM adoption. In other words, the results confirm that as firms grow in size, their optimum level of TQM adoption rises. This reflects the fact that the incentive to implement TQM is stronger for large firms because they can enjoy greater potential benefits from a more efficient management of their information or coordination problems.

With regard to the effect of the subsector on the level of TQM adoption (see Table 5), the data show that more than 60% of the firms working mainly in Building construction do not intend to adopt TQM. In contrast, almost 80% of the firms operating mainly in civil engineering have started the process of implementing TQM, and another 8% intend to adopt TQM in the future. The Specialised construction activities subsector shows a similar distribution of firms in Building construction but with a higher level of TQM adoption. The Complementary activities subsector has a profile similar to that of civil engineering, but with a lower level of TQM adoption. Finally, the high proportion (over 50%) of diversified firms that do not intend to adopt TQM is interesting. This figure can be explained by the fact that more than 80% of these diversified firms do a large amount of their work in the Building construction subsector, so their pattern of behaviour is marked by that of the Building construction firms.

We tested *H2* to determine whether an association exists between the different subsectors and the optimum level of TQM adoption. Table 6 shows the results of this test, which involves the Pearson statistic and the Likelihood ratio. The results follow a chi-square distribution with 8 degrees of freedom. At a significance level greater than 99%, the null hypothesis postulating the non-existence of association or dependence between subsector and optimum level of TQM adoption is rejected. Thus the results confirm that the specific subsector in which the firm concentrates its operations does condition its optimum level of TQM adoption.

Table 4. Chi-square test of association-independence.

	Value	*p*-Value
Pearson chi-square	34.006	0.000
Likelihood ratio	38.077	0.000

Source: The authors.

Table 5. TQM adoption in function of subsector.

	Level of TQM adoption			
	Do not intend to adopt	Intend to adopt	Implemented or in process of implementation	Total
Subsector				
Building construction	**72**	**14**	**28**	**114**
	63.2%	12.3%	24.6%	100.0%
	49.3%	*41.2%*	*24.8%*	*38.9%*
Civil engineering	**6**	**3**	**29**	**38**
	15.8%	7.9%	76.3%	100.0%
	4.1%	*8.8%*	*25.7%*	*13.0%*
Specialised construction activities	**31**	**9**	**22**	**62**
	50.0%	14.5%	35.5%	100.0%
	21.2%	*26.5%*	*19.5%*	*21.2%*
Complementary activities	**7**	**1**	**14**	**22**
	31.8%	4.5%	63.6%	100.0%
	4.8%	*2.9%*	*12.4%*	*7.5%*
Diversified firms	**30**	**7**	**20**	**57**
	52.6%	12.3%	35.1%	100.0%
	20.5%	*20.6%*	*17.7%*	*19.5%*
Total	146	34	113	293

Note: Total firms are in bold; percentage of row total in roman; percentage of column total in italic.
Source: The authors.

The higher level of TQM adoption in the civil engineering subsector in comparison to Building construction may be explained by TQM's greater capacity to create wealth in the former sector. Fundamentally, two reasons exist for this. First, a greater level of specific knowledge exists in the civil engineering subsector than in Building construction. In this latter subsector carrying out tasks is routine and the knowledge necessary to carry them out is identical from one building site to the next. The working conditions are relatively stable. As an illustrative example, in the tiling process for bathrooms and kitchens, the materials may change from one building site to the next but the processes and tasks are mostly similar. Thus the transmission of knowledge is relatively simple via workshops or on-site training and the knowledge acquired is easily applicable to practically any other situation. Firms sometimes even decentralise their decision-making via the market, using subcontracting.

In contrast, in the civil engineering subsector the transmission of knowledge is much more difficult and costly. This subsector has the characteristic that each civil engineering project is unique per se because its environmental conditions always differ. Thus the relevant information for carrying out certain tasks is acquired via the experience people accumulate after having to face and solve certain problems that, although they are

Table 6. Chi-square test of association-independence.

	Value	*p*-Value
Pearson chi-square	40.094	0.000
Likelihood ratio	40.674	0.000

Source: The authors.

similar at source, have very different environments and determinants from one building site to the next. The knowledge necessary to carry out these tasks is very difficult and costly to transmit from one person to another since it is impossible to reproduce the different environmental conditions that a person will have to face. The most highly qualified workers have gained the necessary knowledge through the experience they have gradually built up by carrying out tasks in different building sites and environments. Consequently, measuring output and performance is also difficult to do, as is installing systems to ensure objectives are achieved. Each building site may need a specific solution and the person best suited to determine the optimum solution in each case is someone with previous experience in resolving that type of problem in a large number of different situations. In this case, because of the difficulty and cost of transmitting the relevant knowledge for the particular decision, it is more efficient from the organisational design perspective to allocate the decision rights to the people with the relevant information. This is true even if these people are at low hierarchical levels. The delegation of responsibilities to low levels is one of the foundational aspects of TQM. Consequently, TQM's potential to generate wealth is relatively high in the civil engineering subsector and so civil engineering firms have a stronger incentive to adopt TQM, hence the higher level of TQM adoption.

Another possible reason for the higher level of TQM adoption in the civil engineering subsector in comparison to Building construction lies in the specific nature of the market in which these firms operate. Firms in the Building construction sector earn high margins, and this has a perverse effect on their productive efficiency. These firms have not had the incentive or the discipline from the market to invest or behave in a way that improves their productive and organisational efficiency because the prices in their market have been relatively high. In contrast, the tender processes typical for civil engineering projects force firms to make increasingly competitive offers. This situation encourages civil engineering firms to constantly seek to improve their productivity and efficiency in an attempt to maintain their margins.

4. Conclusions and managerial implications

A large amount of research has examined and explained the capacity of TQM to generate wealth from the conceptual framework of the RBV. From this analytical perspective, TQM is basically an inimitable resource (Powell, 1995) that generates competitive advantages (Savolainen, 2000). Researchers can use the RBV to justify and explain the behaviour of firms that have adopted TQM, but the perspective is less helpful in explaining the behaviour of firms that do not intend to adopt TQM in the future. From the perspective of the RBV these firms would be behaving irrationally because they would be renouncing the potential benefits available from adopting TQM.

The current work provides alternative arguments that can help explain the different levels of TQM adoption among firms. We use the theoretical and conceptual framework of Transaction Cost Theory (Williamson, 1975, 1985). From this analytical perspective, TQM is conceptualised as an organisational design option (Wruck & Jensen, 1994, 1998; Brickley et al., 2004; García-Bernal & Ramírez-Alesón, 2010) that allows firms to efficiently manage the information problems that arise by delegating decision rights to the people with the information relevant for each particular decision.

TQM's capacity to generate wealth is not uniform among firms and a number of factors exist, as we have argued and empirically confirmed here, that can explain why the level of TQM adoption varies in a population of firms.

The first important aspect that determines TQM's capacity to generate wealth is firm size. Considering TQM as an organisational design option that offers the firm a more efficient management of its information or coordination problems (Wruck & Jensen, 1994, 1998), because these problems increase with the number of employees, TQM's potential to generate wealth also grows. The greater TQM's potential to generate wealth, the greater the incentive to adopt it, and so larger firms will conceivably show a higher level of TQM adoption than smaller ones. These larger firms will gain greater benefits from adopting TQM, which will compensate the higher direct costs they have to incur to intensify adoption. The empirical analysis carried out here shows that the level of TQM adoption is indeed higher as firms grow in size.

Another determinant of TQM's capacity to improve the firm's performance is the sector in which the firm concentrates its activities, and specifically, the volume of specific knowledge necessary to carry out the firm's daily activities effectively and efficiently in that particular sector. The greater the quantity of specific knowledge necessary to carry out the firm's activities, the greater TQM's potential to generate wealth, since an inefficient management of the information problems will generate a greater volume of RLs. In this sense, looking in detail at the specific characteristics of each of the subsectors in the construction sector we have identified the civil engineering subsector as having substantially higher levels of specific knowledge than the Building construction subsector. The data on the level of TQM adoption confirm that TQM adoption is indeed higher in the civil engineering subsector than in Building construction. We should also point out that the higher level of TQM adoption among civil engineering firms could also have something to do with their larger mean size.

Any examination of TQM adoption in the construction sector should mention lean construction. Lean construction accepts the design criteria of lean production as a standard of perfection (Howell, 1999) and has the goal of better meeting customer needs while using less of everything. Lean production philosophy, six sigma steps and TQM practices are essentially the same (Dahlgaard & Dahlgaard-Park, 2006). In fact, the term 'Lean Six Sigma' (LSS) is widely used today (Cheng & Chang, 2012; Psychogios & Tsironis, 2012; Wang & Chen, 2012).

As possible future lines of research we recommend replicating the study in other economic sectors and expanding the geographic scope to the whole of Spain. This would allow researchers to generalise our results to other sectors and to other regions of Spain or indeed other countries.

The current study has examined the economic and organisational nature of TQM, and justified and explained the effect of the factors firm size and sector on the level of TQM adoption among firms. The results and conclusions of the current study should shed light on the behaviour of Aragonese construction firms, which account for an important part of the region's economic activity and employment.

Acknowledgement

We gratefully acknowledge funding from MICINN-FEDER through research project ECO2009-09623, from the IDECONSA Chair, and from DGA-FSE through the CREVALOR research group.

Notes

1. The specialist consultancy that helped design the questionnaire was Qualitas Management.
2. The non-profit organisation Fundación Laboral de la Construcción en Aragón provided the data on the location, size and contact details of all the firms in the original population.

3. In May 2003 the European Commission adopted a new definition of micro, small and medium-sized enterprises. The aim was to promote entrepreneurship, investment and growth, facilitate access to venture capital, reduce administrative costs, and strengthen legal certainty. This definition came into force on 1 January 2005, and establishes the following categories based on the number of workers: large enterprise $\geq$250 workers; medium-sized enterprise $<$250 workers; small enterprise $<$50 workers; micro-enterprise $<$10 workers.

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