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Determining Contingencies in the Management of Construction Projects

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Abstract

This research describes the managerial approaches that contractors follow to determine different types of contingencies in construction project management. Two large Spanish general contractors were selected for an in-depth analysis. Interviews and surveys were conducted with six additional companies to explore the external validity of the findings. Managers constrain time and cost buffers through project objectives, applying heuristics to determine inventory buffers. The management of capacity buffers is entrusted to subcontractors. The contractors take advantage of scope and quality buffers to meet project objectives but rarely share these buffers with the owner, unless the owner is an internal client.

Keywords

buffer, contingency, risk management, project, uncertainty

Introduction

Construction companies determine contingencies in order to actively manage the known and unknown risks. Contingencies provide a cushion to hedge or absorb the potential materialization of those risks without jeopardizing the accomplishment of the project objectives (Laryea & Hughes, 2010; Thal, Cook, & White, 2010). Contingencies are therefore an essential factor in both risk management and project success (Ford, 2002; Howell, 2012).

The concept of contingency has been broadly documented in the literature, although the ideas of Thal et al. (2010), Laryea and Hughes (2010), and Howell (2012) suggest that it is described in a partial manner. Some authors address the phenomena only from the perspectives of owners, whereas others explore the perspectives of contractors who do not follow a comprehensive approach; rather, they solely focus on the bidding process or on specific types of contingencies. In fact, no holistic studies describing how contractors manage and determine contingencies during the construction phase have been found.

On that basis, analyzing how contractors actually determine contingencies during construction could be the first step in enhancing their management. Nevertheless, following the approach of Alvesson and Sandberg (2011), this study relies on problematizing the current knowledge, not just identifying some potential gaps in the literature. Thus, the research presented in this article aims to supplement the current knowledge, at least partially, by answering the following research question: What managerial factors constrain the determination of the different types of contingencies that construction companies actually use in project management?

To that end, we conducted a review of the literature regarding the management of contingencies, which identified variables then used to build a case-study protocol. This article presents the resulting multi-case study design, including characteristics of the companies analyzed, sources of data, and key targets to be accomplished by the research design. Findings are then presented and discussed. The article concludes with a summary of its contributions to the body of knowledge, practical implications, and limitations.

Literature Review

Concept of Contingency

The Project Management Institute (PMI) characterizes the concept of contingency within the context of the strategies to combat negative risks: "The most common active acceptance strategy is to establish a contingency reserve, including amounts of time, money, or resources to handle the threat if it occurs" (Project Management Institute, 2017, p. 443).

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Contingencies are means used to manage residual risks and absorb uncertainty, thereby improving project performance (Project Management Institute, 2017). *Contingency* and *buffer* are the most typical terms used; the former being more common when money is the resource base of the reserve, and the latter used mostly for other types of resources. Nonetheless, in accordance with PMI's approach (2017), the terms *contingency* and *buffer* will be used interchangeably throughout this document. Although we believe the aforementioned definition of contingency is better suited for the purpose of this research, it is also worthwhile to discuss the different defining characteristics of the concept posed by other authors. Indeed, for some authors contingency is a reserve of a single resource, be it cost (Günhan & Arditi, 2007), time (Russell, Hsiang, Liu, & Wambeke, 2012), or even work in progress (González, Alarcón, & Molenaar, 2009). Other efforts, in line with the aforementioned definition from PMI (2017), stress the multiple natures of the resources that can provide the reserve (i.e., time, money, etc.) (Godfrey, 2004). Nonetheless, all of the abovementioned authors agree that contingency, whatever its resource, is a tool used to manage risk and uncertainty. Ballard (2005, p. 33) suggests another feature of contingencies when claiming that buffers are tools of process improvement since they "enable experimentation without the risk of commercial failures." Another facet of the concept arises from an extension of the view of Covey and Merrill (2006) about organizational trust, suggesting that contingencies may well be viewed as indicators of organizational trust.

Types of Contingencies

PMI's aforementioned definition of contingency encompasses two concepts that provide insight. First, contingencies refer to resources, and different types of resources give rise to different types of contingencies. Current literature mainly addresses the nature of the resource that provides the contingency (time, money, capacity, or stocks) as it relates to its instrumental goal of absorbing uncertainty and variation, and/or to its final purpose of protecting certain project objectives (Barraza, 2011; Günhan & Arditi, 2007). Thus, several types of contingencies can be considered according to the nature of the resource: (1) time buffers (Alves & Tommelein, 2004; Barraza, 2011; Leach, 2003; Lee, Peña-Mora, & Park, 2006); (2) cost contingency (Baccarini, 2004; Günhan & Arditi, 2007; Idrus, Nuruddin, & Rohman, 2011; Noor & Tichacek, 2009; Smith & Bohn, 1999; Yeo, 1990); (3) inventory buffers, both material buffers and work in progress (WIP) (Alves & Tommelein, 2004; Espino et al., 2012; González et al., 2009; Horman & Kenley, 1998; Horman & Thomas, 2005; Lee et al., 2006); (4) capacity buffers (i.e., excess means of production) (Alves & Tommelein, 2004; González et al., 2009; Horman & Kenley, 1998); and (5) tolerances in the specifications (i.e., scope and quality buffers) (Godfrey, 2004). PMI (2017, p. 725) defines *tolerance* as "the quantified description of acceptable variation for a quality requirement." Tolerance in the specifications is a tool used to handle variability. Since variability is a factor of uncertainty and risk (Barraza, 2011; Tommelein & Weissenberger, 1999), the tools used to deal with variability may well be viewed as tools of risk management, which considers *tolerance in the specifications* as a type of contingency whose resource base is scope and quality. For this reason, this type of contingency is mostly referred to as *scope and quality buffer* throughout this article.

Table 1. Types of Contingencies

	Objectives of the Project		
Resource Base	Cost	Time	Specifications
Cost	X		
Time		X	
Scope and quality			X
Inventories (WIP)		X	
Inventories (raw material)		X	
Capacity		X	

Table 1 summarizes the types of contingencies used (time, cost, or specifications) and the nature of the resource used to provide the contingency (time, cost, scope, and quality; inventories such as WIP and raw material; and capacity). The cost objective is protected by cost buffers, the specifications objective is protected by scope and quality buffers, and the time objective is covered by time buffers. However, given the potential multi-objective character of the contingencies, some of them whose resource is other than time—such as inventories (WIP and raw material), and capacity—can also protect time objectives (Chan & Au, 2009; Espino et al., 2012; Ford, 2002; González et al., 2009; Horman & Kenley, 1998; Leach, 2003).

Determination of Contingencies

The aforementioned definition of contingency states that contingencies are *established* or, in other words, *determined*. Literature shows that the establishment of contingencies requires the determination and analysis of four different aspects: decision makers, format, conditioning factors, and sizing. The four aspects are described in the following section.

Ford (2002) states that the project manager is the decision maker who defines cost contingencies. Tah, Thorpe, and McCaffer (1993) and Laryea and Hughes (2010) challenge such an assertion, highlighting that the procurement phase is when several decision makers may act, either in a coordinated manner or not, setting cost contingencies.

Moreover, contingencies can adopt different formats and may be included in a hidden manner within both budget estimates and work schedules through an increase in unit cost or task duration (Chan & Au, 2009; Laryea & Hughes, 2010; Leach, 2003; Smith & Bohn, 1999). Contingencies might also be set up in an explicit way, as a time float allocated in some parts of the schedule (Goldratt, 1997) or as a fixed percentage line added to the base estimate (Baccarini, 2004; Yeo, 1990).

Table 2. Methods Used to Determine Time and Cost Contingencies

1. Expert panel
2. Predetermined guidelines: Subjective judgment as well as empirical data are used at several levels.
3. Simulation: The output of the expert panel is used as an input of the simulation. There are two types of simulation:
   –Estimation ranges
   –Expected value
4. Parametric modeling: It is based on an algorithm with an empirical base whose development uses several subjective values and there are two types:
   –Regression analysis
   –Artificial neural network
5. Other: Fuzzy logic, for example

Regarding the conditioning factors of contingencies, Howell, Laufer, and Ballard (1993b) highlighted how project objectives constrain project management, and how, in general, project objectives may therefore condition contingency management too. Molenaar, Anderson, and Schexnayder (2010) considered that the volume of contingencies must be consistent with the risk they try to cover. Since risks are determined by risk factors and uncertainty, risk factors would in turn rule the contingency.

The proposal of sizing the methods of time and cost contingencies is one of the most documented aspects in contingency management. Even so, there are only a few contributors who propose methods to size WIP buffers, and there are no references about sizing methods of the remaining contingency types in the literature. Table 2 displays the different types of methods used to determine time and cost contingencies, according to Hollmann (2009).

As for the second method shown in Table 2 (i.e., predetermined guidelines), it is important to qualify the idea of subjectivity. The Cambridge Dictionary defines *subjective* as "influenced by or based on personal beliefs or feelings, rather than based on facts"; thus, according to this definition, the decision makers on contingencies would size them based on personal professional experience rather than on formal methods.

A third descriptive characteristic of contingencies is that they can be used. The concept of contingency is extremely complex, which is why there are many aspects to contingencies not addressed in this article. How contingencies are used is one of these aspects. Another aspect is the potential relationship between contingencies included in cost estimates that are prepared during the sales process and contingencies included in the project budget (Artto, Martinsuo, & Kujala, 2011). Therefore, we also stress the limitations of this study in terms of the determination of construction execution phase contingency. Since contingencies have a relevant role in effective project risk management, describing construction companies' actual practice on contingency management involves analyzing work processes, organizational environment, and people (Thamhain, 2013). This is the goal of this study.

Research Method

Taking into consideration the state of knowledge discussed earlier, this study addresses the following aforementioned research question: What managerial factors constrain determination of the different types of contingencies that construction companies actually use in project management? To explore this question in detail, this research applied a qualitative research strategy with a two-case study approach. After the literature review, a case study protocol was established. The data were then collected and analyzed for each of these cases (company IC and company RC). A comparison between cases was performed (cross-case analysis) to obtain the results of the study. Finally, six additional construction companies were contacted to explore the external validity and generalizability of the results. This approach is suitable for exploring a contemporary phenomenon in its actual environment; it is especially useful when there are more variables than data (Yin, 2009).

The company was chosen as the unit of analysis, as opposed to the individual project managers. According to Laryea and Hughes (2010), decisions about contingencies may well not rely only on project managers. Indeed, as will be seen later, the results of the research confirm that project managers are not the only decision makers when it comes to contingency determination. Furthermore, according to Yin (2009), the number of cases to be studied depends on the complexity of the expected outcome of the research; thus, to set a simple and descriptive theory, as in this research, two cases may suffice. This coincides with Taylor, Dossick, and Garvin (2010), who suggest that the external validity of the results drawn from the two-case study approach can be enhanced by confirming them with additional companies other than those primarily investigated. For this reason, we conducted additional validation interviews.

The selection of the two main companies was purposive and aimed at facilitating replication (Yin, 2009). To facilitate literal replication, two companies with similar features regarding the seven first criteria listed in Table 3 were chosen. To facilitate theoretical replication, the two selected companies present opposing characteristics with regard to at least one characteristic. In this case, the research team decided that the key characteristic was the type of relationship between the construction company and its clients, which is a key factor in contingency management (see criterion 8 in Table 3). Company IC (Integrated Company) was chosen because it is an integrated company; it works exclusively for the developer of its corporate group and it obtains construction projects without participating in any kind of open bidding (Pellicer, Sanz, Esmaeili, & Molenaar, 2016). Company RC (Regular Company) was chosen because it is a non-integrated company. Company RC procures its contracts in competitive bids to build the facility. Company RC generally works in a traditional design–bid–build delivery environment, which is the most commonly used strategy in the Spanish construction industry (de la Cruz, del Caño, & de la Cruz, 2006; Oviedo-Haito, Jiménez, Cardoso, & Pellicer, 2014; Pellicer & Victory, 2006; Pellicer et al., 2016).

A protocol for case study research is fundamental in order to overcome investigator bias and better generalize results. This protocol has to establish how to meet: (1) reliability, (2) construct validity, (3) internal validity, and (4) external validity (Yin, 2009). Developing the case study protocol as well as a database to control evidence makes the research reliable. Construct validity is achieved by defining all relevant aspects in the theoretical framework, using multiple sources of information (survey, document analysis, participant observation, and semi-structured interviews), and using triangulation to support the chain of evidence. Internal validity is attained through comparing theory to observed reality (pattern-matching) and identifying rival explanations to support the findings. The use of two cases allowed implementing replication logic (both literal and theoretical) in order to enhance external validity. Additionally, upon completion of the research, interviews to discuss the results with top managers from six different companies (V1, V2, V3, V4, V5, and V6 hereafter) granted the generalization of the findings to the research domain exclusively (Miles, Huberman, & Saldaña, 2013; Taylor, Dossick, & Garvin, 2010).

The data collection process was carried out between November 2013 and May 2014. The data collection used different data sources: a survey questionnaire, document analysis, participant observation, and semi-structured interviews.

The first source of data was a survey questionnaire. The questionnaire consisted of 15 questions. The first five questions of the questionnaire referred to demographics: construction industry experience, current company experience, educational background, and current position. The respondent's current position (question 4) directed the respondent to one of two groups of questions (questions 6–15) based on whether he or she was a project manager or held a different position. Both sets of questions were, however, very similar. Project managers were asked what they believe about a range of topics, while the remaining respondents were asked what they believe project managers think about. Those who were not project managers occasionally had the opportunity to answer: "I do not know." Table 4 summarizes the survey questionnaire participation rates. Only valid responses were taken into account; a response is considered to be valid when all the questions of the survey were answered. The entire questionnaire is included in Appendix 1. The results of this survey are displayed as tables of frequencies in Appendix 2.

The surveys were followed by a set of interviews to provide additional data. The interviews were semi-structured, face-to-face, and over one hour long (Woodside, 2010). The interviews were carried out with one program manager (referred to as IC1 and RC1 hereafter) and six project managers from both companies (IC2, IC3, IC4, IC5, IC6, IC7, RC2, RC3, RC4, RC5, RC6, and RC7 hereafter). The interviews took place at the job sites where project managers were working at that time. In order to get the most out of the visit to the job sites, the interviewer spent at least one day onsite. During that time, different documents were analyzed (purchase orders, work plans, and budgets) and different situations were observed (team meetings and conversations with subcontractors). The guidelines used for the interviews are detailed in Appendix 3. Both closed and open-ended questions were included in the interviews. Closed questions used a five-point Likert scale, asking interviewees for their level of agreement with each statement (strongly disagree, 1; disagree, 2; neutral, 3; agree, 4; and strongly agree 5). The fact that all the interviewees selected choice 5 (strongly agree) to answer a specific question implies that all the interviewees agreed with that statement. Interviewees were also asked to comment on the topic (open questions). The interviews were not recorded to allow interviewees more freedom to speak openly; rather, a transcript was written down and recorded in the database. A code was assigned to every type of data in order to ensure traceability (Miles et al., 2013). The number of interviewed project managers was not set in advance. The research team stopped at the sixth interviewee per company when it reached saturation (Guest, Bunce, & Johnson, 2006; Miles et al., 2013).

Table 3. Characteristics of Companies IC and RC in Relation to the Selection Criteria

Selection Criteria	Company IC	Company RC
Field of specialization: civil engineering and building construction (residential, industrial, and commercial) general contractors	Yes	Yes
Location: Spain	Yes	Yes
Number of housing units built over the last 20 years (more than 7,000)	16,700	9,000
Credit worthiness: no bankruptcy history over the last 20 years	Yes	Yes
Convenience: projects in the Madrid area	Yes	Yes
Interest of the research: high	Yes	Yes
Revenue > 50 MEur (millions of Euros) (2013)	85	300
Level of integration: uneven	100% of the contracts with internal clients	<10% of the contracts with internal clients

The data analysis followed the approach of Miles et al. (2013), who view the qualitative data analysis process as three concurrent and interactive activity flows: data condensation, data presentation, and extraction of conclusions. The generation and display of condensed data were essential aspects of the analysis. Condensing data into simpler units transforms the raw data into categories, which are consistent with the research question. The condensed data can be displayed through matrices with rows and columns to fit with such categories. These matrices facilitate analysis and pattern identification. For example, Appendix 4 shows a condensed data matrix related to finding 1 (determining time and cost contingencies). The outputs of this analysis were the findings of each

Table 4. Summary of Survey Participation Rates

	Company IC		Company RC		Total	
	Quantity	(%)	Quantity	(%)	Quantity	(%)
Questionnaires sent (total)	53	100	203	100	256	100
Valid responses (total)	47	89	94	46	141	55
Questionnaires sent (to project managers)	11	21	97	48	108	42
Valid responses (from project managers)	8	73	33	34	41	38

Table 5. Characteristics of the Companies Whose Managers Were Interviewed During the External Validation Process

Company	Revenues (MEur)	Level of Integration
V1	45	Total
V2	15	Partial (~75%)
V3	100	Total
V4	7,000	None
V5	1,000	None
V6	500	Partial (~60%)

individual case (IC and RC). Those findings were derived from 141 survey responses, 14 interviews (two program managers and 12 project managers), more than 100 hours of direct observation, and a vast amount of document analysis.

Later, the cross-case analysis compared the results of both cases. The analysis enabled the extraction of propositions that resulted in the provisional findings of the research using literal and theoretical replication logic. As mentioned earlier, according to Taylor et al. (2010), showing the applicability of the results in scenarios that differ from those analyzed enhances the internal and external validity of the results. Therefore, several different semi-structured interviews were carried out with managers from the abovementioned six different construction companies. These six managers were chosen to get a range as wide as possible of companies considering the different levels of integration and sizes of these firms. According to the European Union (EU) criteria (EU, 2003), V1 and V2 are medium-sized companies, whereas V3, V4, V5, and V6 are large companies. The level of integration is defined as the percentage of the total revenues that the company gets through non-competitive bidding processes. The level of integration was collected from the project managers and rounded up to the nearest 5%. Table 5 describes the characteristics of these six companies.

These interviews scrutinized a number of statements on a five-point ordinal scale. Each statement was directly related to one of the aforementioned provisional findings. Each program manager was asked about his or her level of agreement with each statement (strongly disagree, 1; disagree, 2; neutral, 3; agree, 4; and strongly agree, 5). At the conclusion of the six interviews, the median of the six answers to each question was computed, evaluating the provisional results according to the following criteria: Strong validity (Me $\geq$ 4); acceptable validity (3 $\leq$ Me < 4); weak validity (2 $\leq$ Me < 3); and non-valid (1 $\leq$ Me < 2). For each of the statements, the interviewees were encouraged to add any comment or opinion on the matter at hand. The conclusion was that all the provisional findings had strong validity, since the median of the interviewees' answers was greater than or equal to four in all cases. The outcome of this validation process was the set of definitive findings of the research, which are presented in the following section.

Once the results of the two-case analysis were confirmed by these six companies, the domain to which the findings can be generalized is defined by the following criteria: (1) Spanish general contractors; (2) specialize in civil engineering and building construction (residential, industrial, and commercial facilities); (3) large and medium-sized companies; (4) construction phase of the life cycle; and (5) with any degree of integration between the client and the constructor. Therefore, in the following sections on findings and discussion, and conclusions, the term *construction companies* refer to those construction firms that meet the above criteria.

Findings and Discussion

As noted earlier, companies IC and RC were selected in a purposive manner, with the aim of facilitating replication. Subsequently, the results of the research were discussed with the managers of six companies other than companies IC and RC (companies V1 to V6), enabling the formulation of the following findings. In order to enrich the discussion, some references, either challenged or confirmed by this research, are provided along with each finding.

Finding 1. Determining Time and Cost Contingencies: Project managers do not use formal methods to determine time and cost contingencies. Instead, they make such decisions according to what may well be viewed an extension of Parkinson's Law: They establish as much time and cost contingency as project objectives allow them to do.

The research team posed several ideas about time and cost contingencies to the interviewees, which had been addressed by various authors over time, specifically:

1. Both companies define hidden time and cost contingencies as greater unit costs or tasks that last longer (Laryea & Hughes, 2010; Leach, 2003);
2. Project managers are the main decision makers when determining contingency (Ford, 2002); and
3. Project managers do not use any of the formal methods proposed by the literature to size time and cost contingencies (Ford, 2002; Smith & Bohn, 1999).

All interviewees explicitly agreed with these ideas. Based on this response, we continued narrowing down the research question. Ultimately, the research showed that project managers are not the only decision makers determining contingencies. Indeed, their hierarchical superiors are also involved in the determination process; they define the project objectives and, in this way, they tacitly set the maximum amount of contingency. This approach confirms the abovementioned view of Howell et al. (1993b) about the role of project objectives in constraining project management. Yet, all the interviewees agreed with the fact that once the project objectives have been set, project managers are the only decision makers who determine time and cost contingencies. They carry out the determination process consistently with the previously defined project objectives, but they seldom discuss it with their managers (i.e., they typically work in a non-cooperative way).

All the interviewees (project managers) stated that they do not use formal methods to size time and cost contingency within the constraints that project objectives set. Rather they determine time and cost contingency in a subjective manner (i.e., based on their professional experience). Several authors have pointed out that contingencies are subjectively defined in different contexts. Thus, Smith and Bohn (1999) and Laryea and Hughes (2010) describe how construction companies subjectively define cost contingencies during bidding processes. Baccarini (2004) and Adafin, Wilkinson, Rotimo, and Odeyinka (2014) state that clients set up cost contingency during design processes in a subjective way; however, no references have been found about the approach that construction companies follow during the construction phase of projects.

Building on these premises, the researchers went deeper into the time and cost contingency determination process that both companies IC and RC carry out on their projects. Some project managers (IC2, IC3, IC4, RC3, RC4, RC6, and RC7) stressed that they base the decision on a risk register; however, none of them provided any other evidence of such assertion. The remaining project managers recognized that they determine contingency in a more arbitrary way, since they do not explicitly consider a set of risk factors to support their decisions. At this point, the results about the specific procedure of determination proved inconclusive, and that project managers of both companies determine contingencies based on their professional experience. The interviewed project managers were reluctant to provide more details about how they determine time and cost contingency. However, RC5's words shed some light on the matter: "... We define as much contingency as the project objectives allow us to do. But once project objectives are set, contingency is our business." Indeed, all the project managers (with the exception of IC2) agreed with RC5, which indicates that project managers define time and cost contingencies on the basis of a single heuristic: They set as much time and cost contingency as the project objectives allow them to do. This may be viewed as an extension of Parkinson's Law (Parkinson, 1957), which states: Work expands to fill the time available for its completion.

Finding 2. Determining Scope and Quality Buffers: When executing projects, integrated construction companies (developer-builders) usually respect the agreed-on scope and quality specifications. This implies that project managers share with their internal clients the excessive scope and quality buffers they identify. However, non-integrated construction companies tend to use the scope and quality buffers as a tool to optimize the cost and time of the project. Such a managerial approach implies that project managers do not typically share with the client the excessive scope and quality buffers they might detect in the specifications.

Koskela (2000) and Reginato and Alves (2012) point out that construction companies often consider the management of scope and quality as a tool to enhance project results, through change orders and claims. Furthermore, Harbuck (2004) and Rooke, Seymour, and Fellows (2004) state that the traditional competitive bidding approach is the root cause of such behavior, since companies tend not to price risk in order to win contracts. Instead, once they obtain a contract they try to optimize it by means of claims and change orders. This research shows how RC's managerial approach of scope and quality fits the view of those authors (RC obtains the majority of its contracts through competitive bidding processes). Consistent with its nature, the relationships among the different business units of IC are more integrated and less adversarial. One comment made by IC2 is paradigmatic in this regard: "Of course we are a single company; our top manager, who is also the owner, is always reminding us of this." Both companies are family owned and managed.

When identifying tolerances in specifications as contingency, Godfrey (2004) delves into the field of scope and quality management. As discussed earlier, tolerances in specifications are, in essence, contingencies whose resource base is neither time nor cost, rather the scope and quality of projects. In this respect, all the interviewees of both companies agreed that scope and quality specifications present both implicit and explicit tolerances (i.e., buffers). The interviewees also agreed that a common use of those contingencies is to reduce cost and/or project time. Beyond this, there was little agreement between the companies with regard to scope and quality buffers.

The IC project managers manage scope and quality buffers in a clearly different way. Likewise, if the IC project managers consider that the specifications include some excessive scope and quality buffers, which could be used to reduce cost or time, they openly discussed it with their internal client. In this regard, IC1 affirmed: "When we realize that the design can be streamlined by introducing some changes in technical solutions or brands, we openly pose it to our client. If they accept the modification, the budget and/or the schedule are amended, even though our particular business unit profit expectations drop. But we never make changes in the scope or quality without the agreement of our client." The IC project managers made similar remarks. As IC6 stated: "I definitely inform my client about all the potential improvements that I find when reviewing the specifications. But they are the decision makers about that. I just try to improve the project, I look at my company as a whole. I do not care if those changes are going to imply less profit for our business unit."

RC typically manages scope and quality buffers in a different way. As RC1 stressed: “Of course, the specifications usually present buffers, and we try to make them be on our side.” RC4 affirmed: “We do not trick our clients, but if different specifications contradicted each other, we would implement the one which was most profitable for us . . . ”. RC5 stated: “When the contract states that we can use a certain brand for a specific material or any similar one . . . , I always use the similar one.” Furthermore, RC7 pointed: “I try to manage scope and quality; it is one of the ways in which we make money. But we always do it without putting the project at risk, since we are aware of the fact that specifications are usually over-dimensioned. For example, we use material brands other than the specified.” To a greater or a lesser extent, all the project managers of RC recognized that they often try to handle specifications in order to increase the company earnings.

The way in which RC and IC determine scope and quality buffers derives from the earlier discussion; in both cases the starting point is the same. The designers, implicitly or explicitly, define such buffers. What contractors do is to try to partially use such buffers to increase their profit expectations. However, while IC openly discusses the matter with its internal client, RC tries to capitalize on these contingencies as described earlier.

The non-integrated (traditional) versus integrated (developer-builder) nature of the companies implies that RC obtains their contracts through competitive bidding processes, which explains why RC and IC manage scope and quality buffers so differently. The described behavior of both companies is consistent with the view of Slauson (2005), who considers that the traditional delivery methods generate mistrust among the different parties involved in a construction project. This mistrust, in turn, fosters a silo mentality of construction companies. This finding was confirmed by the managers of companies V1, V2, V3, V4, and V5.

This finding has been reached through replication logic. In relation to the research question, both companies were found to act differently due to their level of integration, which was the key opposing characteristic that led to their selection. Nonetheless, the remaining findings have been developed by means of literal replication logic, since both companies were found to act similarly in relation to the research question.

Finding 3. Determining Inventory Buffers: Project managers tend to determine inventory buffers (e.g., raw material and WIP buffers) relying on their professional experience. Material buffers have two facets: (1) an excess of materials in relation to those estimated as necessary in the planning of the project (measures); and (2) the fact that the materials are made available to the work before they are going to be necessary in accordance with the scheduling of related activities. WIP buffers also have two variants: Work is scheduled so that a WIP buffer is created and maintained among consecutive critical activities. Work is also scheduled so that non-critical activities can be carried out to create working areas for idle craftsmen.

Production planning and control aim to achieve a reliable work flow. To that end, it is necessary to reduce the intrinsic variation of work flow in construction and then absorb the remaining variability through buffers (Ballard & Howell, 1998). Inventory buffers (both raw materials and WIP buffers) are useful tools for increasing work flow reliability (Espino et al., 2012; Horman & Thomas, 2005).

Unlike for time and cost contingencies, all the interviewed project managers were keen on describing how they determine both material and WIP buffers. Two aspects of material buffers arose when researching the purchasing processes of materials that both companies follow. In this regard, the research team checked a set of documentary records (purchase applications, bills of quantities, and so forth) in addition to interviewing the managers. The results show that project managers determine both the quantity and the delivery schedule of the different work materials on the basis of their professional experience. Indeed, all the interviewed managers confirmed that they usually try to make work materials available to the work teams earlier than scheduled. For example, the project managers count on personal and specific approaches to define the timing of availability. IC3 stated: “We normally break the construction of housing buildings into detached houses (or apartments) packages. I usually set the stockpiles two months earlier, but I do not purchase everything at the same time. I usually order the material for the first package, a few weeks later I order the material for the second package, etc. The time lag between those orders depends on the space available for stockpiles and whether the material can be damaged.” In the same vein, RC3 affirmed: “I form the stockpiles 15 or 20 days before I plan to need them, but I do not like to have too big stockpiles on site because they make the workflow more difficult. We have to cope with the procurement staff because they try to make us delay the purchases . . . they argue that the later we purchase, the better prices we get . . . but I am not sold on that . . . ” Indeed, as IC3 said, making work materials available to work teams earlier than scheduled creates a time buffer; Tommelein and Weissenberger (1999) and Horman and Thomas (2005) called it “time lag buffer.” It shows the additional time that a certain activity can last due to the extra availability of the required materials.

The second aspect of raw material buffers relates to the quantity of purchased materials. In this regard, all the interviewed managers of both companies stated that they usually overestimate the amounts to buy. Even so, most of the project managers clarified that upon completion of the projects they do not need to deal with remaining materials. The research showed that project managers also calculate the excess material to be purchased according to different personal criteria and procedures developed over time. IC6 said: “I always purchase a little bit more of each material to take into account waste or measurement errors. For example, bricks: 5%; tiles: 8%–10%, etc.” RC2’s approach was in essence the same: “Yes, I always purchase material in excess. I know that I will have to absorb waste, robbery, etc. The excess depends on the type of material, but I know perfectly well how much, because at the end of each project I never have to deal with leftover materials.”

Another characteristic of construction is the interdependence of processes and its link with variability in production (Howell, Laufer, & Ballard, 1993a). This implies that if the actual duration of an activity is different than planned, the start and/or the duration of downstream dependent tasks may be affected, which can negatively impact project performance. González et al. (2009, p. 96) define WIP as: "The difference between cumulative progress of two consecutive and dependent processes, which characterizes work units ahead of a crew that will perform work (e.g., work units that have not been processed yet, but that will be)." These authors also highlight the role of WIP buffers to cope with the abovementioned problem. The approach of both companies with regard to WIP buffers seems to be the same, since all the interviewees stated that project managers schedule the activities so that dependent downstream activities take into account the workload ahead.

With regard to how companies RC and IC determine inventory buffers, managers of both companies agreed that they define them in a subjective manner, based on their expert judgment, thereby confirming the claims of Horman and Thomas (2005) and González et al. (2009). In general, IC and RC project managers tend to calculate WIP buffers as the number of days required to complete a specific workload ahead of a crew, but they express and manage it within the activity being performed. In this regard, IC4 stated: "I calculate the gap (i.e., WIP buffer) between dependent activities in accordance with the complexity of the upcoming activity. The greater the complexity, the larger the gap. However, I always try to avoid different subs working in the same area of the site." RC6 further stated: "I normally divide each floor into four areas, so that in each area only one sub is working. When a sub completes one area, they move to the next one and another sub (the one that carries out the dependent activity) starts working on the area that the first sub has just completed." As with raw material buffers, the earlier quote suggests that project managers usually base the calculation of WIP buffers on different heuristics devised over time. In this regard, the words of RC5 elaborate: "I have come up with my own method. I have been working for many years in this industry and I have coped with many different scenarios. I use different amounts of WIP buffers depending on the type of project, the subs (if I have worked with them before or not), the deadline, etc."

Finding 4. Determining Capacity Buffers: Construction companies tend to use capacity buffers, but they mainly entrust their management to subcontractors. Construction companies use potential working time extensions (i.e., working overtime) and increased resources (i.e., equipment and labor) as capacity buffers.

Horman and Thomas (2005) define capacity buffers as additional equipment and craftsmen provided to an operation beyond the anticipated need for completion. Consistent with that definition, the research team initially focused on analyzing how the two companies acquire the equipment and labor that they need for construction. Both companies subcontract construction services to a number of specialized companies. This finding fits the idea of Slauson (2005) and Oviedo-Haito et al. (2014), who state that the construction industry is characterized by extensive subcontracting. Accordingly, RC and IC subcontractors define and provide the required resources to construct the job, including the extra resources (i.e., capacity buffers). The project managers, on behalf the construction company, are indirectly involved in the management of these capacity buffers. Project managers of both companies warn the subcontractors and suppliers that they have to be able to provide additional resources if needed, but they do not get involved in evaluating the volume of in-excess resources (i.e., they do not get involved in determining capacity buffers).

Koskela (1992) and Espino et al. (2012) claim that inventory buffers could be considered waste from the *lean* approach point of view. Moreover, Horman and Kenley (1998) highlight the importance of capacity buffers when pointing out that they should replace inventory buffers. They argue that capacity buffers promote greater flexibility, greater responsiveness, and ultimately better performance. However, the fact that the analyzed companies are not explicitly involved in the determination of capacity buffers seems to challenge such importance. Some project managers' statements describe the logic that underlies this apparent contradiction. IC3 stated: "If a sub or a supplier cannot provide additional resources when required, we have a lot of subs and suppliers eager to collaborate with us." Along this vein, RC7 pointed out: "I always ask my subs if they have in-excess capacity and they always claim they do. However, I know they would say the same if they didn't, but I don't care, if a sub lets me down, I can easily find plenty of companies willing to replace it." In addition to the audit function of project managers, both companies use contracts to try to ensure that subcontractors and suppliers will provide extra resources (Oviedo-Haito et al., 2014). We analyzed a number of subcontracting agreements and all of them included clauses requiring the subcontractor to provide additional resources if the general contractor so desires. IC3's and RC7's statements show that such a managerial approach is based on an implicit assumption: The resources in general (means of production) are unlimited because the capacity buffers are excess resources (i.e., it can be assumed to be unlimited). This assumption may make sense in the current Spanish construction industry, which is characterized by industry overcapacity (Oviedo-Haito et al., 2014). It seems clear that both IC and RC mainly rely on subcontractors for management (and determination) of capacity buffers, which raises the question of how subcontractors carry out such a process.

The aforementioned findings solely relate to the construction phase of projects. As previously discussed, future research should focus on analyzing the relationship between contingencies defined in the bidding phase and those defined in the execution of the project by the construction company.

Conclusions

This research shows that construction companies use different types of contingencies to cover risks during the project construction phase, including time and cost contingencies, scope and quality buffers, inventory buffers, and capacity buffers. The research also describes how two Spanish general contractors determine such contingencies. Results reveal that project managers and their hierarchical superiors are the main actors for determining cost and time contingencies. The latter define project objectives, whereas the former set the contingency in a manner consistent with those objectives (Finding 1, determining time and cost contingency). This finding provides additional insight into the constraining nature of project objectives that was proposed by Howell et al. (1993b). Smith and Bohn (1999), Laryea and Hughes (2010), and Ford (2002) state that experts define the amount of time and cost contingency through heuristic techniques based on their professional experience. The research expands such insight when showing that project managers do not use any formal method; rather, they determine time and cost contingency according to a single heuristic technique: Project managers set as much time and cost contingency as the project objectives allow them to do, which may be understood as an extension of Parkinson's Law that states that work expands to fill the time available for its completion.

Finding 1 also shows that managers determine time and cost contingencies in a non-cooperative way. Lack of cooperation is a shortcoming of the current practice on determination of time and cost contingency. Further research is needed on the root causes of the above described non-cooperative behavior. Since project objectives are the leading constraints of contingency, further research on the behavior of those who define such objectives (i.e., the hierarchical superiors of project managers) is also needed.

Both companies manage time and cost contingencies in a similar manner. However, these companies manage scope and quality and hence scope and quality buffers, in a markedly different way (Finding 2, determining scope and quality buffers). While, the integrated company shares the specific buffers with its client (internal), the non-integrated company does not typically do this and sometimes tries to capitalize on these contingencies. The cause of such distinct behaviors is tied to the different level of integration of both companies. Companies adopt a less cooperative approach when managing scope and quality if the client is external. The literature hardly addresses the concept of scope and quality buffers as a type of contingency. In fact, Godfrey (2004), who merely mentions the existence of this type of contingency, is the only reference we identified on the subject.

The third contingency type used onsite by construction companies is inventory buffers (raw materials and WIP). As described earlier in the discussion on Finding 3 (determining inventory buffers), both companies use raw material buffers in two different ways: (1) an excess of materials in relation to those estimated as necessary in the planning of the project (measures); and (2) the materials are made available to the work before they are going to be necessary, in accordance with the scheduling of related activities, confirming the use of what Tommelein and Weissenberger (1999) and Horman and Thomas (2005) called "time lag buffers." Both companies also use WIP buffers in two ways: (1) scheduling of activities so that a WIP buffer is created and maintained among consecutive tasks; and (2) performing non-critical activities to create available working areas so that eventual idle craftsmen could be put to work. This contingency type presents one peculiarity in relation to the abovementioned types because, by their own nature, they are explicit. However, they share a management characteristic with the other contingency types; project managers determine them on the basis of their professional experience rather than on formal methods. Horman and Thomas (2005) stated that construction companies set the size of material stockpiles based on intuition. In a similar vein, González et al. (2009) affirmed that in construction, current WIP buffering practices generally follow an intuitive and/or informal pattern. This finding expands such insights when describing some of the empirical practices that IC and RC project managers have individually developed over time in order to determine inventory buffers.

Finally, the fourth contingency type used onsite by construction companies is capacity buffers. As described earlier in the discussion on Finding 4 (determining capacity buffers), both companies largely entrust capacity buffer management to subcontractors. In this regard, the construction companies' common strategy is that project managers often warn the subcontractors that they have to include a buffer of additional resources, but the project managers do not get further involved in managing such buffers. The subcontracting contract is another tool used by both companies to ensure that subcontractors are accountable for additional resources, if necessary. Nevertheless, the fact that the companies analyzed are not actively involved in the management of capacity buffers seems to challenge the importance of capacity buffers. This finding supplements what Horman and Kenley (1998) stated regarding this type of buffer.

This research has explored several types of contingencies: Time and cost contingencies, scope and quality buffers, inventory buffers, and capacity buffers. The research has at least partially characterized how construction companies determine these contingencies, the elements of such determination processes, and their consequences. Table 6 summarizes the contributions of the research to the construction project management body of knowledge.

Table 7 summarizes the practical implications of the research. These are stated by linking the research findings with the previously discussed managerial shortcomings. This provides a clear set of practical contributions (i.e., possible improvements) that contractors may well implement.

This research opens the door to several possible lines of investigation. What managers actually do, as opposed to what theory or various standards suggest, requires more in-depth study of the project managers' informal/heuristic approaches; to that end, the project-as-practice research approach may well be suited (Blomquist, Hällgren, Nilsson, & Söderholm, 2010; Hällgren & Wilson, 2008). The importance of looking at the logic that underlies the non-cooperative process of determination of all contingency types in greater depth is also noteworthy in this respect. It is also worth exploring the effect of the kind of

Table 6. Detailed Contributions to the Body of Knowledge

Findings	Descriptions of the Findings	Previous Insights Challenged
Finding 1: Determining time and cost contingency	• Project and program managers are the decision makers • Program managers constrain buffers through project objectives • Project managers define as much buffer as they are allowed by project objectives	• Project managers were considered to be the only decision makers (Ford, 2002) • How do program managers determine buffers? • How do project managers determine buffer?
Finding 2: Determining scope and quality buffers	• Project managers identify the already defined scope and quality buffers (both explicitly or implicitly) by designers and owners • Project managers decide how to use those buffers (either sharing them with the client or capitalizing on them)	• Who are the decision makers regarding how to use these scope and quality buffers? • How are these contingencies used?
Finding 3: Determining inventory buffers	• Project manager apply heuristic methods to determine inventory buffers	• Detailing the inventory buffers determination process
Finding 4: Determining capacity buffers	• Subcontractors define and manage capacity buffers	• Who are the decision makers?

Table 7. Practical Implications of the Research

Findings	Shortcomings	Practical Implications
Finding 1: Determining time and cost contingency	Lack of cooperation between the decision makers	• Buffer determination decision makers should work as a team • Connect risk level to buffer amount
Finding 2: Determining scope and quality buffers	Non-cooperative management of scope and quality buffers	• Embrace integrated project delivery
Finding 3: Determining inventory buffers	Management based on intuition	• Document the heuristics to determine inventory buffers • Share them within the entire organization
Finding 4: Determining capacity buffers	General contractors lack effective control of those buffers	• Implement a team-work approach with subcontractors

relationship between the general contractor and client on how the general contractor manages scope and quality buffers. Furthermore, another research line may cover a more extensive treatment of the other types of contingencies than the conventional cost and time buffers, such as scope and quality buffers, inventory, and capacity (already considered in this research).

The results of the research can be applied to medium- and large-sized Spanish general contractors specialized in civil engineering and building construction, with any degree of integration between the client and the contractor. Notwithstanding the foregoing, an empirical investigation would be needed to be able to generalize the findings to non-Spanish companies, other types of companies (e.g., small companies), or even other industries (e.g., industrial construction).

Appendix 1. Survey Questionnaire

Demographic Questions (these are the same for all the participants)

1. How long have you been working in the construction industry?
   a. Less than 1 year.
   b. Between 1 and 5 years.
   c. Between 5 and 10 years.
   d. Between 10 and 20 years.
   e. More than 20 years.
2. How long have you been working for this company?
   a. Less than 1 year.
   b. Between 1 and 5 years.
   c. Between 5 and 10 years.
   d. Between 10 and 20 years.
   e. More than 20 years
3. Education.
   a. Architect (MS).
   b. Engineer (MS).
   c. Architect (BS).
   d. Engineer (BS).
   e. College degree other than the aforementioned.
   f. No college degree.
4. Which of the following choices better fits your position?
   a. Foreman.
   b. Supervisor.
   c. Project manager.
   d. Commercial or technical staff.

e. Program manager.
f. Regional manager.
g. Senior manager
5. How long have you been working in that position?
a. Less than 1 year.
b. Between 1 and 5 years.
c. Between 5 and 10 years.
d. Between 10 and 20 years.
e. More than 20 years.

Specific Questions for Project Managers

6. Please indicate your opinion about the corporate procedure of your company to manage uncertainty related to events or facts that could affect construction project performance.
a. I am not aware of such a procedure in my company.
b. I know the procedure but I normally do not use it because I consider it useless.
c. I know the procedure but I normally do not use it because it is non-mandatory.
d. I know the procedure and I normally use it while it needs improvement.
e. I know the procedure, I normally use it, and I consider it good enough.
7. Please indicate if you make initial schedule, initial costs, and income budgets for your construction projects.
a. Always.
b. Almost always.
c. Very frequently.
d. Just sometimes.
e. Never or hardly ever.
8. Regarding the abovementioned initial schedule and budget, please, indicate if you take into account those coming from the bidding process.
a. Always.
b. Almost always.
c. Very frequently.
d. Just sometimes.
e. Never or hardly ever.
9. Please indicate if you include time buffers (explicit or not) within the schedule to absorb uncertainty about the materialization of different events and its impact on the length of the scheduled tasks.
a. Always.
b. Almost always.
c. Very frequently.
d. Just sometimes.
e. Never or hardly ever.
10. Please indicate which one of the following methods is the one you more frequently use to set up the abovementioned time buffers:
a. I subjectively determine buffers based on different factors that could delay the completion of the construction project.
b. I subjectively determine buffers, but not based on any previously identified factors.
c. Critical Chain.
d. Monte Carlo.
e. Others (name).
11. Please indicate if you include cost buffers (explicit or not) within the cost budget to absorb uncertainty about the materialization of different events and its impact on the cost of the construction project.
a. Always.
b. Almost always.
c. Very frequently.
d. Just sometimes.
e. Never or hardly ever.
12. Please indicate which one of the following methods is the one you more frequently use to set up the abovementioned cost buffers:
a. I subjectively determine buffers based on different factors that could make the construction project overrun.
b. I subjectively determine buffers, but not based on any previously identified factors.
c. Monte Carlo.
d. Others (name).
13. Please indicate how the target completion date and the contract completion date relate to each other.
a. They usually match.
b. The target completion date is usually earlier than the contract completion date.
c. The target completion date is usually later than the contract completion date.
14. Whenever the target completion date is earlier than the contract completion date it is due to:
a. Some opportunities have been identified to speed up the construction project.
b. It is needed to speed up the construction project despite no opportunities have been identified to do it.
c. The two are mixed together.
15. The rationale behind the profit target of the initial budget that you make is based on:
a. Incomes and costs that can be objectively estimated.
b. Capitalizing on opportunities identified as potential driving forces to reduce costs or to increase incomes of the construction project.
c. The two are mixed together.

Specific Questions for Non-Project Managers

6. Please indicate your opinion about the corporate procedure of your company to manage uncertainty related to events or facts that could affect construction project performance.
a. I am not aware of such a procedure in my company.
b. I know the procedure but I normally do not use it because I consider it useless.

c. I know the procedure but I normally do not use because it is non-mandatory.
d. I know the procedure and I normally use it while it needs improvement.
e. I know the procedure, I normally use it, and I consider it good enough.
f. I know the procedure but I do not know whether it is normally used or if it is good enough.

7. Please indicate if you believe that project managers make an initial schedule, initial costs, and incomes budget in their construction projects.
   a. Always.
   b. Almost always.
   c. Very frequently.
   d. Just sometimes.
   e. Never or hardly ever.
   f. I do not know.
8. Regarding the abovementioned initial schedule and budget, please indicate if you believe that project managers take into account those coming from the bidding process.
   a. Always.
   b. Almost always.
   c. Very frequently.
   d. Just sometimes.
   e. Never or hardly ever.
   f. I do not know.
9. Please indicate if you believe that the initial schedule includes time buffers (explicit or not) to absorb uncertainty about the materialization of different events and its impact on the length of the scheduled tasks.
   a. Always.
   b. Almost always.
   c. Very frequently.
   d. Just sometimes.
   e. Never or hardly ever.
   f. I do not know.
10. Please indicate which one of the following methods is more frequently used by project managers to set up the abovementioned time buffers:
   a. They subjectively determine buffers based on different factors that could delay the completion of the construction project.
   b. They subjectively determine buffers, but not based on any previously identified factors.
   c. Critical Chain.
   d. Monte Carlo.
   e. Others (name).
   f. I do not know.
11. Please indicate if you believe that the initial budget includes cost buffers (explicit or not) to absorb uncertainty about the materialization of different events and its impact on the cost of the construction project.
   a. Always.
   b. Almost always.
   c. Very frequently.
   d. Just sometimes.
   e. Never or hardly ever.
   f. I do not know.
12. Please indicate which one of the following methods is more frequently used by project managers to set up the abovementioned cost buffers:
   a. They subjectively determine buffers based on different factors that could make the construction project overrun.
   b. They subjectively determine buffers, but not based on any previously identified factors.
   c. Monte Carlo.
   d. Others (name).
   e. I do not know.
13. Please indicate how the target completion date and the contract completion date relate to each other.
   a. They usually match.
   b. The target completion date is usually earlier than the contract completion date.
   c. The target completion date is usually later than the contract completion date.
   d. I do not know.
14. Whenever the target completion date is earlier than the contract completion date it is due to:
   a. Some opportunities have been identified to speed up the construction project.
   b. It is needed to speed up the construction project even though no opportunities have been identified to do it.
   c. The two are mixed together.
   d. I do not know.
15. The rationale behind the profit target of the initial budget that project managers make is based on:
   a. Incomes and costs that can be objectively estimated.
   b. Capitalizing on opportunities identified as potential driving forces to reduce costs or to increase incomes of the construction project.
   c. The two are mixed together.
   d. I do not know.

Appendix 2. Results of the Survey

Demographic Questions (Questions 1 to 5)

Question	Answer	Company IC	Company RC	Total
1	A	0	0	0
	B	3	0	3
	C	10	21	31
	D	26	60	86
	E	8	13	21
2	A	4	0	4
	B	5	10	15

(continued)

Appendix 2. (continued)

Question	Answer	Company IC	Company RC	Total
	C	17	55	72
	D	19	25	44
	E	2	4	6
3	A	3	3	6
	B	19	34	53
	C	9	23	32
	D	14	30	44
	E	2	2	4
	F	0	2	2
4	A	0	1	1
	B	6	13	19
	C	8	33	41
	D	21	14	35
	E	3	17	20
	F	4	8	12
	G	5	8	13
5	A	2	4	6
	B	13	24	37
	C	21	46	67
	D	9	19	28
	E	2	1	3

Specific Questions for Project Managers (Questions 6 to 11)

Question	Answer	Company IC	Company RC	Total
6	A	6	12	1
	B	0	1	1
	C	0	1	1
	D	2	15	17
	E	0	4	4
7	A	7	29	36
	B	1	1	2
	C	0	3	3
	D	0	0	0
	E	0	0	0
8	A	6	7	13
	B	0	11	11
	C	0	4	4
	D	2	8	10
	E	0	3	3
9	A	2	5	7
	B	1	8	9
	C	1	4	5
	D	2	14	16
	E	2	2	4
10	A	6	17	23
	B	2	8	10
	C	0	8	8
	D	0	0	0
	E	0	0	0
11	A	2	7	9
	B	1	4	5
	C	0	6	6
	D	4	12	16
	E	1	4	5

Specific Questions for Project Managers (Questions 12 to 15)

Question	Answer	Company IC	Company RC	Total
12	A	5	31	36
	B	3	2	5
	C	0	0	0
	D	0	0	0
13	A	4	21	25
	B	1	7	8
	C	3	5	8
14	A	5	8	13
	B	2	4	6
	C	1	21	22
15	A	3	13	16
	B	2	2	4
	C	3	18	21

Specific Questions for Non-Project Managers (Questions 6 to 10)

Question	Answer	Company IC	Company RC	Total
6	A	27	31	58
	B	1	0	1
	C	0	1	1
	D	5	15	20
	E	6	11	17
	F	0	3	3
7	A	33	50	83
	B	5	9	14
	C	1	2	3
	D	0	0	0
	E	0	0	0
	F	0	0	0
8	A	18	15	33
	B	13	19	32
	C	2	9	11
	D	6	12	18
	E	0	4	4
	F	0	2	2
9	A	6	5	11
	B	9	21	30
	C	8	7	15
	D	11	16	27
	E	2	9	11
	F	3	3	6
10	A	15	26	41
	B	7	18	25
	C	9	8	17
	D	0	0	0
	E	0	0	0
	F	8	9	17

Specific Questions for Non-Project Managers (Questions 11 to 15)

Question	Answer	Company IC	Company RC	Total
11	A	6	5	11
	B	11	16	27
	C	5	13	18
	D	9	17	26
	E	5	8	13
	F	3	2	5
12	A	22	40	62
	B	6	15	21
	C	0	0	0
	D	0	0	0
	E	11	8	19
13	A	12	27	39
	B	12	19	31
	C	15	5	20
	D	0	0	0
14	A	17	16	33
	B	5	11	16
	C	16	32	48
	D	1	2	3
15	A	10	13	23
	B	8	8	16
	C	16	39	55
	D	5	1	

Appendix 3. Interview Guidelines (Interviewees: Project and Program Managers of IC and RC)

1. Project objectives:
   - Who are the decision makers?
   - What types of project objectives are set?
   - Are the project objectives monitored during the work?
   - What factors can lead to failing to reach project objectives?
   - What factors do program managers consider in order to define project objectives?

2. Risk management (threats):
   - Does the company have a risk (threats) management procedure?
   - At the start of the work:
     - Do project managers plan threats management?
     - Do project managers identify threats?
     - Do project managers plan responses to threats?
     - Do project managers identify risk factors?

3. Risk management (opportunities):
   - Does the company have a risk (opportunities) management procedure?
   - At the start of the work:
     - Do project managers plan opportunities management?
     - Do project managers identify opportunities?
     - Do project managers plan how to get the most out of the opportunities identified?
   - What are the main sources of opportunities?

4. Time and cost management:
   - Do project schedules and budgets include time and cost buffers?
   - Why does the company set time and cost buffers?
   - Are these buffers hidden or explicit?
   - Who are the decision makers?
   - What is the method that the decision maker uses to set the buffers?
   - What is the view of the decision makers about buffers? Are they positive or negative?
   - What might happen if time and cost buffers were reduced?

Appendix 4. An Example of a Data Condensation Matrix

		Category 1	Category 2	Category 3	Category 4	Category 5
	SOURCES OF DATA	**Time and cost buffers are subjectively defined**	**Subjective definition is the single or the best method**	**Subjectively defined due to lack of resources to use a different method**	**Subjectively defined because managers do not know other methods**	**Decision makers and their role**
1	**Survey questionnaire**	RC company subjectively determines time and cost contingencies.				

(continued)

Appendix 4. (continued)

	SOURCES OF DATA	Category 1 **Time and cost buffers are subjectively defined**	Category 2 **Subjective definition is the single or the best method**	Category 3 **Subjectively defined due to lack of resources to use a different method**	Category 4 **Subjectively defined because managers do not know other methods**	Category 5 **Decision makers and their role**
2	**Interview with program managers**	RC1 claims to strongly agree with the fact that time and cost buffers usually are defined in a subjective manner, without taking into account which factors can cause delays or create over costs.			RC1: *But is there any other way to do it?*	RC1 agrees with RC5's idea that within the limits of project objectives the project managers are the single decision makers as well as they normally define as much contingency as they can. He also affirmed that program managers set project objectives to consciously constrain the amount of contingency.
3	**Interview with project managers (statistical analysis)**	All RC company's project managers affirm to strongly agree with the fact that time and cost buffers are defined in a subjective manner. RC3, RC4, and RC5 state that they do not take into account any specific risk factor; however RC2, RC6, and RC7 assure to take into account risk factors.			No RC's project manager knows any other method to determine contingency.	All RC company's project managers affirm to strongly agree with RC1 and RC5's ideas that program managers set project objectives to consciously constrain the amount of contingency, but within the limits of project objectives the project managers are the single decision makers as well as they normally define as much contingency as they can.
4	**Interview with project managers (qualitative data)**		RC2: *I subjectively defined them on the basis of my personal judgment. The personal judgment of a project manager is really relevant for anything. RC3:…because it is the single way! RC4:…because each project is a world on its own!*	RC6: *I set buffers in a subjective way because I lack the time to study the project in depth!*	RC7: *I do not know any other way to do it!*	RC5: "*…we define as much contingency as the project objectives allow us to do. But once project objectives are set, contingency is our business*"

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