



UNIVERSITAT
POLITÈCNICA
DE VALÈNCIA



LABOR PRODUCTIVITY IN THE CONSTRUCTION INDUSTRY

*-Study about the factors influencing the Spanish
Construction Labor Productivity-*

Master Thesis

ESCUELA TÉCNICA SUPERIOR DE INGENIEROS DE CAMINOS, CANALES Y PUERTOS

MÁSTER UNIVERSITARIO EN PLANIFICACIÓN Y GESTIÓN EN INGENIERÍA CIVIL

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September 2014

Institut für Technologie und Management im Baubetrieb

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PREFACE

Karlsruhe, 7th July 2014

This report titled *“Labor Productivity in the Construction Industry. -Study about the factors influencing the Spanish Construction Labor Productivity-”* is the Master of Science Thesis of Guillermo Robles, guest student of Master's Degree in Planning and Management for Civil Engineering from Polytechnic University of Valencia, Spain.

The research was developed from February 2014 to July 2014 in the Institute for Technology and Management in Construction, Karlsruhe Institute of Technology in Germany, under the supervision of Prof. Dr. Sascha Gentes and MSc.-Ing. Ahmed Stifi.

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Guillermo Robles Martínez

Karlsruhe, July 2014

ACKNOWLEDGEMENTS

*I would like to thank the **Karlsruhe Institute of Technology (KIT)** where I got the great opportunity to develop and write this thesis.*

*Especially I would like to show gratitude to Mr. **Ahmed Stifi** for the opportunity he gave me and for the guidance and support. The start of the thesis was not easy, but together we have been able to clarify the scope and direction of the thesis. Professor **José Luis Ponz** deserves equal gratitude for sharing his expertise and guidance during the thesis writing process. Finally, I also thank Professor **Eugenio Pellicer** for all his help and time so I could defend this thesis on time.*

*Dedicated to my dad **Natalio**, whose I am very proud to be his son and I have always in my mind, I will never forget you.*

*Furthermore I am very thankful for the affection, support and understanding of **Carolina**. During the difficult times of my thesis writing, she was always there.*

*I would also like to thank to **all my family**, with especial mention to my mum and my sister **Yolanda** and **Paula**, for all the efforts made so I had the chance of studying abroad. Thank you for your priceless caring during my stay in Germany.*

*I am very grateful to all **my friends** with whom I have shared the best moments of my life. Thank you very much for the support given in the first days of my stay in Karlsruhe.*

*Finally, special thanks to **Eusebio** and all the people, who have helped me and made me easier the task of distributing the surveys to practitioners.*

SUMMARY

Strong competition between companies for a position in the market has been generated in the construction industry in Spain during last years. Since construction is a labor-intensive industry and generally labor costs represent up 30% to 50% of the overall cost of the project, improvement's efforts for increasing labor productivity levels inside construction companies in Spain should be taken under consideration. So, this will not only make the construction companies more profitable, but also more competitive and consequently increasing the chances of survival within the sector. Understanding critical factors affecting labor productivity can be used to develop strategies to reduce inefficiencies and to improve the effectiveness of project performance. Previous researchers have studied the factors influencing construction labor productivity in the last decade in different countries; however, no studies has been conducted in Spain concerning construction labor productivity, thus deeper research is still needed to improve labor productivity in Spain. Therefore, the main objective of this study is to identify, analyze and rank factors affecting labor productivity in the Spanish construction industry with respect to their relative importance. For this purpose, this research aims to define an appropriate research methodology, identifying through the literature the main factors affecting labor productivity in construction. Using a selected set of 35 factors, structured questionnaire survey was utilized as the way to collect data from companies. Target population is comprised by a random representative sample of practitioners related with the construction industry. Data analysis using the relative importance index technique and factor ranking was then performed. Top ten ranked factors by their effect in construction labor productivity in Spain are as follows: (1) shortage or late supply of materials; (2) clarity of the drawings and project documents; (3) clear and daily task assignment; (4) tools or equipment shortages; (5) level of skill and experience of laborers; (6) delays in payments to workers; (7) coordination between crews; (8) improper coordination of subcontractors; (9) insufficient supervision of subcontractors; and (10) communication problems. Finally, this research also pretends to provide simple and comprehensive recommendations so that they could be implemented by contractors and construction managers for the effective management of construction labor forces and thus help to enhance labor productivity levels in Spain. Several of these proposals are addressed from the Lean construction point of view.

KEYWORDS:

Labor productivity; Factors; Construction management; Improvement; Spain.

RESUMEN

En los últimos años se ha venido generando una fuerte competencia para poder mantener la posición dentro del mercado de la construcción en España. El sector de la construcción es considerado un sector intensivo en cuanto a la mano de obra se refiere en el que generalmente, los costes laborales representan del 30% al 50% de costes total de los proyectos. Por estas razones, se deberían de tener en consideración esfuerzos encaminados a aumentar la productividad laboral. De esta manera, no solo favorecería que las empresas presentaran mejoras en los beneficios, sino que también las haría más competitivas aumentando las posibilidades de supervivencia dentro del sector. Entender los factores críticos que afectan a la productividad laboral puede ser usado para desarrollar estrategias que reduzcan las ineficiencias y mejoren la efectividad de los resultados del proyecto. Anteriores investigadores han estudiado durante la última década en diferentes países los factores con influencia sobre la productividad laboral en la construcción, sin embargo, no existen estudios relacionados con la productividad laboral en la construcción en España. En consecuencia, una investigación profunda es aún necesaria para mejorar la productividad laboral en España. Por lo tanto, el principal objetivo de este estudio es identificar, analizar y elaborar un ranking con los factores que afectan a dicha productividad en España en base a su índice de importancia relativa. Para este propósito, esta investigación pretende definir una adecuada metodología de investigación, identificando a través de la literatura existente los principales factores que afectan a la productividad laboral en la construcción. Utilizando un conjunto de 35 factores, la principal manera de recoger datos de las compañías fue utilizar un cuestionario estructurado. La población objetivo de esta encuesta está comprendida por una muestra representativa aleatoriamente escogida de profesionales del sector de la construcción. El análisis y posterior ranking de los resultados fue llevado a cabo mediante la herramienta del índice relativo de importancia. Lo 10 factores más relevantes por sus efectos sobre la productividad laboral en España son: (1) escasez o suministro tardío de materiales; (2) Claridad en los planos y documentos del proyecto; (3) asignación de tareas clara y diaria; (4) escasez de equipos y herramientas; (5) nivel de habilidad y experiencia de los trabajadores; (6) retrasos en los pagos a los trabajadores; (7) coordinación entre equipos de trabajo; (8) incorrecta coordinación de los subcontratistas; (9) insuficiente supervisión a los subcontratistas; y (10) problemas de comunicación. Por último, esta investigación pretende también proporcionar sencillas y concisas recomendaciones de modo que puedan ser implantadas por los contratistas y los encargados de proyectos para una gestión efectiva de los recursos humanos y así mejorar los niveles de productividad laboral en España. Algunas de estas propuestas son abordadas desde el punto de vista de “Lean construction”.

PALABRAS CLAVE:

Productividad laboral; Factores; Gestión de la Construcción; Mejora; España.

TABLE OF CONTENTS

CHAPTER 1. INTRODUCTION AND OBJECTIVES	21
1. Background.....	23
2. Statement of the problem.....	24
3. Object:	25
4. Scope:	25
5. Academic context:.....	26
6. Objectives.....	26
6.1. Overall objective:	26
6.2. Specific objectives:	26
7. Planning schedule:	27
8. Research Methodology	29
9. Structure of the document.....	33
CHAPTER 2. CONTEXT: ECONOMIC REVIEW AND CONSTRUCTION INDUSTRY.....	35
1. International framework and Spanish economy.....	37
1.1. Evolution and prospects of the international framework.....	37
1.2. Background and situation of the Spanish economy.....	43
1.3. Prospects for the Spanish economy and macroeconomic scenario	47
2. Construction industry.....	51
2.1. Characteristics of the construction industry	52
2.2. Structure of the construction industry.....	53
2.3. Classification of the construction companies	55
2.4. Agents involved in the construction industry	56
3. Construction industry in Spain	57
3.1. Construction evolution.....	57
3.2. Indicators used for measuring the evolution of the sector	60
3.3. Spanish construction industry nowadays.....	61
CHAPTER 3. THEORICAL FRAMEWORK: LABOR PRODUCTIVITY AND LABOR PHILOSOPHY	67
1. Construction Labor Productivity: Definition and main characteristics	69
1.1. An introduction to productivity.....	69

1.2. Defining Labor Productivity.....	70
2. Measurement of the productivity.....	70
2.1. Why measuring productivity?	70
2.2. Productivity Measurement in Construction.....	71
3. Productivity from Lean Philosophy perspective.....	75
3.1. An approach to Lean Philosophy.....	75
3.2. Differences between traditional production and lean production.....	75
3.3. Techniques in Lean Manufacturing.....	76
3.4. Adapting Lean Manufacturing to Lean Construction and its principles.....	77
CHAPTER 4. LITERATURE SEARCH	81
1. Preliminary approach	83
2. Bibliometric search.....	84
3. Classification of the papers	91
CHAPTER 5. LITERATURE REVIEW	97
1. Introduction.....	99
2. Literature review.....	100
CHAPTER 6. QUESTIONNAIRE DESIGN.....	111
1. Introduction.....	113
2. Establishing the factors affecting Construction Labor Productivity.....	113
2.1. Project related factors' category.....	113
2.2. Human related factors' category	114
2.3. Management or organizational related factors' category:.....	116
2.4. Materials and tools related factors' category.....	119
2.5. Environmental related factors' category	119
3. Structure of the questionnaire.....	120
3.1. Likert scale.....	126
4. Pilot study.....	127
5. Sending the questionnaires.....	127

CHAPTER 7. DETERMINATION AND SELECTION OF SAMPLES	131
1. Introduction.....	133
2. Determination of samples.....	133
3. Selecting the samples.....	135
CHAPTER 8. RESULTS AND DISCUSSION	137
1. Introduction.....	139
2. Results from the survey.....	139
2.1. Number of responses obtained.....	139
2.2. Study regarding the evolution of the responses received	139
3. Classification of the questionnaires received from respondents	143
3.1. By size of the company or organization by number of employees.....	143
3.2. By geographical scope of the company or organization	144
3.3. By location of the respondents	145
3.4. By age of the respondents	148
3.5. By gender of the respondents.....	150
3.6. By number of years of experience in the construction field.....	151
3.7. By maximum level of studies reached by the respondents	152
4. The Relative Importance Index technique	153
5. Analyzing and discussing the results by categories of factors	155
5.1. Project related factors' category.....	156
5.2. Human related factors' category	158
5.3. Management or organizational related factors' category	160
5.4. Materials and tools related factors' category.....	164
5.5. Environmental related factors' category	165
6. Ranking by categories and overall classification of all factors surveyed	169
6.1. Ranking by categories	169
6.2. Overall classification of all factors surveyed	170
CHAPTER 9. CONCLUSIONS AND FUTURE LINES OF INVESTIGATION.....	173
1. Conclusions.....	175
2. Future lines of investigation.....	178

CHAPTER 10. REFERENCES.....179

ANNEXES.....189

LISTING OF CHARTS

Chart 1. Evolution of the inflation rate in the EMU; Source: Eurostat.....	39
Chart 2. Evolution of GDP in the European Monetary Union; Source: European Commission..	40
Chart 3. Unemployment rate of some European countries. Source: Eurostat 2014	41
Chart 4. Evolution of GDP in Euro area and Spain	43
Chart 5. Contribution of the construction investment in GDP growth. Adapted from Seopan..	46
Chart 6. Evolution of the difference between the yield on Spanish 10-year bonds and German 10-year bond. Source: Datosmacro.com	47
Chart 7. Evolution of the unemployment rate in Spain	48
Chart 8. Evolution of the GDP in Spain.....	49
Chart 9. Unemployment rate in Spain. (Feb. 2014)	50
Chart 10. GVA participation of the construction in GDP.....	57
Chart 11. The construction cycle and GDP.....	58
Chart 12. Evolution of the unemployment rate in Spain	59
Chart 13. The activity of construction in Spain	60
Chart 14. Concrete consumption (thousand Tons)	65
Chart 15. Results of the literature search at the end of each stage	90
Chart 16. Distribution of the References by their Contribution	91
Chart 17. Nº of factors affecting CLP-related publications per year.....	93
Chart 18. Evolution of the daily number of responses obtained	142
Chart 19. Number of responses obtained per day.....	142
Chart 20. Classification of the responses by the size of the company or organization by number of employees.....	144
Chart 21. Classification by geographical scope of the company or organization	145
Chart 22. Number of responses according to the age of the respondents.....	149
Chart 23. Classification according to the gender of the respondents.....	150
Chart 24. Number of responses according to the year of experience of the respondents	151
Chart 25. Number of responses by the highest level of studies reached by the respondents.	153

LISTING OF FIGURES

Figure 1. Research Framework for this research study.....	29
Figure 2. Evaluation method using Likert scale.....	31
Figure 3. Drewin's open construction conversion system (Thomas et al. 1990)	74
Figure 4. Sequential search from general to specific results	84
Figure 5. Research framework for this study (adapted from Hong et al. 2012)	85
Figure 6. Appearance of the first part of the questionnaire	121
Figure 7. Appearance of the second part of the questionnaire	125
Figure 8. Appearance of the thanking final part of the questionnaire	126
Figure 9. Evaluation method using Likert scale.....	127
Figure 10. Methodology followed for developing the database.....	128
Figure 11. Number of responses per province.....	148
Figure 12. Evaluation scale.....	155

Figure 13. Map of average temperatures in Spain and values obtained by high/low temperature factor for different provinces. Map source: AEMET.....	166
Figure 14. Map of average rainfalls in Spain and values obtained by rain factor for different provinces. Map source: AEMET.....	167
Figure 15. Map of basic speed of the wind in Spain and values obtained by “high winds” factor for different provinces. Map source: DB-SE-AE	168

LISTING OF TABLES

Table 1. Distribution of approximated number of pages by paragraphs.....	28
Table 2. Prospects for global activity Source: IMF 2014	37
Table 3. European Monetary Union macroeconomic scenario	39
Table 4. Evolution of the inflation rate in the EMU; Source: Eurostat.....	39
Table 5. Extract from the GDP statistics. Source: INE 2014	45
Table 6. Types of activities within the construction industry. Source: SEOPAN	53
Table 7. Classification of the construction companies according to size of their workforce	56
Table 8. Number of companies by strata of employees. Source: M.FOM 2014	61
Table 9. Number of companies by groups of activities. Source: CNAE 2009	62
Table 10. Number of employees by strata of employees. Source: M.FOM 2014	62
Table 11. Number of employees by groups of activities. Source: CNAE 2009.....	63
Table 12. Structure personnel costs (EUR million).....	63
Table 13. Value of the production by components. (EUR million).....	64
Table 14. Value of production by strata size (EUR million).....	64
Table 15. Value of production by groups of activities CNAE 2009. (EUR million).....	64
Table 16. Turnover from construction activities by type of work.....	65
Table 17. Listing of papers collected from preliminary approach stage	83
Table 18. Search results from Stage 1	86
Table 19. Refinement of data using Mendeley	87
Table 20. SJR Index and Cites per document (2012) by Journal	88
Table 21. Number of articles from “Initial papers” list published on Top-ranked Journals.....	89
Table 22. Classification of articles by Proximity Level to the Topic	89
Table 23. Classification of the articles by their importance.....	91
Table 24. Research origin of papers selected from literature search	92
Table 25. Nº of factors affecting CLP-related publications per year.....	93
Table 26. Authors with the highest number of publications for the 52 selected articles.....	94
Table 27. Journals with highest number of publications	95
Table 28. Methodology or technique used by the authors.....	95
Table 29. Literature Summary of the factors affecting Construction Labor Productivity.....	99
Table 30. Number of registered companies by region and provinces in Spain	136
Table 31. Evolution of the daily number of responses obtained	141
Table 32. Classification of the responses by the size of the company or organization by number of employees.....	143
Table 33. Classification by geographical scope of the company or organization	145
Table 34. Classification by location of the respondents	147

Table 35. Number of responses according to the age of the respondents.....	149
Table 36. Classification according to the gender of the respondents.....	150
Table 37. Number of responses according to the year of experience of the respondents	151
Table 38. Number of responses by the highest level of studies reached by the respondents.	152
Table 39. Overall RII and ranking of factors in the project category	156
Table 40. Overall RII and ranking of factors in the human category.....	158
Table 41. Overall RII and ranking of factors in the management/organizational category.....	160
Table 42. Overall RII and ranking of factors in the materials/tools category	164
Table 43. Overall RII and ranking of factors in the environmental category	165
Table 44. Ranking and overall RII by categories.....	169
Table 45. Ranking and overall RII for all factors surveyed	170

Chapter 1

INTRODUCTION AND OBJECTIVES

1. Background

Background for this research is then exposed in order to clarify the problems concerning construction labor productivity, and particularly in Spain. Efforts to produce better performance and increasing productivity in construction requires an comprehension of the various indicators of productivity as a path to understanding the performance of the project (Atkinson et al. 1997). Besides that, efforts to improve productivity in construction industry can essentially be done by reducing project cost overrun and also project completion delay (Kaming et al. 1998). Productivity enables an organization to be competitive, achieve set goals, attain stakeholder value propositions and maintain strategic and financial health (Durdyev and Mbachu, 2011). There are many challenges that should be addressed in the Spanish construction industry, but one of the most influencing one, and also not only observed in Spain, is low productivity. Despite all technological advancements, abundance of construction materials and financial means available to main contractors, constructions costs are constantly increasing, completion duration of the projects are substantially growing, and most of the projects are significantly overrunning their budgets.

Studying factors affecting construction productivity in different countries is not a new issue and many researchers have identified these problems as factors that affect the productivity of construction and will subsequently affect the performance of a company and the overall economy of the country. The performance of labor is affected by many factors and is usually linked to the performances of time, cost, and quality. The identification and evaluation of factors influencing construction labor productivity have been developed in the last decade; however, no studies has been conducted in Spain regarding labor productivity, thus deeper understanding is still needed to improve labor productivity in Spain.

The principal and traditional construction project procurement and delivery method established in Spain is design/bid/build. The nature of this method permits the contractors to face predetermined decisions regarding the criteria for design and specifications on the one hand, and contractual conditions on the other. The contractor must implement this during the contract duration of the project; hence, as end user, the contractor is in a better position to provide an objective assessment of the effects of such products on the productivity of operatives. This method gives the chance to the clients and engineering firm consultants to address the productivity and factors affecting it in more precise detail, especially in cases of delay and loss of productivity claims (El-Gohary and Aziz, 2014). This provides the importance and the logic behind focusing on the perspectives of contractors in this study.

Appropriate management of resources in construction projects can lead to considerable savings in time and cost. Therefore, identification and evaluation of factors affecting labor construction productivity have become a critical issue facing project managers for a long time in order to increase productivity in construction (Motwani et al. 1995). Understanding critical factors affecting productivity of both positive and negative can be used to develop strategies to reduce inefficiencies and to improve the effectiveness of project performance. Knowledge and understanding of the numerous factors affecting construction labor productivity is needed to determine the focus of the necessary steps in an effort to reduce project cost overrun and project completion delay, thereby increasing productivity and overall project performance. For

this reason, this study aims to identify factors affecting or contributing to the delay of projects completion in Spain through a questionnaire survey. The results will be useful information to improve construction productivity in Spain.

2. Statement of the problem

Construction is a major industry worldwide accounting for a sizeable proportion of most countries gross domestic product (GDP). The global construction industry makes up approximately 9% of the world's GDP. In this sense, this sector is the largest industrial employer in most countries, accounting to around 7% of the total employment worldwide (Horta et al. 2013). Similarly, the level of contribution to GDP by the Spanish construction sector has been declining over recent years, reaching 11.8% in 2012. As for the level of employment in the same sector, it has also been deteriorating since the beginning of the crisis registering a 6.6% of the total amount of employment in Spain in 2012. This level of employment in construction has fallen to a level not reached since the early 80s (Desafíos del sector de la construcción en España 2012).

Although construction industry had greatly improved in terms of productivity in last decades with the development of machinery and work equipment more powerful on the one hand, and new construction procedures on the other. It still continues to be a labor-intensive industry where labor costs still remaining as an important part of the overall project's cost (El-Gohary and Aziz 2014). Construction costs are also constantly on the rise, completion durations of projects are substantially increasing, and most projects are significantly overrunning their budgets.

Labor costs have received increased attention from construction researches and they reported that construction labor costs account for 30-60% of the total cost of a project (Gormar et al. 2002; Hanna et al. 2002) whereas other authors have revealed that labor cost comprises 30% to 50% of the total cost. (Yates and Guhathakurta 1993; McTague and Jergeas 2002). In 2011, labor costs in the Spanish construction industry amounted 27,702.8 million euros which represented a 28.61% of the total incomes from construction work sales (Estructura de la construcción 2012.). It must be emphasized that incomes obtained from sales from construction work executed are mostly higher than projects total cost since this is the basis of the construction companies to make profits. For this reason, construction labor costs in Spain were certainly higher than 30% in 2011. Therefore, labor force should be carefully managed due to the critical importance to the profitability of most construction projects.

Nowadays, although Spain is still suffering the effects of the crisis, its economy begins to show signs of recovery. However, severe cuts during the last years had been made in public works investment in order to control public finances. This decision has generated strong competition between construction companies and each company then faces increased difficulties for a position in the market. Prices, financial status, environmental management, quality management, safety management and skilled labor become issues very carefully assessed when awarding jobs to contractor companies (Rivas et al. 2011). Given this scenario, it is easy

to comprehend that construction labor productivity plays a critical role in most of the construction projects.

Chronic problems such as poor management, inferior working conditions and insufficient quality have been experienced by many construction industry companies and considerable research has been carried out in order to identify these problems and designate them as possible factors that may affect the productivity of construction and will subsequently affect the performance of a company. The performance of labor is affected by a multitude of factors simultaneously and is normally linked to the performances of time, cost and quality since as Jarkas and Bitar (2012) suggest labor power is the only productive resource; hence construction productivity is mainly dependent upon human effort and performance.

For this purpose, identifying as well as analyzing and ranking factors affecting labor productivity becomes not only desirable but also necessary since no research has been previously carried out within the Spanish construction industry.

Once identified effects that influence labor productivity and ranked according to their relative importance, it is easier for construction companies to seek to limit or mitigate the consequences of these effects by implementing corrective measures in case the effect has already been submitted or otherwise develop preventive measures in order to prevent this effect materializes. This easiness for companies comes from the fact that they are ultimately responsible for the management and supervision of labor force whether directly employed or subcontracted.

A study of these factors followed by a deep reflection by contractors may be provide guidance to projects and construction managers for efficient utilization of the labor force, thus assist in achieving a reasonable level of competitiveness and cost-effective operation. These steps are aimed to increase labor productivity which would not be only valuable for construction companies but would also benefit all stakeholders.

3. Object:

The object of this research is the factors affecting to labor productivity in the construction industry in Spain.

4. Scope:

The study will determine the factors affecting to construction labor productivity in the construction industry. Geographically, the scope of this research is limited to the Spanish construction industry due to the limitations of time to develop this thesis. Also limited by the available means, construction companies invited to take part in this research will be restricted to those registered as valid membership in the Official Register of Classified Companies of Spain.

5. Academic context:

This Master Thesis has been done mainly during an Erasmus exchange at the Karlsruher Institut für Technologie (KIT) in Karlsruhe, Germany. The duration of the stay at the University of Karlsruhe was four months. The direction of the Master thesis in Karlsruhe was led by Professor Ahmed Stifi, while the director at the Polytechnic University of Valencia was José Luis Ponz Tienda.

6. Objectives

6.1. Overall objective:

The overall objective of this research is to conduct a study of the factors influencing labor productivity in the construction industry in Spain. This study pretends through the development of an adequate research methodology, to investigate, analyze and rank factors affecting labor productivity with respect to their relative importance. Also, it is pretended that this research may provide a starting point from which Lean techniques could be implemented in order to improve labor productivity and guide to contractors and construction managers for the effective management of construction labor forces and help to achieve a competitive level of quality and a cost-effective project.

To achieve this overall objective, it has been established the following specific objectives.

6.2. Specific objectives:

The specific objectives that have been intended to achieve are basically:

1. To have the Master thesis developed within the deadline established.
2. To generate a fundamental and conceptual framework for the development of the research base.
3. To define an appropriate research methodology carrying out a set of inquiry questions and selecting standard procedures to solve the research issue.
4. Carrying out a preliminary study about the affecting factors related CLP, defining the strategy for literature search.
5. To identify through the literature the main factors affecting labor productivity in construction.
6. To design a survey with the purpose of understanding the perceptions of professionals on the factors affecting labor productivity in the construction sector in Spain.
7. To conduct a comprehensive analysis of the data obtained from the survey and rank the factors by their importance.
8. To provide guidance to contractors and construction managers for the effective management of construction labor forces.
9. To provide a starting point from which Lean techniques could be implemented in order to improve labor productivity.

7. Planning schedule:

One of the limitations of deciding to carry out the Master's thesis abroad was that the total amount of available time to develop the thesis was fixed as the total time of the stay in Germany.

Being aware of this constraint and in order to ensure that the Master's thesis could be finished on time, since the stay in Germany for carrying out this research was limited only for 4 months, it was decided to develop a Schedule where the activities which have to be done were noted and temporalized according to an estimation of their durations.

Activities that have been taken into account were:

- Planning schedule
- Organizing references
- Statement of the problem
- Re-writing Overall and Specific Objectives
- Research Methodology
- Research Design and Literature Search
- Literature Review
- Questionnaire design
- Determination and selection of the samples
- Sending questionnaires to companies
- Waiting time for companies to respond
- Writing "Context" chapter
- Writing "Theoretical Framework" chapter
- Analyze results from questionnaires
- Results and Discussion
- Conclusions and future lines of investigation
- Background
- Structure of the document
- Glossary of terms
- References
- Annexes
- Indexing the document
- Assembling the document

After this step, scheduled duration of each activity was established in the best possible way according to my own and advisor's experience with related studies or researches. It was intended to adjust the total scheduled duration to the available time to elaborate it. An excel sheet was used for this purpose in order to make this stage easier. The available time to perform the research was from beginning of March to the beginning of July. The total amount of time needed for the thesis was set in 19 weeks as it was the available time in Germany.

Once all the tasks were registered, a Gantt's diagram was performed. This diagram served as guidance for checking if the thesis's development was on time or if it was delayed on time. The diagram also made easier to decide which activity should be started when the next one was

finished. This was not only a very useful tool but also very important as every week the diagram was revised and updated with all the finished activities and the activities in progress.

The second purpose of the planning schedule was to advise about the approximated number of pages that each part of the document should have to ensure that the minimum number of pages was covered. As shown in Table 1, the number of pages was approximately set in 160.

Tasks to be developed	No. of approx. pages
Re-writing Overall and Specific Objectives	1
Research Methodology	3
Research Design and Literature Search	10
Literature Review	10
Questionnaire design	5
Determination and selection of the samples	5
Sending questionnaires to companies	-
<i>Waiting time for companies to respond</i>	-
Writing "Context" chapter	30
Writing "Theoretical Framework" chapter	30
Analyze results from questionnaires	-
Results and Discussion	30
Conclusions and future lines of investigation	10
Background	5
Structure of the document	3
Glossary of terms	2
References	6
Annexes	5
Indexing the document	-
Assembling the document	-
TOTAL	160

Table 1. Distribution of approximated number of pages by paragraphs

The numbers of pages indicated above were only orientative numbers and they only had the purpose of making a general idea of how large the thesis was going to be. Some of the tasks had longer extension and other ones had fewer pages than estimated.

The complete planning schedule at the point of Master's thesis starting is shown in the Annexes.

8. Research Methodology

To carry out this research, first it was necessary to determine the methodology to be used. To do this, two sources of documentation were mainly used. On the one hand, research studies with similar purposes were examined to get an idea of how their authors developed their research methodologies. These observations were important sources of information and were taken into account. On the other hand, research conducted by Colin Robson (2002) in his book “Real World Research”, served to establish the basis of the methodology. This book was also utilized to complement and adapt research procedures from related similar researches.

Finally, the research methodology followed to carry out the research about factors relating construction labor productivity consisted in different stages: (1) Literature review, (2) Design of the questionnaire, (3) Pilot test of the questionnaire, (4) Determination and selection of samples, (5) Data analysis, (6) Results and discussion and (7) Final report and conclusions. Figure 1 shows the overall research methodology of this study.

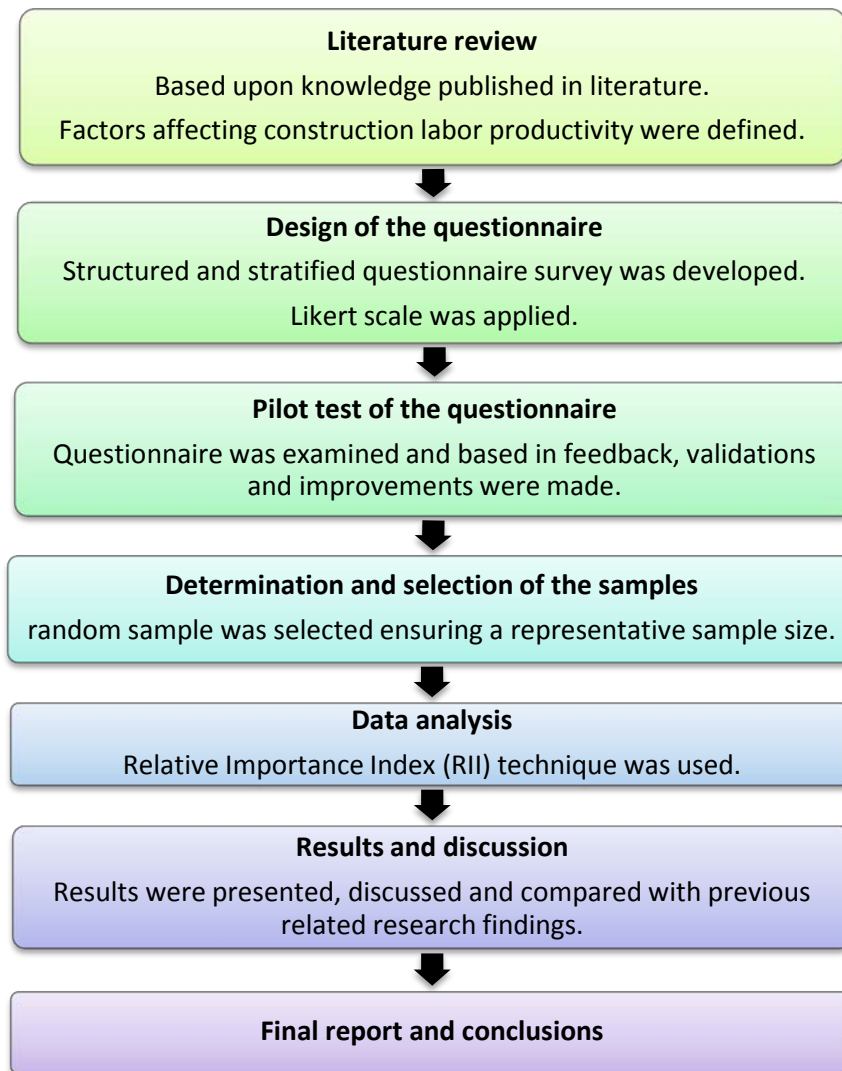


Figure 1. Research Framework for this research study

8.1. Literature review

In this first stage, Bibliographical search has been carried out in order to quantitatively and qualitatively analyze existing scientific articles on the factors affecting CLP-related. To perform the bibliographic search, a series of initial and refinement parameters have been set such as search engines used, keywords, searching period of time, language used within the articles and type of publications.

Literature search has been performed sequentially, entering keywords in each of the four search engines. A sequentially search provides relevant information when analyzing the current state of knowledge from the general to the particular.

The main goals to achieve with the development of a literature review are:

- Exposing mains gaps in knowledge and identify principal areas of dispute and uncertainty.
- To help identify general patterns to findings from multitude examples of research in the same area.
- To analyze and process the articles resulting from the bibliographic search, extracting the main contributions of each investigation.
- To facilitate define the terminology or identify variations in definitions used by researchers or practitioners.
- To identify appropriate research methodologies and instruments (e.g. interview schedules, validated tests and scales).

8.2. Design of the questionnaire

For carrying out this study, the main instrument of collecting data from construction companies was decided to be a structured questionnaire survey. This way of getting data from respondents has proved its effectiveness since they can be extremely efficient at providing large amounts of data, at relatively low cost, in a short period of time. Some of the questions of the questionnaire have been adapted from knowledge published in literature in order to fit the analysis context.

The survey is displayed as a series of statements generated on the basis of related researches about factors constraining construction labor productivity. For this purpose, literature review becomes a determining issue since data acquired from papers and related publications will be the base for the structured questionnaire survey preparation. Participants were required to rate the factors for the way they thought construction labor productivity could be affected, taking into account time, cost and quality using their own experiences on construction sites.

Main characteristics of the questionnaire design were that statements used had to be easy to read, understandable and interpreted in the same way by all respondents. More accuracy in the final outcome as well as needing a short period of time to be answered by respondents have been also very important issues taken into account while the questionnaire was being developed. The need of taking smaller time as possible for construction companies to respond

was considered very seriously in order to obtain the maximum possible answers. The optimum inverted time for answering the questionnaire should not take more than several minutes. Participants were contacted by email and only by email as the manner to invite them to participate in the research.

For this research, Likert scale has been used to assess the individual’s performance or standing on the attribute of the given questions. Nowadays, the summated rating approach is very widely used. It has the added advantage of being relatively easy to develop. This measurement scale was original devised by Likert in the 1930s and scales developed by this method are commonly termed Likert scales.

In this study, respondents were required to rate the factors affecting labor productivity on a scale with the rating of “1,” very little effect; “2,” little effect; “3,” average effect; “4,” high effect and “5,” very high effect, according to the degree of importance on construction labor productivity. The number assigned to the agreement scale (1, 2, 3, 4, 5) do not indicate that the intervals between the scales are equal, nor do they indicate absolute quantities. Evaluation scale is shown below in Figure 2.

1	2	3	4	5
Little effect (L)	Some effect (S)	Average effect (A)	High effect (H)	Very high effect (VH)

Figure 2. Evaluation method using Likert scale

8.3. Pilot test of the questionnaire

The meaning of this stage is to help minimizing some of the inevitable problems of converting the design of the questionnaire into reality. A little survey was piloted on a small scale in order to ensure readability, accuracy and comprehensiveness of the questionnaire to participants. Two researchers in the same field examined the questionnaire and based in their feedback validations and improvements were made in terms of wording of statements, the overall content, and the format and layout. Accordingly, the questionnaire was validated through this process with suggestions from experts before launching the survey.

8.4. Determination and selection of samples

The relevant data to this investigation were collected by a structured closed-ended questionnaire survey. On the basis of related previous studies on labor productivity and the suggestions from industry experts, a series of factors were identified and requested to participants to rate.

The target population included all construction companies cataloged in the Official Register of Classified Companies of Spain. This register is compiled by the Ministry of Finance. The classification criteria for Spanish contractors are based upon:

- The technicality of a company, which is dependent on the number and category of their technical staff.
- The rate of mechanization of a company, which is dependent on the current value of its machinery.
- Capital and financial strength of the firm.
- Previous experience of the firm.

In order to ensure a representative sample size, n , of participants of all targeted contractors, a systematic random sample was selected by using equations (1) and (2):

$$n = \frac{m}{1 + \left(\frac{m-1}{N}\right)} \quad (1)$$

Where n = the sample size of the limited population; N = the sample size of the unlimited population and m is estimated by the following equation:

$$m = \frac{z^2 \times p \times (1-p)}{\varepsilon^2} \quad (2)$$

Where z = the statistic value for the confidence level used; p = the value of the population proportion that is being estimated and ε = the sampling error of the point estimate.

8.5. Data analysis

For analyzing data, the relative importance index (RII) was used. Factors were grouped into categories according to the nature of the problem. The RII for the different factors of each category are calculated by using the next equation (3).

$$\text{RII}(\%) = \frac{5(n_5) + 4(n_4) + 3(n_3) + 2(n_2) + (n_1)}{5(n_1 + n_2 + n_3 + n_4 + n_5)} \times 100 \quad (3)$$

Where n_1 , n_2 , n_3 , n_4 and n_5 = the number of respondents who selected: "1", for very little effect; "2", for little effect; "3", for average effect; "4", for high effect and "5", for very high effect respectively.

The RIIs ranks within the corresponding category, and the overall ranks of the factors under investigation are presented, discussed and compared to previous related research findings. Moreover, the category importance indices are also established to determine their relevant importance by quantifying the average value of the RII of the factors of each category.

8.6. Results and discussion

The perceived effect of each of the factors explored in construction labor productivity in Spain is determined. Using the relative importance index technique, ranks of each one of the different factors investigated within their corresponding category could be presented, discussed and compared with previous related research findings.

8.7. Final report and conclusions

Final report will be carried out including main findings and conclusions obtained from the results of the analyses of the data from questionnaires and secondly from the comparative with related researches.

9. Structure of the document

This research is composed by 10 different chapters and annexes which are organized as follows:

- **Chapter 1:** Introduction and objectives
- **Chapter 2:** Context: Economic Review and Construction Industry
- **Chapter 3:** Theoretical Framework: Labor Productivity and Lean Philosophy
- **Chapter 4:** Literature search
- **Chapter 5:** Literature review
- **Chapter 6:** Questionnaire design
- **Chapter 7:** Determination and selection of samples
- **Chapter 8:** Results and discussion
- **Chapter 9:** Conclusions and future lines of investigation
- **Chapter 10:** References
- **Annexes**

First chapter, named **introduction and objectives**, is related with background and the statement of the problem. Also overall objective and specific objectives are described in this chapter. Moreover, planning schedule according to the time limitations is settled. The last part of this chapter explains the research methodology followed in order to accomplish the research.

Next chapter consists in creating a **context** for the thesis development. First, an evolution and the prospects for the economy are explained. Then, the situation of the Spanish economy and its prospects are reported. The second part of the chapter is related with the construction industry, where the main characteristics, structure and agents involved are presented.

Theoretical framework chapter is sorted third. Definition and main characteristics of the construction labor productivity are explained. Moreover, how the productivity is measured in the construction industry is also detailed. To conclude this chapter, a brief approach to Lean Philosophy is carried out.

In the **literature search** chapter, a bibliographical search is conducted in order to quantitatively and qualitatively analyzes the existing scientific articles related with factors affecting construction labor productivity. Lastly, classifications of these publications regarding different characteristics are developed.

The following chapter is denoted as **literature review**, in this section, main contributions extracted from most relevant articles are collected, determining a summary of the factors affecting construction labor productivity. This summary of factors will be used later to establish the factors used for the design of the questionnaire in order to know the perception regarding each factor from practitioners.

Questionnaire design chapter establishes the factors affecting construction labor productivity that will be considered for the research. Factors will be grouped into 5 different categories depending of the nature of each factor. Likert scale is explained since it is going to be the technique for rating each factor. Last part of this chapter consists in the pilot study and the process of sending questionnaires.

Next chapter it is related with the **determination and selection of samples**. In this section, target population will be selected and determined in order to get a representative sample. Then, a systematic random sample will be prepared with the purpose of ensuring the sample representativeness of all targeted participants.

In this **results and discussion** chapter, data obtained through the questionnaires submitted by the Spanish construction companies is analyzed. In the first part of the interpretation of the results, an examination of the answers from respondents will be carried out. The second part of the chapter consists in a statistical analysis of the data provided by respondents using RII technique. Lastly, comparison and discussion with related researches in different countries will be also developed.

The following chapter is **conclusions and future lines of investigation**, where main outcomes are presented. These conclusions will aim to clarify for a better comprehension the impact of each factor and will present tools which can help to minimize the influence of these factors on labor productivity. Lastly, future lines of research regarding construction labor productivity in Spain are considered.

References chapter pretends to provide all citations from articles, proceedings, thesis, reports, or other kind of publications used for this research.

Last section of the master's thesis, although it is not considered properly as a chapter, **annexes** attach important information about documents related with the development of this research.

Chapter 2

CONTEXT:

**ECONOMIC REVIEW AND
CONSTRUCTION INDUSTRY**

1. International framework and Spanish economy

1.1. Evolution and prospects of the international framework

The year 2013 confirmed a dual evolution of the global economy, strong in emerging economies and developing countries but weaker in advanced economies, although establishing greater dynamism in the United States versus moderate contraction in the euro area.

According to estimates from International Monetary Fund (IMF), growth in emerging economies will reach 5.3% in 2013 and 5.7% in 2014. In the U.S., the prognosis is positive: 1.9% in 2013 and 3.0% in 2014, while for the euro area is expected -0.3% and 1.1% in 2013 and 2014 respectively. Prospects for year 2014 and variations on Gross Domestic Product (GDP) from year 2011 were shown in Table 2 below.

	% contribution to worldwide GDP	2011 (%)	2012 (%)	2013 (%)	Prospect 2014 (%)
Developed C.	50.1%	1.6	1.2	1.2	2.2
U.S.	18.9%	1.8	2.2	1.9	3.0
Japan	5.6%	-0.6	2.0	1.6	1.4
UEM	13.7%	1.4	-0.6	-0.3	1.1
Germany	3.8%	3.1	0.9	0.6	1.5
France	2.7%	1.7	0.0	-0.1	0.9
Spain	1.7%	0.4	-1.6	-1.2	0.7
U.K.	2.8%	0.9	0.2	0.7	1.5
Emerging C.	49.9%	6.4	5.1	5.3	5.7
Russia	3.0%	4.3	3.4	3.4	3.8
China	14.9%	9.3	7.8	8.0	8.2
India	5.6%	7.7	4.0	5.7	6.2
Brazil	2.8%	2.7	0.9	3.0	4.0
Mexico	2.1%	3.9	3.9	3.4	3.4
WORLDWIDE	100.0%	4.0	3.2	3.3	4.0

Table 2. Prospects for global activity Source: IMF 2014

The negative growth in the euro area in 2013 was a result of weak countries in the periphery, most notably Spain and Italy, but also a softening in Germany and stagnation in France. The process of internal devaluation was highlighted, which favors improving competitiveness in most of these countries, although in both cases very slowly. This improvement is boosting exports, but not strong enough to offset weak domestic demand.

In Japan, after a long period of deflation and moderate or no growth, new government is pushing a policy based on fiscal stimulus and structural reforms. These policies are now driving growth. However, there are doubts about their future in the medium term, given the high level of existing public debt nowadays.

Meanwhile, in emerging economies, expectations still remain positive. Under current high prices for raw materials, low interest rates and strong influx of capital that usually have led to

overheating of the economy. However, in general, it has been managed to maintain aggregate demand in line with its potential level.

In its latest outlook for the world economy, the International Monetary Fund estimated that the global outlook has improved again, but the path to recovery in advanced economies shows high uncertainty, indeed, it is estimated a very weak progress in most of them. While world GDP increased by 3.3% in 2013, it is anticipated that world GDP will grow 4.0% in 2014. Meanwhile, in advanced economies was expected that the activity gradually accelerated from the second half of 2013, confirming that the divergence in these economies will remain in view of the strength in the evolution of private demand in U.S. Within European Monetary Union (EMU), for the Spanish economy, a decline in activity at around 1.6%, which in the case of Italy is moderated to 1.5%, is anticipated. Regarding emerging economies, it is anticipated a gradual acceleration of activity which will continue to the next year.

Most of the major advanced economies outside the Euro area are registering a moderate recovery, although several factors continue to limit growth prospects in the medium term. In emerging economies, growth experienced a slight slowdown at the beginning of the year, but is expected to recharge momentum during 2013. Therefore, it is expected that these economies contribute significantly for a positive trend of growth. At the same time, there has been lack of dynamism of world trade but sentiment indicators still pointing its gradual recovery. With respect to consumer price inflation in advanced economies, it has redirected its downward trend, while the evolution of the emerging economies has been more uneven.

The main short-term dangers are related with fatigue problems due to the adjustments required in the euro area such as weak balance sheets, disruption of credit channels in the periphery and insufficient degree of progress towards the achievement of a stronger economic and monetary union. In the medium term, downside risks are concentrated on the lack of credible plans for fiscal consolidation in the United States and Japan; by strong borrowing of the private sector, limited room for maneuver in economic policy and the insufficient institutional developments in the euro area, which could cause a long period of moderate growth; distortions arising from the adoption of lax monetary policy and unconventional in many advanced economies, which binds excess investment and rising prices in the assets of many emerging and development countries.

1.1.1. Situation and Prospects of the Economic and Monetary Union

The most important feature was the significant easing of financial constraints in the final part of year 2012. This was favored by the actions of the European Central Bank, the agreements of the European Council last December and the launch of the Unique Mechanism Monitoring and agreements concerning the Greek assistance program, which binds to the compliance programs in Ireland, Portugal and Spain and reduction of what is called "Fiscal gap" in the U.S.. However, this moderation in tensions has not led improvements in the economic outlook.

The evolution throughout 2012 showed a progressive worsening as the year progressed, closing the year with an annual rate of -0.9%, which implied a variation in average -0.6%

compared to 1.4% observed in 2011. From the standpoint of aggregate demand, this is explained by the progressive deterioration of private and public consumption. The growth of exports, united mainly the extension of the fall in imports, favored the positive contribution of the external sector to global growth, but could not compensate the contraction of domestic demand.

European Monetary Union macroeconomic scenario displayed by its annual rate in % from 2011 to 2013 is shown below in Table 3.

	2011	2012	2013
Private consumption	2.5	1.9	2.4
Public consumption	-3.1	-1.7	-3.0
Residential investment	-0.14	12.1	12.1
Non-residential investment	8.6	8.0	5.3
Domestic demand	1.8	2.0	1.9
Exports	6.7	3.4	3.1
Imports	4,8	2.4	2.0
GDP	1,8	2.2	2.0

Table 3. European Monetary Union macroeconomic scenario

Inflation has slowed down after the downfall of the impacts of recent increases in energy prices. The inflation in the EMU reached a maximum peak of 3.7% rate inflation in year 2008 followed by a minimum in year 2009. The outlook for 2013 suggests that inflation should continue progressive relaxation, stabilizing at 1.5% in the euro area. Table 4 and Chart 1 present an evolution of the inflation rate for the European Monetary Union by % variation.

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Inflation rate	2.5	2.1	2.3	2.3	2.3	2.4	3.7	1.0	2.1	3.1	2.6	1.5

Table 4. Evolution of the inflation rate in the EMU; Source: Eurostat

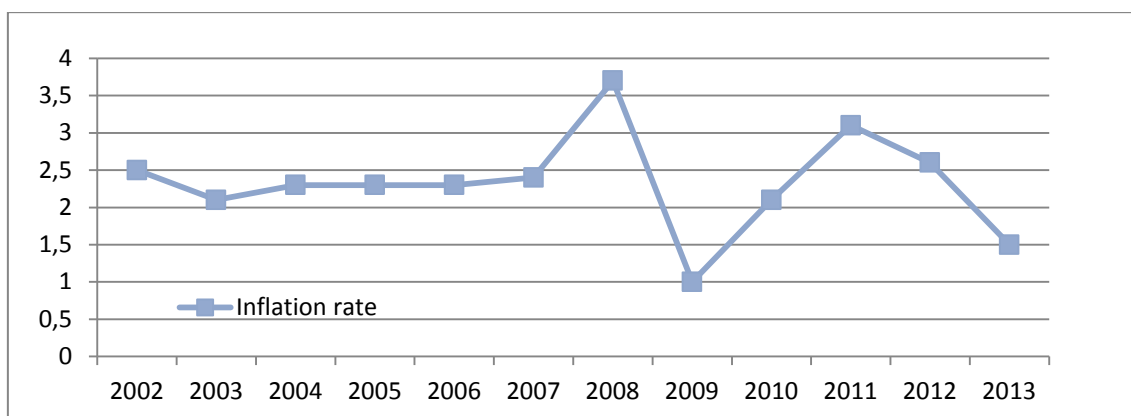


Chart 1. Evolution of the inflation rate in the EMU; Source: Eurostat

The most recent cyclical data suggest that GDP continued to contract in the second quarter of 2013, although at a slower pace than the last part of the exercise above. For the second part of the exercise, the recovery that different international organizations and most private analysts expect, will be driven by the continuity relaxation in monetary policy by the greater strength of world trade and the consolidation of improved confidence as progress has been made in resolving the financial crisis. However, domestic demand will remain weak through the deleveraging process and ongoing fiscal consolidation in some countries.

Around these perspectives, the downside risks predominated. The most important were related with a possible worst-evolution of demand from abroad or a potential worsening of the financial crisis, which could come associated with a deterioration of the confidence as a result of insufficiently ambitious and determined implementation of agreed reforms. Moreover, the recent events in Italy and Cyprus have increased the uncertainty surrounding this scenario and have increased the downside risks in those countries.

Considering the estimates of the European Commission, it can be anticipated that the European Union economy will tend to stabilize in the first half of this year and throughout the next, as it can be observed in Chart 2, a gradual recovery in GDP growth, reaching a decrease in 2013 -0.4 % compared to -0.6 % estimated for the preceding year.

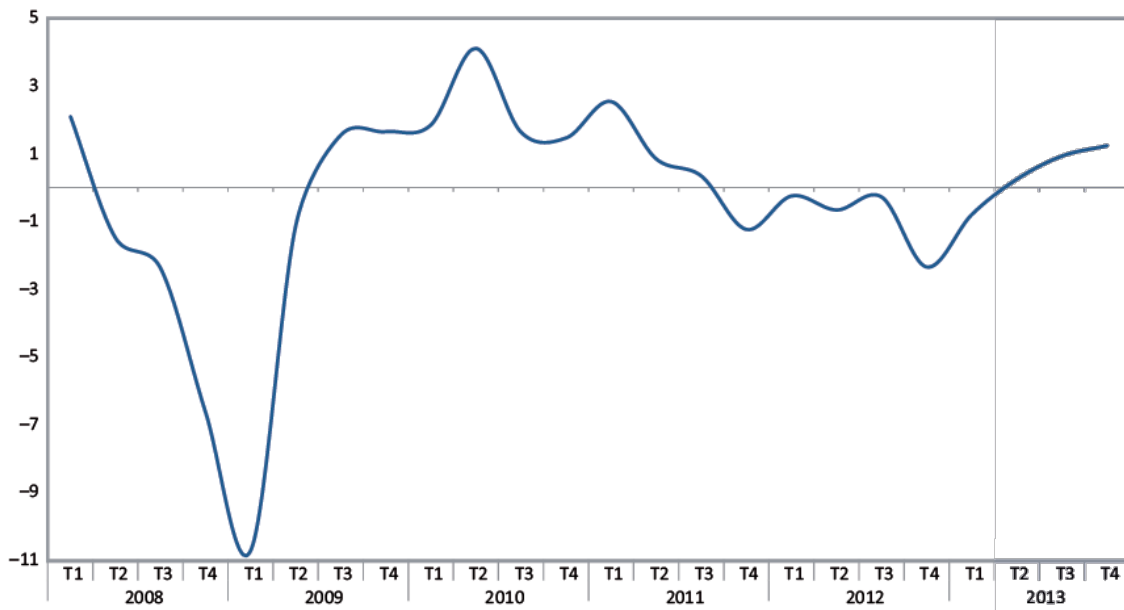


Chart 2. Evolution of GDP in the European Monetary Union; Source: European Commission.

Among the features of recent developments, it is highlighted the ongoing adjustment of the balance sheets and credit restrictions, particularly in the periphery and weak expectations on profits and future income and high uncertainty about the economic outlook. These factors hinder investment and domestic consumption. Moreover, it was noticed a considerable improvement in the situation of financial markets and interest rates of the sovereign bonds.

However, their effects have not yet been felt in the real economy, and only signs of moderation are noticed because of perceived financial fragmentation in the Member States, concluding that companies in most vulnerable economies continue to suffer the stringent credit conditions.

It is expected that the recovery in economic activity is still moderate to reduce unemployment. According to forecasts, in 2014 the unemployment rate will reach 12 % in the EMU, although wide differences exist between Member States.

By countries, in particular Spain, expectatives indicate that although in 2014 there will exist a poor decrease in the unemployment rate, it will not be possible to reduce the rate below 25% until 2015. The other side of the coin, Germany, will keep its unemployment rate stable in a level around 5%.

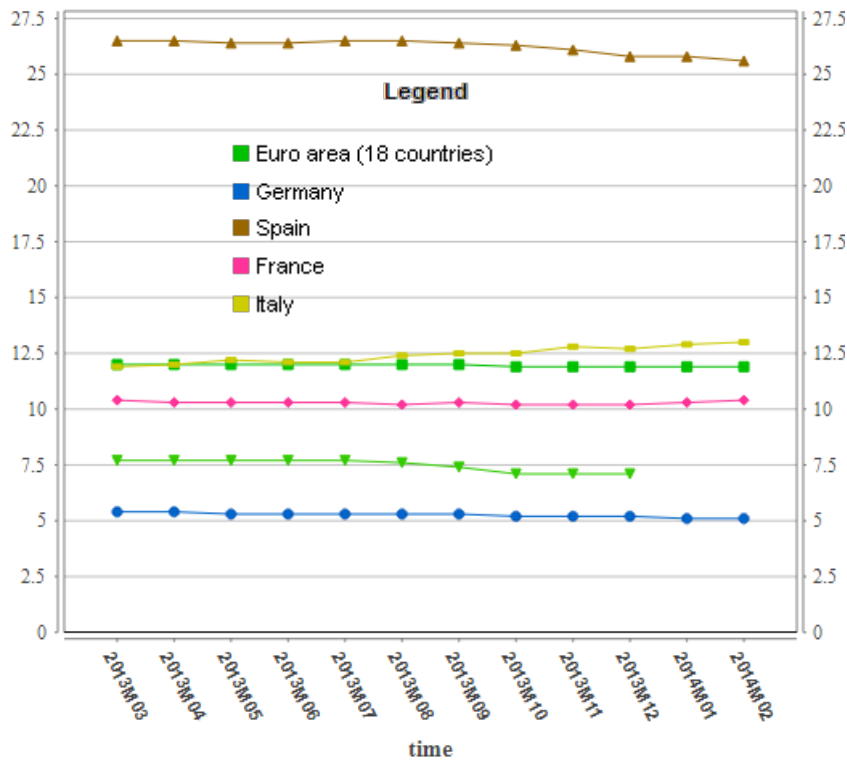


Chart 3. Unemployment rate of some European countries. Source: Eurostat 2014

Regarding public finances, is expected to continue to reduce the deficit to 2.9% in the euro area in 2013. However, believes that the pace of sanitation, terms of structural budget balances, will be slower than that observed in 2012.

The risks to this outlook are manifested balanced, thanks to the important strategic decisions taken since last summer. However, elevated levels of unemployment reached in some Member States might affect social cohesion, with emphasis on the need for policies that will alleviate this situation. More generally, the effective implementation of the measures and

adjustment policies to strengthen the structure of the EMU remains crucial to prevent the return of financial market tensions. In contrast, the favorable situation on the financial markets or a further advance faster than expected in the process of adjustment and reform could accelerate the return of confidence and promote recovery. Global growth could also be more dynamic than expected demonstrating overall inflation prospects globally balanced.

1.1.2. Situation and perspectives of other economies

In the **U.K.**, GDP grew by 0.3% quarter on quarter in the first quarter of 2013. It was expected the economic recovery gains strength gradually, although domestic demand remains limited by restrictive financial framework, adjusting the balance of private and public sector and the lack of dynamism in the real income of households. The labor market is showing behavior positive, although slowed, so the unemployment rate has hovered around 8%. The review recent indicators suggest that the economy has continued to grow at a moderate pace during the second quarter of this year, driven mainly by domestic demand.

In **Japan**, the first estimate of last quarter of 2013 confirmed that the economy had taken momentum early in the year. GDP grew at a quarterly rate of 0.9 % after expanding 0.3% in the third quarter of the same year. The pickup in growth relied primarily on solid growth in private consumption and the positive contribution of demand outside that, in turn, were driven by a growth in the exports of goods and services. Government spending also contributed positively to growth, although it was increased in a more moderate rate than in previous quarters, especially with respect to public investment. At the same time, private residential investment continued growing dynamism, partially offsetting the weakness in private investment non-residential, which fell for the fifth consecutive quarter. Looking ahead, gradually strengthening recovery is expected, mainly driven by additional measures fiscal and monetary stimulus and a rebound in exports as a result of weakening of the yen, as well as a recovery in global demand.

Economic growth in **emerging Asian** was weaker than expected in the last quarter of 2013. Absence of dynamic demand, both internally and external, contributed to the slowdown. Expectations suggest that economic growth increased slightly in the region by the gradual improvement in the external environment and the strengthening consumption and investment.

In **Latin America**, activity accelerated in the latter part of 2012, to continue recovering in the first months of 2013, albeit at a slower rate. This recovery has been supported by previous measures easing the monetary policy and incentives from Government to encourage investment in major countries, especially in Brazil and by favorable financing conditions. Forecasts developed by the World Bank point to a supported growth on the strength of domestic demand and the gradual strengthening of external demand.

1.2. Background and situation of the Spanish economy

Retrospective confirms that the first recession period in the Spanish economy touched down in the first quarter of 2009, with a quarterly growth of -1.6%, which in annual rate term was -3.4 %. From that moment, the activity indicators, demand and employment began to show a lower intensity in the process of deterioration, recognizing that the worst of the crisis had passed. Throughout the second part 2009, the quarterly rate of decline in activity eased, closing the year at a rate of -3.1 % yearly. Moderating quarter profile spending in 2009 was related to direct payments for the purchase of vehicles, while the benefits of project implementation were collected from the State Fund Local Investment (FEIL). The evolution of activity throughout 2010 maintained recuperation in a smooth path. The salient features of this development are based on prolonging the weak recovery of household consumption and investment in goods. To this moderation importantly adjustment in the residential sector is added, and positive contribution to GDP growth of external demand, not however, experienced a reduction in annual terms of 1.7 points compared to 2009, bringing its positive contribution at a point of GDP. Despite this improvement profile gradual, the GDP experienced a drop of 0.3 % in 2010, compared with a fall of 3.7 % observed in the previous exercise as it can be observed in Chart 4 below.

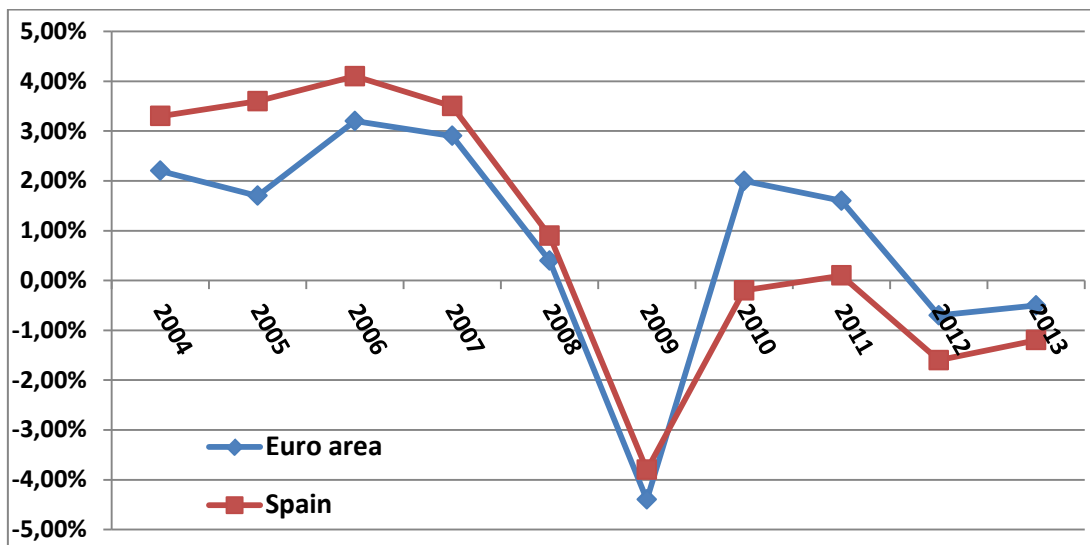


Chart 4. Evolution of GDP in Euro area and Spain

However, in the second part of 2011, the Spanish economy entered a new recessive phase to file a quarterly falls of 0.5% in the last quarter of that year. This new period of recession is less intense but more prolonged in time than previous. The evolutionary pattern of this period of crisis is similar to the previous since it is influenced by regression domestic demand, only partially dampened by the positive contribution of the sector exterior.

The framework that has followed the Spanish economy during 2011 and 2012 is determined by the intensification of the sovereign debt crisis in the euro zone, to the raised about the viability

of the Economic and Monetary Union, besides the obvious impact on the financial system, causing a worsening of the condition funding and further eroding the confidence of agents. This showed the limitation the ability of European authorities to address the tensions observed about the euro project. Not only in the field of coordination and supervision policies, but also in the institutional framework.

As it has been already described, important decisions were taken both in the own field national economies and in the EMU. Design stands out a roadmap for EMU reform and governance; and the trailing pulse for the achievement of a junction bank. In this regard, it is noteworthy the effect of the announcement by the European Central Bank (ECB) of its program Monetary Operations Purchase (MOP), which helped to overcome the most tense episodes, as it took place on the occasion of the election results in Italy and the difficulties in resolving the financial crisis in Cyprus. To this is added the generous liquidity provision by the ECB allowed some extent alleviate the restriction external financing.

Nowadays, as a result of the double recession that the Spanish economy is experiencing, loss of 7% in the level of GDP is estimated from the peak reached in early 2008. Nevertheless, the negative features are still increasing unemployment. Regarding internal imbalances, stresses the deficit reduction in current accounts plus moderation in labor costs, inflation and its differential with the euro area. Another feature, particularly significant concerns the deficit reduction of Public Administrations, which is an important pillar in the recovery of the confidence of the markets.

The profile of GDP during 2012, shows a clear contraction, experiencing a fall of 0.5% in the last quarter of 2012, which agreed a number of factors essentially temporary nature, eventually the average rate stood at -1.4 %. From the demand perspective, it should be noted the occurrence of negative developments in its components. Specifically, consumption of households experienced an average drop in 2012 2.2 % against moderate trimming (-0.8 %) than reported in the previous period. Once again, this stagnation was marked by strong uncertainty, unfavorable and bad labor market prospects, falling disposable income and the declining value of wealth both financial and non-financial. The contraction in consumption was particularly intense in the end of the year, when several measures with concentrated impact on household income.

Given this evolution of income and household wealth, the decline in the savings rate, which is now below 2009 levels, allowed smooth consumption behavior. The substantial fall in the savings rate is a clear indication of the difficulties that is going families spending the complexity of the immediate future in a setting that must still reduce their high level of debt. In the beginning of 2013, is maintained a path down, although the prospects anticipate some moderation as advance exercise.

Meanwhile, **public consumption** fell by -3.3% in 2012, as a result of the intensification the fiscal consolidation process, especially in the area of government regional, extending to -5.8% in the beginning of this year.

These data exposed in lines above related with GDP features had been obtained from GDP statistics offered by the National Institute of Statistics of Spain. In the next page an extract of

these statistics are shown in Table 5. However, they have not been translated into Spanish due to the nature of their contents and its difficulty to find proper terms in English.

	2012	2013	2012				2013			
			T I	T II	T III	T IV	T I	T II	T III	T IV
Gasto en consumo final	-3,3	-2,1	-2,6	-3,4	-3,3	-3,9	-3,7	-3,1	-1,2	-0,3
- Gasto en consumo final de los hogares	-2,8	-2,1	-1,8	-3,1	-2,8	-3,6	-4,2	-3,0	-1,8	0,7
- Gasto en consumo final de las ISFLSH	-0,2	-0,1	-0,1	-0,4	0,0	-0,2	-1,0	-0,4	0,1	0,9
- Gasto en consumo final de las AAPP	-4,8	-2,3	-4,9	-4,4	-4,9	-5,0	-2,3	-3,4	0,2	-3,5
Formación bruta de capital fijo	-7,0	-5,1	-6,0	-6,9	-7,5	-7,7	-7,2	-5,8	-5,3	-1,7
- Activos fijos materiales	-7,8	-5,5	-6,8	-7,6	-8,6	-8,3	-7,9	-6,1	-5,6	-2,5
• Construcción	-9,7	-9,6	-8,6	-9,3	-10,9	-10,0	-9,8	-10,1	-9,8	-8,6
• Bienes de equipo y activos cultivados	-3,9	2,2	-2,9	-4,3	-3,8	-4,8	-4,1	1,7	2,2	9,5
- Activos fijos inmateriales	2,9	-0,2	3,6	2,6	4,8	0,4	-0,3	-3,3	-2,9	6,0
Variación de existencias	0,0	0,0	-0,1	0,0	0,0	0,1	0,0	-0,1	-0,1	0,0
DEMANDA NACIONAL (*)	-4,1	-2,7	-3,4	-4,2	-4,2	-4,7	-4,3	-3,6	-2,1	-0,6
Exportaciones de bienes y servicios	2,1	4,9	0,1	0,5	3,3	4,4	2,9	9,5	3,5	3,7
- Exportaciones de bienes	2,4	7,2	-0,9	0,5	3,2	6,5	4,6	13,6	6,5	4,3
- Exportaciones de servicios	1,6	-0,1	2,4	0,5	3,6	-0,2	-0,7	1,0	-2,8	2,3
• Gasto de los hogares	-0,5	2,6	-0,1	-1,3	1,4	-2,0	0,8	1,6	2,5	5,6
Importaciones de bienes y servicios	-5,7	0,4	-6,9	-7,7	-4,6	-3,5	-4,9	3,2	0,6	2,7
- Importaciones de bienes	-7,2	1,5	-8,0	-	-5,6	-4,9	-5,6	4,6	2,5	4,7
- Importaciones de servicios	-0,2	-3,7	-3,0	10,1	1,4	-0,9	1,7	-2,4	-1,9	-4,5
• Gasto de los hogares residentes en el resto del mundo	-7,4	1,4	-9,4	-2,6	-9,2	-8,1	-3,8	-2,9	5,0	7,4
PRODUCTO INTERIOR BRUTO a precios de mercado	-1,6	-1,2	-1,2	-1,6	-1,7	-2,1	-1,9	-1,6	-1,1	-0,2
Agricultura, ganadería, silvicultura y pesca	-	1,1	-6,9	-	-11,2	-12,7	-4,1	3,9	0,9	4,1
Industria	-0,5	-1,2	-1,7	-0,7	0,2	0,4	-2,5	-2,1	-0,8	0,3
- Industria manufacturera	-1,1	-0,9	-2,8	-1,8	0,1	0,1	-2,5	-1,2	-0,8	1,2
Construcción	-8,6	-7,7	-9,1	-8,6	-8,7	-7,7	-7,0	-8,3	-7,8	-7,7
Servicios	-0,3	-0,5	0,7	-0,1	-0,4	-1,1	-1,1	-0,9	-0,6	0,5
- Comercio, transporte y hostelería	0,5	-0,2	1,3	0,2	1,0	-0,5	-1,9	-0,2	0,2	1,3
- Información y comunicaciones	0,9	-0,3	0,9	1,3	1,0	0,5	-0,7	1,0	-1,6	-0,1
- Actividades financieras y de seguros	-2,8	-3,3	0,8	1,0	-6,1	-6,9	-3,7	-4,1	-2,7	-2,4
- Actividades Inmobiliarias	1,1	-0,2	0,9	0,8	1,6	1,1	-0,3	-0,6	-0,7	0,6
- Actividades profesionales	-1,9	0,0	-1,2	-2,6	-1,5	-2,2	-0,8	-0,7	-0,5	1,9
- Administración pública, sanidad y educación	-0,5	-0,6	0,4	-0,1	-1,3	-1,1	0,4	-2,0	-0,8	-0,2
- Actividades artísticas, recreativas y otros servicios	-1,7	-0,9	0,7	-2,2	-2,5	-3,0	-2,7	-0,6	-0,7	0,5
Impuestos netos sobre los productos	-4,9	-1,2	-5,0	-4,7	-4,9	-5,1	-2,0	-1,0	-0,8	-1,2
PRODUCTO INTERIOR BRUTO	-1,6	-1,2	-1,2	-1,6	-1,7	-2,1	-1,9	-1,6	-1,1	-0,2

Table 5. Extract from the GDP statistics. Source: INE 2014

Meanwhile, **gross fixed capital formation** expanded its annual rate to -7.0%. This register was supported in the regression of the demand for **capital goods**; a decrease of 4.1% was observed and meant a worsening in their annual progression, moderate in the beginning, 2013. Weakness investment in business was conditioned by the restrictive access conditions to financing, confirming the continuity of the process of deleveraging framed in a context of high uncertainty, a situation that does not favor the start new investment projects.

Most of the adjustment focused, once again, in the negative contribution of investment construction. Historically, the role played by the sector construction is crucial, not only along its expansionary phase, but also in step recession. Since joining the EMU until 2007, the contribution of investment in construction GDP more than 6 points was increased to about 18%, contributing, alone, about 24% of real GDP growth and over 26% of job creation. However, over the past five years, the role of the sector has declined in over 10.4 percentage points of GDP (of which 6.9 points are linked to housing), it explaining a substantial part of the evolution of the real economy and justifies about 60% of job losses in those years.

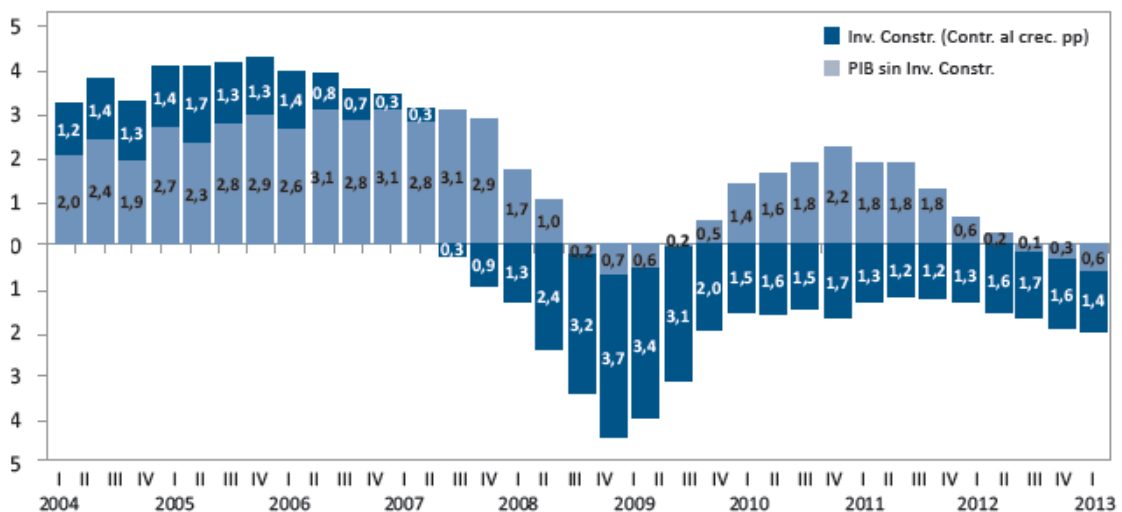


Chart 5. Contribution of the construction investment in GDP growth. Adapted from Seopan

Chart 5 shows the contribution of the construction investment in GDP growth, corroborating their relevant impact on the evolution of the aggregate in recent years. specifically in 2012, construction activity, via demand subtracted the average GDP growth 1.6 points (0.5 points are attributable to residential investment, while investment in other constructions contributed the remaining 1.1 points), having cut in the first quarter 2013 to 1.4 points of GDP, of which 0.5 points this time are attributable to changes in the residential sector, while the rest of the sector (they dominated mostly by civil works) moderate negative contribution to growth to 0.9 points.

In the evolution of the accounts of the **Public Administrations**, it is observed an increase of financing needs, reaching 10.6% of GDP, but excluding aids to financial institutions the deficit was 7%, representing a reduction of 2 points. With reference to the weight of public debt at

the end of the year amounted to 84.2% of the GDP, representing 50 points from its lowest value in 2007. An analysis of the consolidation process since its beginning confirms that fiscal adjustment is focusing on spending, but with a raised impact on capital expenditures, especially public investment. From the perspective institution, it should be emphasized that the effort of process initially focused on the Administration Central and only in 2012 was extended to regional governments. Conversely, Social Security has a gradual worsening, to experience a deficit in the last year.

1.3. Prospects for the Spanish economy and macroeconomic scenario

In the international economic outlook, European financial markets remained at the beginning of 2013 in the climate of gradual improvement that was observed in the second half, 2012. This climate was altered by new episodes of uncertainty associated the results of the Italian elections and expressed difficulties in financial assistance agreement with Cyprus. These episodes temporarily interrupted reduction of sovereign spreads in peripheral countries, and the stock markets and the exchange rate of the euro slowed their upward trends.

According to the latest forecasts, the difference between the yield on Spanish 10-year bonds and German 10-year bond (bund) is expected to continue with the relaxation since the maximum reached in the summer in year 2012 and tending to stabilize over the 150 basic points. See Chart 6 below.



Chart 6. Evolution of the difference between the yield on Spanish 10-year bonds and German 10-year bond. Source: Datosmacro.com

In this context, activity in the euro area continued to contract in the beginning of the year although at a slower pace than in the previous period. Outside the euro area, the path of recovery in the U.S. dominated the international scenario. Also it was confirmed some

improvement in the outlook economic of Japan and finally, the maintaining of the dynamism in emerging economies a slightly moderate profile.

Throughout the first quarter of 2013, the Spanish economy shrank 0.5% on first quarter, compared with 0.8 in the previous quarter. Meanwhile, **domestic demand** turned to go back to record a contribution to aggregated growth of -4.9 points, while external demand increases a tenth its contribution, from 2.8 to 2.9 points.

Most of the demand components showed negative trends in yearly terms and, in the case of **final consumption expenditure**, even greater extent than in the previous quarter, bringing its decline to -3.9%. Spending by government expands its regression two tenths to 4.3%.

Gross fixed capital formation attenuates its decrease by 1.3 points to -9.0%. Attending to different types of assets, the materials show a similar trend to aggregate goods.

The **demand for capital equipment** assets and cultivated assets moderated its decline to -6.5%. Construction investment slowed its decline at one point, going from -12.3% to -11.3%, consistent with the employment data in this sector. this evolution responds to a smaller decline in the demand for investment in infrastructure and other structures, It goes from -15.7% to -13.3% in the first of 2013, offset the greater decrease demand for investment in housing, which has a rate of -9.1 compared to -8.7% of previous period.

Unemployment rate, measured in terms of fulltime jobs (FTE) decreases annual decrease of two percentage points, to 4.5%. As a result of this, 761,000 full-time jobs were destroyed in the year 2013, which only 22 % are attributable to the construction sector, where the average of the previous year was over 33%. Chart 7 presents below the evolution of the unemployment rate within the period 1990 to beginning of 2014.

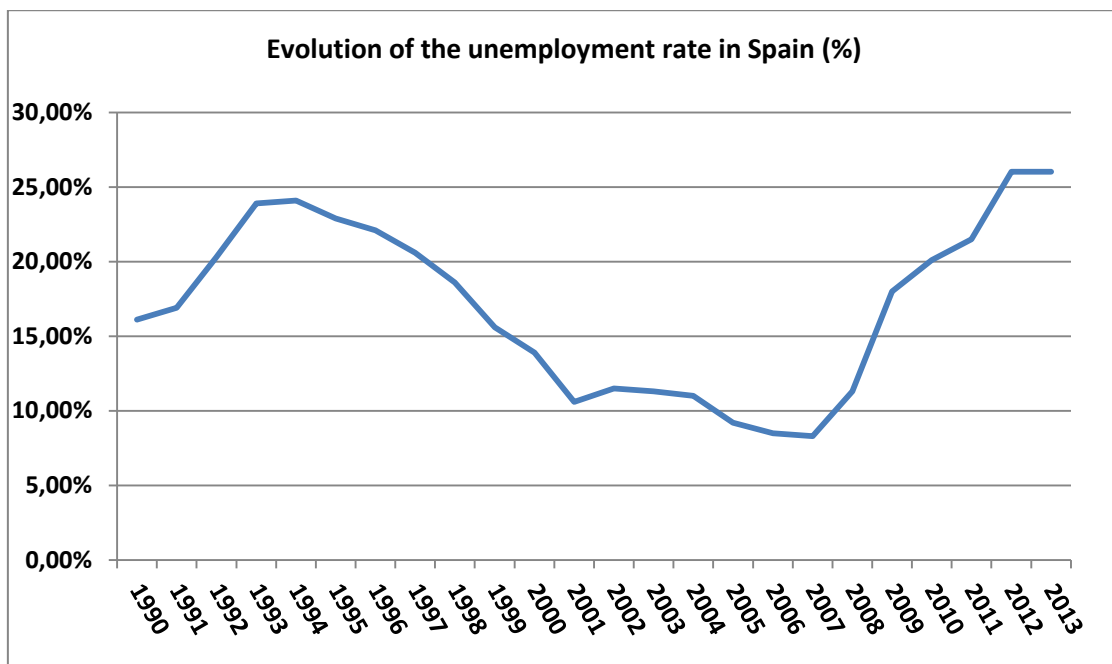


Chart 7. Evolution of the unemployment rate in Spain

Estimates observed in the first quarter of 2013 have been within expected, so that the forecasts do not significantly vary with respect to the formulated beginning of the year. In the coming quarters, the rates will remain negative, however, in the fourth trimester is expected to become rising again (See Chart 8). Therefore, at the time of closing this chapter, predictions determined by the most recent indicators return to a path of gradual improvement in activity.

A noteworthy aspect is the relaxation of the public deficit target for this year and next, which will mean an adjustment of lower intensity and therefore contribute to moderate its contractionary effects on activity. Additionally, it will counteract the worsening the international context, especially in the European context. Regarding factors remaining, no substantial changes were observed in the short term. Thus, the voltagages as result of the sovereign debt crisis have subsided, favoring the reduction of risk premium, which in the short term will not change the financial terms for private sector, which will remain in a restrictive framework. (SEOPAN, 2013) The adjustment the real estate sector still has a long way to go, while processes deleveraging will continue conditioning the spending capacity of families and companies.

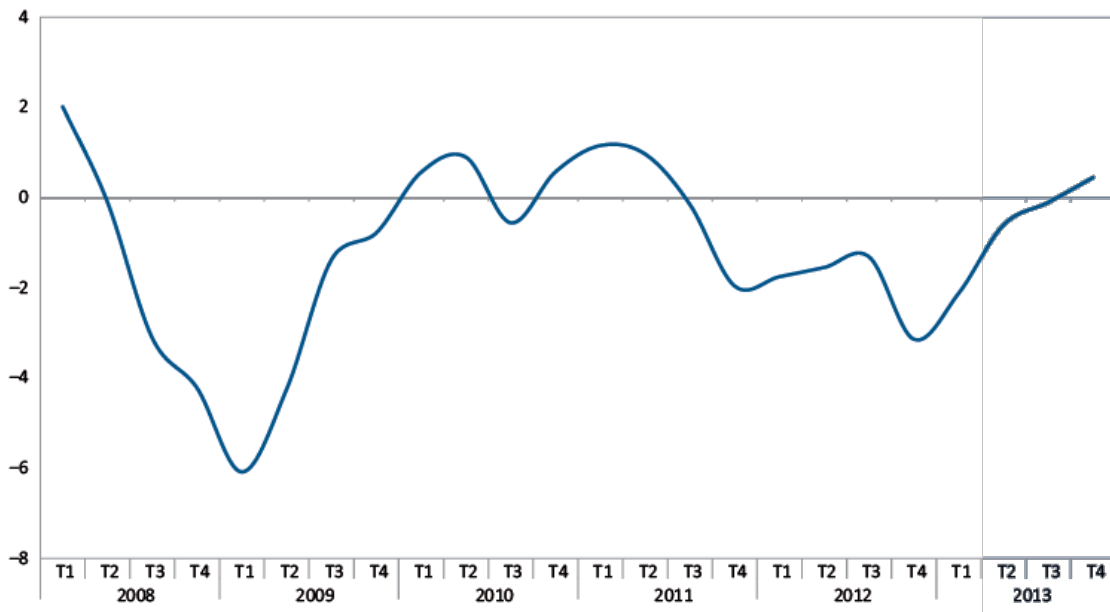


Chart 8. Evolution of the GDP in Spain

The baseline scenario for the Spanish economy is conditioned by the consolidation of improving confidence in the European economy and supported in the recovery and stabilization of confidence markets, which would achieve a rate of decline of 1.5% in 2013, although showing a rising profile as exercise progresses, allowing anticipate modest growth in 2014. Regarding employment, it is estimated for the current year reduction of 3.9 on average.

Private consumption will show a profile of gradual improvement although on average experience higher than the previous year regression. Among the factors that determine this

development include note the reduction in disposable income of families as a result of market developments labor and the increase in VAT. Falling real estate wealth is expected to continue in the short term. On the contrary, the recovery of the net financial wealth, reducing the rate of household savings, the absence of inflationary demand pressures and containment types interest at low levels, they soften the expected contraction in consumption.

Consumption of Spanish regions, in Spanish called “Comunidades Autónomas” will acknowledge the process of fiscal consolidation of public accounts that is expected to intensify in the current year.

Construction investment is determined by the continuity of the adjustment to a new home, which is for the immediate future the need to promote the rehabilitation market recession but also in a more positive and more stable expectations. It should be noted, in demand for housing, starring by foreign citizens whose recovery is estimated around 25% in 2012, racking up three consecutive years of growth, expected keeps in the short and medium term. Regarding the next year, it is estimated that the improvement of the capital markets and the lower level of the stock of unsold homes in some areas of the Spanish geography will be factors that should lead to stabilization investment in housing over the next year. The outlook for non-residential investment have improved slightly as a result of the need for a smaller budget adjustment in public works, although its evolution in the short term, is determined by the budgets public , emphasizing the continuity of adjustment on all regional administrations.

Employment will continue to decline this year, with a lower intensity than that observed in the previous year. Expectations for the next anticipate a growth rate the end of the year with a support contained job creation.

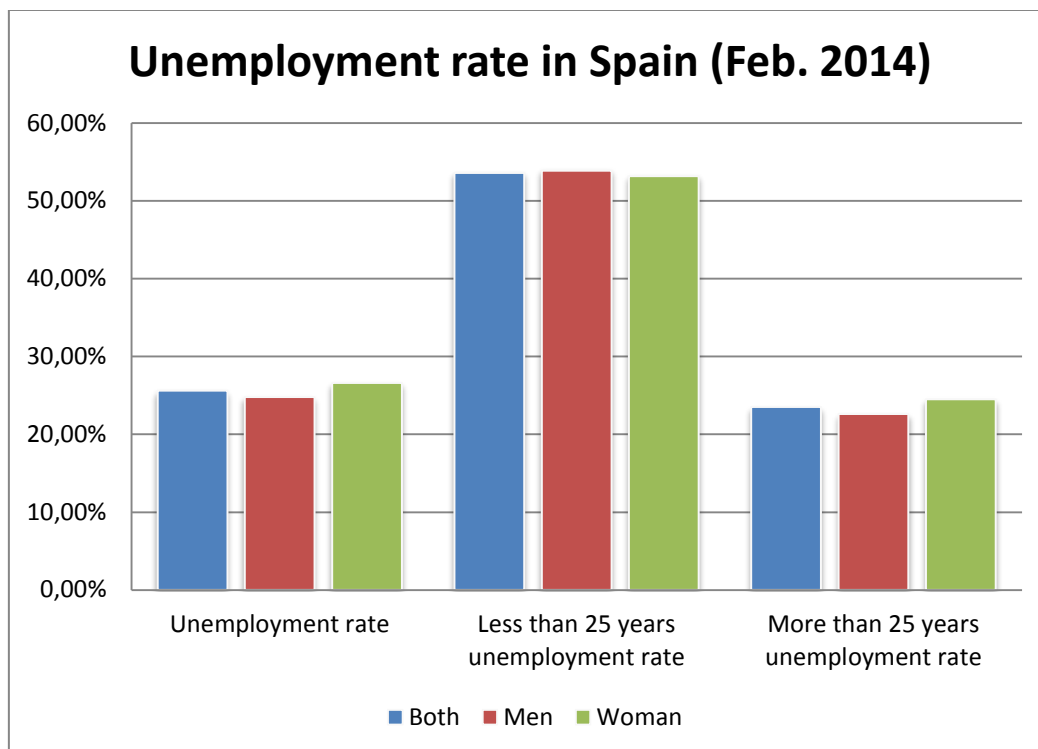


Chart 9. Unemployment rate in Spain. (Feb. 2014)

Undoubtedly, the risk scenario for the Spanish economy would be the lack of gradual confidence recovery in financial markets and, therefore, the failure of economic policy, so it would be in a scenario of extreme financial hardship. It could be stress, differential appearance as compared to the baseline scenario, an additional regression of consumption and investment and in general, experiencing an even sharper recoil construction investment, especially in its non-residential side, and in particular into the related civil works. Additionally, it is estimated the possibility of a less positive contribution of external balance, motivated by a less marked expansion of the international environment. This lower activity delayed the beginning of the recovery, which in turn would move to employment.

Another factor that could add uncertainty to financial markets is the recent local tensions appeared in Ukraine as a result of the toppling of its president. As a result of this, the financial markets have seen a resurgence of tensions on the occasion of the election of a new president in Ukraine. The impact in the short term has been increased volatility in stock markets, acceptable in the short term although the need for continuity in moderation increases with the time. It is therefore urgent to identify and clear these uncertainties at the same time new objectives of the fiscal consolidation process were developed. Moreover, the completion of the restructuring of the financial system and structural reforms still being unfinished.

It is clear that the measures taken have improved growth expectations in the Spanish economy. However, from the European Commission, additional actions in some cases apart from those already implemented are recommended.

2. Construction industry

The economic system of a country is divided into three basic sectors:

- **Primary Sector:** Whose products obtained directly from nature such as raw materials.
- **Secondary Sector:** The activities carried out in this sector transform raw materials into finished or semi-finished products.
- **Tertiary Sector:** It is also considered as a service sector, producing no goods but services.

The construction has been linked from the beginning to the secondary or industrial sector, but due to its importance in the production and unique aspects compared with other industries requires its study to be done separately (Rico, 2001). The construction industry presents characteristics that determine the existence, structure and functioning of firms operating in this market (Pellicer, 2003).

The construction activity is very sensitive to economic changes and plays, extended, fluctuations in the general economy. The importance of these effects makes it a sector with great power employment induction and activity for other industries so it has been given the nickname “locomotive of the economy” (Rico, 2001). The importance of this sector is based on three essential characteristics: its size, its consideration as investment good and its dependence on the public sector (Llorca and Fernández, 2006).

2.1. Characteristics of the construction industry

Rico (2001) lists some characteristics of the construction industry that differentiates it from other industrial sectors so that it makes it unique in many aspects:

- The construction activity is usually **carried out in the outside**.
- **The final product is not transportable**. The production center is located in the place where works will be carried out, and once it is completed, production center disappears.
- **Diversity of products**. All building products are different.
- The sector is related to unequal demands and whose scattered works function, size and location are different. Among the customers who demand products there are public and private.
- **Market fragmentation**. The differences that exist between the building and civil engineering construction classify the activity of construction companies.
- **Intensive use of labor**. The construction industry uses largely labor of low-skilled and high mobility.
- **Close relationship with the economic cycle**. The more developed is a society, the greater demand for construction activities.
- **Poor organization of production**. This is a result of a large number of factors involved, and there are many materials and many different forms to reach the same result.
- **Greater reliance on local suppliers**. As the company builds where it is required, then contact local suppliers.
- **Strong environmental impact**. The extraction of materials is an activity that strongly degrades the landscape. The construction material used in manufacturing consumes lot of energy.
- **Long product life**. During the life of the product many maintenance costs are involved.
- Separation from design and construction activities. It exists total clearance between project activities and implementation.
- **Overspending**. Practically all works end up costing customer more than originally budgeted. Theses deviations arise from what is been projected and finally executed.
- **Participation of many professionals**. Landowners, professionals for project development (roads engineers, technical architects, architects), Local Governments, Municipalities and Communities Autonomous, builders and installers, notaries and registrars property, legal and tax advisors, brokerage firms the housing market, publicity and advertising companies, banks and savings, public finance clients (Llorca and Fernandez, 2006).

According to the characteristics above, it follows that the sector is characterized by "the production of heterogeneous and disparate goods that are made in many places and circumstances, capable of machining processes and working on most occasions on request without power, thus extending too much on the time horizon of their activity" (Pellicer et al., 2004).

The singularities of the final product and the construction activity itself make the construction industry to show little transparency in the market. This level of transparency which is dispersed and fragmented leads Company to present strong fluctuations. Therefore, companies should be flexible, allowing their production to accommodate their demand structures (Pellicer, 2003).

The construction sector is constituted mostly of small size companies, which try to adapt themselves to what the demand requires. An important part of these companies are dedicated to ordinary repairs (usually buildings) and small rural works. The other fraction is outsourcing, which has a strong dependence with the main contractors. In this sense, outsourcing can be defined as "that part of the construction activity that is not executed with materials or personal media own by the companies that hire or work awarded directly without they will give up their implementation of all or part to other companies, however, it is the company which has ultimate responsibility" (Pellicer, 2003).

2.2. Structure of the construction industry

The criteria used in the specialized statistical and economics documents in Spain and also in the EU coincide in the definition of the construction industry as the group of companies whose business are directly related with the execution of complete works or parts of them, both building and civil or industrial engineering. Regarding productive activities are conventionally grouped by the type of work performed such as:

- **Residential building:** It specifically relates to residential construction.
- **Non-residential building:** Under this category are grouped buildings which are not dedicated to housing such as hospitals, theaters, stadiums, schools, etc.
- **Rehabilitation and maintenance:** Activities that are carried out in residential or non-residential buildings.
- **Civil Works:** Construction and maintenance of infrastructure such as roads, dams, canals, airports, ports, etc.

The following Table 6 shows the weight of each of these activities in the construction sector in the year 2013:

Activities	Weight
Residential building	26.3%
Non-residential building	17.8%
Rehabilitation and maintenance	28.6%
Civil Works	27.3%
TOTAL	100%

Table 6. Types of activities within the construction industry. Source: SEOPAN

These four groups define the subsector through which the construction industry is analyzed, especially from the point of view of production and business.

In the same way, these subsectors are composed by a wide list of activities collected in the National Classification of Economic Activities (CNAE, 2009) which for the construction industry are grouped under the following types of activities:

F Construction

- **41 Construction of buildings**
 - **411** Property development
 - **4110** Property development
 - **412** Building construction
 - **4121** Construction of residential buildings
 - **4122** Construction of non-residential buildings
- **42 Civil Engineering**
 - **421** Construction of roads and railways, bridges and tunnels
 - **4211** Construction of roads and motorways
 - **4212** Construction of railways and underground railways
 - **4213** Construction of bridges and tunnels
 - **422** Construction of utility
 - **4221** Construction of utility projects for fluids
 - **4222** Construction of electrical networks and telecommunications
 - **429** Construction of other civil engineering projects
 - **4291** Water works
 - **4299** Construction of other civil engineering projects
- **43 Specialized construction activities**
 - **431** Demolition and site preparation
 - **4311** Demolition
 - **4312** Preparation of land
 - **4313** Drilling and boring activities
 - **432** Electrical, plumbing and other construction installation works
 - **4321** Electrical installations
 - **4322** Plumbing, heating and air conditioning
 - **4329** Other facilities in construction
 - **433** Building completion
 - **4331** Plastering
 - **4332** Joinery installation
 - **4333** Floor and walls
 - **4334** Painting and glazing
 - **4339** Other building completion
 - **439** Other specialized construction activities
 - **4391** Construction of decks
 - **4399** Other specialized construction activities

These divisions and subdivisions in particular types of work and activities, show the enormous complexity of the sector.

2.3. Classification of the construction companies

➤ **Depending on size:**

The types of companies in the construction sector are very similar throughout the country and form a pyramidal shape. In the dome, in a very small number, large companies that are active throughout the territory. The intermediate zone is composed of medium-sized companies, whose business is conducted at the regional level, and finally a huge number of small businesses operating in local markets.

Among the reasons mentioned to explain the structure in the companies related with the construction industry, where small companies predominate, is the specialization of activities; in particular, differentiation between residential construction and civil works.

Occasionally, companies are distinguished by size considering the amount of money billed per year, as it is shown in the next classification:

- **Very large size companies:** Those whose billing is over 60 million euros.
- **Large size companies:** Those whose billing is between 30 and 60 million euros.
- **Medium size companies:** Those whose billing is between 6 and 30 million euros.
- **Medium-Small size companies:** Those whose billing is between 3 and 6 million euros.
- **Small size companies:** Those whose billing is between 0.3 and 3 million euros.
- **Microcompanies:** Those whose billing is below 0.3 million euros. Represent up to 30% of total companies in the construction industry.

According with the percentage of each of these groups indicated in lines above, microcompanies predominate as a form of business organization and, in the case of building, especially in maintenance and reform activities becomes more pronounced.

➤ **Depending on number of employees:**

Other classification for the companies of the construction industry, more used in official documents, regards about the size of their workforce. The structure of this classification is not far from the classification of the construction companies by size. In this case, the shape is more similar to a bell where small and medium size companies represent great part of the total of the companies. Firstly, microcompanies employ less than 10 salaried. In second place, Small and Medium size companies are those whose workforce is between 10 and 250 salaried. Lastly, large size companies are those with more than 250 salaried in their workforce.

Similarly, the Spanish Ministry of Development, in its surveys and cyclical statistics, analyzes the size of the companies by using seven layers related to the size of the workforce as it is displayed in Table 7 next page.

Size of the companies by number of employees	
Layer 1	Companies with less than 10 employees
Layer 2	Companies between 10 and 19 employees
Layer 3	Companies between 20 and 49 employees
Layer 4	Companies between 50 and 99 employees
Layer 5	Companies between 100 and 249 employees
Layer 6	Companies between 250 and 499 employees
Layer 7	Companies between 500 and 999 employees
Layer 8	Companies with more than 1000 employees

Table 7. Classification of the construction companies according to size of their workforce

2.4. Agents involved in the construction industry

Due to the complexity and heterogeneous of the sector, in which many agents are involved, and each agent tries to defend their respective interests, these agents are (Rico, 2001):

- Customer.
- Designers.
- Contractor.
- Subcontractors.
- Manufacturers and suppliers.
- Construction Staff.
- Buyers and users.

Customer of the infrastructures/building is the promoter, who is the person who orders the construction can be public or private, depending on whether the work to be run is a public or private construction work. Over 90% of the construction investments in Civil engineering works are funded by government (Pellicer et al., 2004).

Designers are the practitioners designed by the promoter in order to design and develop all the necessary documents so the infrastructure/building can be built.

Contractor: Construction Company designed by the promoter who is responsible for the building of the infrastructure/building.

Subcontractors: Frequently, the main contractor outsources with other construction companies some parts of the work or activities which requires for specialized companies.

Manufacturers and suppliers are responsible for supplying of needed materials and equipment.

Construction Staff: Composed by site managers who manage the worksite and supervise the development of the construction. Laborers are responsible for a proper construction of the infrastructure/building.

Buyers and users are the final customers who enjoy the infrastructure/building.

3. Construction industry in Spain

3.1. Construction evolution

It is well known the influence of construction in the global economic activity cycle. Over the past four years, its role has been reduced by the current period of crisis, now showing its dark side.

Its incidence lies in the transcendental effects it has on the drag assembly economy, acting both "backwards" due to the boost that construction activity has on other sectors intermediates suppliers (defined by doctrine economic direct effect) as "forward", to provide the necessary infrastructure for the development of other economic activities, thus contributing to the increase productivity and capacity for long-term growth of the economy, especially the private sector (indirect effect).

In the case of the Spanish economy, it has been especially prominent role to over the last period of growth that began in the mid-nineties, but their increasing participation began to intensify in the end of that period. In that phase, the construction sector had acted as a driver of economic growth, both directly (through the demand) and indirectly (through the offer). This cycle of dynamism stemmed from several factors, including its impact on the sector include point, the observed drop of interest rates to record lows, after entry the Economic and Monetary Union, the massive influx of labor from immigration and the significant financial contribution made by the Structural Funds European.

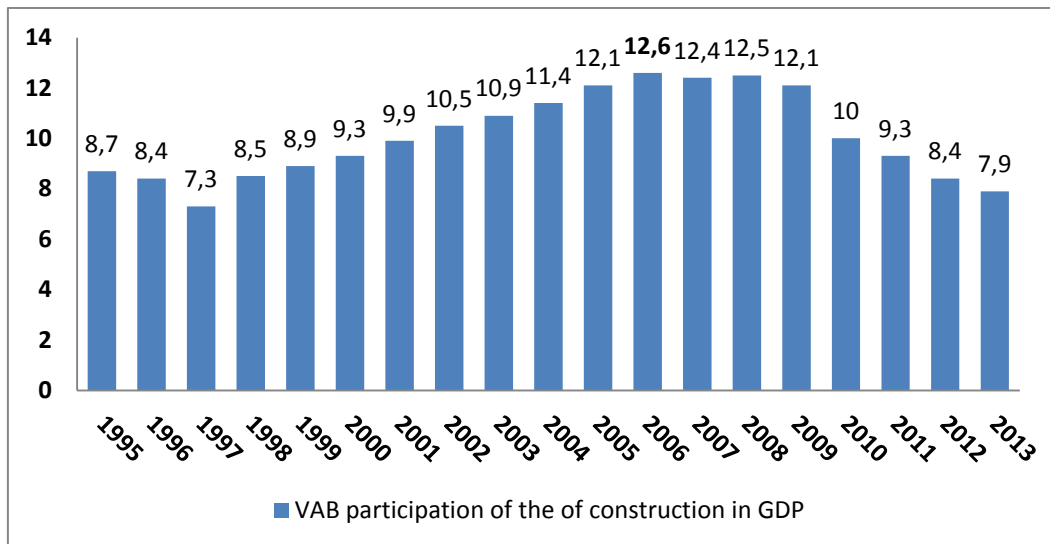


Chart 10. GVA participation of the construction in GDP

From a historical perspective presented in Chart 10 above these lines, the analysis of the evolution of the **Gross Value Added of construction (GVA)** confirms that between the years 1996 and 2006 grew at an average annual rate of 6.0%, compared to 3.8 % growth registered

by the total GVA. That progression led to increases the share of construction in GDP, from 7.3 %, minimum observed in 1997, to a record high of 12.6 % registered in 2006.

In the first part of 2006 , when a cyclical peak reached in activity from adjustment which initially observed moderate character, but gradually intensified throughout 2007 to record negative rates in the following year and reach a cyclical low, less than 15%, in mid-2010. Below is confirmed progressive reduction until end of 2011 with an average annual rate of -4.5%, recording higher by more than 11 percentage points to points a year earlier. Then the developmental profile was deteriorated until the second half of 2012, confirming a change cycle in the first quarter of 2013, from a rate of -8.5 % in the previous period to -6.3 %.

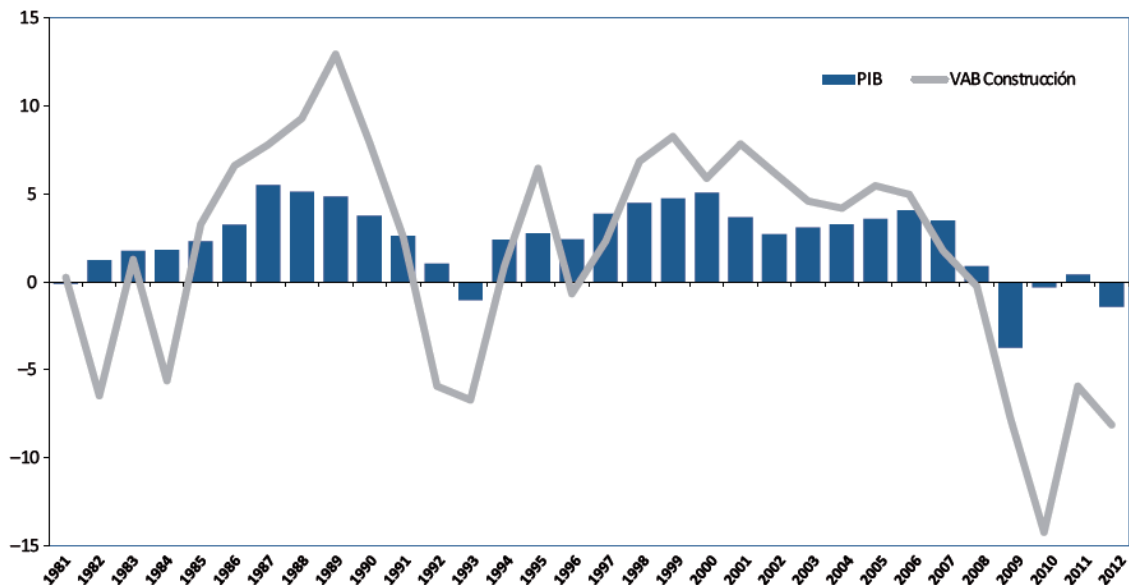


Chart 11. The construction cycle and GDP

Regarding the **evolution of the level of employment**, measured in terms of jobs full-time equivalents, the high level of job creation is confirmed coinciding the expansionary phase of the activity, with an estimated increase to an average annual rate than 8%. Subsequently, the decline in activity contributed to the destruction of 11.7 % of employment in 2008 and 21.2% in 2009, moderating job loss in the 2010 to 12.6%. However, in the last two years further deterioration is recorded bringing the year to -15.7% and -18.6% rate in 2012. This has meant that employment in the construction has increased from 10% of the total in 1996 to 14 % in 2007 to below down, to participate with 7% of total employment in the last year. Despite of recent developments, the number of workers employed in the sector rose to 1.1 million in 2012, slightly lower than the 1.2 million employed in 1996.

The evolution of employment, confirms its parallelism with the progression of the activity, showing a similar evolutionary path. Thus, measured in terms of jobs full-time equivalents, the sector experienced a change in the last year of -18.6% compared to -15.6% of previous year. However, the quarterly profile observed throughout 2012, determines a first posterior

stabilization and moderation in its decline, reaching in the first quarter current rate of destruction of high and estimated at -14.1% employment rates. In the last five years, the crisis in the sector accumulates the destruction of 1.6 million jobs, representing more destroyed 60% of total employment. However, membership figures confirm the Social Security moderating job losses in the latter part of 2012 and beginning of the current.

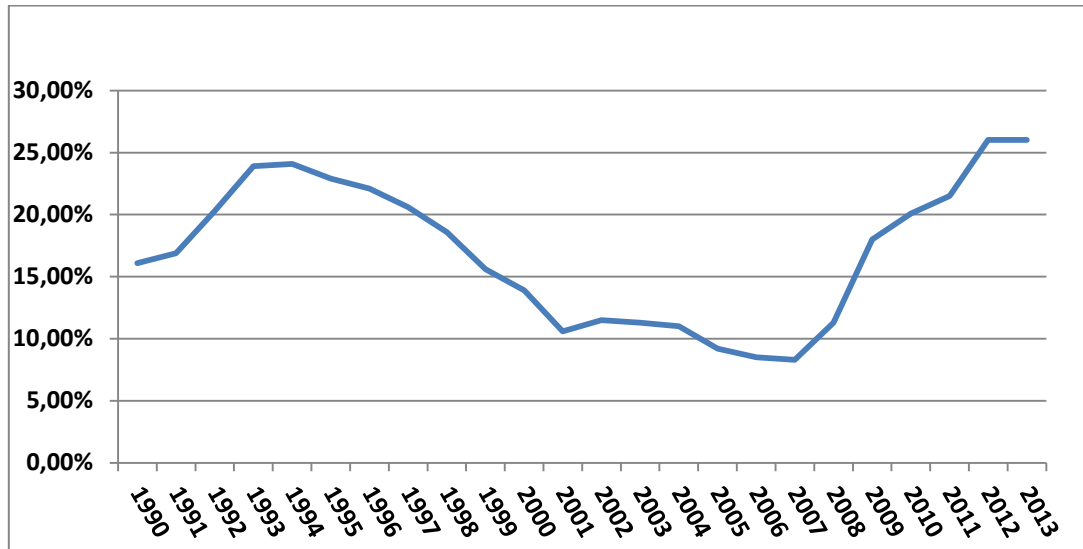


Chart 12. Evolution of the unemployment rate in Spain

From the analysis of the main indicators, representative of the short-term evolution of activity in the construction sector, a change of cycle is confirmed in the second half of 2012. This new attenuation step drop in activity, in general, is registering more rapidly in employment figures and consumption, while indicators of national accounting collect it with a delay, close to two quarters. It can therefore be seen passing a new cyclical low activity, estimating its consolidation throughout 2013. However, other indicators do not provide as accurate information on the cyclical activity. Thus, the value of **production index** of construction companies declined in real terms by 6% in 2012, after having decreased by 13% the previous year. In this indicator contained attends a fall, even an increase in the second part of year but instead begins 2013 showing a slight decline. In the field of building the recoil is less pronounced compared to that observed in civil engineering.

The indicator of the **number of completed houses** shows a continued and deeper retracement to over the past five years. Thus in 2012 120 thousand homes were completed, representing a decline cumulating to 81% (taking as reference the 641,000 completed homes in 2007, the highest of the series). The temporal correlation of this indicator with activity, we recall the existence of a reflection delay time of registration of certification end (depending on the source that delay can range from two to five months) so that part of the adjustment observed in the last period is attributable to the previous financial year.

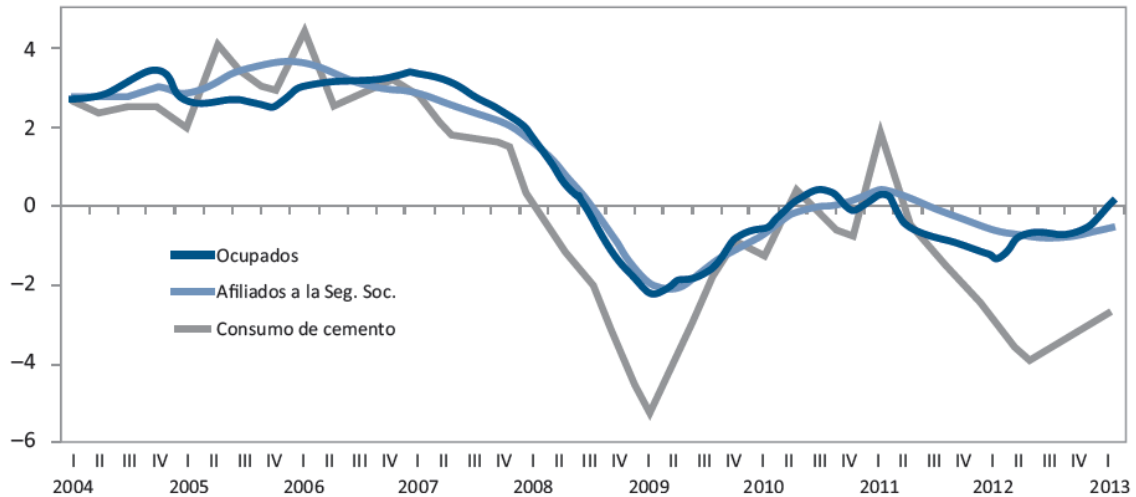


Chart 13. The activity of construction in Spain

The **business confidence indicators** show accusing major deterioration intensity somewhat lower than the previous year and in line with the evolution of the remaining indicators activity. Meanwhile, both the index of industrial climate and the confidence index, recorded significant negative balances, highlighting those observed in the home.

The **orders for goods**, valued at days of guaranteed work, remains at levels similar to those observed in the previous exercise. In either case, these figures are anticipating a framework still very regressive activity for 2013. Responses concerning the limiting factors production, also highlight the weakness in demand over 2012: 58% of respondents are concerned about the weak demand, especially in the private, although this represents an improvement over the 70% observed in the previous exercise.

3.2. Indicators used for measuring the evolution of the sector

As it has been already mentioned in lines above, the evolution of the sector affects the entire state economy but, in turn, it is one of the most sensitive sectors directly affected to the economic cycles. In general, economic studies agree on measuring construction activity during certain periods as well as forecasts for the future, through the following three indicators:

- The volume of official bidding.
- The number of housing starts.
- The rate of increase of the contribution of the sector to GDP.

The first factor has a great impact in the construction activity, if we consider that a large percentage of civil engineering and non-residential construction are contracted by the government.

The second factor indicates the evolution of most of the remaining activities such as residential construction (which excludes the activity for the reconstruction and rehabilitation), and is a reflection of the demand for real estate. A lack of a more accurate indicator, the number of

housing starts shows comparatively the evolution of activity during different periods. Housing demand depends primarily on demographic and economic factors. In the longer term, demographic influences specifically in the growth of the total population, the characteristics of migration flows and the age structure of the population.

Among socioeconomic factors, we can find the impact on unemployment with economic cycles. It is suggested that unemployment, which affects mainly young women, directly negative impact on housing demand, reducing the formation of new households and delay the parental home leaving. From the point of view for only strictly economic factors which have affected the housing affordability: the average price of housing, family income, the interest rate of mortgage loans and repayment terms.

Meanwhile, the third factor is related with the growth rate of GDP and is quite determined by investments in industrial buildings, investment in infrastructure, office buildings and housing.

3.3. Spanish construction industry nowadays

In this chapter a brief description of the values obtained from the Spanish construction industry in 2013 is presented. Also a comparison is made with the data obtained in 2012, for the different variables that are involved in the construction activity.

3.3.1. Number of companies

The number of companies active in the construction sector during 2013 in throughout the country was 320,872, representing a decrease of the previous year of 6.25%. This decrease is more pronounced in size businesses medium (10-249 employees).

The results, ranked by the size of the company (stratification by number of employees) and groups of activity where the company has presence are displayed in Tables 8 and 9. Also the percentage to total construction companies operating in the country.

Stratification by number of employees	Year 2012	Year 2013	Dif. 2012/2013 (%)
Companies without salaried employees	182,036	171,211	-5.95
Companies with less than 10 employees	139,747	134,983	-3.41
Companies between 10 and 19 employees	12,547	9,435	-24.8
Companies between 20 and 49 employees	6,154	3,995	-35.08
Companies between 50 and 99 employees	1,096	741	-32.43
Companies between 100 and 249 employees	499	360	-27.85
Companies between 250 and 499 employees	98	78	-20.84
Companies between 500 and 999 employees	45	39	-13.33
Companies with more than 1000 employees	35	30	-14.2
TOTAL NUMBER OF COMPANIES	342,257	320,872	-6.25

Table 8. Number of companies by strata of employees. Source: M.FOM 2014

Groups of activity CNAE 2009	Year 2012	Year 2013	Dif. 2012/2013 (%)
41.1 Property development	54,206	36,092	-33.42
41.2 Building construction	130,702	127,568	-2.4
42.1 Construction of roads and railways, bridges and tunnels	1,298	1,101	-15.17
42.2 Construction of utility	608	573	-5.78
42.9 Construction of other civil engineering projects	1,168	1,054	-9.72
43.1 Demolition and site preparation	10,525	10,116	-3.89
43.2 Electrical, plumbing and other construction installation works	68,393	72,943	6.65
43.3 Building completion	66,589	62,862	-5.6
43.9 Other specialized construction activities	8,768	8,563	-2.34
TOTAL NUMBER OF COMPANIES	342,257	320,872	-6.25

Table 9. Number of companies by groups of activities. Source: CNAE 2009

3.3.2 Number of employees

The total number of people employed during the year 2013 in the construction sector was 1,112,233. Compared to the previous year, it can be noted a decrease in the number of employees (-6.25%) respect year 2012.

The decomposition by company size (employee strata) and the activity pursued is shown in the Tables 10 and 11.

Stratification by number of employees	Year 2012	Year 2013	Dif. 2012/2013 (%)
Companies without salaried employees	216,118	190,926	-11.66
Companies with less than 10 employees	448,740	427,178	-4.81
Companies between 10 and 19 employees	172,074	128,173	-25.51
Companies between 20 and 49 employees	183,550	119,350	-34.98
Companies between 50 and 99 employees	75,976	51,629	-32.05
Companies between 100 and 249 employees	74,451	55,348	-25.66
Companies between 250 and 499 employees	33,108	27,543	-16.81
Companies between 500 and 999 employees	30,375	27,754	-8.63
Companies with more than 1000 employees	88,977	84,333	-5.22
TOTAL NUMBER OF EMPLOYEES	1,323,371	1,112,233	-15.95

Table 10. Number of employees by strata of employees. Source: M.FOM 2014

Groups of activity CNAE 2009	Year 2012	Year 2013	Dif. 2012/2013 (%)
41.1 Property development	109,092	69,971	-35.86
41.2 Building construction	514,481	417,141	-18.98
42.1 Construction of roads and railways, bridges and tunnels	65,085	46,689	-28.27
42.2 Construction of utility	28,809	26,790	-7.01
42.9 Construction of other civil engineering projects	23,374	19,455	-16.77
43.1 Demolition and site preparation	45,654	37,988	-16.79
43.2 Electrical, plumbing and other construction installation works	319,761	304,511	-4.77
43.3 Building completion	155,030	135,415	-12.65
43.9 Other specialized construction activities	61,723	54,274	-12.07
TOTAL NUMBER OF EMPLOYEES	1,323,371	1,112,233	-15.95

Table 11. Number of employees by groups of activities. Source: CNAE 2009.

3.3.3. Personnel costs

The total amount of laborers employed in the construction sector has generated costs that amounted to 27,702.9 million euros in 2012, 17.58% less than the costs of 2013, in line with the decrease in the number of people employed in the sector.

Contributions of individuals (autonomous) are included in the chapter on Social Security costs. The following Table 12 presents the personnel costs of the year 2012 and 2013 and its variation in %. Costs are expressed in millions of euros.

Personnel Costs	Year 2012	Year 2013	Dif. 2012/2013 (%)
Net wages and salaries	25,011.8	20,523.8	-17.94
S.S.	7,626.34	6,299.8	-14.40
Allowances	698.7	641.8	-8.15
Contributions to pension plans	21.5	19.0	-11.72
other social costs	254.34	218.9	-13.95
TOTAL STAFF COSTS	33,612.8	27,702.9	-17.58

Table 12. Structure personnel costs (EUR million)

3.3.4. Value of production

In 2013 the value of real output by construction companies and individuals (self-) construction amounted to 119,303.4 million euros, a decrease of 23.55% over the previous year.

The structure of production value with respect to other variables (company size by number of employees and by groups of activity) is reflected in the Tables 13, 14 and 15.

Components	Year 2012	Year 2013	Dif. 2012/2013 (%)
Intermediate consumption	105,533.9	78,201.0	-25.90
Gross value added at factor cost	49,404.3	40,579.3	-17.86
Personnel costs	33,612.8	27,702.9	-17.58
Gross operating surplus	15,791.6	12,876.4	-18.46
Taxes (net of subsidies)	1,119.6	523.1	-53.28
TOTAL VALUE OF PRODUCTION	156,057.9	119,303.4	-23.55

Table 13. Value of the production by components. (EUR million)

Stratification by number of employees	Year 2012	Year 2013	Dif. 2012/2013 (%)
Companies without salaried employees	18,033.8	13,865.0	-23.12
Companies with less than 10 employees	37,089.4	32,293.5	-12.93
Companies between 10 and 19 employees	16,673.1	12,386.1	-25.71
Companies between 20 and 49 employees	21,113.6	15,658.7	-25.84
Companies between 50 and 99 employees	12,045.3	7,755.7	-35.61
Companies between 100 and 249 employees	14,488.5	9,518.8	-34.30
Companies between 250 and 499 employees	6,418.3	6,273.5	-2.26
Companies between 500 and 999 employees	7,813.4	4,512.8	-42.24
Companies with more than 1000 employees	22,382.4	17,039.3	-23.87
TOTAL VALUE OF PRODUCTION	16,057.9	119,303.4	-23.55

Table 14. Value of production by strata size (EUR million)

Groups of activity CNAE 2009	Year 2012	Year 2013	Dif. 2012/2013 (%)
41.1 Property development	31,627.3	20,942.9	-33.78
41.2 Building construction	53,520.7	42,480.3	-20.63
42.1 Construction of roads and railways, bridges and tunnels	15,286.9	10,746.0	-29.70
42.2 Construction of utility	4,756.5	4,163.1	-12.48
42.9 Construction of other civil engineering projects	3,729.8	2,977.7	-20.17
43.1 Demolition and site preparation	4,499.4	3,876.4	-13.85
43.2 Electrical, plumbing and other construction installation works	28,374.4	23,498.0	-17.19
43.3 Building completion	8,309.9	6,464.8	-22.20
43.9 Other specialized construction activities	5,953.0	4,154.2	-30.22
TOTAL VALUE OF PRODUCTION	156,057.9	119,303.4	-23.55

Table 15. Value of production by groups of activities CNAE 2009. (EUR million)

3.3.5. Concrete consumption

The apparent consumption of concrete in 2013 confirms regression and continues with the downward trend started in 2007. A decrease in the concrete consumption of -34.3% is estimated respecting year 2012. Its evolution throughout the year points to a gradual slowdown, even in the first quarter of this year although the concrete consumption has reached values never seen before since the beginning of the 70s decade.

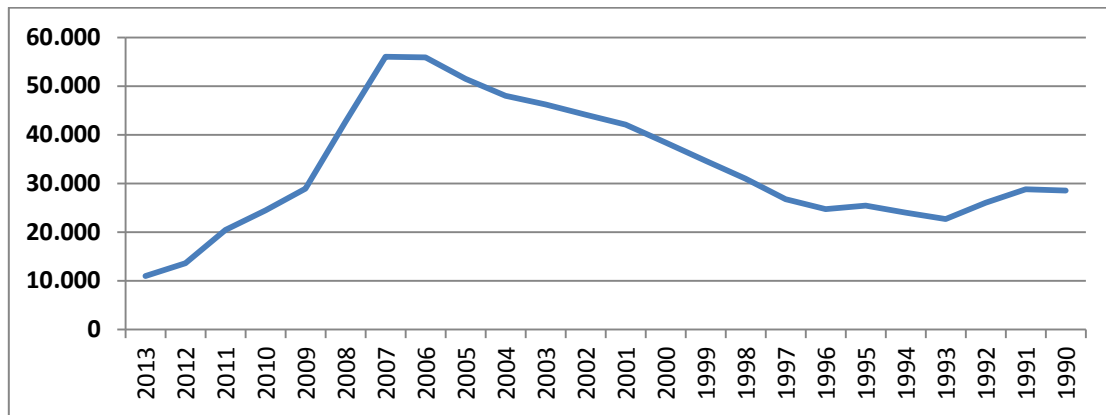


Chart 14. Concrete consumption (thousand Tons)

3.3.6. Turnover from construction activities

In this section, the value of turnover from construction activities during year 2013 is shown. The turnover from construction activities in 2013 amounted to 114,957.8 million euros. It is not included the resale value of goods and services purchased for resale in the same condition in which they were acquired. As shown in Table 16, in 2013, the volume of building business activity (53.66%) is double than the turnover from Civil Engineering (26.54%). Property development represents 19.80% of the total business volume within construction activities.

Type of work	Value (EUR million)	% total
Property development	22,759.5	19.80
Edification	61,684.7	53.66
<i>Residential</i>	38,479.3	33.47
New construction	17,369.8	15.11
Restoration and conservation	21,109.5	18.36
<i>No Residential</i>	23,205.4	20.19
New construction	12,676.2	11.03
Restoration and conservation	10,529.1	9.16
Civil engineering	30,5013.6	26.54
New construction	22,549.2	16.62
Restoration and conservation	7,964.4	6.93
TOTAL TURNOVER	114,957.8	100.00

Table 16. Turnover from construction activities by type of work

Chapter 3

**THEORETICAL FRAMEWORK:
LABOR PRODUCTIVITY
AND LEAN PHILOSOPHY**

1. Construction Labor Productivity: Definition and main characteristics

1.1. An introduction to productivity

The first time the word productivity was named can be traced back to 1766 when it was first mentioned in an article by Quesnay (Vaggi 1987). In 1950, the Organization for European Economic Cooperation (OEEC) introduced a formal definition of productivity as “a quotient obtained by dividing output by one of the production factors” (Sumanth 1984). Consequently, many different ways about speaking about the productivity became possible such as capital, investment, or raw materials according to whether the output is being considered in relation to capital, investment, or raw materials (Sumanth 1984).

Nowadays, according to the dictionary of the Royal Spanish Academy (RAE), productivity is a concept that describes the link between what is produced and the means that have been used to get (labor, materials, energy, etc.). Productivity is often associated with efficiency and time: the less time spent on achieving the desired outcome, the greater the productive nature of the system. Other definition for the term productivity can be found at Cambridge’s dictionary defines productivity as the rate at which goods are produced. (Cambridge 2014). Regarding this definition, the term “productivity” denotes a relationship between output and the associated inputs used in the production process. Moreover, the Concise Oxford Dictionary defines productivity as the *power of being productive, efficiency* and also matches with the Cambridge’s dictionary in defining productivity as the *rate* at which goods are produced. Three different components of the concept of productivity are brought out by this definition as Yi and Chan (2013) explain:

1. *Power of being productive* is the force behind production itself.
2. *Efficiency* is a measure of how well the factors are used for producing the goods.
3. *Rate* is a measure of the output of the factors of production over a defined period of time.

Productivity tests the ability of a structure to develop the products in the level at which the available resources are used. Obtaining better productivity implies higher returns for each company. In a company, productivity is essential to grow or increase profitability. To achieve good productivity it should be analyzed in detail the methods used in the operations and how the time is spent during carrying out an activity in order to minimize the time spent or lost during developing a specific activity. There exist many strategies which aim a productivity increment; most of them focus on the incremental reductions of waste of time, queue time, and other non-value adding activities. By eliminating wasteful time elements along the manufacturing process, workers are able to spend more of the working day producing products. However, in this research other strategies will be considered. Thus, a study regarding the impact of different factors have on labor productivity will be carried out.

Finally, trying to find a synonym of the term, effectiveness could be one since both productivity and effectiveness require good management of resources to achieve a relationship as high as possible of the resources used for producing one item and also in terms of the methods utilized for its production.

1.2. Defining Labor Productivity

Since construction is a labor-intensive industry Thereby, it can be argued that manpower is the dominant productive resource, thus construction productivity is mainly dependent on human effort and performance (Jarkas 2010). In this way, labor productivity becomes crucial because of the concentration of manpower needed to carry out a specific task.

While there exist numerous measures of performance, construction labor productivity is related directly to cost and schedule performance. If the labor productivity is poor, both the cost and schedule performance will probably poor. If the project is accelerated, schedule performance may improve, but the cost performance is likely to be poor. If the project is “done-on-the-cheap” the cost performance may be satisfactory, but at the possible expense of subpar schedule performance. Only when there is good labor productivity, is there a high probability that both cost and schedule performance will be satisfactory.

There are two aspects involved in the construction labor productivity definition. The first one is related with what is produced in a finite period of time (output or quantities of produced products) and the craft hour over the same period of time needed to produce the output (input or work-hours needed). The most common and widely recognized measure of labor performance is the unit rate that is defined as follows in (4):

$$Unit\ rate = \frac{Input}{Output} = \frac{Workhours}{Units\ of\ work} \quad (4)$$

One of the most widely used outputs for measuring labor productivity in construction is hourly outputs, thereby, using a labor hour as the input unit and the units of completed work as output. For instance, when pouring concrete in a slab, then it is used a labor hour as input and the cubic meters of concrete placed as output. For concrete pouring, labor productivity can be expressed as hours per cubic meter or cubic meter per hour. When labor productivity is defined as the ratio between work-hours and units of work produced, lower productivity values indicate better productivity performance. As Eastman and Sacks (2008) suggest, measurement by hourly output helps to avoid many external factors than cause cost variance.

Thus, the measurement of labor performance (productivity) by hourly output is a function of inputs and outputs and it is also commonly recognized as a reliable manner for productivity measurement in construction operational activities.

2. Measurement of the productivity

2.1. Why measuring productivity?

Improving productivity is a major concern for any profit-oriented organization, as representing the effective and efficient conversion of resources into marketable products and determining business profitability (Wilcox et al, 2000).

The measure of productivity has great impact in final contractor’s profit. Productivity can be measured by two different ways. The first one is based in estimations on the broad conditions

under the work will be carried out and it must be done during the period when a construction company is making its estimations for the bidding phase. In this phase, all interested companies in the work studies the project and basing in their human and material resources estimations try to set the lowest price for its execution. In the Spanish bidding system for public works there exist more than one variable that must be taken into account in a public bidding such as total time of execution, total budget, etc. However in some occasions the only variable chosen to elect the winning company is the difference between the original budget and the budget offered by each company. In other words, the amount of money that in theory the tendering organization or public administration would save itself. Once awarded the contract, the winning company in charge of the construction must ensure that the level of productivity estimated in the bidding phase is achieved or even bettered. So, in this case, construction companies are interested in the cumulative average productive value which would be measured while an activity is being carried out. If productivity levels do not reach estimated or projected levels by project managers, the contractor in charge of the construction works will need more time with the same number of resources or by the contrary, increase the number of resources involved in a determined task or activity which consequently will increase the scheduled budget and so finally, the expected profit will decrease.

2.2. Productivity Measurement in Construction

Although numbers of publications exist on construction productivity, there is no agreed upon definition of work activities nor a standard productivity measurement system. Researchers have concluded that it is difficult to obtain a standard method to measure construction labor productivity because of project complexity and the unique characteristics of construction projects (Oglesby et al. 1989). The uniqueness and non-repetitive operations of construction projects make it difficult to develop a standard productivity definition and measure (Sweis 2000). A few researchers have attempted to develop common definitions and a standard productivity system; however, those were not based on the consensus of academia and industry. One of the problems researchers have to face with is that measuring productivity at a project level depends on the construction activity. A concrete pouring activity can be measured in cubic meters of concrete placed per hour, whereas structural steel placement activity may be measured in linear meter of steel placed per hour. As Yi and Chan (2013) explain, there exist differences between production rate levels among job types. For example, the average production rate for pouring columns is less than that for pouring walls because of job characteristics.

The CICE Project report reviewed construction productivity measurement procedures and then recommended that productivity measurement programs should be established (BRT 1982). In 1990, CII developed a productivity measurement system that includes a reporting system, an output and input measuring system, and a performance evaluation system to measure site-level productivity (CII 1990). Adrian and Boyer (1976) established the method productivity delay model to measure, predict, and improve the productivity of a given construction method. Weber and Lippiatt (1983) reviewed the methods for measuring single factor

productivity and total factor productivity in construction. Thomas and Yiakoumis (1987) described the factor model that contains environmental, site, management, and design factors for structural steel and masonry formwork activities. Sanders and Thomas (1993) further identified factors such as construction methods, design requirements, and weather that affect masonry productivity and investigated the effect of factors using the factor model with data obtained from standardized collection procedures. Another model, the action–response model, also provides a framework for evaluating the causes of productivity loss on projects to mitigate or eliminate the loss of productivity. The CII research report also documented the factors that could affect craft worker productivity such as engineering/design, site conditions, materials, construction management, and labor problems (CII 2001).

As Liou and Borchering (1986) determined, productivity measurement is not a one-time task. Continuous measurement and comparison with other projects or companies are the keys to productivity improvement. Thomas and Yiakoumis (1987) stressed the importance of a standardized productivity data collection system to provide reliable analyses.

The productivity measurement research studies mentioned above have focused on how to report, measure, control, evaluate, and improve construction productivity. Yet, those studies lack a common set of definitions of activities and a standard data collection method. Furthermore, the existing productivity measurement systems have focused on microlevel activities to manage daily or monthly productivity during construction and that are tied to a sophisticated cost control system that is too complex to track and evaluate construction productivity.

The way in which productivity should be measured is profoundly influenced by the purpose for which the results will be used. The problem about measuring productivity lies in establishing reliable norms for setting standards. It also depends on the method used to measure productivity and on the extent to which all of the factors are accounted for that may affect productivity.

Imagine for example, the productivity in the construction of a bridge in Madrid and Frankfurt is compared; an indicator such as square meters of floor area completed per week could be used for measuring the productivity. However, this may not account for differences in specification (quality), design (build ability), building regulations, construction technology, available resources, and climate (Horner and Talhouni 1998).

On the basis of the preceding review, it is obvious that the general consensus among the various researchers is to define productivity as the ratio of output to input. Consequently, construction productivity can be regarded as a measure of outputs that are obtained by a combination of inputs. In view of this, two measures of construction productivity emerge:

- Total factor productivity (TFP)
- Partial factor productivity (PFP)

Total factor productivity (TFP), where all outputs and inputs are considered; and Partial factor productivity (PFP), often referred to as single factor productivity, where outputs and single or selected inputs are considered (Talhouni 1990; Rakhra 1991).

2.2.1. Total factor productivity

Total factor productivity (TFP) is defined as the ratio of outputs to the summation of all inputs, and is expressed as shown in Eq. (5) and Eq. (6):

$$TFP = \frac{\textit{Total output}}{\Sigma \textit{ of all input resources}} \quad (5)$$

or

$$TFP = \frac{\textit{Total output}}{\textit{Labor} + \textit{Materials} + \textit{Equipment} + \textit{Energy} + \textit{Capital}} \quad (6)$$

where TPF = ratio of dollars of output to dollars of input.

All input resources may include, but are not limited to, labor, materials, equipment, energy, and capital. Total productivity is a comprehensive measure that accounts for all outputs and inputs whether tangible or intangible. To get a meaningful total factor productivity index, however, outputs and inputs should bear a common base measurement unit. As suggested by Thomas et al. (1990), a monetary value base unit is appropriate, and thus TFP is quantified as shown in Eq. (7):

$$TFP = \frac{\textit{Pound value of output}}{\textit{Pound value of intput}} \quad (7)$$

TFP measure is often impractical since it is difficult to accurately measure and to determine all of the input resources utilized to achieve the output.

The complex nature of the construction process and the interaction of its activities make the single factor productivity measure a more desirable option because effective control systems separately monitor each input. Moreover, reliable and accurate data can be obtained focusing on a selected factor, e.g., labor input, which makes the measurement process easy and controllable.

2.2.2. Partial factor productivity

Partial factor productivity (PFP) establishes a relationship between outputs and a single or selected set of inputs. The definition is best exemplified by the term labor productivity, where only the input of labor is considered. Other single or partial factor productivity measures include capital, plant, and equipment productivity. Therefore, PFP can be defined as shown in Eqs. (8a)–(8c).

$$\textit{Labor productivity} = \frac{\textit{Output quantity}}{\textit{Labor hours}} \quad (8a)$$

or

$$\textit{Capital productivity} = \frac{\textit{Profit}}{\textit{Invested capital}} \quad (8b)$$

or

$$\text{Equipment or plant productivity} = \frac{\text{Output quantity}}{\text{Equipment or plant hours}} \quad (8c)$$

The advantages of the partial factor productivity are many. By focusing on a selected factor, e.g., labor input, the measurement process becomes easier and more controllable. As a result, reliable and accurate data can be obtained. The complex nature of the construction process and the interaction of its activities, moreover, make the partial factor productivity measure the popular option because effective control systems monitor each input separately (Jarkas and Bitar 2012).

Open conversion system shown in Figure 3 developed by Drexin (Thomas et al., 1990) can be applied to most of construction operations. This open conversion system, which is closer to Eq. (8c), models the construction process and the primary factors affecting its productivity. It provides examples of categorized factors that affect the overall construction productivity, including labor, and reflects the complex nature of the construction process as an open conversion system. Also, it shows the flow of feedback information that allows a continual improvement in construction productivity. This can help the practitioner to understand the role of factors affecting the construction process, and thus to control and improve its productivity.

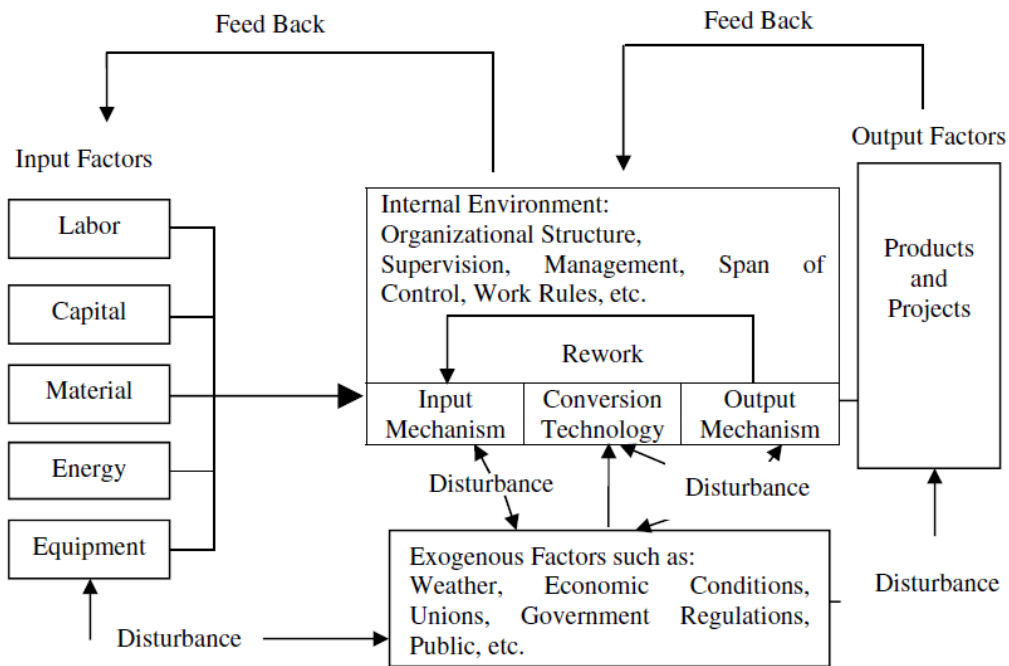


Figure 3. Drexin’s open construction conversion system (Thomas et al. 1990)

3. Productivity from Lean Philosophy perspective

3.1. An approach to Lean Philosophy

Lean manufacturing is originally based in the Toyota manufacturing system, which was designed to minimize waste and add value consistently during the manufacturing process (Alarcón and Pellicer 2009). After that, Japanese manufacturing techniques have been benchmarked by Western manufacturers since a study developed at the late 80s by the Massachusetts Institute of Technology proved that productivity in some Japanese factories was 50% higher than in American factories.

After a study conducted by the International Motor Vehicle Program (IMPV) also focused the Japanese techniques, they started to be seen as part of a new production system, known as lean production (Krafick 1988; Bartezzaghi 1999). The scope of the techniques was not limited to manufacturing. In fact, Bowen and Youngdahl (1998) present cases of process-based services that apply lean production practices.

Having the characteristics of both “production” and “service” systems, the construction industry has also taken some steps toward applying the lean production concept (Howell 1999). However, lean construction, presents challenges because it involves project-based production. The lean enterprise concept (Murman et al. 2002) comprises a variety of production systems that share certain principles, including waste minimization, responsiveness to change, just-in-time, effective relationships within the value stream, continuous improvement, and quality from the beginning.

Lean construction has sought a new foundation for project management (Koskela 2002): the International Group for Lean Construction (IGLC). The IGLC has led research on the application of lean techniques in the construction industry and has provided tools for operational planning and control, supply, visualization, and continuous improvement. Emerging techniques have started to change the way constructors manage their own operations.

The extension of specific manufacturing techniques to lean construction is still an open question. It is clear that both contexts conform to a socio technological construct (Niepce and Molleman 1998), in which the combination of human and technical elements ensures higher performance outcomes (Moore 2002). In practice, however, it is important to determine the set of tools that can be applied to achieve higher performance outcomes for construction projects.

3.2. Differences between traditional production and lean production

While lean manufacturing philosophy focus in value, traditional manufacturing process is developed under the following assumptions: be outlined as follows (Koskela 1992):

- A production process is a conversion of inputs to an output.
- The conversion process can be divided into sub-processes, which also are conversion processes.

- The cost of the total process can be minimized by minimizing the cost of each sub-process.
- The value of the output of a process is associated with costs (or value) of inputs to that process.

The lean construction system sees production as a flow of material, information, equipment, and labor from raw material to the product. In essence, the new model consists of conversions and flows. The overall efficiency of production is attributable to both the efficiency of the conversion activities performed, as well as the amount and efficiency of the flow activities. While all activities expend cost and time, only conversion activities are value-adding activities. The core idea of lean construction is to reduce or eliminate non value-adding activities and increase efficiency of value-adding activities (extracted from Abdel-Razek et al. 2007).

3.3. Techniques in Lean Manufacturing

Lean manufacturing combines the capabilities of the workforce with organizational techniques to achieve high outcomes with few resources (Katayama 1996). Lean principles determine the goals of lean manufacturing. Womack and Jones (1996) present value specification, value stream waste elimination, flow, pull, and continuous pursuit of perfection as the lean principles. The lean organization defines the activities on which the system focuses; Womack et al. (1990) refer to design, supply, and manufacturing as the core activities of the lean organization. Japanese manufacturers, especially Toyota Co., have developed the techniques that support the principles of lean production. Monden (1983) and Ohno (1988) introduced the Toyota Production System (TPS) as a combination of methods with consistent goals: cost reduction; quality assurance, and respect for humanity so as to ensure sustainable growth. Monden identified four main elements of the TPS:

- Just-in-time (JIT)
- Autonomation
- Workforce flexibility
- Creative thinking

Just-in-time is based on the concept that inventories are not valuable and should be regarded as waste; accordingly, units should be available only when required (Salem et al. 2006). In order to reach such a low rate of inventories, three different tools are used: The first one, the *kanban* system is used to minimize inventories according to backward requests that flow through cards, baskets, or digital signals (Chaoiya et al. 2000). The second method uses production leveling in order to ensure that fluctuation in demand can be met by the right sequence of products in minimum batches (Miltenburg 2002). The last one consists in decreasing the number of setup activities so as to reduce the number of activities performed during downtime so that changeovers do not interfere with minimum batches. Planned critical activities supported by single-minute exchange devices (SMED) should reduce the effect of alternating different products (Salem et al. 2006).

Autonomation can be explained as the prevention of defects. It is considered an alternative to traditional quality control. Autonomation is based in a functional management system which keeps and promotes quality and cost management throughout the company and into all the activities of the organization: design, supply and production (Ho and Fung 1194). Furthermore, it is also used a method called autonomous control, which prevents the flow of defective parts through the process. In this way, visual inspection (*Poka-yoke*) devices support this level of control, differing from traditional autonomation that does not allow direct intervention in the process (Shingo 1985).

Workforce flexibility, or in other words, maintaining a flexible workforce allows a company to match its labor requirements with the fluctuating level of demand for its product. (Salem et al. 2006). For this purpose, two different methods exist: multifunctional lay-out design and standard operations. Both of them allow flexible work and adapt the crew size to the pace required.

Creative thinking involves a series of techniques which have their base in the trust and reliance on workforce capabilities. These procedures offer continuous improvement through feedback and support the continual improvement of a production line's daily tasks (Salem et al. 2006). Thus, the human component makes lean manufacturing a dynamic system that always seeks to achieve higher performance.

3.4. Adapting Lean Manufacturing to Lean Construction and its principles

Howell (1999) defined the word "lean" as "Give customers what they want, deliver it instantly, with no waste." One of the main objectives of lean production explained in the paragraphs above is to eliminate non value-adding activities, "waste", from the production process (Koskela 2002). According to Koskela, wastes include overproduction, waiting, transporting, inspection, inventories, moving, and making defective parts and products. In contrast to the craft and mass production, lean production combines the advantages of both. Volumes of a great variety of products are provided at a relatively low cost by using resources of multi-skilled workers at all levels of organization and highly flexible, increasingly automated machines (Jeong 2003). Lean construction results from the application of a new form of production management to construction and thus lean construction becomes a new way to manage construction based on:

- Trying to make work flow more predictable (Flow variability)
- Controlling the variability in the processes (Process variability)
- Improving reliability (Transparency)
- Carrying out efforts to reach continuous improvement. (Continuous improvement)

Flow variability greatly influences lean construction practices because the late completion of one trade can affect the overall completion time of a project. "Last planner" is a technique that supports the realization of plans in timely manners (Ballard 2000). "Last planner" technique aims to make work flow more predictable. Last planners are the people accountable for the completion of individual assignments at the operational level. The last planner process starts

with the reverse phase schedule (RPS), i.e., a detailed work plan specifying handoffs between trades for each phase (Ballard and Howell 2003). Based on the RPS, a “lookahead” schedule provides the activities to be completed during the coming weeks and the backlog of ready work. Each planner prepares weekly work plans to control the workflow. If assignments are not completed on time, planners must determine the root cause of the variance and develop an action plan to prevent future recurrences of the problem (extracted from Salem et al. 2006).

Process Variability in the construction industry can also be improved with automation tools. Automation (*Jikoda*) is the notion that immediate action should be taken to prevent defects at the source so that they do not flow through the process (Salem et al. 2006). In lean manufacturing, visual inspection allows workers the autonomy to control their own machines so that when they identify defective parts, they can stop the process to identify the root cause. Fail-safe (*Poka-yoke*) devices are used to automatically prevent defects from going to the next process (Shingo 1985).

Because defects are difficult to find before installation, quality in construction has traditionally been focused on conformance. Lean construction concentrates efforts on defect prevention. Failsafe actions can be implemented on a job site to ensure first-time quality compliance on all assignments (Milberg and Tommelein 2003).

Transparency involves a series of attitudes which have their base in the trust and reliance on workforce capabilities. These attitudes aim to improve reliability between construction agents. Furthermore, lean manufacturing intends that any resource that does not contribute to better performance is regarded as waste that should be eliminated from the system. The five S’s can be used to identify housekeeping in plants. They are sort (*seiri*), straighten (*seiton*), standardize (*sieso*), shine (*seiketsu*), and sustain (*shisuke*). In construction, the five S’s allow for a transparent job site, at which materials flow in an efficient way between warehouses and specific jobs in the construction site. Since construction has mobile workstations, increased visualization can help identify the work flow and create awareness of action plans on a job site (Moser and dos Santos 2003).

Continuous improvement (*Kaizen*) cannot be associated with a specific technique. In fact, all techniques are set to drive continuous improvement via problem solving and creative thinking. However, in lean manufacturing, quality circles provide an opportunity for workers to actively participate in process improvement. These teams meet periodically to propose ideas for the most visible problems in the workplace. Quality, maintenance, cost reduction, and safety issues can be worked out by the teams to provide potential solutions for future activities. The benefits of the quality circles are not only the implemented ideas but also the learning process that workers experience (extracted from Salem et al. 2006).

The PDCA (plan, do, check, and act) cycle is used to develop the first-run study. First, one “plans” a work process to study, analyzes the process steps, and brainstorms how to eliminate unneeded steps. To “do,” one tests new ideas on the first run. To “check,” what actually happens is described and measured. To “act,” the team is reconvened, and teammates communicate the improved method as the standard to meet. To ensure continuous

improvement, the team's capabilities must be best used to develop both individual and joint contributions (West 1998).

So as conclusion of these lines, the principles in which lean construction is based include among others:

- Practice just-in-time (JIT).
- Use pull-driven scheduling.
- Reduce variability in labor productivity.
- Improving flow reliability.
- Eliminate waste, and simplify the operation.
- Benchmarking.

Chapter 4

LITERATURE SEARCH

1. Preliminary approach

After reviewing the framework of CLP, a significant body of literature has been dedicated to research how construction labor productivity influences on progress and performance of construction projects all over the world. The aims of many authors were to understand the underlying theories and the industrial practices used by construction firms. It has been also widely studied by many researchers the factors and how they effect on CLP. In this study, it is pretended to achieve a better comprehension of the factors affecting construction labor productivity in Spain, for this purpose, an intensive literature review becomes an important need.

The preliminary approach and bibliometric search consisted on a search, review and reading of the articles found as well as scientific books, or PhD thesis related with the study issue. The objective of the preliminary approach was to obtain a better comprehension of the terms used and main ideas from related knowledge published in literature in order to enable a more precise literature search. This exploration was carried out by different searches in the Scopus search engine based on the references provided by some papers given by advisors (Jarkas and Bitar 2012) and (Durdyev et al. 2013). This first enquiry served as a starting point from where literature search was realized. Table 17 was elaborated by searching into references of the papers provided and constituted the listing of papers collected in the preliminary approach stage.

No.	Title	Author	Year
1	Factors Affecting Construction Labor Productivity in Kuwait.	Jarkas and Bitar	2012
2	Construction Productivity in Turkmenistan: Survey of the Constraining Factors.	Durdyev et al.	2013
3	Factors affecting construction labour productivity for Malaysian residential projects.	Abdul Kadir et al.	2005
4	Factors Affecting the Motivation of Iranian Construction Operatives' productivity.	Zakeri et al.	1996
5	Critical Factors Influencing Construction Productivity in Thailand.	Makulsawatudom et al.	2004
6	Factors affecting labour productivity in building projects in the Gaza strip.	Enshassi et al.	2010
7	Factors influencing craftsmen's productivity in Indonesia.	Kaming et al.	1997
8	More for less, a contractor's guide to improving productivity in construction.	Horner and Duff	2001
9	Modeling Construction Labor Productivity.	Thomas et al.	1990
10	Construction productivity: Issues encountered by contractors in Singapore.	Lim and Alum	1995
11	Research of factors influencing construction productivity.	Herbsman and Ellis	1990

Table 17. Listing of papers collected from preliminary approach stage

2. Bibliometric search

In this section it has been carried out a bibliographical search in order to quantitatively and qualitatively analyzes existing scientific articles on the factors affecting CLP-related. To perform the bibliometric search, a series of initial and refinement parameters have been set as shown below:

Search engines: It was decided to use 4 important search engines where most of the higher ranked journals were indexed. These search engines were Scopus, ScienceDirect (SD), Web of Science (WOS) and the American Society of Civil Engineers (ASCE) Library.

Keywords: “construction”, “productivity”, “labo(u)r” and “factors” had been used as Keywords in the research. Those keywords were chosen from first approach literature review and tried to guide search from general to specific results since search methods were based on sequential operations as shown in Figure 4.

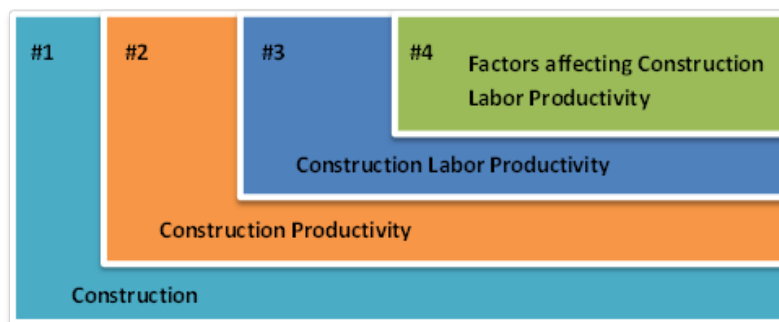


Figure 4. Sequential search from general to specific results

Language: The language chosen for this study was English, being the predominant language in scientific community.

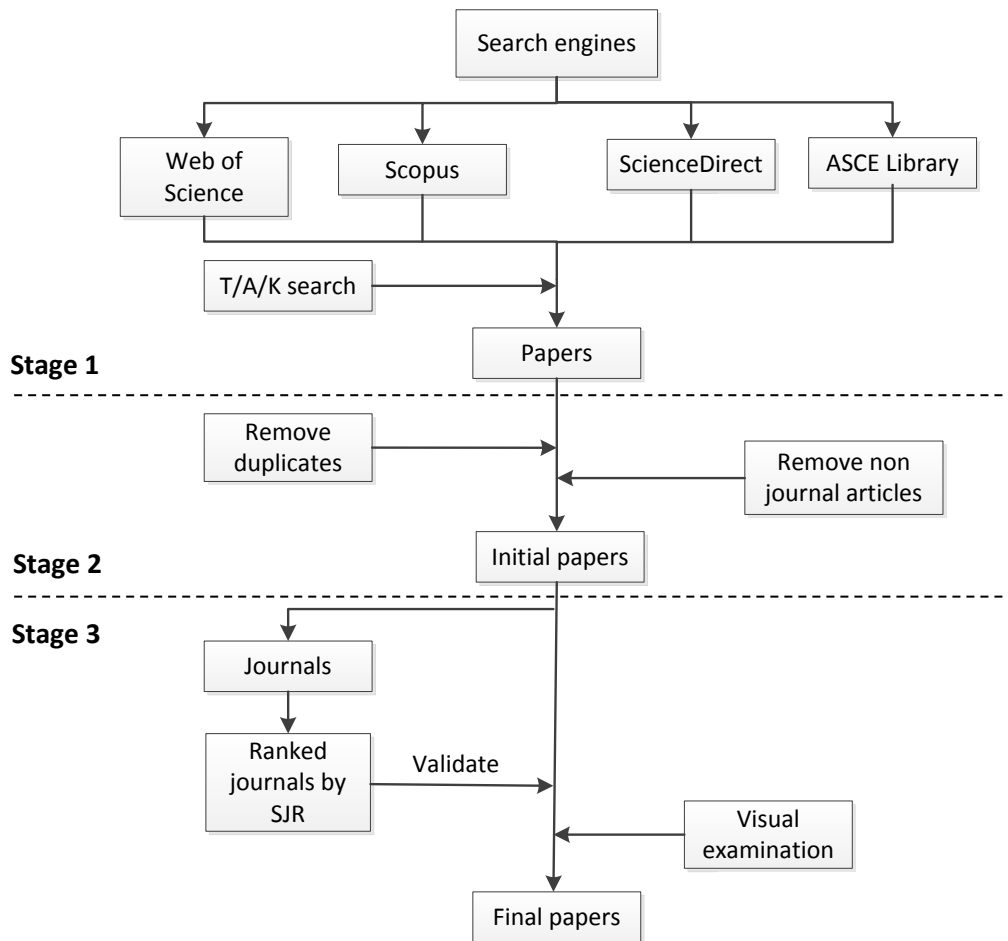
Search Period: A consideration must be done at this point. Since buildability and management as well as the information technologies (IT) had greatly improved during last decades, search period was established since 1985. That meant that old publications will not be as relevant as recent ones. Moreover, all databases are searchable since 1985 onwards; therefore, the search parameters had been set in each search engine between 1985 and late February 2014.

Publication type: This research has been focused on articles published in scientific journals.

The bibliometric search has been performed sequentially, entering keywords in each of the four search engines. The search sequentially provides relevant information when analyzing the current state of knowledge from the general to the particular. The keywords used in the search were extracted from the preliminary approach. Basic Boolean operator "AND" was used to link keywords. Search parameters explained above were applied in order to refine results within the different databases.

The first step was to identify well known articles relating factors affecting labor productivity in the construction industry in order to develop a literature review of the findings revealed. A

three-stage literature review was conducted to acquire a more deeply understanding of factors affecting CLP research by conducting a content analysis of papers found from 1985 to 2014. Figure 5 presents the review process followed.



Note: T/A/K - Title/Abstract/Keywords; SJR - SCImago Journal Rank

Figure 5. Research framework for this study (adapted from Hong et al. 2012)

In stage 1, a comprehensive desktop search was conducted under the “article tittle/abstract/keyword” field of Scopus and ScienceDirect. It was also developed a desktop search under “topic” field of Web of Science. Moreover, advanced search was conducted in the ASCE Library under the “article tittle/abstract/keyword” field. Search keywords included “construction”, “productivity”, “labo(u)r” and “factors”. Papers considered to have fulfilled the requirements of this research study were those with the specific terms above in the title, abstract or keyword (T(A/K)). The search was also limited to subject areas such as engineering, environment, business, management, decision sciences, economics and social sciences with the document type of article or review. The search process was carried out into a sequential mode. Firstly, one keyword was added and after results were collected another keyword was added and then linked with the Boolean operator "AND" to the first keyword. The process was repeated until all keywords were in the field search. Secondly, the rest of limiting conditions were introduced such as language = English and year of publication >= 1985. The search results from stage 1 are shown in Table 18 Results indicated that 245 at #6 from 6,059,714 at #1

publications were successful with the search requirements by Scopus search engine, A sequential search allowed to move from 8,724,489 at #1 to 186 articles at #6 in Web of Science, from 839,286 at #1 to 147 publications at #6 publications by ScienceDirect and finally 86 results were obtained in the ASCE Library. As a result, a total of 664 Factor affecting CLP-related publications were identified in the first stage. Search done by a sequential mode allowed to manage great number of publications at first stages, however, handy number of publications fulfilled six strategy steps in a successful way which means that search strategy based on a sequential way was adequate.

#	SEARCH STRATEGY	SCOPUS	ASCE L.	SD	WOS
		T/A/K	T/A/K	T/A/K	Topic
1	TITLE-ABS-KEY(construction)	6,059,714	3,103	839,286	8,724,489
2	(TITLE-ABS-KEY(construction) AND TITLE-ABS-KEY(productivity))	60,770	468	6.290	55.690
3	(TITLE-ABS-KEY(construction) AND TITLE-ABS-KEY(productivity) AND TITLE-ABS-KEY(labor))	1,324	12	210	871
4	(TITLE-ABS-KEY(construction) AND TITLE-ABS-KEY(productivity) AND TITLE-ABS-KEY(labor) AND TITLE-ABS-KEY(factors))	288	99	164	203
5	(TITLE-ABS-KEY(construction) AND TITLE-ABS-KEY(productivity) AND TITLE-ABS-KEY(labor) AND TITLE-ABS-KEY(factors) AND LANGUAGE(english))	264	98	155	194
6	(TITLE-ABS-KEY(construction) AND TITLE-ABS-KEY(productivity) AND TITLE-ABS-KEY(labor) AND TITLE-ABS-KEY(factors) AND LANGUAGE(english)) AND PUBYEAR > 1984	245	86	147	186

Note: T/A/K – Tittle/Abstract/Keyword; %RPS - percentage with respect to the previous search

Table 18. Search results from Stage 1

In stage 2, an analysis of the results from stage 1 was carried out. Firstly, publications repeated in more than one search engines were removed in order to get only one article without duplications. The duplicate elimination process was performed using Mendeley tool. This allows two types of comparison: by “exact duplicates” or "close duplicates". In this analysis

both criteria were used. The process was developed in two stages. In the first stage a study of each of the databases was made separately, in order to observe whether within their own searches of each database duplicate results. In the second step common items were compared between the databases used as it can be seen in Table 19.

MENDELEY	Scopus	ScienceDirect (SD)	Web of Science (WOS)	ASCE Library	SCOPUS/SD/WOS/ASCE
Exact duplicates	1	1	0	0	214
Close duplicates	5	2	0	1	146
TOTAL	6	3	0	1	360

Table 19. Refinement of data using Mendeley

As a result, more than half of the publications were detected to be repeated and consequently removed. That meant that existed only 304 different publications and the rest, 360 were repeated in more than one search engine. “Mendeley” software was used to find exact duplicates and close duplicates within each database.

The following step was to exclude articles published under the broad categories of editorial, book review, forum, discussions/closures, letter to the editor, article in press, foreword, index, introduction, conference/seminar report, briefing sheet and comment from the stage 2 analyses. Only articles published in Indexed Journal were taken into account with the purpose of reduce the amount of publications obtained from stage 1.

After stage 2 completion, 548 publications were removed and only 116 articles remained useful to the third stage of literature review. These amounts of articles were named as “initial papers” to help visualize the level of completion of the research framework.

Stage 3 served as a mean to complement the analysis developed in stage 2 with the aim of getting a handy number of factors affecting CLP related articles. In this stage, articles were selected and compared by their SCImago Journal Rank (SJR indicator). As Falagas et al (2008) explained, this indicator is a measure of scientific influence of scholarly journals that accounts for both the number of citations received by a journal and the importance or prestige of the journals where such citations come from.

Publications from journals which have important and prominent positions in the research community of construction were selected in the third stage. Also, articles published in journals with have been highly cited have been also taken into account. On the other hand, articles from journals with the lowest SJR were removed from the list of initial papers. SJR of the year 2012 was obtained from each source from where all the remaining 116 papers were published. Table 20 shows SJR index and cites per document in the year 2012 for each journal. As a result of this, 18 papers were removed of the list since their respective Journals obtained the lowest SJR index.

Journal	SJR (2012)	Cites per Doc. (2012)
European Journal of Operational Research	2.60	2.73
Building research and Information	1.36	2.38
Building and Environment	1.27	2.76
International Journal of Construction Supply Chain Management	1.27	2.33
Automation in Construction	1.25	3.04
International Journal of Project Management	0.99	2.53
Journal of Construction Engineering and Management	0.93	1.58
International Journal of Industrial Ergonomics	0.83	1.62
Journal of Civil Engineering and Management	0.73	6.73
Construction Management and Economics	0.70	0.94
Journal of Management in Engineering	0.57	1.03
International Journal of Civil Engineering	0.24	1.69
KSCE Journal of Civil Engineering	0.23	0.50
International Studies of Management and Organization	0.22	0.68
Journal of Construction in Developing Countries	0.18	0.08
Procedia Engineering	0.16	0.27
International Journal of Integrated Engineering	0.15	0.26
International Journal of Economics and Management	0.15	0.32
Australasian Journal of Construction Economics and Building	0.13	0.33

Table 20. SJR Index and Cites per document (2012) by Journal

As explained in lines above, journals with lowest SJR index were not taken into account. The following journals obtained the lowest ranking and consequently they were removed. In addition, all of these journals were classified in Q3 or Q4 in their respective category. International Journal of Civil Engineering with a 0.24 SJR in 2012, KSCE Journal of Civil Engineering with a 0.23 SJR, International Studies of Management and Organization got a 0.22 SJR in 2012, Journal of Construction in Developing Countries with a 0.18 SJR, Procedia Engineering with a 0.16 SJR, International Journal of Integrated Engineering and International Journal of Economics and Management both with a 0.15 SJR index and finally the Australasian Journal of Construction Economics and Building obtained a 0.13 SJR in the year 2012 included a number of 18 papers.

An examination of the 98 remaining papers indicated that the Journal of Construction Engineering and Management (JCEM) published the most number of factors affecting CLP-related articles with 26 publications. The rest of the five top-ranked construction journals with

more number of the initial papers published were: International Journal of Project Management (IJPM); Journal of Management in Engineering (JME); Construction Management and Economics (CME) and Journal of Civil Engineering and Management (CEM). These results and the number of articles from the initial papers list are shown below in Table 21.

Journal	Number of articles published
Journal of Construction Engineering and Management	26
International Journal of Project Management	19
Journal of Management in Engineering	15
Construction Management and Economics	13
Journal of Civil Engineering and Management	11
Building research and Information	3
Building and Environment	3
International Journal of Industrial Ergonomics	3
European Journal of Operational Research	2
Automation in Construction	2
International Journal of Construction Supply Chain Management	1
TOTAL articles from "Initial papers" list published in top-ranked Journals	98

Table 21. Number of articles from "Initial papers" list published on Top-ranked Journals

A total of 98 from 116 factors affecting CLP-related articles were published in international Journals with an important SJR within its category, and therefore, were accepted for the last step. During this final step a visual examination was performed to the total 98 articles. In the visual examination phase, abstract and main conclusions were read from each paper. Those articles which did not matched with the terms of this investigation were removed. All the articles were classified according to their Proximity Level to the Topic as shown in Table 22.

For Proximity Level to the Topic, it settled three categories "A", "B" and "C", with "A" being the most linked to the subject of study and "C" which was not related to the construction labor productivity. It is noteworthy that the articles placed in Category "C" were within their summaries or abstract keywords bibliometric search but were not necessarily related to the specific subject under study.

CLASSIFICATION OF ARTICLES BY PROXIMITY LEVEL TO THE TOPIC		
Level	Description	Quantity of articles
A	Very related	35
B	Medium related	17
C	Little/ nothing related	46
	Total	98

Table 22. Classification of articles by Proximity Level to the Topic

It was decided to remove articles that were in category C in terms of proximity level to the topic, given that they were not related to the subject matter. As a result, a total of 46 papers were eliminated from the total during the visual examination and the 52 remaining articles were downloaded and saved as “Final papers”. Some of these “Final papers” list will be the base for the later literature review of the factors affecting construction labor productivity.

In order to manage “Final papers” list in a better way and to fulfill one of the specific objectives proposed “To organize and classify the literature found in an effective way in order to improve the management of the references”, an Excel sheet was created and all literature from “Final papers” was included. Classification regarding title of the paper, author or authors of the document, year of publication and source where the research was published was undertaken. Moreover, papers were grouped by different categories according to the content of the research developed. Some examples of these categories were Factors affecting CLP category, Modeling CLP, etc.

In summary, from the 664 publications found by the four search engines used in this investigation, 360 were repeated in more than one database. After removing articles published under the broad categories of editorial, book review, forum, discussions/closures, letter to the editor, article in press, foreword, index, introduction, conference/seminar report, briefing sheet and comment only 116 papers remained useful for this study and formed the initial papers list. With these two steps, stage 2 was completed and stage 3 continued deepening with the analysis of the publications. In final stage each journal in which papers were published was compared by their SJR, those publications with the lowest SJR in their journals were removed from the list and a final procedure was carried out consisting on a visual examination of the abstract and main conclusions of each article and those which did not match with the objectives of the study were also removed. 64 publications were eliminated during the stage 3, 18 of them during the classification of the journals by SJR and other 46 while visual examinations was being accomplished. After an exhaustive analysis of the publications found only 52 articles has been classified have been classified as really useful tools and will be taken into the next phase of research, which will consist of a thorough study of each of the papers with the purpose of present a summary of previous studies in different countries of the factors affecting construction labor productivity. Chart 15 shows the results at the end of each stage in terms of valid number of articles.

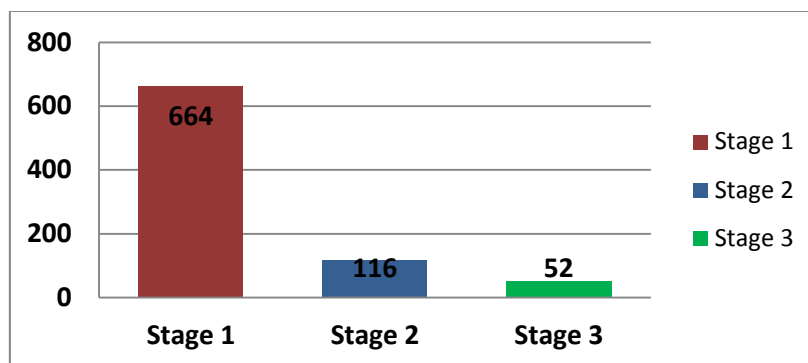


Chart 15. Results of the literature search at the end of each stage

3. Classification of the papers

In this paragraph, results obtained from the bibliometric search were exposed. A total of 52 factors affecting construction labor productivity related papers were found in different search engines. The articles collected fill a gap in knowledge of factors affecting labor productivity in countries where they were carried out, which can be used by industry practitioners to develop a wider and deeper perspective of the factors influencing the efficiency of operatives and provide guidance to construction managers for efficient utilization of the labor force, hence assist in achieving a reasonable level of competitiveness and cost-effective operation (Jarkas and Bitar 2012).

The 52 final articles were classified by Relevance of the Article, established three categories 1, 2 and 3, with 1 being the articles that, according to the author, presented a significant contribution, 2 articles whose contribution could not be classified as very good nor bad and 3 which did not provide a significant contribution. This classification identified articles worth reading more closely and whose contribution was included in Table 23.

CLASSIFICATION OF ARTICLES BY THEIR IMPORTANCE		
Level	Description	Quantity of articles
1	Significant contribution	29
2	Medium contribution	15
3	Little contribution	8
	Total	52

Table 23. Classification of the articles by their importance

The depth reading of the most relevant articles, as well as the review of all articles selected after the depuration of the articles, enabled analyze the results, that are in the next phase. In the next Figure, it is possible to see the distribution of that contribution of the articles by percentage.

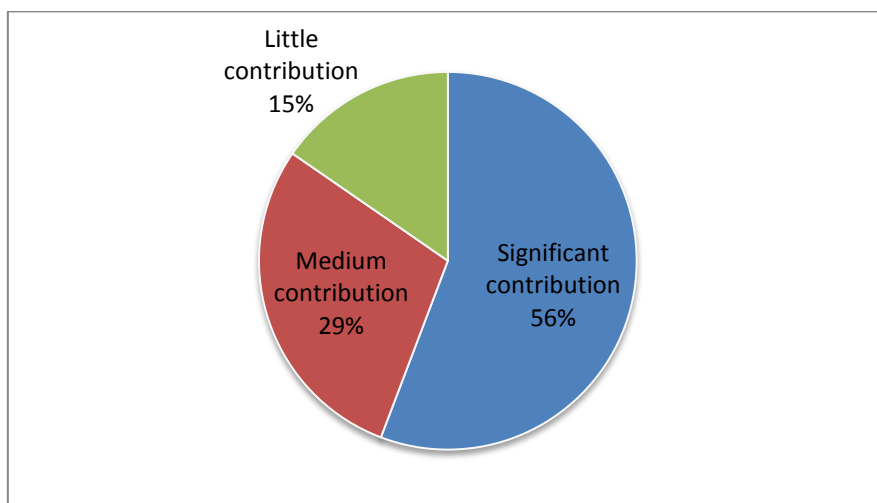


Chart 16. Distribution of the References by their Contribution

Then, a summary of the publications regarding factors affecting labor productivity in construction industry from the research origin countries is exposed in Table 24. It is also presented the percentage respect the total amount of selected papers.

Country	Number of articles	% Percentage
Australia	2	3.85%
Chile	2	3.85%
China	3	5.77%
Dominican Republic	1	1.92%
Egypt	2	3.85%
Gaza Strip	2	3.85%
Greece	1	1.92%
India	1	1.92%
Indonesia	2	3.85%
Iran	3	5.77%
Korea	1	1.92%
Kuwait	3	5.77%
Malaysia	3	5.77%
New Zealand	1	1.92%
Nigeria	1	1.92%
Portugal	1	1.92%
Saudi Arabia	1	1.92%
Singapore	3	5.77%
Thailand	2	3.85%
Turkey	1	1.92%
Turkmenistan	2	3.85%
Uganda	1	1.92%
United Kingdom	2	3.85%
United States	11	21.15%
TOTAL	52	100%

Table 24. Research origin of papers selected from literature search

As it can be observed, little research has been carried out in Europe. Few European countries such as United Kingdom (U.K.), Greece or Portugal have been studied the importance and relevance of labor factors affecting their productivity in the construction industry and although several studies have been developed not long time ago and productivity in construction has received increased attention from construction researchers a deeper and widely understanding is still needed to improve labor productivity. This researching need was related to the overall objective of the study and was one of the main reasons to establish the research focus on Spain.

Possibly due to the critical importance of the construction labor productivity to the profitability of most construction projects, it had been made efforts to better comprehend which factors are the most representative and how they affect labor productivity. Proof of this is that more than half of the publications related to factors affecting CLP, 33 out of 52 which represented a 63.46%, have been published less of 5 years ago (2014-2010). Table 25 and Chart 17 manifest the increasing evolution of publications related to factors affecting CLP. In early 2014, two articles have already been published and quite possibly will not be the last. During 2013 were inserted in journals 11 articles which marked up a maximum in number of related publications within the period 1985-2014.

Year of publication	Number of publications	% Partial to total articles
2014	2	3.85%
2013	11	21.15%
2012	8	15.38%
2011	8	15.38%
2010	4	7.69%
2009	3	5.77%
2007	2	3.85%
2005	3	5.77%
2002	2	3.85%
2001	2	3.85%
1999	1	1.92%
1998	1	1.92%
1997	2	3.85%
1990	2	3.85%
1986	1	1.92%
TOTAL	52	100%

Table 25. Nº of factors affecting CLP-related publications per year

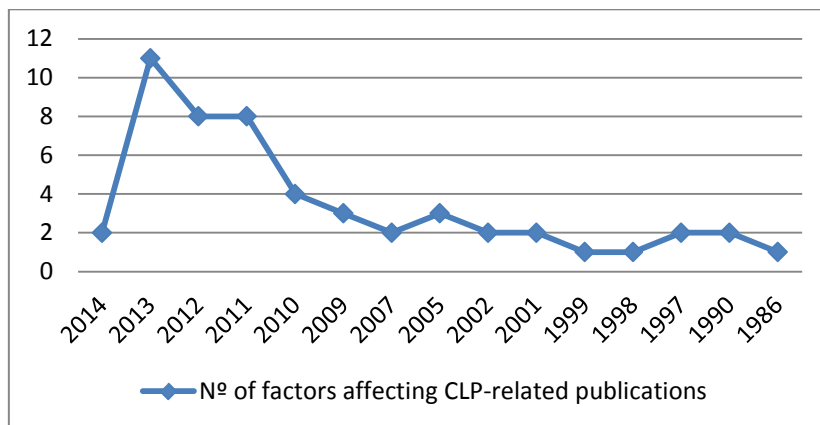


Chart 17. Nº of factors affecting CLP-related publications per year

Authors with highest number of Publications

Some of the information that can be extracted of the bibliometric search, and it can illustrate the state of knowledge on the topic under study, are the authors with the highest number of publications.

Table 26 presents the authors with the highest number of publications to the total of 52 articles identified, considering only authors with more than 2 articles. The only authors with more than 2 articles are “H. Randolph Thomas” and “Jiukun Dai” with 4 articles published each of them, accounting for 7.69%. Abdulaziz M. Jarkas is the only author with 3 articles published representing a 5.77% of the total amount. Then, with 2 articles each one (3.85%) are Luis F. Alarcon, Serdar Durdyev, Adnan Enshassi and Mahmood Zakeri. The rest of the authors have only one article.

Only the authors whose names appear in first or second position in the publications have been taken into account in the preparation of this list.

Author	No. of articles	% Partial to total articles
H. Randolph Thomas	4	7.69%
Jiukun Dai	4	7.69%
Abdulaziz M. Jarkas	3	5.77%
Luis F. Alarcon	2	3.85%
Serdar Durdyev	2	3.85%
Adnan Enshassi	2	3.85%
Mahmood Zakeri	2	3.85%
Total articles		52

Table 26. Authors with the highest number of publications for the 52 selected articles

Journals with highest number of publications

The “Final papers” listing composed by 52 articles were published in many different journals. Table 27 presents the journals that have had more than three publications. As it can be seen, Journal of Construction Engineering and Management was the journal that published the largest number of articles with 16 publications which represents a 30.77% of the total final papers. Secondly, International Journal of Project Management published 11 papers relating factors affecting CLP which represented a 21.15% of the total amount of papers. In the third place, Journal of Management in Engineering had 9 papers published from papers selected in step three of search stage representing 17.31% of the total respectively. The rest of selected papers for the literature review were published by Construction Management and Economics Journal (5 papers), Journal of Civil Engineering and Management (3 articles), Building research and Information (2 articles), International Journal of Industrial Ergonomics (2 articles), Building and Environment (1 article), European Journal of Operational Research (1 article), Automation in Construction (1 article) and lastly, International Journal of Construction Supply Chain Management with 1 article published from “Final papers” list.

Journal	Journal SJR (2012)	Number of articles published	% Partial to total articles
Journal of Construction Engineering and Management	0.93	16	30.77%
International Journal of Project Management	0.99	11	21.15%
Journal of Management in Engineering	0,57	9	17.31%
Construction Management and Economics	0.70	5	9.62%
Journal of Civil Engineering and Management	0.73	3	5.77%
Building research and Information	1.36	2	3.85%
International Journal of Industrial Ergonomics	0.83	2	3.85%
Building and Environment	1.27	1	1.92%
European Journal of Operational Research	2.6	1	1.92%
Automation in Construction	1.25	1	1.92%
International Journal of Construction Supply Chain Management	1.27	1	1.92%
TOTAL articles from "Final papers" list	-	52	100%

Table 27. Journals with highest number of publications

Methodology or technique used by the authors

The methodology or technique used by the authors of the articles processed was also analyzed to get an approximation of how these authors manage similar researches. Results presented in Table 28 shows that the methodology or technique more often used was surveys to practitioners with 44.23%, followed by Interviews with 23.08%. Bibliometric research and Case study were used by 7.69% each one. Finally, Simulation was the least used technique with only 1.92%.

Methodology or technique used by the authors	Number of Art.	% Partial to total articles
Surveys	23	44.23%
Interviews	12	23.08%
Bibliometric Research	4	7.69%
Case Study	4	7.69%
Simulation	1	1.92%
Not specified	8	15.38%
Total	52	100%

Table 28. Methodology or technique used by the authors

Chapter 5

LITERATURE REVIEW

1. Introduction

As it had been explained in the previous chapter, determining the factors affecting labor productivity in constructions has received increased attention during the past decades (Rivas et al. 2011). For this reason, search stage was developed in order to identify and classify which countries have studied the importance of these factors. In this chapter, main contributions extracted from most relevant articles are collected, determining a summary of the factors affecting CLP. Factors used for this research and the design of the questionnaire were obtained from the summary.

The summary of the factors that would be carried out aims to fulfill one of the specific objectives of the research: "To identify through the literature the main factors affecting labor productivity in construction". A total of 52 factors affecting construction labor productivity related papers were identified in the previous stage. The articles collected fill a gap in knowledge of factors affecting labor productivity in countries where they were carried out, and help to better understand where main wastes of labor productivity were located.

Then, a summary of the publications regarding factors affecting labor productivity in construction industry in those countries in which they had been studied is exposed in Table 29. Each article is referenced by their or theirs authors as well as the year of publication and the country to which the paper is referred to. Moreover, it is also indicated the number of the studied factors affecting CLP in that article. Note that not all of the 52 final papers are included in Table 29 due to not all papers relates about a specific country. Only 18 papers related factors with certain countries.

Country	Reference	Total number of studied factors
China	Deng et al. (2013)	34
Chile	Rivas et al. (2011)	38
Dominican Republic	Senior and Rodríguez (2012)	29
Egypt	El-Gohary and Aziz (2014)	30
Gaza Strip	Enshassi et al. (2007)	45
India	Doloi et al. (2011)	45
Indonesia	Kaming et al. (1997)	11
Indonesia	Soekiman et al. (2011)	113
Iran	Zakeri et al. (1196)	13
Kuwait	Jarkas and Bitar (2012)	45
Malaysia	Abdul Kadir et al. (2005)	50
New Zealand	Durdyev and Mbachu (2011)	56
Singapore	Lim and Alum (1995)	17
Thailand	Makulsawatudom et al. (2004)	23
Turkmenistan	Durdyev et al. (2013)	23
Uganda	Alinaitwe et al. (2007)	36
U.K.	Horner et al. (1989)	13
U.S.	Dai et al. (2009)	83

Table 29. Literature Summary of the factors affecting Construction Labor Productivity

2. Literature review

According to the theory that if all the factors that affect construction productivity were known and could be perfectly quantified, it would become possible to forecast productivity in an effective way (Lema, 1995). Several researches have been made to investigate the factors influencing labor productivity. However, researchers have not coincided on a universal set of factors with significant influence on productivity and no agreement has been reached on the classification of these factors (Enshassi et al. 2007).

The literature summary will be shown below. The structure of this summary or in other words, the manner in which contributions from other authors have helped to fill gaps in knowledge is presented as it follows: First, the general idea of the article was submitted. Then the methodology the author used for the preparation of research is briefly described. Thereafter, in order to classify and handle in the best possible way the factors that affect construction labor productivity, a study about the primary or global groups or categories in which factors were firstly classified was carried out. And finally the number and the different factors that each author has used for their research are presented. The point of all this is to have a clearer understanding of the factors that were taken into account when developing similar research. Thus, it will be much easier to design the questionnaire based on related research studies on construction labor productivity.

The notation used for the realization of this chapter was the following: To refer to a categories of factors, it has been used the Roman numerals in brackets (I), (II), (III), etc. and for the enumeration of the different factors identified were used Latin numerals in brackets (1), (2), (3), etc.

Numerous approaches have been adopted in relation to the classification of the factors affecting construction labor productivity. A United Nations report (1995) stated that in ordinary situations two major sets of factors affect the site labor productivity requirements: Organizational continuity and execution continuity. Organizational continuity encompasses physical aspects of work, such as number of hours worked by day, specification requirements that are related to quality, design details, etc. Execution continuity relates to the work environment and how effectively a job is organized and managed. Management aspects include weather, material and equipment availability, congestion and out-of-sequence work.

As a part of his Master's thesis, Singh (2010) studied the factors affecting the productivity of construction operations in the United Arab Emirates. The author classified the factors into four categories: (I) industry level factors; (II) labor factors; (III) site management factors and (IV) external factors. Within these categories, Singh studied the following overall 10 factors with respect to their categories to help improve the productivity: (1) priority of production in the industry; (2) production system design; (3) financial issues; (4) predictability of demand; (5) skill and experience issues; (6) work schedule and crew mix; (7) training policy; (8) coordination and supervision; (9) material and equipment quality; and (10) weather and statute.

Deng et al. (2013) adopted Porter's Diamond Model to develop potential factors that could affect the competitiveness of the construction industry. This model is an attempt to explain and predict economic growth. The model has been successfully applied to analyze the

competitiveness in various industries, such as the apparel industry or the tourism industry among others. In order to get empirical findings, a questionnaire survey was managed to investigate the significance of these factors, and factor analysis was also applied. In this research factors identified were grouped in six categories: (I) factor conditions which included human, capital and physical resources as well as infrastructure; (II) demand conditions which referred to home market factors; (III) firm strategy, structure and rivalry; (IV) related and supporting industries which have relation with industrial clustering, related industries and IT support; (V) government referring to political and economic governance and governmental support and (VI) chance distinguishing between external and internal ones.

As to the factors identified by Deng et al. to assess in their research were (1) abundant poor manpower; (2) skilled workers; (3) qualified professionals; (4) Higher education and professional training; (5) Management and work ethic; (6) low cost and good value for money; (7) cheap materials; (8) road, railway, electricity, telecommunication etc.; (9) basic size of the home market; (10) steady growth of home market; (11) level of competition among industrial players; (12) regional competition and protection; (13) concentration of market; (14) extent of privatization; (15) proportion of SOEs and COEs; (16) management and corporate governance practices; (17) corporation related corruption; implementation of partnering concept; (18) bidding strategy; (19) level of industrial clustering; (20) level of industrial clustering; (21) performance of real estate market; (22) performance of local suppliers; (23) performance of designing industry; (24) performance of consulting industry; (25) supports from IT industry; (26) favorable geopolitical environment; (27) stable macroeconomic environment; (28) improvement of the business environment; (29) investment and encouragement on R&D; (30) support in creation of innovation-driven industry; (31) booming international construction market; (32) more open global construction market; (33) Chinese constructions industry's reform and (34) increasing collaboration and partnering.

The analysis of these factors further revealed six underlying factors: (F-I) stable home market); (F-II) supply chain management; (F-III) corporate management practices; (F-IV) qualified professionals; (F-V) satisfactory business environment and (F-VI) migrant workers. The study provided insights in finding key areas that formulate the competitiveness of the CCI, as well as valuable implications for other countries.

Rivas et al. (2011) focused their efforts on identifying and understanding the productivity factors affecting projects in the Chilean construction company. For that purpose, authors administered questionnaires to both direct workers and midlevel employees. Factors were classified in this case in eight main categories: (I) schedule acceleration which included (1) overcrowding and/or over manning, (2) peak craft level and single craft population and (3) scheduled overtime; (II) poor coordination category included (4) staking of trades and (5) concurrent operations; (III) changes category grouped the following factors (6) reassignment of manpower, (7) deterioration of learning curves, (8) ripple effect and (9) engineering errors and omissions; (IV) resources and site management section involved (10) site conditions and organization, (11) materials and tools availability, (12) material handling space, (13) site access, (14) interference, (15) poor lighting ad housekeeping, (16) the size and dispersion of tasks, (17) methods and equipment and (18) size of a crew; (V) management characteristics were related with (19) management control or project team and (20) dilution of supervision; (VI) project

characteristics grouped the next factors (21) projects size, (22) work types, (23) beneficial occupancy, (24) joint occupancy, (25) fast track and (26) subcontract; (VII) Labor and morale category included (27) quality of craftsmanship, (28) quality control and quality assurance practices, (29) absenteeism, (30) craft turnover, (31) fatigue, (32) morale and (33) wages. The last factors category was (VIII) project location and external conditions with was related with (34) economic activity or availability of skilled labor, (35) commuting time, (36) support community size, (37) weather and (38) population differences. The main findings indicated that the critical areas affecting construction labor productivity were related to materials, work, equipment, truck availability and the workers motivational dynamics. These results showed to be similar to those obtained in previous studies in the United States and in Chile.

A study developed in Dominican Republic examined the perceived importance, easiness to overcome and the criticality of 29 barriers to productivity increment. This research was carried out by Senior and Rodriguez (2012). The potential contestants were contacted by email and completed surveys were collected directly from each participant. The questionnaire consisted on 29 questions which had to be evaluated. Likert scale was used for the responses as the way to measure the different indicators. Authors grouped the factors into three categories according to their driving factors: (I) environment driven. This category included factors external to the participant's ability for influencing significantly, such as the quality of materials, worker skills and the price of commodities. Second category was (II) top-management driven. These factors were difficult to control by mid and lower level managers in construction company Examples of factors in this category included reward system based on team goals, organizational culture supporting teamwork and provision of benchmarks. Last category was (III) field-management driven which included factors related to communication within teams, well-defined focus of teams, defect prevention and similar factors in this category were considered to be realistic targets for improvement by the middle and lower level personnel in the field. Results from this research pointed that barriers with high criticality tended to be driven by field management and those with low criticality tended to be driven by top management. In the same way, the perceived need for improvement was not followed by optimism for achieving it.

El-Gohary and Aziz (2014) aimed to identify, investigate and rank factors perceived to affect construction labor productivity in the Egyptian construction context with respect to their relative importance. In this research, the relative importance index technique was used. For achieving the objective of the study, authors invited to participate practitioners and experts that comprised a statistically representative sample in a structured questionnaire survey. That questionnaire comprised 30 productivity factors that were classified under the following three primary categories: (I) human/labor; (II) industrial and (III) management. The following factors were identified in this research and they are numbered by the ranking position got in the Egyptian study: (1) laborer experience and skill; (2) incentive program; (3) availability of materials and their ease of handling; (4) leadership and competency of construction management; (5) competency of labor supervision; (6) construction technology (construction method and technology); (7) labor operating system(daily wage, lump sum); (8) planning, work flow and site congestion; (9) constructability (integrated design and construction); (10) clarity of instructions and information exchange; (11) surrounding events (revolutions); (12) weather effect (temperature, humidity); (13) labor age; (14) distance between site and cities; (15)

services offered to laborers (social insurance, medical care); (16) effect of labor availability-work capacity (shortage); (17) project specifications; (18) over time (up to 4h after 8 h/day); (19) project scale; (20) available quantity of the daily work (workload); (21) work interruptions (design changes); (22) effect of labor availability-work capacity (excess); (23) work at heights; (24) degree of laborer education; (25) rest time(s) during the work day; (26) total project duration (total work hours); (27) construction management type (individual, firms); (28) over time (more to 4h after 8 h/day); (29) management of subcontractors and (30) type of project (industrial, residential). From results, it can be observed that the management category was ranked first, followed by the labor category and the industrial category.

Factors affecting labor productivity within building projects was the aim of a study developed by Enshassi et al. (2007). Other of the objectives to fulfill was to rank these factors according to their relative importance from a contractor's viewpoint. The research was based on a survey designed to gather all necessary information. The survey presented 45 productivity factors generated on the basis of related research work on construction productivity. These factors were classified into 10 groups: (I) manpower; (II) leadership; (III) motivation; (IV) time; (V) materials/tools; (VI) supervision; (VII) project; (VIII) safety; (IX) quality and the last category (X) which included external factors. Factors were then described in the same way they were ranked in the research: (1) material shortage; (2) lack of labour experience; (3) lack of labour surveillance; (4) misunderstandings between labour and superintendent; (5) drawings and specification alteration during execution: (6) payment delay; (7) labour disloyalty; (8) inspection delay; (9) working 7 days per week without taking a holiday; (10) tool and equipment shortage; (11) rework; (12) misuse of time schedule; (13) accidents; (14) labour dissatisfaction; (15) supervisor's absenteeism; (16) inefficiency of equipment; (17) misunderstanding among labour; (18) low quality and row materials; (19) working within a confined space; (20) unsuitability of materials storage location; (21) lack of financial motivation system; (22) high quality of required work; (23) violation of the safety precautions; (24) interference; (25) lack of competition; (26) method of employment (using direct work system); (27) insufficient lighting; (28) increasing number of labours; (29) weather changes; (30) increase of laborer age; (31) working overtime; (32) lack of labour recognition programs; (33) construction method; (34) type of activities in the project; (35) bad ventilation; (36) augmentation of Government regulations; (37) working at high places; (38) lack of periodic meeting with labour; (39) non-provision of transport means; (40) lack of place for eating and relaxation; (41) labour absenteeism; (42) labour personal problems; (43) unemployment of safety officer on the construction site; (44) lack of training sessions and finally (45) noise.

The analysis of the 45 factors considered in the survey indicated that the main factors negatively affecting labour productivity were: material shortage, lack of labour experience; lack of labor surveillance, misunderstandings between labour and superintendent, and drawings and specification alteration during execution.

By using a selected set of 45 attributes, Doloi et al. (2011) identified the key factors affecting delay in Indian construction industry and then established the relationship between the critical attributes for developing prediction models for assessing the impacts of these factors on delay. The basis of the research was formed by a questionnaire and personal interviews. Regression model was also used in this study. Delay attributes were identified under six broad categories

namely (I) project related; (II) site related; (III) process related; (IV) human related; (V) authority related and (VI) technical issues. The 45 attributes were the next ones: (1) increase in scope of work; (2) ambiguity in specifications and conflicting interpretation by parties; (3) faulty soil investigation report; (4) rework due to change of design or deviation order; (5) unrealistic time schedule imposed in contract; (6) non availability of drawing/design on time; (7) rework due to error in execution; (8) restricted access at site; (9) extreme weather conditions; (10) slow decisions from owner; (11) delay in material delivery by vendors; (12) site accidents due to negligence; (13) site accidents due to lack of safety measures; (14) unforeseen ground conditions; (15) hostile political conditions; (16) inaccurate specification of site condition; (17) delay in material to be supplied by the owner; (18) delay in approval of completed work by client (i.e. stage passing); (19) delay in material procurement by contractor; (20) delay in approval of shop drawings and samples; (21) delay in running bill payments to the contractor; (22) delay in handing over of site; (23) delay in finalization of rates for extra items; (24) improper storage of materials leading to damage; (25) consultant or architect's reluctance for change; (26) poor site management and supervision; (27) conflict between owners and other parties; (28) lack of skilled operators for specialized equipment's; (29) poor coordination among parties; (30) frequent change of sub-contractors; (31) obtaining permission from local authorities; (32) bureaucracy in client's organization; (33) poor organizational structure for client or consultant; (34) changes in government regulations and laws; (35) lack of control over sub-contractor; (36) poor means of contracting; (37) lack of motivation for contractors for early finish; (38) improper planning of contractor during bidding stage; (39) financial constraints of contractors; (40) poor labour productivity; (41) inadequate experience of contractor; (42) change in material prices or price escalation; (43) inefficient use of equipment's; (44) use of improper or obsolete construction methods and (45) unrealistic inspection and testing methods proposed in contract.

From the analysis, most critical factor of construction delay were identified as (1) lack of commitment; (2) inefficient site management; (3) poor site coordination; (4) improper planning and (5) lack of clarity in project scope. Moreover, regression model indicated that slow decision from owner, poor labour productivity, architect's reluctance for change and rework due to mistakes in construction were the reasons that affect the overall delay of the project significantly.

Kaming et al. (1997) researched the problems influencing craftsmen's productivity on 27 medium and high-rise building sites surveyed in Indonesia. Craftsmen participated in a comprehensive structured survey of production problems conducted over a 4-month period. The study instruments included craftsmen questionnaires and an activity sampling survey. The productivity problems that were rated by practitioners were: (1) lack of materials; (2) lack of tools; (3) equipment breakdown; (4) rework; (5) changing of workers; (6) interference; (7) absenteeism; (8) supervision delays; (9) changing of foremen; (10) too much work and (11) over crowded. Findings showed that that craftsmen in Indonesia spend in average 75% of their time working productively and five specific productivity problems were identified such as lack of materials, rework, absenteeism, lack of equipment and tools and gang interference.

Similarly, Soekiman et al. (2011) conducted a study with the aim to get the latest information on key factors that affect project performance in terms of project completion time. The

research reported on a survey made on respondents who involve in managing various types of projects in wide area in Indonesia. Respondents were required to rate using their experience how 113 factors identified from past researches, which were grouped into 15 categories: (1) design; (2) execution plan; (3) materials; (4) equipment; (5) labor; (6) health and safety; (7) supervision; (8) working time; (9) project factors; (10) quality; (11) financial; (12) leadership and coordination; (13) organization; (14) owner/consultant and (15) external related factors. The result showed that the groups of factors that given high effect were: supervision factors, material factors, execution plan factors, and design factors. In addition to these factors, for large companies equipment factors had also high effect. While in small and medium companies, owner/consultant factors also needed special attention because it had high effect too. Research findings also showed that health and safety factors have not been a concern of small and medium companies and only had some effect, while in large companies were better, although not as major concern and had average effect.

Zakeri et al. (1196) carried out a research to find out the constraints on Iranian construction operative's productivity. For that purpose, data were collected through a structured questionnaire survey. Zakeri et al. utilized the relative importance index ranking technique, so the identified problems were prioritized for detailed analysis and discussion. The main causes of poor productivity and hour's loss named in this study were: (1) lack of materials; (2) weather and site condition; (3) equipment breakdown; (4) drawing/spec./change order; (5) lack of proper tools and equipment; (6) inspection delay; (7) absenteeism; (8) safety (accidents); (9) improper plan of work; (10) repeating work; (11) changing crew size/ turnover; (12) interference at work and (13) poor communication. Results indicated that the five highest-ranking problems were: materials shortage, weather and site conditions, equipment breakdown, drawing deficiencies/change orders and lack of proper tools and equipment.

Since there are many challenges facing the construction industry in the state of Kuwait, Jarkas et al. (2012) proposed themselves to identify and rank the relative importance of the factors perceived to affect labor productivity on construction sites in Kuwait. To achieve this objective, a statistically representative sample of contractors was invited to participate in a structured questionnaire survey, comprising 45 productivity factors, classified under the following four primary groups: (I) management; (II) technological; (III) human/labor; and (IV) external. On the basis of related previous studies on labor productivity and the input of local industry experts, professionals, and practitioners, 45 factors were identified as it is shown: (1) clarity of technical specifications; (2) extent of variation/change orders during execution; (3) coordination level among various; (4) lack of labor supervision; (5) proportion of work subcontracted; (6) design complexity level; (7) lack of incentive scheme (8) lack of construction managers' leadership; (9) stringent inspection by the engineer; (10) delay in responding to RFI; (11) high/low temperature; (12) high humidity; (13) compatibility and consistency among contract documents ; (14) motivation of labor; (15) unsuitability of storage location; (16) rework; (17) working overtime; (18) site restricted access; (19) confinement of working space; (20) skill of labor; (21) physical fatigue; (22) shortage of experienced labor; (23) crew size and composition; (24) unrealistic scheduling and expectations of labor performance; (25) labor interference and congestion; (26) sandstorms; (27) shortage of materials; (28) construction method; (29) payment delay; (30) communication problems between site management and labor; (31) accidents as a result of poor safety program; (32) site layout; (33) late arrival, early

quits, and frequent unscheduled breaks; (34) unavailability of suitable tools; (35) inspection delay by the Engineer; (36) lack of training offered to labor; (37) inspection delay by site management; (38) sequencing problems, (39) lack of recognition program; (40) lack of periodical meetings with crew leaders; (41) high wind; (42) owner's representative intervention with site management and operatives; (43) lack of suitable rest area offered to labor on site; (44) lack of providing labor with transportation and (45) rain.

Among the factors explored, the subsequent 10 are discerned to be the most significant in their effects on labor productivity: (1) clarity of technical specifications; (2) the extent of variation/change orders during execution; (3) coordination level among design disciplines; (4) lack of labor supervision; (5) proportion of work subcontracted; (6) design complexity level; (7) lack of incentive scheme; (8) lack of construction manager's leadership; (9) stringent inspection by the engineer; and (10) delay in responding to requests for information. The results obtained fill a gap in knowledge of factors affecting labor productivity in Kuwait.

Abdul Kadir et al. (2005) conducted a study to evaluate and rank the importance, frequency and severity of project delay factors that affect the construction labour productivity for Malaysian residential projects. The research methodology followed to achieve the goals proposed was similar to other related studies. Respondents were asked to indicate how important each item of a list of 50 project related factors was to construction labour productivity. The data were then subjected to the calculation of important indices which enabled the factors to be ranked. The five most important factors identified by them were: (1) material shortage at site; (2) non-payment to suppliers causing the stoppage of material delivery to site; (3) change order by consultants; (4) late issuance of construction drawing by consultants and (5) incapability of contractors' site management to organize site activities. On the other hand, the five most frequent factors were: (1) material shortage at project site; (2) non-payment to suppliers causing the stoppage of material delivery to site; (3) late issuance of progress payment by the client to main contractor; (4) lack of foreign and local workers in the market and (5) coordination problem between the main contractor and subcontractor.

A research carried out by Durdyev and Mbachu (2011) aims to identify the key constraints to on-site labour productivity and improvement measures. Using the descriptive survey method, views of some project managers, contractors and subcontractors in New Zealand were canvassed via pilot interviews and questionnaire surveys at the qualitative and quantitative data gathering stages, respectively. Multi-attribute technique was used to analyse the quantitative data. Factors were grouped in 8 main categories attending to the nature of the factors. The first three categories were related with external constraints: (I) statutory compliance; (II) unforeseen events; (III) other external forces. Internal constraints grouped from category (IV) to category (VIII): (IV) project finance; (V) workforce; (VI) technology/process; (VII) project characteristics and finally (VIII) project management. Results showed that the key external constraints to on-site labour productivity comprise, in order of decreasing impact, statutory compliance, unforeseen events and wider external dynamics. The internal constraints were found to have much higher impact on onsite productivity than the external factors. In order of diminishing levels of impact, the internal constraints comprise reworks, level of skill and experience of the workforce, adequacy of method of construction, buildability issues, and inadequate supervision and coordination.

A research conducted in the late 1992 by Lim and Alum (1995) described about a survey of top civil-engineering and building contractors which was conducted to identify the perceptions of top management in relation to construction productivity. The paper describes one part of the survey that related to productivity issues encountered by contractors at construction sites. Respondents were asked to rank a list of 17 problems that could affect construction productivity. Problems were grouped in 3 different categories: (I) manpower, which included the following factors: (1) recruitment of supervisors; (2) recruitment of workers; (3) labour turnover; (4) absenteeism; (5) communications problems with foreign workers; (6) alcoholism and similar problems among workforce and (7) labour disruptions. Next category was (II) management: (8) materials shortages; (9) delays in materials deliveries to site; (10) disruption of power/water supplies; (11) stop-work orders because of site accidents; (12) stoppages because of work being rejected by consultants; (13) stop-work orders because of infringements of government regulations; (14) stoppages because of disputes with owners/consultants and (15) stoppages because of insolvency of subcontractors/suppliers. The last group of factors was (III) environment: (16) health and (17) inclement weather. The three items of greatest concern were identified as (a) difficulty in the recruitment of supervisors, (b) difficulty in the recruitment of workers, and (c) a high rate of labour turnover. The problems encountered least often included stop-work orders issued because of infringement of government regulations, and work stoppage resulting from disputes with owners/consultants.

Thailand is not an exception and has experienced productivity problems like many other countries. Makulsawatudom et al. (2004) identified factors that should be focused upon, when productivity improvement is to be initialized. To do so, 34 project managers working in the construction industry in Thailand completed a structured questionnaire survey and the factors were ranked according to their perception of their levels of influence and their potential for improvement based on their overall experience in managing projects in the industry. To supplement the questionnaire data, in depth interviews were conducted with some project managers. Factors that had to be rated by respondents were: (1) lack of material; (2) incomplete drawing; (3) incompetent supervisors; (4) lack of tools and equipment; (5) absenteeism; (6) poor communication; (7) instruction time; (8) poor site layout; (9) inspection delay; (10) rework; (11) occasional working overtime; (12) change orders; (13) tools/equipment breakdown; (14) specification and standardization; (15) interference from others or other crew members; (16) workers turnover and changing crewmembers; (17) scheduled working overtime; (18) safety (accidents); (19) poor site conditions; (20) changing of foreman; (21) overcrowding; (22) shift work and (23) weather.

The aim of the study developed by Durdyev et al. (2013) was to identify the key factors constraining labour productivity of Turkish contractors in Turkmenistan based on the views of project manager consultants, contractors and subcontractors. Qualitative data was collected through literature review formed the basis for questionnaire surveys conducted among the target populations. In-depth literature review revealed that 28 labour productivity constraining factors were used in this research: (1) working overtime; (2) rework; (3) work permit of the local labours; (4) high cost of the needed resources: material, money & machinery; (5) work delay caused by Inspection delays by local authority; (6) cost of the wasted materials on site; (7) inadequate financial policies of the government; (8) payment Delay; (9) lack of experienced Local project managers; (10) lack of labour motivation; (11) frequent changes in government

policies/legislations impacting on construction; (12) financial Weakness of the Contractor; (13) working 7 days/week without taking holiday; (14) high cost of foreign labour; (15) lack of communication between government authority and contractor; (16) over influence of the government on the construction process; (17) material shortage; (18) schedule pressure caused by government; (19) lack of local experienced labour; (20) frequency of design changes/ change orders; (21) poor estimation; (22) immigration department policies and (23) unfamiliarity with current job and conditions.

As it can be observed from similar researched explained in lines above, the productivity of labour is particularly important especially in developing countries, where most of the building construction work is still on manual basis. For this purpose, Alinaitwe et al. (2007) reported on a survey made on project managers of building projects in Uganda, where an increase in productivity is being sought. Respondents were required to rate using their experience how 36 factors affect productivity with respect to time, cost and quality. The survey was carried out by a questionnaire and responses received over a period of 3 months. The ten most significant problems affecting labour productivity were identified as: (1) incompetent supervisors; (2) lack of skills from the workers; (3) rework; lack of tools/equipment; (4) poor construction methods; (5) poor communication; (6) inaccurate drawings; (7) stoppages because of work being rejected by consultants; (8) political insecurity; (9) tools/equipment breakdown and (10)harsh weather conditions. Although lack of materials is ranked highest with regard to average rating on loss of time, it was not ranked among the top ten using the importance index that takes into account time, cost as well as work quality.

Horner et al. (1989), in a questionnaire survey to a wide section of British constructors, have identified the next 13 significant factors: (1) skill of labor; (2) buildability; (3) quality of supervision; (4) method of working; (5) incentive scheme; (6) site layout; (7) complexity of construction information; (8) crew size and composition; (9) length of working day; (10) availability of working tools; (11) absenteeism; (12) total number of operatives on site and (13) proportion of work outsourced. Regarding the results obtained by Horner et al., they further substantiate previous findings of the importance of applying the constructability concept to the productivity of the construction process.

Studies completed in the 1980s reported that construction labor productivity in the U.S. has gradually declined since the 1960s. Dai et al. (2009) made an effort to quantify craft workers' perspective of construction productivity, a nationwide survey was carried out involving 1,996 craft workers. The survey quantified the relative impact of 83 productivity factors, which had been identified through a series of focus group sessions involving craft workers conducted on construction jobsites located throughout the United States. A statistical comparative analysis was also employed to distinguish the significant factors encountered by craft workers on projects with relatively low perceived productivity. Factors were grouped in different categories according to their nature, the first one was (I) supervisor direction which included the next factors: (1) inadequate instruction provided; (2) not receiving directions due to size of the project; (3) receiving compliments for doing a good job; (4) being notified of mistakes when they occur and (5) lack of goals for craft workers. The next category was communication (II): (6) different languages spoken on a project; (7) disregard of crafts' productivity improvement suggestion; (8) Lack of "Big Picture" view on behalf of the crafts; (9) craft worker

importance and (10) lack of communication among site management. Third category was safety (III) which grouped the following factors: (11) shortage of personal protective equipment and (12) lack of site safety resources. Tools and consumables (IV) was established as other category with the next factors: (13) availability of consumables; (14) restrictive project policy on consumables; (15) availability of hand tools; (16) availability of power tools; (17) lack of power source for tools; (18) lack of extension cords; (19) inexperienced tool room attendants; (20) misplaced tools and (21) poor quality power tools. Material's category (V) included (22) availability of material; (23) poor material quality; (24) availability of bulk commodities; (25) errors in prefabricated material and (26) difficulty in tracking material. Engineering drawing management category (VI) was formed by (27) drawing errors; (28) availability of drawings; (29) slow response to questions with drawings; (30) drawing legibility and (31) needed information not on drawings. Labor (VII) category consisted of (32) availability of skill training; (33) jobsite orientation program; (34) availability of health and safety training; (35) qualified craftsmen; (36) craftsmen's pride in their work; (37) craftsmen's incentive; (38) motivated craft workers; (39) equal pay on projects in a geographic area and (40) craft workers' trust in supervisors. Category related with Foreman (VIII) grouped (41) foremen people skill; (42) qualified foremen; (43) fair/just performance reviews; (44) foremen allowing crafts to work autonomously; (45) lack of construction knowledge on behalf of foremen; (46) lack of authority to discipline craft workers and (47) lack of proper resource allocation. Supervisor direction category (IX) was related with (48) proper managerial and administrative support and (49) excessive paperwork. Superintendent category (X) grouped (50) superintendent's people skill; (51) qualified superintendents; (52) lack of experience on behalf of superintendents; (53) respect for craft workers; (54) micromanagement on behalf of superintendent; (55) political/performance competitions within company; (56) inconsistent safety policies established by different superintendents and (57) different work rules by superintendents. Project management category (XI) was formed by (58) delay in work permits; (59) out of sequence work assignments; (60) absenteeism; (61) reasonable project goals and milestones; (62) respect for craft workers and foremen; (63) layoff of qualified craft workers; (64) awareness of on-site activities and project progress; (65) pulling people off a task before it is done; (66) jobsite congestion; (67) different pay scales for the same job on a project; (68) different per diem rate; (69) incentive for good performance; (70) material storage area too far from workface; (71) insufficient size of material storage area; (72) shortage of temporary facilities; (73) coordination between the trades; (74) slow decisions; (75) correct crew size; (76) vehicle traffic routes and (77) weather protection. Last category was construction equipment (XII) which clustered the following factors: (78) availability of crane or forklift; (79) availability of manlift; (80) waiting for people and/or equipment to move material; (81) poor equipment maintenance; (82) equipment repairs and (83) maintenance of power tools.

Dai et al. (2009) found out that craft workers do have a good understanding of the factors affecting their daily productivity, and most of the adversarial factors affecting productivity can be addressed by site management teams. Factors involving tools and consumables, materials, engineering drawing management and construction equipment were identified as having the greatest impact on productivity from the craft workers' perspective.

Once all the factors studied by different researchers throughout the last decades have been exposed, factors selected for this research and also its justification of why they have been selected for this research are exposed in next chapter.

Chapter 6

QUESTIONNAIRE DESIGN

1. Introduction

Main instrument of collecting data from construction companies was decided to be a structured questionnaire survey. This way of getting data from respondents has proved its effectiveness since they can be extremely efficient at providing large amounts of data, at relatively low cost, in a short period of time. Some of the questions of the questionnaire have been adapted from knowledge published in literature in order to fit the analysis context.

The survey is displayed as a series of statements generated on the basis of related researches about factors constraining construction labor productivity. For this purpose, literature review becomes a determining issue since data acquired from papers and related publications will be the base for the structured questionnaire survey preparation. Participants were required to rate the factors for the way they thought construction labor productivity could be affected, taking into account time, cost and quality using their own experiences on construction sites.

2. Establishing the factors affecting Construction Labor Productivity

Once factors previously studied by many other authors have been collected, it was decided to develop a list of 35 factors for this research. Then, the listing of these factors and a brief description of each one was exposed. Factors were grouped then in 5 different categories according to the nature of the factors involved. These categories were numbered by Latin numbers just like in previous chapters and were shown below: **(I) project category** used by factors related with the project itself; **(II) human category** for the factors affecting the laborers; **(III) management or organizational category** for those factors referred to planning, scheduling and supervising issues; **(IV) materials and tools category** for those factors related with the supply or shortage of materials, tools, equipment's or machinery; and finally **(V) environmental factors category** encompassing factors which cannot managed.

2.1. Project related factors' category

In this category the following factors were grouped: (1) construction method; (2) design complexity; (3) incomplete or unclear drawings or project specifications and (4) project scale. All these factors referred characteristics given by the project itself, so it is needed to face with them in the best possible way.

Factor No. 1: Construction method

One of the most difficult tasks an engineer has to face up is to decide and create the construction method that is going to be used for a specific construction work. Sometimes, answering how we want to build something becomes harder than responding what we want to build mainly due to the buildability of the design. Construction method and the technology used make from this decision to have great implications on productivity and performance of the construction workforce (Enshassi et al. 2007). Therefore, as Durdyev and Mbachu (2011)

suggested, the method should depend on the design as well as the conditions and circumstances of the project.

Factor No. 2: Design complexity

It is easy to understand that the more complex a project becomes, more time construction crews will need to understand how it should be run. Building a deck may provide a good example of how design complexity affects labor productivity. Building a curve shaped deck is far more difficult for workers unfamiliar with this type of construction and they will need to use more time on order to ensure that they understand the drawings and technical specifications than executing the same deck but with flat design.

Factor No. 3: Incomplete or unclear drawings or project specifications

Lack of clarity or incomplete drawings or technical specifications require continuous requests for clarifications, hence consecutive interruptions and/or disruptions to work progress. Furthermore, possible modifications, or substantial reconsiderations may be necessary to design documents, which can lead to rework, consequently, low productivity is incurred. This impact is perhaps related to the short time available to designers between the design start up and the call for tender. As a result, tender documents are most often incomplete, unclear, or contain serious conflicts among the various disciplines involved (Jarkas and Bitar 2012).

Factor No. 4: Project scale

This factor refers to the importance of the size project. Large projects are more difficult to supervise due to the distance between construction sites and the high number of crews inside the project. Moreover, crowded projects may impact on labor productivity if there is not enough availability of equipment for all the crews working or if they interfere one with other because the site congestion.

2.2. Human related factors' category

In this category, factors related with labor or human characteristics such as age, experience, etc. were listed: (5) laborer experience and skill; (6) laborer's ability to adapt to changes and new working environments; (7) labour motivation; (8) working overtime; (9) rest time(s) during the workday; and (10) integrity.

Factor No. 5: Laborer experience and skill

Poorly trained and unskilled operatives are commonly characterized by low and faulty outputs coupled with unjustifiably high inputs. In addition, their outputs are almost always rejected by the inspection engineer, either in whole or in part, resulting in extensive and expensive rework, rectifications, or repairs. On the contrary, experienced operatives possess sound intellectual abilities, practical solutions to obstacles, and high technical and motor skills. All of these lead to higher productivity, lower cost of labor, and better quality of finished outputs.

Factor No. 6: Laborer's ability to adapt to changes and new working environments

This factor refers to the possible influence based on the ability to changes new working environments, new construction techniques and their learning curves.

Factor No. 7: Labour motivation

Motivated laborers are usually more enthusiastic and initiative. They work harder and respond faster to instructions. Their pace is, moreover, associated with a greater sense of pride, satisfaction, and responsibility, thus they typically achieve better levels of productivity, in comparison with demotivated or discouraged laborers.

Factor No. 8: Working overtime

This effect is expected because working overtime causes physical fatigue to operatives and decreases their agility, stamina, and motor skills, thus leading not only to low productivity, but also to a high probability of poor workmanship, rework, and worst, accidents on sites.

Factor No. 9: Rest time(s) during the workday

Working without making any pause creates an adverse effect on the motivation and physical conditions of laborers, thus decreasing their productivity. However, having too many pauses is not beneficial to increase productivity since there are wastes of time while laborers stop what they are doing in that moment, go to the resting area and then return to his job.

Factor No. 10: Integrity

Although this factor has been barely studied before as a factor that could affect labor productivity, we think it can have wide importance as a factor affecting labor productivity in the construction industry. The meaning of this word is related with the adherence to moral and ethical principles; the soundness of moral character and also with honesty. This factor which has been just presented is intended to highlight its importance for increasing performance in the construction industry in the way people reaches their commitments acquired when their word is given to someone else. As Erhard et al. (2013) explained, integrity means that you either keep your word, or as soon as you know that you will not, you say that you will not be keeping your word to those who were counting on your word and clean up any mess you caused by not keeping your word. Or in other words "keeping your word" means doing what you said you would do and by the time you said you would do it. Being consequent when you compromise with someone else is also the path to creating whole and complete social and working relationship thus the pathway to earning the trust of others is provided. Building trust between the actors responsible for the execution of the work is very important as well as the fulfillment of the commitments made. Non-compliance with these commitments or not telling them in time can be compromising with the scheduling of the construction project.

To have a better comprehension of this phenomenon, an example of how this effect can affect performance is shown. Imagine there is a crew "B" responsible of installing the bars for a concrete reinforced pile of a bridge, before they can start working; another crew "A" has had

to install the formworks so the bars could be placed and concrete could be later poured in. Person in charge of the crew "A" gave his word so he committed to have their task done in 3 days. During the second day there was a big storm with high winds in the construction site so the crane could not lift the different formworks and consequently they could not be installed. In third day, the responsible of crew "A" knew there was going to be a delay caused by the storm the previous day but instead of advising the responsible of crew "B" of that delay, he thought they could work faster the third day and finish the installation of the formworks in time. When third day was over it was already obvious that crew "B" could not start installing bars for the reinforcement concrete next day because there was a part of the formwork which had not been placed yet. Even so, the responsible of crew "A" did not alert of that fact and next day crew "B" was at the base of that pile waiting to start installing the bars. Crew "B" had to wait for one hour before crew "A" finish with the formwork and they could start lifting and placing bars. If we assume the crew was formed by 4 people, then 4 hours of labor were lost. This is only one of the many examples that they can be seen at the construction site. This decrease of the labor productivity (since they were not working, the productivity was 0) was due mainly by two facts. The first one was that the responsible of crew "A" did not accomplish their commitment or said in other words, he failed his word. The second fact was that if instead of still denying the delay, he had advised the responsible of crew "B" at time, crew "B" could have been working in other place until they have finished before moving to the pile or at least have arrived one hour later.

Similar examples could be noted with late supply of materials, tools, equipment or machinery. Construction projects have a lot of chained activities where one activity cannot be started if the previous one has been finished or at least it has been partially finished. This means that construction laborers should be aware that failing their word, it does not only affect him but also affects to other activities with consequent loss of human and maybe material resources and so productivity. The way to fix this should be that as soon as your knew you could not finish or fulfill your commitments on time, then advise of that and try to clean up any mess caused by the fact of not accomplishing your commitments on time.

2.3. Management or organizational related factors' category:

The next factors were group under Management factors category: (11) incentive policies; (12) clear and daily task assignment to laborers; (13) supervision of subcontractors; (14) coordination of subcontractors; (15) inadequate planning of the work due to incompatibilities or restrictions; (16) site congestion; (17) delays in payments to workers; (18) delays in payments to suppliers (19) unrealistic scheduling and expectations of labor performance; (20) communication problems between site management and workers; (21) reallocation of laborers; (22) coordination between crews during execution; (23) lack of labor supervision or inspection delay; and (24) rework. All these factors are related with planning, scheduling or supervising issues.

Factor No. 11: Incentive policies

Motivation provided by incentive policies is essential to laborers, as it gives site workers satisfaction such as achievement, sense of responsibility and pleasure of the work itself.

Factor No. 12: Clear and daily task assignment to laborers.

One of the main objectives of the project manager is to maintain a constant workload for all workers. They should avoid interruptions because these workers would stop producing so their productivity would be 0 and instead, the construction Company has to continue paying them.

Factor No. 13 and No. 14: Management of subcontractors

Supervision and proper coordination of subcontractors have the most significant impact on on-site labour productivity. (Abdul Kadir et al. 2005) put emphasize on coordination with subcontractors, which was ranked as one of the influential factors in the study. Furthermore other similar researches argued that effective project integration management, comprising the activities that integrate, coordinate and bring together the various functions and multiple stakeholders, is the key to achieving onsite productivity and performance.

Factor No. 15: Inadequate planning of the work due to incompatibilities or restrictions

Liu et al. (2011) concluded that labor productivity was positively correlated with percent plan complete (PPC), a measure of work flow variation. The relationship between productivity and the ratio of total task completion to planned tasks, weekly workload, weekly work output, and weekly work hours was also studied, and no significant correlation was found. The results suggest that productivity is not improved by completing as many tasks as possible regardless of the plan, nor from increasing workload, work output, or the number of work hours expended. In contrast, productivity does improve when workflow is made more predictable.

Factor No. 16: Site congestion

Site congestion is usually attributed to inappropriate construction site arrangement and overcrowding of the workers in some workplaces, which can cause obstructions to the desired productivity and quality. The overcrowding of workers usually results from inappropriate general planning of construction site activities.

Factor No. 17 and No. 18: Delays in payments to workers and suppliers

These factors may have a negative effect on a laborers' mood due to the loss of confident in its company, and consequently decreases its productivity. Moreover, late payment to providers can bring delays in delivering the materials or a reduction in the quality of materials delivered.

Factor No. 19: Unrealistic scheduling and expectations of labor performance

Unrealistic scheduling and expectation of labor performance due to overconfidence from project managers may lead to overcrowding, interference between activites, overtime, uneasiness, hastiness, and sloppiness on operatives' part, resulting in bad workmanship, rejection, and rework, and hence discouragement and low labor productivity. In addition, previous research shows that attempting to reduce the time available to complete a project

through schedule compression not only negatively impacts the efficiency of labor but also becomes a source of dispute between employers and contractors (Chang et al. 2007).

Factor No. 20: Communication problems between site management and workers

This factor due to the lack of clarity of the instructions and the information exchange between site management and laborers may have great consequences on labor productivity. The misunderstandings lead to a loss of time that can produce that some part of the work already done had to be reworked. In order to overcome communication problems, instead of informal verb communication, documentation such as work procedures, manuals, charts and guidelines should be used.

Factor No. 21: Reallocation of laborers

Moving laborers from one activity to other activity in short periods of time may decrease labor productivity since workers need time to get used to the new job site and the new activity they have to develop. This effect can be explained by the Learning curves which can help us to get a better comprehension of this phenomenon.

Factor No. 22: Coordination between crews during execution

Interference between gangs and workers is caused by mismanagement on construction sites, with steel fixers suffering more of this, possibly because they are more dependent on other trades. For example, if the carpenters have not completed the formworks, steel fixers will have to wait before fixing the reinforcement rods.

Factor No. 23: Lack of labor supervision or inspection delay

Continuous supervision of labor is necessary to optimize the productive input. Lack of supervision encourages operatives, especially those who are under the direct employment method, to engage in unproductive activities, take frequent unscheduled breaks, wait idle, or even leave the job sites during working hours to attend to personal matters. Direct supervision of labor is required to avoid faulty and nonconforming work to contractual specifications and thus minimize the expensive incidents of rework and the associated delays to activities at hand. In the same way, a work inspection by a supervisor is an essential process to proceed in work; for example, as contractors cannot cast concrete before inspection of formwork and steel work, inspection delay contributes to delays in work activities.

Factor No. 24: Rework

The more rework, the more time and cost needed for construction (Makulsawatudom et al. 2004). Causes of rework can be attributed mainly to incompetent laborers and incompetent supervisors. Insufficient working skill and knowledge of drawings are examples of an incompetent laborer, while lack of experience, leading to deficient supervision, is an example of incompetent supervisors. Other causes of rework advised where change orders and incomplete drawing.

2.4. Materials and tools related factors' category

In this category, the three following factors were related with the supply or shortage of materials, tools, equipment's or machinery and so, they were grouped: (25) material shortage or late supply of materials; (26) unsuitability of materials storage location; and (27) tools and equipment shortages.

Factor No. 25: Material shortage or late supply of materials

As work cannot be accomplished without necessary materials, unavailability of materials caused by material shortage or late supply from providers may negatively affect labour productivity.

Factor No. 26: Unsuitability of materials storage location

This factor refers when either workers or machinery have to move long distances in order to get the tools they will use from unsuitable storage locations, this entails a waste of time and therefore productivity will decrease. To avoid this, it becomes so important to plan where storages will be placed before the construction project begins.

Factor No. 27: Tools and equipment shortages

As presented in different researches conducted in US, UK, Indonesia, and Nigeria (Guhathakurta et al, 1993; Olomolaiye et al, 1996), tools and equipment shortages also have a high effect in the similar researches developed in This result might be justified, as labour needs a minimum number of tools and equipment to work effectively. If there is lack of equipment and/or tools, productivity will decrease.

2.5. Environmental related factors' category

This category encompasses the last eight factors: (28) working at night; (29) working at height; (30) limitation of motion at the jobsite; (31) air humidity; (32) high/low temperatures; (33) rain; (34) high winds; and (35) distance between construction sites and cities.

Factors from No. 28 to No. 30: Site conditions

Site conditions such as insufficient lighting, working at high places and limitation of motion at jobsites may be responsible for laborers cannot work effectively, and consequently, they may have negative impacts on labour productivity.

Factors from No. 31 to No. 34: Weather conditions

Weather conditions such as level of relative humidity, temperature, rain, high winds or storms change constantly and more so in a country like Spain. These conditions can vary greatly depending on the region in which you are within Spain. For example, the temperature in the North is moderate in summer while in the south extremely high temperatures are reached

during the summer months. Adverse winter weather such as winds and rains reduce labour productivity; particularly external work such as formwork, steel work, concrete casting, external plastering, external painting, and external tiling. Adverse weather sometimes stopped work totally.

Factor No. 35: Distance between construction sites and cities

El-Gohary and Aziz (2014) observed that distance between construction sites and cities may be an impediment to achieve good productivity because of the difficulties and transport time of both materials and workers.

3. Structure of the questionnaire

Once the factors that are going to be used for the questionnaire have been selected, the structure of the questionnaire survey is now presented.

For carrying out this study, the main instrument of collecting data from construction companies was decided to be a structured questionnaire survey. This way of getting data from respondents has proved its effectiveness since they can be extremely efficient at providing large amounts of data, at relatively low cost, in a short period of time. Some of the questions of the questionnaire have been adapted from knowledge published in literature in order to fit the analysis context.

The survey was divided in two parts. The first part requested respondents to answer some important data in order to stratify results. Second part displayed as a series of statements generated on the basis of related researches about factors constraining construction labor productivity. For this purpose, literature review carried out in the previous chapter becomes a determining issue since data acquired from papers and related publications will be the base for the structured questionnaire survey preparation.

Although the whole master thesis has been developed in English, the questionnaire was designed directly in Spanish as respondents will be Spanish or at least would have knowledge of the language. Factors were taken from literature in English and statements generated for each factor in order to rate factors were also developed in English. This was helpful to discuss them with my advisor in Germany. Subsequently, each statement was then translated into Spanish to add it up to the questionnaire.

The first part of the questionnaire shows a series of data that should be provided by respondents in order to later make a stratification of the results obtained. First part includes personal and professional data of interest for the research and under this category is requested: (1) name of the company or organization; (2) size of the company or organization by number of employees; (3) geographic scope of the company; (4) province where the respondent develops his work at present; (5) age; (6) gender; (7) maximum level of studies reached; (8) years of experience in the construction industry; and (9) professional fields where professional experience was acquired. In order to facilitate the answer from respondents, most of the previous questions had the possible answers in a list below the question. For

instance, In the age question (5), possible answers were displayed in a list as follows: (a) less than 24 years old; (b) between 25 and 29 years old; (c) between 30 and 34 years old; (d) between 35 and 39 years old; (e) between 40 and 44 years old; (f) between 45 and 49 years old; (g) between 50 and 54 years old; (h) between 55 and 59 years old; and (i) more than 60 years old. So the procedure is very quick and easy for the respondent since he/she only needs to see which answer fits best with him/her and mark it. The appearance of the first part of the questionnaire was shown in the Figure 6 below.

APARTADO I: Información personal y profesional de interés

1. Empresa u organización a la que pertenece *	<input type="text"/>
2. Tamaño de la empresa u organización por número de empleados.*	<input type="text" value="▼"/>
3. Ámbito de actuación geográfica de la empresa u organización.*	<input type="text" value="▼"/>
4. Provincia donde desempeña su función en la empresa u organización actualmente.*	<input type="text"/>
5. Edad*	<input type="text" value="▼"/>
6. Sexo*	<input type="radio"/> Hombre <input type="radio"/> Mujer
7. Máximo nivel de estudios alcanzado*	<input type="text" value="▼"/>
8. Años de experiencia en el sector de la construcción*	<input type="text" value="▼"/>
9. Ámbitos profesionales donde ha obtenido la experiencia mencionada en el apartado 8. (marcar máximo dos)*	<input type="checkbox"/> Empresa constructora <input type="checkbox"/> Proveedor <input type="checkbox"/> Consultoría <input type="checkbox"/> Despacho arquitectura <input type="checkbox"/> Asistencia técnica <input type="checkbox"/> Dirección facultativa <input type="checkbox"/> Otros

Figure 6. Appearance of the first part of the questionnaire

Then, the second part of the questionnaire survey is displayed as a series of statements generated from selected factors based on literature review and related researches. These statements were translated into Spanish since the questionnaire was going to be sent to Spanish practitioners. Statements tried to summarize all the description of the factors previously given in lines above in a brief sentence so the reader can clearly understand what that factor means and rate them in consequence.

These statements were then displayed so as their translation into Spanish for each of the factors studied.

Statement for Factor No. 1: Construction method

- **Spanish:** El proceso constructivo utilizado para ejecutar el proyecto diseñado.
- **English:** The construction method used to execute the project designed.

Statement for Factor No. 2: Design complexity

- **Spanish:** Influencia del diseño de una infraestructura a la hora de ejecutarla.
- **English:** The complexity of the design when executing a construction project.

Statement for Factor No. 3: Incomplete or unclear drawings or project specifications

- **Spanish:** Calidad en los planos o documentos del proyecto constructivo.
- **English:** Quality on the drawings or construction project documents.

Statement for Factor No. 4: Project scale

- **Spanish:** Tamaño del proyecto.
- **English:** Project scale.

Statement for Factor No. 5: Laborer experience and skill

- **Spanish:** Nivel de capacitación y experiencia previa de los trabajadores.
- **English:** Level of skill and previous experience of the laborers.

Statement for Factor No. 6: Laborer's ability to adapt to changes and new working environments

- **Spanish:** Capacidad de adaptación a los cambios y nuevos entornos de trabajo.
- **English:** Ability to adapt to changes and new working environments by the laborers.

Statement for Factor No. 7: Labour motivation

- **Spanish:** Motivación de los operarios a la hora de realizar su trabajo.
- **English:** Labour motivation when performing their work.

Statement for Factor No. 8: Working overtime

- **Spanish:** Trabajar más horas de las correspondientes durante la jornada laboral.
- **English:** Working overtime.

Statement for Factor No. 9: Rest time(s) during the workday

- **Spanish:** Influencia del número de descansos y duración de los mismos durante la jornada laboral.
- **English:** Influence of the number of breaks and their duration during the workday.

Statement for Factor No. 10: Integrity

- **Spanish:** Influencia de la honestidad y comportamiento ético de los trabajadores en el desempeño del trabajo y el valor del proyecto.

- **English:** Influence of worker's Integrity as a set of moral principles, honesty and ethical behavior on labour performance and project value.

Statement for Factor No. 11: Incentive programs

- **Spanish:** Influencia de las políticas de incentivos en el desempeño de los trabajadores.
- **English:** Influence of incentive policies on worker performance.

Statement for Factor No. 12: Clear and daily task assignment to laborers

- **Spanish:** Asignación clara y diaria de las tareas a los trabajadores.
- **English:** Clear and daily task assignment to laborers.

Statement for Factor No. 13: Supervision of subcontractors

- **Spanish:** Insuficiente supervisión de los subcontratistas.
- **English:** Insufficient supervision of subcontractors.

Statement for Factor No. 14: Coordination of subcontractors

- **Spanish:** Incorrecta coordinación de los subcontratistas.
- **English:** Improper coordination of subcontractors.

Statement for Factor No. 15: Inadequate planning of the work due to incompatibilities or restrictions

- **Spanish:** Incorrecta planificación de los tajos de trabajo debido a incompatibilidades o restricciones.
- **English:** Inadequate planning of the work due to incompatibilities or restrictions.

Statement for Factor No. 16: Site congestion

- **Spanish:** Elevada congestión en la obra.
- **English:** High congestion in the construction site.

Statement for Factor No. 17: Delays in payments to workers

- **Spanish:** Retrasos en los pagos a trabajadores.
- **English:** Delays in payments to workers.

Statement for Factor No. 18: Delays in payments to suppliers

- **Spanish:** Retrasos en los pagos a proveedores.
- **English:** Delays in payments to suppliers.

Statement for Factor No. 19: Unrealistic scheduling and expectations of labor performance

- **Spanish:** Planificación poco realista debido al exceso de confianza por parte de los responsables del proyecto.
- **English:** Unrealistic scheduling due to overconfidence from project managers.

Statement for Factor No. 20: Communication problems between site management and workers

- **Spanish:** Problemas de comunicación entre los responsables de proyecto y los trabajadores.
- **English:** Communication problems between site management and workers.

Statement for Factor No. 21: Reallocation of laborers

- **Spanish:** Reasignación de los operarios a nuevos tajos de obra en función de las necesidades.
- **English:** Reallocation of laborers depending of the working needs.

Statement for Factor No. 22: Coordination between crews during execution

- **Spanish:** Coordinación entre equipos de trabajo durante la ejecución de la obra.
- **English:** Coordination between crews during execution of the construction project.

Statement for Factor No. 23: Lack of labor supervision or inspection delay

- **Spanish:** Inadecuada supervisión de las actividades ejecutadas.
- **English:** Lack of supervision or delay in inspecting the activities executed.

Statement for Factor No. 24: Rework

- **Spanish:** Necesidad de volver a ejecutar una actividad debido a una mala ejecución.
- **English:** Rework.

Statement for Factor No. 25: Material shortage or late supply of materials

- **Spanish:** Escasez o suministro tardío de los materiales necesarios para ejecutar una actividad.
- **English:** Shortage or late supply of needed materials to accomplish an activity.

Statement for Factor No. 26: Unsuitability of materials storage location

- **Spanish:** Falta de idoneidad en la ubicación del acopio de los materiales.
- **English:** Unsuitability of materials storage location.

Statement for Factor No. 27: Tools and equipment shortages

- **Spanish:** Escasez de herramientas y maquinaria necesaria para ejecutar una actividad.
- **English:** Tools and equipment shortages when needed to accomplish an activity.

Statement for Factor No. 28: Site conditions: working at night.

- **Spanish:** Realización de trabajos durante la noche.
- **English:** Performing work at night.

Statement for Factor No. 29: Site conditions: working at height.

- **Spanish:** Influencia de la realización de trabajos en altura.

- **English:** Influence of working at height.

Statement for Factor No. 30: Site conditions: Limitation of motion at the jobsite.

- **Spanish:** Limitación del movimiento debido a las condiciones del puesto de trabajo.
- **English:** Limitation of motion due to the conditions at the jobsite.

Statement for Factor No. 31: Weather conditions: air humidity

- **Spanish:** Influencia de la humedad del aire en el desempeño de los trabajadores.
- **English:** Influence of air humidity on laborer’s performance.

Statement for Factor No. 32: Weather conditions: high/low temperatures

- **Spanish:** Influencia de altas/bajas temperaturas en el desempeño de los trabajadores.
- **English:** Influence of high/low temperatures on laborer’s performance.

Statement for Factor No. 33: Weather conditions: rain

- **Spanish:** Influencia de la lluvia en el desempeño de los trabajadores.
- **English:** Influence of rain on laborer’s performance.

Statement for Factor No. 34: Weather conditions: high winds

- **Spanish:** Influencia de vientos de intensidad en el desempeño de los trabajadores.
- **English:** Influence of high winds on laborer’s performance.

Statement for Factor No. 35: Distance between construction sites and cities

- **Spanish:** Distancia desde la localización de las obras a la residencia de los trabajadores.
- **English:** Distance between construction sites and residences of the workers.

The appearance of the second part of the questionnaire is then shown in Figure 7.

APARTADO II: Valoración de las percepciones sobre la influencia de los siguientes factores en la productividad del trabajo

A continuación, usted deberá valorar el grado de influencia que, en su opinión, cada una de estas afirmaciones tienen sobre la rendimiento de los trabajadores en su empresa u organización.

Leyenda:

"1" Muy poco efecto; "2" poco efecto; "3" efecto medio; "4" efecto moderado; y "5" elevado efecto.*

	1	2	3	4	5
1. El proceso constructivo utilizado para ejecutar el proyecto diseñado.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. Influencia del diseño de una infraestructura a la hora de ejecutarla.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. Calidad en los planos o documentos del proyecto constructivo.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 7. Appearance of the second part of the questionnaire

After the 35 statements referring to different factors were exposed and consequently requested to be rated, a final message was displayed thanking the respondents for their participation in the research and also indicating if the respondent would like to obtain a copy of the results obtained in the research. It also reminded the respondents to click on the "Submit questionnaire" button below in order to submit the results.

Lastly, a legal note was added in order to provide some legal information about the management and storage of the data as well as its diffusion to external people accordingly to the laws in force in Spain. These were the laws related to the legal note:

- Law 15/1999 of December 13, Protection of Personal Data
- Law 34/2002 of the Information Society and Electronic Commerce (LSSI).

All these questions mentioned in lines above were taken into account and then translated into the questionnaire as it can be seen in Figure 8.

¡Muchas gracias por su participación!

Por último, si desea recibir una copia de los resultados obtenidos en este estudio, indique su Correo electrónico al cual desea que sea enviada.

No olvide pulsar el link inferior "[Enviar cuestionario](#)" para enviar las respuestas

Nota Legal:
 Los datos proporcionados serán tratados de acuerdo con la protección y especificaciones contenidas en la Ley 15/1999, de 13 de Diciembre, de Protección de Datos de Carácter Personal así como su normativa de desarrollo.

NO se utilizarán dichos datos para el envío de comunicaciones comerciales por correo electrónico no solicitadas o no autorizadas expresa y previamente por el interesado, según lo estipulado en la Ley 34/2002 de Servicios de la Sociedad de la Información y de Comercio Electrónico (LSSI).

Figure 8. Appearance of the thanking final part of the questionnaire

3.1. Likert scale

In order to assess the individual's performance or standing on the attribute of the given questions, Likert scale has been used. Nowadays, the summated rating approach is very widely used. It has the added advantage of being relatively easy to develop. This measurement scale was original devised by Likert in the 1930s and scales developed by this method are commonly termed Likert scales.

In this study, respondents were required to rate the factors affecting labor productivity on a scale with the rating of "1," very little effect; "2," little effect; "3," average effect; "4," high effect; and "5," very high effect, according to the degree of importance on construction labor productivity. The number assigned to the agreement scale (1, 2, 3, 4, 5) do not indicate that

the intervals between the scales are equal, nor do they indicate absolute quantities. Evaluation scale is shown below in Figure 9.

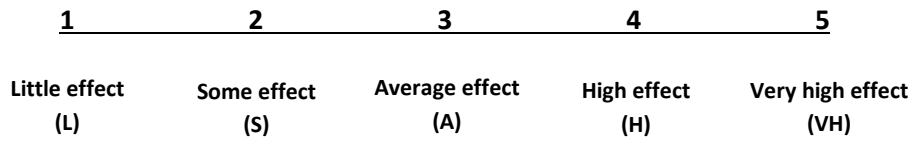


Figure 9. Evaluation method using Likert scale

Main characteristics of the questionnaire design were that statements used had to be easy to read, understandable and interpreted in the same way by all respondents. More accuracy in the final outcome as well as needing a short period of time to be answered by respondents have been also very important issues taken into account while the questionnaire was being developed. The need of taking smaller time as possible for construction companies to respond was considered very seriously in order to obtain the maximum possible answers. The optimum inverted time for answering the questionnaire should not take more than several minutes. Participants were contacted by email and only by email as the manner to invite them to participate in the research.

4. Pilot study

Pilot study was made in order to help minimizing some of the inevitable problems of converting the design of the questionnaire into reality. A little survey was piloted on a small scale in order to ensure readability, accuracy and comprehensiveness of the questionnaire to participants. Two researchers in the same field examined the questionnaire and based in their feedback validations and improvements were made in terms of wording of statements, the overall content, and the format and layout. Accordingly, the questionnaire was validated through this process with suggestions from experts before launching the survey.

Suggestions were collected from the experts and some changes were made in some of the statements to improve the readability by the potential respondents. This step was very important to ensure that each statement could be read and rated without misunderstandings.

5. Sending the questionnaires

A huge amount of email had to be sent to potential respondents to assure that all needed answers would be collected; the minimum amount of answers was calculated in the chapter "Determination and selection of the samples" and so, settled in 367 answers.

During the previous months before coming to Germany, when the research methodology was still unclear but carrying out a survey or a questionnaire seemed to be the way to collect data from construction companies, it was then decided to begin getting emails addresses from the companies. The methodology is showed in Figure 10 and then showed: Firstly, a search was conducted one by one by different provinces. After that step, companies from the given list were selected and their names were noted and added to the database. At last, another searching was undertaken in the website of each company with the aim of getting the email address and store them in a database for the purpose of inviting companies to participate in the study. These construction companies were selected from those who hold valid membership in the Official Register of Classified Companies of Spain. (O.R.C.C. 2014)

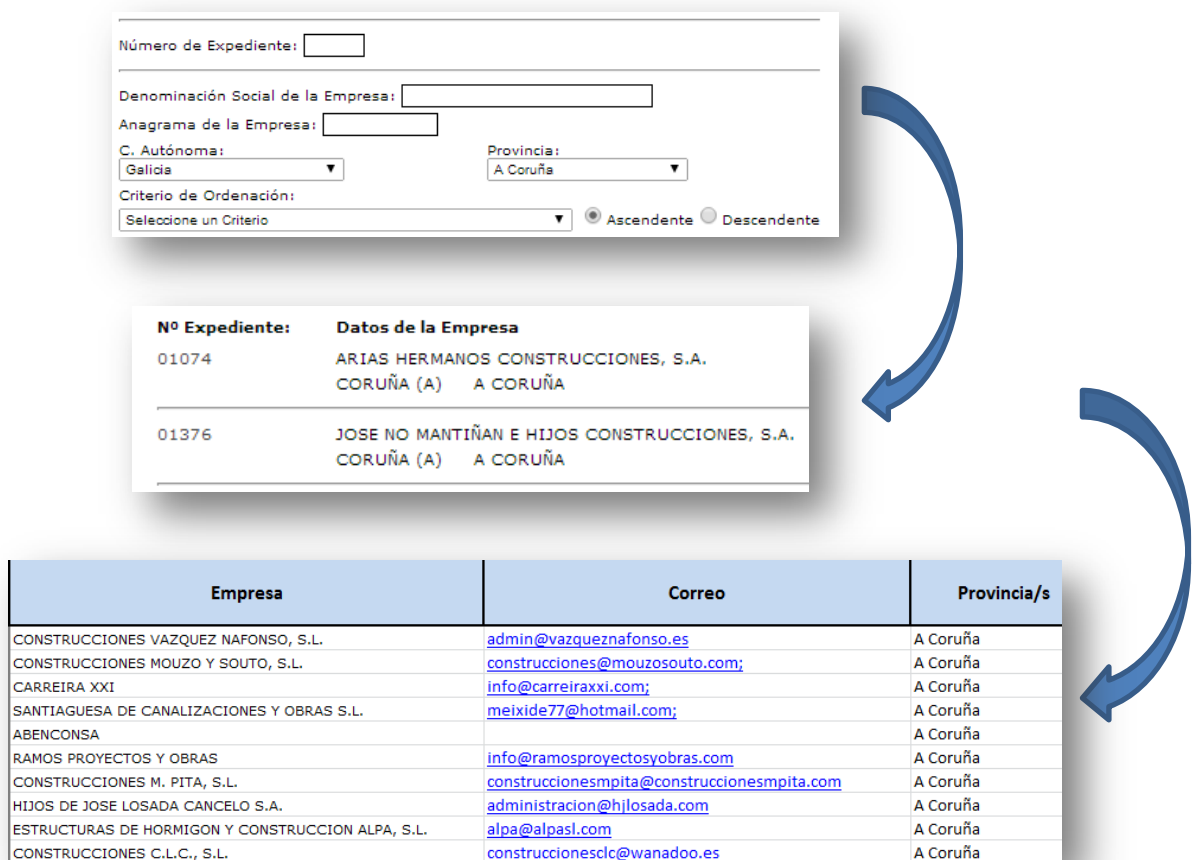


Figure 10. Methodology followed for developing the database

After some months of recovering data, a total amount of 1450 email addresses from construction companies were collected. This meant that the ratio of valid answers by number of emails sent was approximately established in 1:4 as the required amount of answer was previously established in 367 in order to be a representative sample.

As sending such amount of emails seemed to be difficult task since email providers could detect an abnormal amount of submission emails, it was established that emails were going to be sent in 4 batches. Each one of these batches would be sent in different days and the quantity of mails per batch is then showed.

- **First batch:** 350 emails
- **Second batch:** 350 emails
- **Third batch:** 350 emails.
- **Fourth batch:** 400 emails.

A new email address was opened for this research "*proyecto.upv.kit@gmail.com*". The purpose of this action was to send all the emails and receive all the answers back from practitioners in the same account.

Finally, an introductory letter was written in order to present the study, explaining to practitioners how was going to be developed, how they could take part in it and the advantages those constructions companies would have by participating in it. Finally, it was also attached the link to the online questionnaire. This covering letter is displayed in the Annexes.

Chapter 7

**DETERMINATION AND
SELECTION OF SAMPLES**

1. Introduction

The relevant data to this investigation were collected by a structured closed-ended questionnaire survey. On the basis of related previous studies on labor productivity and the suggestions from industry experts, a series of factors were identified and requested to participants to rate in the lines above. In this chapter, target population will be selected and determined in order to get a representative sample. For this research, participants were selected from those who hold valid membership in the Official Register of Classified Companies of Spain. To ensure a representative sample of all targeted participants, a systematic random sample was prepared by using equations from (Hogg and Tanis 2009). It has also been taken into account when determining the sample the number of respondents answering and sending back the survey from all that have been submitted. This is important because related researches showed that approximately they only had feedback from respondents in less than half of the cases.

2. Determination of samples

The target population included all companies related with the construction industry cataloged in the Official Register of Classified Companies of Spain. This register is compiled by the Ministry of Finance. This classification groups all Spanish contractors which can contract with the administration. The criteria for being a registered company are based upon:

- The technicality of a company, which is dependent on the number and category of their technical staff.
- The rate of mechanization of a company, which is dependent on the current value of its machinery.
- Capital and financial strength of the firm.
- Previous experience of the firm.

In consequence, the numbers of contractors classified are 7,840 (O.R.C.C. 2014) which represents the size sample of the available population (N). In order to ensure a representative sample size (n) of participants of all targeted contractors, a systematic random sample was selected by using the next equations (9) and (10):

$$n = \frac{m}{1 + \left(\frac{m-1}{N}\right)} \quad (9)$$

Where n = the sample size of the limited population; N = the sample size of the available population and m = sample size of the unlimited population which is estimated by the following equation:

$$m = \frac{z^2 \times p \times (1-p)}{\varepsilon^2} \quad (10)$$

Where z = the statistic value for the confidence level used. A confidence level of 95% (also expressed as follows: $\alpha = .05$) corresponds to $z = 1.96$ sigma's or standard errors; $z = 2$ (two sigma's) corresponds to a 95.5% (approximately $\alpha = .045$). In this research it has been decided to adopt a confidence level of 95% which corresponds to $z = 1.96$.

p = the value of the population proportion that is being estimated. As the population variance is unknown, we put the largest possible variance because higher variance will require a larger sample. Thus, the worst hypothesis of maximum uncertainty was used and a conservative value of 0.50 was applied so that the sample size obtained was at least as large as required

Sampling error of the point estimate was represented with the letter ε meaning the error or diversion when extrapolating the results. It is the margin of error that is acceptable. For example, if the margin of error is 3.16%, the formula will $\varepsilon = 0.0316$. and if from the total respondents for a given question a 64.3% have answered "yes", this means that the answer "yes" in the population is between $(64.3 - 3.16)\%$ and $(64.3 + 3.16)\%$. The lower the sampling error is, the more accuracy we will have but also obviously we increase the ratio: more subjects will be needed. For this research it was selected a sampling error $(\varepsilon) = 0.05$.

It is easy to see in the formula that, indeed, the sample size (the result of the formula) will be higher as we choose a higher level of confidence and the expected variance in the population (numerator in the formula) and as we elect a lower margin of error that are willing to admit (the denominator in the formula). So, using a confidence level of 95% which corresponds to $z = 1.96$; a value of the population proportion that is being estimated of $p = 0.50$ and a sampling error $(\varepsilon) = 0.05$, the formula 10 was approximated as follows:

$$m = \frac{z^2 \times p \times (1 - p)}{\varepsilon^2} = \frac{(1.96)^2 \times 0.50 \times (1 - 0.50)}{(0.05)^2} = 384.16 \approx 385$$

Thus, the total number (N) of considered companies related with the construction industry cataloged in the Official Register of Classified Companies of Spain equals 7,840.

Then, the sample size was statically determined from the equation 9 shown lines above and was developed as follows:

$$n = \frac{m}{1 + \left(\frac{m - 1}{N}\right)} = \frac{385}{1 + \left(\frac{385 - 1}{7,840}\right)} = 366.25 \approx 367$$

On the basis of this equation, the sample size necessary in this research to ensure a representative sample size was 367.

3. Selecting the samples

Although only 367 participants were necessary to guarantee the representativeness of the size, a total of 1450 the participants were selected randomly from a combination of the contractors registered in the Official Register of Classified Companies of Spain. This increment in the number of email addresses for participating in the research was due not all contractors will accept the invitation to take part in the study.

In order to make more attractive for construction companies to take part in this study, a question came to our mind. What benefits will get the companies by completing and sending back the questionnaire survey? Then, it was decided to send a back a document with the results, conclusions and main findings of this research to those companies who completed and submitted the questionnaire.

Time needed for companies to respond the questionnaire was considered very seriously in order to obtain the maximum possible answers. It was settled that the optimum inverted time for answering the questionnaire should not take more than several minutes (between 5 -8 minutes). Participants were contacted by email as the manner to invite them to participate in the research chiefly due to that email is a free and quick way to communicate whereas other communication manners such as telephone, costs money and even more if they are international calls .

Finally, the listing of construction companies included in the Official Register of Classified Companies of Spain (O.R.C.C. 2014) used for the random selection is presented in its latest update. The number of registered companies is displayed in Table 30 below.

AUTONOMOUS COMMUNITY	PROVINCE	No. of companies
Galicia		698
	A Coruña	296
	Lugo	104
	Orense	102
	Pontevedra	196
Asturias		271
Cantabria		114
País Vasco		314
	Álava	64
	Guipuzcoa	94
	Vizcaya	156
Navarra		142
Aragón		367
	Huesca	93
	Teruel	48
Cataluña		894
	Barcelona	509
	Gerona	119

AUTONOMOUS COMMUNITY	PROVINCE	No. of companies
	Lérida	102
	Tarragona	164
Valencia		606
	Alicante	237
	Castellón	89
	Valencia	280
La Rioja		117
Extremadura		323
	Badajoz	155
	Cáceres	168
Castilla y León		655
	Ávila	30
	Burgos	102
	León	147
	Palencia	41
	Salamanca	89
	Segovia	42
	Soria	51
	Valladolid	107
	Zamora	46
Castilla y La Mancha		455
	Albacete	89
	Ciudad Real	151
	Cuenca	59
	Guadalajara	45
	Toledo	111
Madrid		768
Andalucía		1.531
	Almería	145
	Cádiz	169
	Córdoba	179
	Granada	210
	Huelva	77
	Jaén	142
	Málaga	237
	Sevilla	372
Murcia		255
Baleares		104
Canarias		199
	Las Palmas	112
	Tenerife	87
Ceuta		14
Melilla		13
Total number of registered companies		7.840

Table 30. Number of registered companies by region and provinces in Spain

Chapter 8

RESULTS AND DISCUSSION

1. Introduction

In this chapter, data obtained through the questionnaires submitted by the Spanish construction companies will be analyzed. In the first part of the interpretation of the results, an examination of the answers from respondents will be carried out. This examination includes a classification of the answer by size of the company which completed the questionnaire, the age and also gender of the respondent and finally the number of years of experience of the respondent in the construction field. The second part of the chapter will consist in a statistical analysis of the data provided by respondents using RII technique. Lastly, comparison and discussion with related researches in different countries will be also developed. These findings will aim to clarify for a better comprehension the impact of each factor and will present tools which can help to minimize the impact of these factors on construction labor productivity.

2. Results from the survey

2.1. Number of responses obtained

Finally, the number of valid questionnaires submitted by the respondents was **376**. Valid questionnaires are referred to those surveys in which all the questions were completely filled in and submitted by practitioners. This reached number of valid answers guarantees that the sample comprised will be a statistically representative sample since the minimum number of answers required was 367, this means that the amount of answers from respondents not only fulfilled the sample size requirement but also surpassed it, ensuring robustness and reliability of the findings. The statistical analysis of this chapter will be carried out with the data obtained from these 376 questionnaires.

2.2. Study regarding the evolution of the responses received

In this paragraph, an evolution of how the answers were collected will be presented. The purpose of these lines is to present the methodology followed in order to achieve the minimum number of needed answers from practitioners in the time required. A study of how the construction companies handled the questionnaire can help to understand the reasons why or why not and additionally when, a company decides to answer a questionnaire and thus, improve survey management for following researches involving the realization of questionnaires.

To answer the first question: *Why or why not a company answers a survey?* We have to try to convince companies to participate in the study, a brief introductory letter was written (displayed in the Annexes) in order to present the study, with also explanations of how the study was going to be developed, how they could take part in it and the most important thing: the advantages to those constructions companies would have in case of taking part in the study. Moreover, it was pretended and also desirable to make the potential respondents spend the minimum time as possible in completing the questionnaire as time in companies is

very valuable. So finally, from the experience gained in this study, the main conclusions for improves the chances of getting an answer from companies are:

- To provide incentives to companies so as they can find benefits in taking part on it.
- Trying to make things easier to companies and hence to the practitioners who will respond the survey.

In this research, a combination of incentives to companies explained in the introductory letter as well as the need of taking smaller time as possible for construction companies to respond the questionnaire were the keys so as to improve the chances of obtaining more answers and consequently, ensuring the fulfillment of the minimum sample size required.

Regarding the evolution of the answers obtained by the respondents, a consideration must be done. Three different consignments were made when a high decrease in the number of daily answers was noticed.

The first consignment was sent during April 25th, 26th, 27th and 28th. It was comprised by 4 batches. Each one of these batches was sent in different days and the quantity of mails per batch is then showed.

- **First batch:** Sent on April 25th, 350 emails
- **Second batch:** Sent on April 26th, 350 emails
- **Third batch:** Sent on April 27th, 350 emails.
- **Fourth batch:** Sent on April 28th, 400 emails.

On May 10th and 11th the second consignment was sent again to companies as a reminder consisting in two batches:

- **First batch:** Sent on May 10th, 900 emails.
- **Second batch:** Sent on May 11th, 550 emails.

Finally, a third consignment was e-mailed to potential respondents on May 24th and 25th in order to fulfill the minimum number of answers required. This last consignment was comprised by two batches:

- **First batch:** Sent on May 24th, 700 emails.
- **Second batch:** Sent on May 25th, 750 emails.

Observations were made in order to study how the number of companies which submitted the completed questionnaire varied each day. The following days after a consignment was sent to the construction companies, the number of daily answers obtained from respondents increased greatly. After a couple days of high daily number of answers, the response rate decreases until reaching low rate of daily responses. This is due to the fact that when an new email arrives to the inbox of a company inviting them to take part in something, if the addressee do not respond the e-mail when he/she reads it, then, the probabilities that the practitioner respond the questionnaire and submit it back decreases exponentially with the time passed since the e-mail was received.

Then, supporting which has been explained in lines above, the evolution of the daily number of answers obtained from respondents is shown in Table 31.

	Date	No. Of answers obtained		Minimum No. Of E-mails required
		No. Of answers	Accumulated	
1st Consignment	25/04/2014	9	9	367
	26/04/2014	0	9	367
	27/04/2014	0	9	367
	28/04/2014	61	70	367
	29/04/2014	52	122	367
	30/04/2014	39	161	367
	01/05/2014	2	163	367
	02/05/2014	3	166	367
	03/05/2014	0	166	367
	04/05/2014	0	166	367
	05/05/2014	14	180	367
	06/05/2014	8	188	367
	07/05/2014	3	191	367
	08/05/2014	5	196	367
	09/05/2014	4	200	367
2nd Consignment	10/05/2014	1	201	367
	11/05/2014	0	201	367
	12/05/2014	57	258	367
	13/05/2014	25	283	367
	14/05/2014	14	297	367
	15/05/2014	9	306	367
	16/05/2014	7	313	367
	17/05/2014	0	313	367
	18/05/2014	0	313	367
	19/05/2014	3	316	367
	20/05/2014	5	321	367
	21/05/2014	1	322	367
	22/05/2014	2	324	367
	23/05/2014	6	330	367
	24/05/2014	0	330	367
3rd Consignment	25/05/2014	1	331	367
	26/05/2014	27	358	367
	27/05/2014	10	368	367
	28/05/2014	3	371	367
	29/05/2014	4	375	367
	30/05/2014	1	376	367
		TOTAL ANSWERS	376	

Table 31. Evolution of the daily number of responses obtained

A better way to visualize the data exposed in the table above might be presenting them in a chart where the vertical axe shows the number of daily answers received from respondents and time is presented in the horizontal axe. In this way, variations in the number of daily responses can be observed more easily. This chart is displayed below:

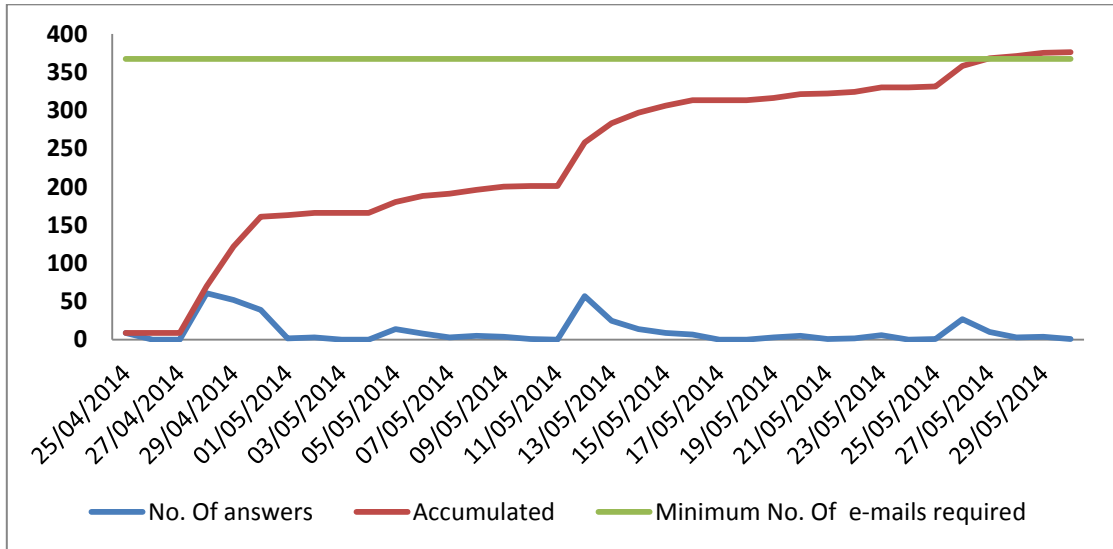


Chart 18. Evolution of the daily number of responses obtained

Observing the blue line from Chart 18 we can notice that there exist three peaks according to each consignment sent. In order to have a further vision of the evolution of the responses throughout time, an enlargement of the blue line will be developed in the following chart.

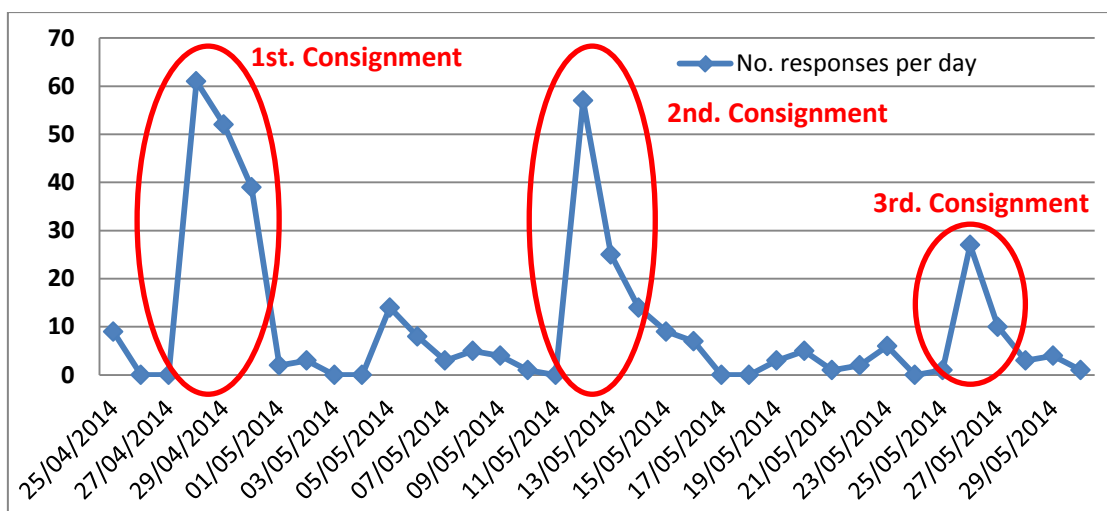


Chart 19. Number of responses obtained per day

As it can be seen in Chart 19 the number of answers from respondents increased greatly after each consignment was sent. Next, the daily response rate decreases till reaching an average of 4 completed questionnaires submitted. For instance, after the second consignment was sent on May 10th and 11th, the number of answers received in the following days was 57, 25, and 14 respectively. After that, the daily response rate decreased to 9, 7, 3, 5, and 1 responses per day, respectively. Furthermore, it can be obviously noted that the response rate reaches almost 0 during the weekends. Thus, it is important to highlight the importance of the use of reminders in order to refresh the invitation for the companies to take part in the study or occasionally, to refresh the potential respondent that the questionnaire has not been submitted yet.

3. Classification of the questionnaires received from respondents

In this section, different classifications according to different parameters will be presented in order to categorize and organize the data provided by practitioners. These parameters include classifications by:

- Size of the company or organization by number of employees
- Geographical scope of the company or organization
- Location of the respondents
- Age of the respondents
- Gender of the respondents
- Number of years of experience in the construction field
- Maximum level of studies reached by the respondents

3.1. By size of the company or organization by number of employees

The first section of the questionnaire aimed to stratify the responses from respondents. Specifically, the second question was designed in order to know the distribution of the responses by the size of construction companies or organizations by number of employees. In this context, Table 32 and Chart 20 below show the results of this stratification.

Classification by number of employees	No. of responses	Percentage (%)
From 1 to 9 employees	50	13%
From 10 to 19 employees	118	31%
From 20 to 49 employees	113	30%
From 50 to 99 employees	42	11%
From 100 to 499 employees	9	2%
More than 500 employees	4	1%
TOTAL RESPONSES	376	100%

Table 32. Classification of the responses by the size of the company or organization by number of employees

As it can be observed, strata “from 10 to 19 employees” and also “from 20 to 49 employees” have the higher number of responses, 118 and 113 responses respectively, reaching together 72% of total responses. The third segment of this classification comprises companies or organizations from 1 to 9 employees. 50 from 376 total responses are included in this stratum. This distribution of data is due to the triangular disposal of companies by number of employees. As it was exposed in chapter 2 in Table 10 (Number of employees by strata of employees.) a pyramidal disposition of construction companies by number of employees is shaped since small companies are much more numerous than large ones. In addition, internal processes within companies for a given survey to be answered are much simpler, shorter and more effective in small firms than in large companies since complicated organizations hinder the information flow.

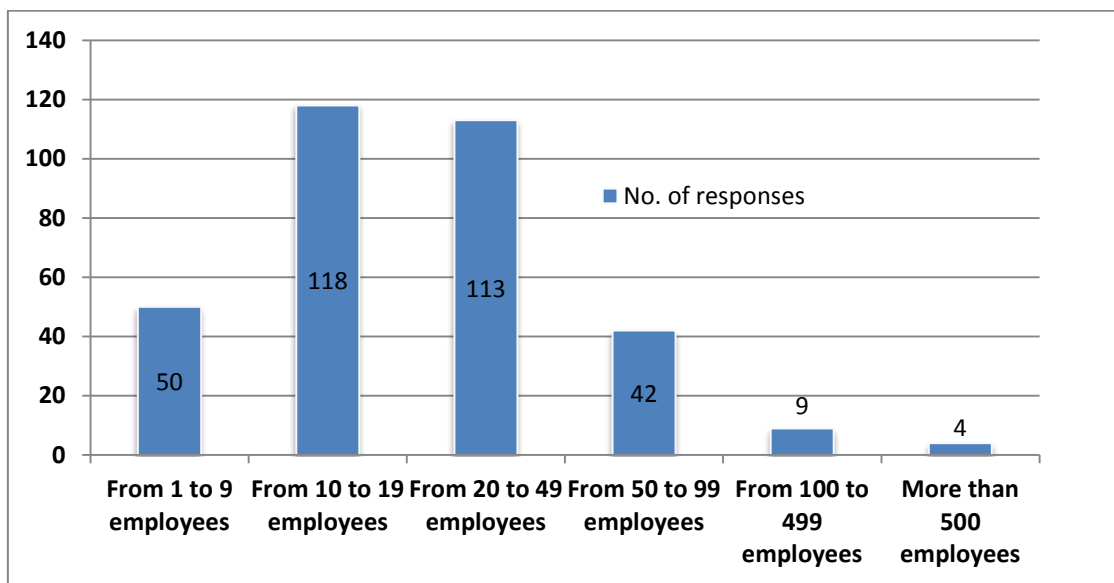


Chart 20. Classification of the responses by the size of the company or organization by number of employees

3.2. By geographical scope of the company or organization

The next classification has been done attending to the geographical scope of the construction companies or organizations. In this regard, the questionnaire settles 4 different geographical scopes for the companies depending on their grade of internationalization:

- Local
- Regional
- National
- International

In the next page, Table 33 and Chart 21 display the number of total responses obtained from respondents and its classification among these categories.

Geographical scope of the company	No. of responses	Percentage (%)
Local	134	36%
Regional	196	52%
National	41	11%
International	5	1%
TOTAL RESPONSES	376	100%

Table 33. Classification by geographical scope of the company or organization

More than the half of the total amount of responses are included under the category “Regional” (196 responses). This means that although they are not considered firms with presence in the entire national territory, they provide its services throughout at least 1 or more Autonomous Communities. The second category with highest number of responses was “Local” (134 responses) which is in consonance with the previous classification related with the number of employees in each company. Companies with greater national presence need more staff to satisfy the needs from clients, therefore, construction companies with wider geographical scope are likely to have a higher workforce. Thus, there exist a there exist a direct relationship between the number of employees in a company and its geographical scope. In other words, local and regional companies have a lower workforce than national or international companies.

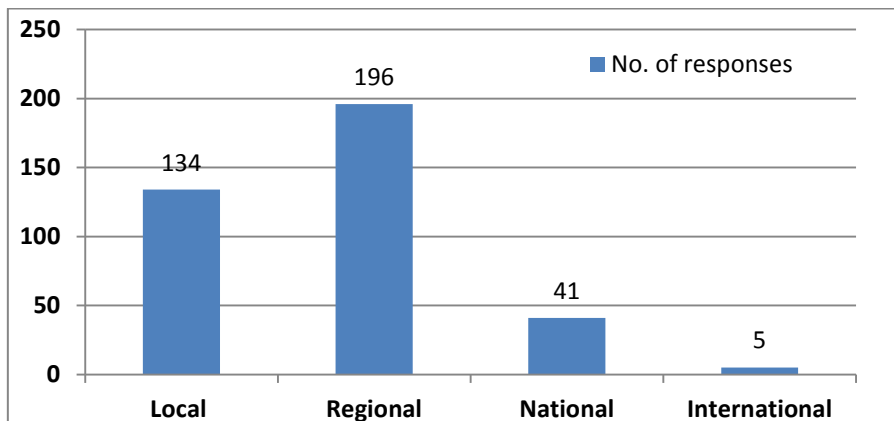


Chart 21. Classification by geographical scope of the company or organization

3.3. By location of the respondents

The following classification has been developed according to the provinces and Autonomous Communities where the questionnaires were submitted from. With this sorting it is pretended to achieve a better comprehension of the location of the respondents. Table 34 in the following page presents a listing of all the provinces and Autonomous Communities with the number of responses in each of them. These data was collected from question number 4 of the questionnaire.

AUTONOMOUS COMMUNITY	PROVINCE	NO. ANSWERS	% ANSWERS/TOTAL
Galicia		32	8,51%
	A Coruña	14	3,72%
	Lugo	5	1,33%
	Ourense	5	1,33%
	Pontevedra	8	2,13%
Asturias		16	4,26%
Cantabria		8	2,13%
País Vasco		28	7,45%
	Álava	7	1,86%
	Guipuzcoa	8	2,13%
	Vizcaya	13	3,46%
Navarra		6	1,60%
Aragón		23	6,12%
	Huesca	6	1,60%
	Teruel	4	1,06%
	Zaragoza	13	3,46%
Cataluña		39	10,37%
	Barcelona	27	7,18%
	Gerona	5	1,33%
	Lérida	4	1,06%
	Tarragona	3	0,80%
Comunidad Valenciana		34	9,04%
	Alicante	9	2,39%
	Castellón	5	1,33%
	Valencia	20	5,32%
La Rioja		6	1,60%
Extremadura		7	1,86%
	Badajoz	3	0,80%
	Cáceres	4	1,06%
Castilla y León		56	14,89%
	Ávila	3	0,80%
	Burgos	9	2,39%
	León	11	2,93%
	Palencia	5	1,33%
	Salamanca	5	1,33%
	Segovia	4	1,06%
	Soria	2	0,53%
	Valladolid	14	3,72%
	Zamora	3	0,80%

AUTONOMOUS COMMUNITY	PROVINCE	NO. ANSWERS	% ANSWERS/TOTAL
Castilla y La Mancha		16	4,26%
	Albacete	3	0,80%
	Ciudad Real	6	1,60%
	Cuenca	2	0,53%
	Guadalajara	1	0,27%
	Toledo	4	1,06%
Madrid		42	11,17%
Andalucía		46	12,23%
	Almería	4	1,06%
	Cádiz	5	1,33%
	Córdoba	7	1,86%
	Granada	7	1,86%
	Huelva	3	0,80%
	Jaén	4	1,06%
	Málaga	6	1,60%
	Sevilla	10	2,66%
Murcia		9	2,39%
Baleares		2	0,53%
Canarias		5	1,33%
	Las Palmas	3	0,80%
	Tenerife	2	0,53%
Ceuta		1	0,27%
Melilla		0	0,00%
TOTAL CONSTRUCTION FIRMS		376	100,00%

Table 34. Classification by location of the respondents

In the table above can be perceived that most part of the provinces with highest number of responses were the ones with more population. The first ranked province by number of questionnaires submitted was “Castilla y León” with the 14.89% of the total responses. This was due to the author’s influence in this Autonomous Community was higher and specifically in Valladolid. This fact was caused because the author was born in Valladolid and studied his Civil Engineering studies in Burgos. Other provinces with high rates of responses were Madrid: 42 responses which represent 11.17% of the total amount; Barcelona (7.18% of the total responses) and Valencia (5.32%). By autonomous communities, those which got the most responses were: Castilla y León (52 responses), Andalucía (46 responses), Madrid (42 responses), Cataluña (39 responses), Valencia (34 responses), and Galicia (32 responses). Conversely, the provinces with lowest number of answers from practitioners were: Soria (2

responses), Cuenca (2 responses), Guadalajara (1 response), Ceuta (1 response), and Melilla (0 responses). This distribution of responses by province and by autonomous communities is clearly justified by the rate of population that exists in each of them. In this way, when the e-mailing list was being performed in chapter number 7, big efforts were made in order to elaborate an equilibrate list with more email addresses in provinces where more construction companies existed and fewer email addresses in those with few companies. The number of construction companies emails addresses in each province was established after considering Table 30 (Number of registered companies by region and provinces in Spain). However, there exist some exceptions like Valladolid or León for instance previously justified in lines above by personal influences since the author is from that region.

Then, a map is shown in Figure 11 as a better way to illustrate to data provided in the table above.

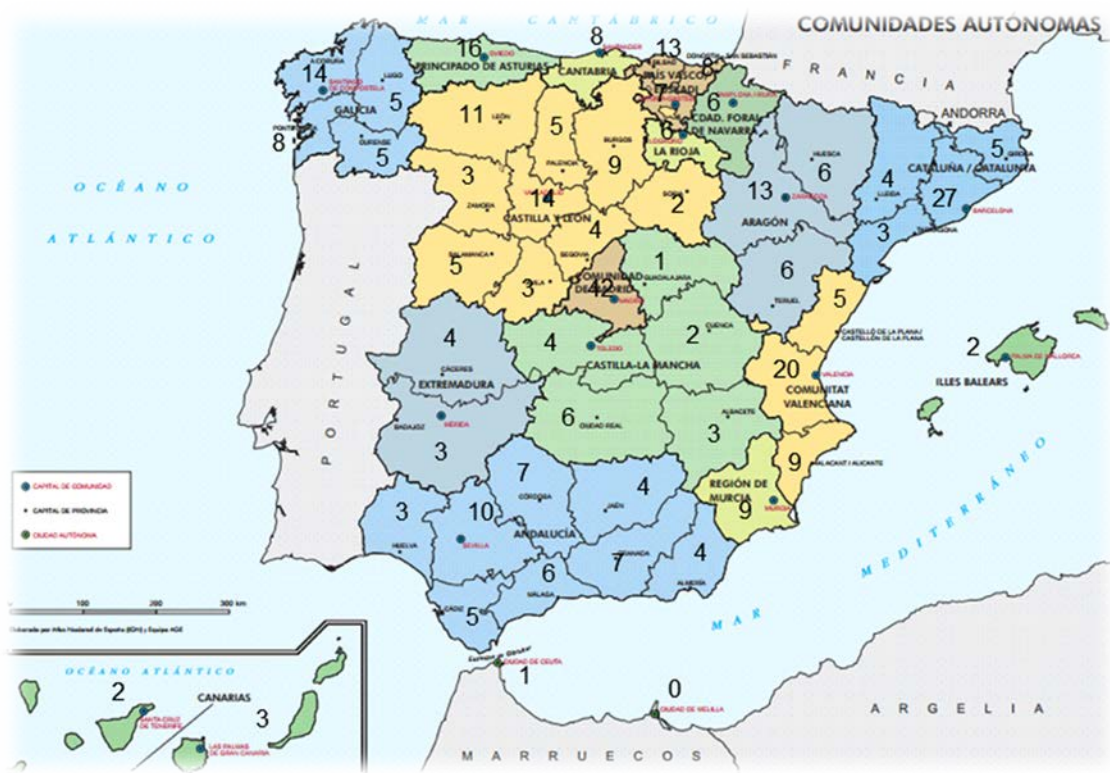


Figure 11. Number of responses per province

3.4. By age of the respondents

This section includes the classification of the responses regarding the age of the respondents. The questionnaire collects these data in different segments of age: Less than 24 years old; between 25 and 29 years old; between 30 and 34 years old; between 35 and 39 years old; between 40 and 44 years old; between 45 and 49 years old; between 50 and 54 years old; between 55 and 59 years old; and more than 60 years old.

Table 35 and Chart 22 shown below display the results obtained through the questionnaires.

Age	No. of responses	Percentage (%)
Less than 24 years old	0	0%
Between 25 and 29 years old	18	5%
Between 30 and 34 years old	38	10%
Between 35 and 39 years old	82	22%
Between 40 and 44 years old	116	31%
Between 45 and 49 years old	76	20%
Between 50 and 54 years old	38	10%
Between 55 and 59 years old	7	2%
More than 60 years old	1	0%
TOTAL RESPONSES	376	100%

Table 35. Number of responses according to the age of the respondents

Respondents comprised between 40 and 44 were the group which more questionnaires submitted (116 responses) followed by 35-39 years group (82 responses) and the 45-49 years category (76 responses). These three age segments amount more than the 75% of the total responses. By contrast, only one response was included in the category “*More than 60 years old*” and no responses were collected from practitioners aged less than 24 years old.

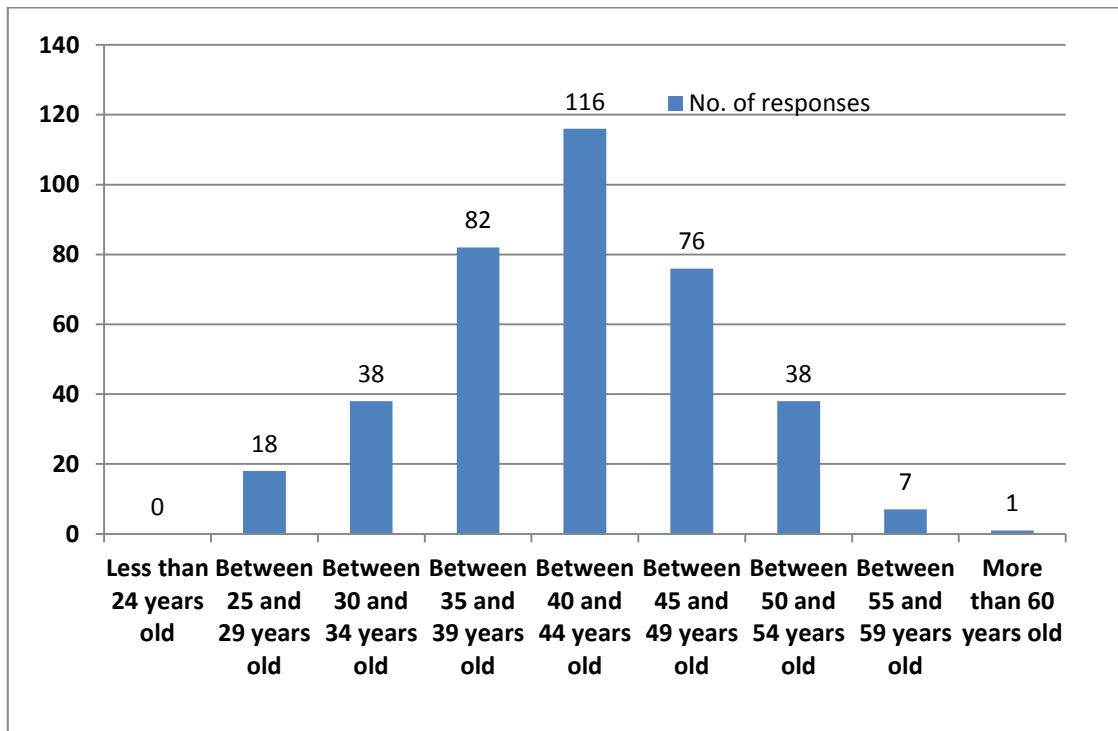


Chart 22. Number of responses according to the age of the respondents

This pyramid shape in Chart 22 could be explained basically due to the need for restructuring the human resources in the companies as a consequence of the crisis, in which, the Spanish construction sector is still involved. Great reduction in workforce was made by construction firms because of the decrease of available workload. These Layoffs were carried out by early retirement and dismissal of those who had spent less time working for companies. Thus, companies have to pay less compensation. Consequently, especially young people and over 60 years old people experienced staff restructuring, which coincide with the age groups with the lowest number of responses.

3.5. By gender of the respondents

In this section, submitted questionnaires are distributed in accordance with the gender of the respondent. Table 36 and Chart 23 below present the results.

Gender	No. of responses	Percentage (%)
Male	293	78%
Female	83	22%
TOTAL RESPONSES	376	100%

Table 36. Classification according to the gender of the respondents

More than 75% of the total amount of responses corresponded to male respondents. This shows that the Spanish construction sector is still being nowadays a sector which is mainly dominated by male.

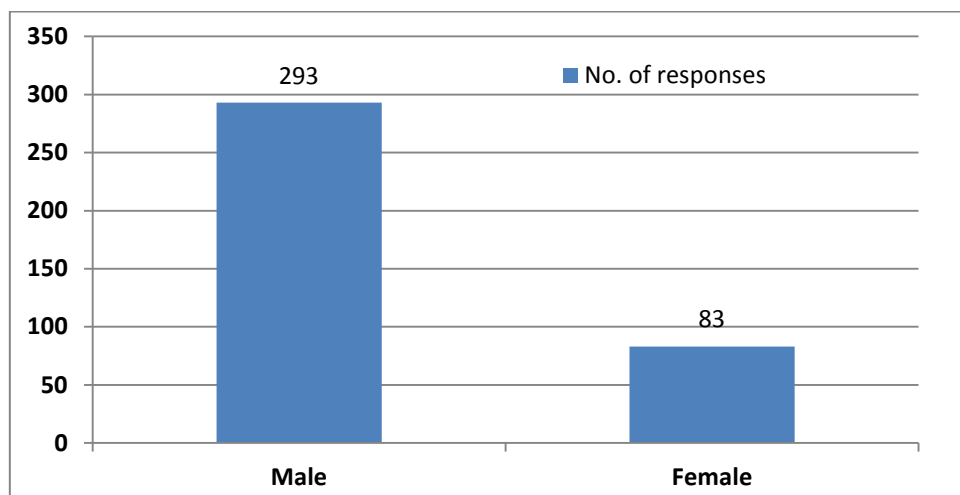


Chart 23. Classification according to the gender of the respondents

3.6. By number of years of experience in the construction field

This paragraph classifies the answers provided by respondents by the number of years of experience practitioners have in the construction field. This data was obtained from question 8 of the questionnaire. Possible answering options for this question were:

- Less than 5 years
- Between 5 and 10 years
- Between 10 and 15 years
- More than 15 years

Table 37 and Chart 24 below show the results from the responses:

Years of experience	No. of responses	Percentage (%)
Less than 5 years	17	5%
Between 5 and 10 years	71	19%
Between 10 and 15 years	112	30%
More than 15 years	176	47%
TOTAL RESPONSES	376	100%

Table 37. Number of responses according to the year of experience of the respondents

Results indicate that almost half of the total amount of the questionnaires submitted were filled in by practitioners with more than 15 years of experience in the construction industry. In second place, respondents between 10 and 15 years of experience amounted 112 questionnaires. In third place 71 surveyed people had between 5 and 10 years of experience in the construction field and lastly only 17 questionnaires which represent 5% of the total amount were completed by professionals with less than 5 years of experience.

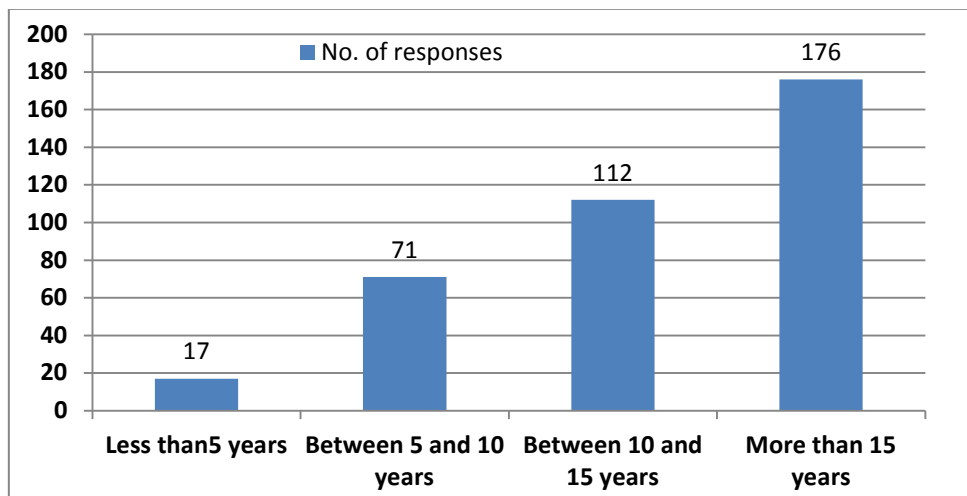


Chart 24. Number of responses according to the year of experience of the respondents

Results from Chart 24 support the conclusions obtained in the previous classifications. These findings shows that almost 80% of the respondents have more than 10 years of experience in the construction field which is in consonance with the age distribution of the respondents from previous classification, in that occasion chart displaying the number of responses according to the age of the respondents shaped pyramidal achieving its maximum value in the range between 40-44 years old. Thus, both classifications are directly related since gaining years of experience implies having greater age.

More than 75% of the feedback was thus from highly experienced practitioners who had the authority to make important decisions regarding productivity in their respective companies or organizations. This feedback provided by highly-experienced practitioners adds quality and reliability to the results, although the findings could not be generalized beyond the data points due to the non-representation of each category of age.

3.7. By maximum level of studies reached by the respondents

Lastly, responses will be grouped regarding the maximum level of studies reached by each respondent. This data were collected through the questionnaires. Different options were proposed to practitioners to choose between according to their level of studies:

- E.S.O. or equivalent
- Bachillerato or equivalent
- F.P. de grado medio
- F.P. de grado superior
- Estudios superiores de primer ciclo
- Estudios superiores de segundo ciclo
- Master’s studies
- Doctorate’s studies

Specifically, the 7th question was designed in order to know the distribution of the responses by the maximum level of studies reached by the respondents. In this context, Table 38 and Chart 25 below show the results of this stratification.

Level of studies reached	No. of responses	Percentage (%)
E.S.O. or equivalent	1	0%
Bachillerato or equivalent	18	5%
F.P. de grado medio	15	4%
F.P. de grado superior	68	18%
Estudios superiores de primer ciclo	166	44%
Estudios superiores de segundo ciclo	91	24%
Master’s studies	17	5%
Doctorate’s studies	0	0%
TOTAL RESPONSES	376	100%

Table 38. Number of responses by the highest level of studies reached by the respondents

It can be noticed that not all the different categories of studies have been translated into English since most of them do not have a proper translation from Spanish, or if exist, there is not exist equivalence between them due to the differences in the education systems.

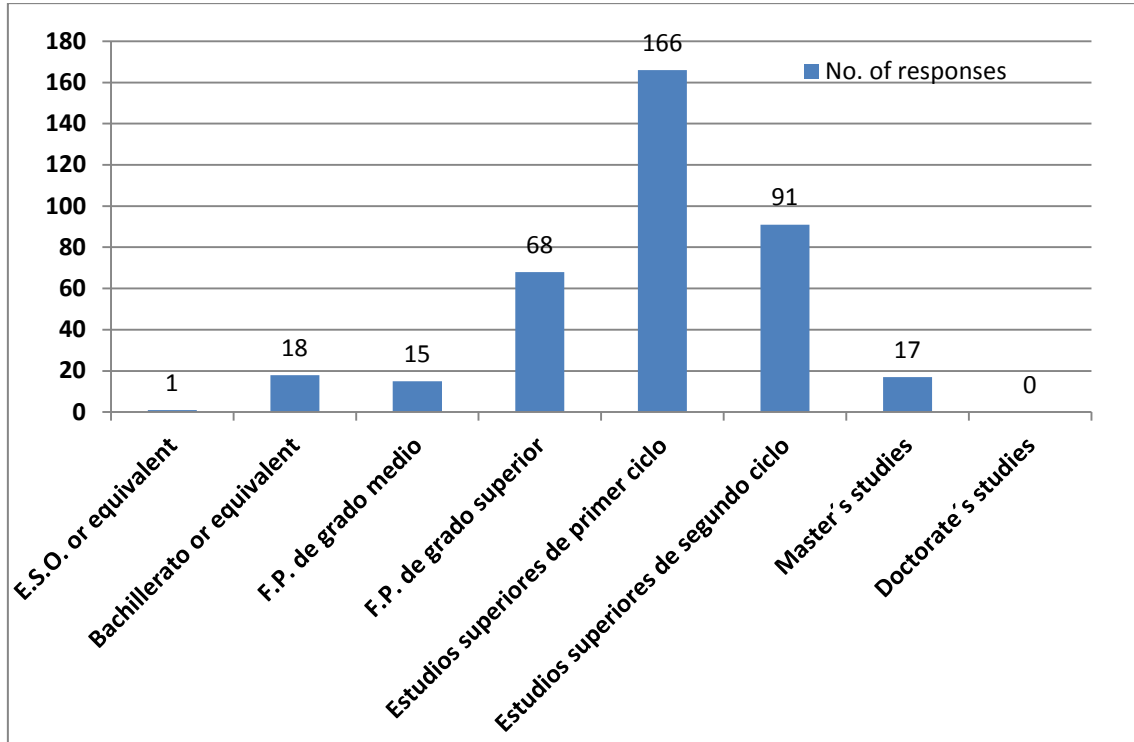


Chart 25. Number of responses by the highest level of studies reached by the respondents

From these results it can be suggested that 274 respondents which correspond to 71% of the total completed questionnaires have attended to the university. This rate can be considered a high number of respondents when it is taken into account the average age of the respondents presented in Table 35 and Chart 22 due not many people had the chance to take university studies some decades ago in Spain. However, if the number of years of experience by the respondents in the construction field is noted, then, an explanation arises since correlation exists between the management positions and the years of experience within the company. Among the findings it can also be noticed that no Ph.D. practitioners were between those who filled in the questionnaire.

4. The Relative Importance Index technique

Since many researchers such as Assaf et al. (1995); Faridi and El-Sayegh (2006); Lyer and Jha (2005); and Kumaraswamy and Chan (1998) come up with the opinion that mean and standard deviation of each individual factor is not a suitable measure to assess global rankings as they do not reflect any relationship between them. Therefore, for analyzing data, the relative importance index (RII) technique was used. This analytical technique is appropriate to group

ratings of the variables in a given set. The analysis involved the computation of a weighted average or representative rating point for the collective ratings made for each variable in the subset (Durdyev and Mbachu 2011). Thus, by using this tool, it is pretended to rank each factor explored. Factors were grouped into the categories established in chapter 6 according to the nature of the problem. In order to calculate the RII for the different factors of each category, the next Equation (11) below is used (Lim and Alum 1995; Enshassi et al. 2007; Jarkas and Bitar 2012; El-Gohary and Aziz 2014) with the purpose of computing every factor for each category of years of experience gained by the respondents. These categories were established following the same 4 strata used in the questionnaires for the practitioners to choose between: (k_1) less than five years; (k_2) between 5 and 10 years; (k_3) between 10 and 15 years; and finally (k_4) more than 10 years.

$$RII_k(\%) = \frac{5(n_5) + 4(n_4) + 3(n_3) + 2(n_2) + (n_1)}{5(n_1 + n_2 + n_3 + n_4 + n_5)} \times 100 \quad (11)$$

Where:

- **RII_k (%)** = RII (%) related to each category of years of experience (k_n).
- **n1** = the number of respondents who selected: "1", for very little effect.
- **n2** = the number of respondents who selected: "2", for little effect.
- **n3** = the number of respondents who selected: "3", for average effect.
- **n4** = the number of respondents who selected: "4", for high effect.
- **n5** = the number of respondents who selected: "5", for very high effect.

RII_k of each factor is computed separately for each category (k_1 , k_2 , k_3 , and k_4). Then, Equation (12) is used for calculating the overall RII (%) for each factor from all completed questionnaires, considering a weighting coefficient for each category (k_1 , k_2 , k_3 , and k_4), so the overall RII (%) is calculated as a weighted average of RII_k obtained from Equation (11).

Weighting coefficients assigned to each category depended of the years of experience in the construction industry: less than 5 years of experience, $k_1=1$; between 5 and 10 years of experience, $k_2=2$; between 10 and 15 years of experience, $k_3=3$; and more than 15 years of experience, $k_4=4$.

$$Overall\ RII\ (\%) = \frac{\sum_{k=1}^{k=4} (k \times RII_k)}{\sum_{k=1}^{k=4} k} \quad (12)$$

Where:

- **Overall RII (%)** = total weighted average percentage of the RII of each factor, which is calculated based upon all of the categories regarding the years of experience of the respondents (from less than 5 years of experience, $k_1=1$; between 5 and 10 years of experience, $k_2=2$; between 10 and 15 years of experience, $k_3=3$; and more than 15 years of experience in the construction field, $k_4=4$).

- **RII_k (%)** = RII (%) corresponding to each category of years of experience (k_n), which is calculated separately for each category ($k_1, k_2, k_3,$ and k_4) of years of experience of categorized respondents and calculated by Equation (11).

After all overall RIIs were computed, factors were arranged in descending order according to their ranks, factors with a score close to 100%, the highest RII rank; indicate that they have maximum impact on labor productivity. Conversely, factors with lowest rank indicate that they have little effect on labor productivity. This evaluation scale used for assessing the impact of each factor is presented in Figure 12 below.

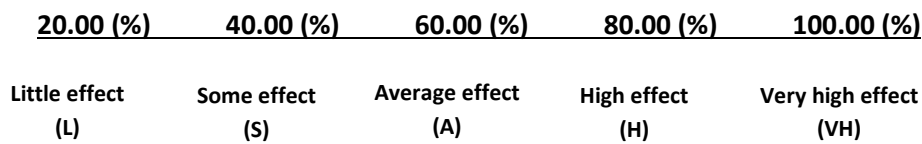


Figure 12. Evaluation scale

In addition, each related factors' category index was estimated by calculating an arithmetic average of the RII of the factors in each related factors' category. So, the RIIs ranks within the corresponding related factors' category, and the overall ranks of each factor under investigation are then presented, discussed and compared to previous related research findings.

5. Analyzing and discussing the results by categories of factors

In the next following sections, each factor will be ranked by its Relative Importance Index according to their category established in chapter 6. These categories are shown below:

- Project related factors' category
- Human related factors' category
- Management or organizational related factors' category
- Materials and tools related factors' category
- Environmental related factors' category

Factors rated by practitioners when completing the questionnaires will be presented in tables sorted by their overall RII from those with highest RII rank to those with lowest score. The RIIs for the factors grouped in each of the 5 categories are computed separately by using Equation 11. In addition, overall RII for all factors is estimated taking into account the level of the experience of each respondent as shown in Equation 12.

Furthermore, discussion taking into account related research from other authors will be carried out in order to compare its different grade of influence depending on the country.

Importance indexes for each category are also quantified so as to determine their relevance before comparison between them is conducted. These results will be discussed and also classified under the 4 age categories previously established so differences between age categories can be noticed. The RII for each category is calculated by using an average measure of the RII of the factors included in each category.

5.1. Project related factors' category

Findings regarding the perceived importance of factors classified under this category are analyzed in Table 39 below.

Rank	Factor	Overall RII (%)
1	Clarity of the drawings and project documents	86.41
2	Complexity of the design	66.86
3	Construction method	65.49
4	Project scale	64.17

Table 39. Overall RII and ranking of factors in the project category

Ranked with a relative importance index of 86.41%, **clarity of the drawings and project documents** arranges first in the project related factor's category but also ranks second among the 35 factors rated by the respondents, in this manner; it becomes a factor with very high effect influencing labor productivity in the Spanish construction industry. This finding supports the results obtained by Jarkas and Bitar (2012), who classified this factor as the most important factor within its category with significant effect on construction labor productivity in Kuwait. Enshassi et al. (2007) also detected a high impact in the Gaza Strip when drawings or specifications were altered during execution. Other researches have also realized about the importance of this factor to labor efficiency. In this way, lack of clarity, incomplete drawings or technical were further recognized among the significant factors affecting construction productivity in the United Kingdom, Thailand, and Uganda (Horner et al. 1989; Makulsawatudom et al. 2004; Alinaitwe et al. 2007). This high rank obtained also considering the findings in other countries indicates that lack of clarity or incomplete drawings, technical specifications leads to continuous requests for clarifications, hence consecutive interruptions and/or disruptions to work progress. Furthermore, possible modifications, adjustments or substantial reconsiderations may be necessary to design documents, which can lead to rework on sites, consequently, low productivity is incurred. In this sense Thomas (1999) stated that loss of efficiency may reach 30% when work changes are being carried out during execution. This impact is perhaps related to the short time available to designers between the design start up and the call for tender. As a result of this, tender documents are most often incomplete, unclear, or contain serious conflicts among the various disciplines involved (Jarkas and Bitar 2012).

Complexity of the design was ranked second within the project related factor's category with a RII of 66.86% although 26th among all 35 surveyed factors. This limited impact of this factor on labor productivity in Spain may be attributed in whole or in part to most of the respondents come from small/medium companies whose construction projects design are relatively simple. However, the existing linear relationship between a complex design of an infrastructure and the time spent by project managers and also laborers in order to perfectly understand the drawings and technical specifications have been supported by Zakeri et al. (1996), Kaming et al. (1997), Makulsawatudom et al. (2004), Abdul Kadir et al. (2005), and Alinaitwe et al. (2007). Similar factors have been studied by other many researchers, El-Gohary and Aziz (2014) studied the impact of constructability in the construction labor productivity in Egypt. The constructability, understood as integrating design and construction processes, was classified second in its category. Also when Horner et al. (1989) studied the impact on labor productivity of 13 factors in the U.K.; constructability was ranked second in importance.

Third ranked factor in project related factor's category is **construction method** with a RII of 65.49%. In the overall classification among the 35 factor analyzed, it was classified in 27th position just below the previous explained factor. Related research conducted by El-Gohary and Aziz (2014) concluded that the "construction method" factor was a high influencing factor, in fact, it was ranked first within its category and sixth among all 30 surveyed factors. Furthermore, Durdyev and Mbachu (2011) suggested that the construction method should depend on the design as well as the conditions and circumstances of the project since they found that the most significant factor related to construction technology affecting the productivity of construction labor is the adequacy of the method of construction. Thomas and Sanders (1991) also support this result since they found in their research that construction method and project features have high impact on labor productivity. However, Enshassi et al. (2007) ranked the same factor third within the project related factor's category and 32th among all 45 explored factors. These finding shows similar results as this study.

This particular low rank in the overall classification among the 35 factor surveyed might be justified in part, because many respondents develop their work in small/medium companies and normally construction projects in that companies are not complex and small in size

Project scale has an average impact on construction labor productivity in Spain, and was ranked in position 4 with a RII of 64.17%. Taking into account all the factors considered in this study, "project scale" factor is ranked 30th. This factor refers to the importance of the size project and as it has been already explained in previous factors, size of construction companies which completed the questionnaire (most of them small or medium companies) are likely to develop small size projects and thus "project scale" factor influence will be limited. El-Gohary and Aziz (2014) also present similar findings as project scale is ranked in position 19 of all 30 factors affecting labor productivity in Egypt.

Finally as explained lines above, RII for project related factors' category is calculated by using an average measure of the RII of each factors included in the category. For this category, a RII of 70.73% is achieved.

5.2. Human related factors' category

This section will analyze and discuss about the factors within the human category. As shown in Table 40 below, 5 human factors were identified and perceived to have influence in the labor productivity on construction sites.

Rank	Factor	Overall RII (%)
1	Level of Skill and experience	83.16
2	Ability to adapt to changes and new environments	80.84
3	Labour motivation	77.47
4	Worker's integrity	75.00
5	Number of breaks and their duration	62.67
6	Working overtime	59.82

Table 40. Overall RII and ranking of factors in the human category

Results show that the factor related with the **level of skill and experience** was ranked in the highest position with a relative importance index of 83.16%. Furthermore, it obtained a 5th position when all 35 factors surveyed are considered. The findings substantiate the results obtained by Horner et al. (1989), ranking the skill of labor factor first in its importance to labor productivity in the United Kingdom. Moreover, this result is further supported by Paulson (1975); Lim and Alum (1995); Heizer and Render (1996); Alinaitwe et al. (2007), and Enshassi et al. (2007), whose researches recognized the skill and experience of laborers among the most significant factors impacting the efficiency of the labor force since the level of skill and experience of laborers is detrimental to the productivity of the construction process. To provide more reliability to these findings, El-Gohary and Aziz (2014) ranked "laborer experience and skill" factor first in the labor/human category and also first among all 30 surveyed factors with RII of 93.29% while Jarkas and Bitar (2012) ranked "Skilled and shortage of experienced labor" factor second and fourth within the human/labor category; 20th and 22 among the 45 factors explored, with relative importance indices of 59.36% and 56.18%, respectively. Jarkas and Bitar (2012) attributed these finding to poorly trained and unskilled operatives are commonly characterized with low and faulty outputs coupled with unjustifiably high inputs high skilled and experience laborers contribute to decrease the impact from learning curves. Additionally, they suggested that poorly trained and unskilled operatives outputs are almost always rejected, either in whole or in part, by the inspection engineer, resulting in extensive and expensive rework, rectifications, or repairs. To the contrary, experienced operatives are able to find practical solutions to encountered obstacles, possessing high technical and motor skills, all of which lead to higher productivity, lower cost of labor, and better quality of finished outputs.

Surveyed practitioners ranked the **ability to adapt to changes and new environments** as the second factor influencing labor productivity in this category, with a relative importance index of 80.84%. This top ranked factor is further classified in position 11 among the 35 factors analyzed, which confirms the high effect of this effect on the efficiency of laborers. This effect

shows the high influence of the ability of laborers to adapt and change to new working environments and new construction techniques. A quick adaptation to changes, new environments and also people allow laborers to limit the effect of the learning curves and achieve optimum productivity levels sooner.

Labour motivation, with a relative importance index of 77.47% is ranked third within the human category and in position 13th among all the factors considered for this study. Motivated laborers are usually more enthusiastic and initiative. They work harder and respond faster to instructions. Their pace is, moreover, associated with a greater sense of pride, satisfaction, and responsibility, thus they typically achieve better levels of productivity, in comparison with demotivated or discouraged laborers. To support this outcome, findings obtained by Hazeltine (1976); Borcharding et al. (1980), and Whitehead (1990) emphasized the importance of this factor to labor productivity. Recent studies carried out by Jarkas and Bitar (2012) also corroborate these findings as they ranked labor motivation first in its human/labor category group and fourteenth among all factors surveyed in Kuwait. They consider this effect follows the character of the human nature.

With a relative importance index of 75.00%, **Worker's integrity** was ranked fourth among the factors belonging to the human category and 17th among the 35 factors surveyed. This factor refers to a set of principles, honestly and ethical behavior laborers should follow aiming to increase labor performance and project value. This factor has been barely studied before as a factor that could affect labor productivity, however, the data obtained through the questionnaire reflects that it has high effect as a factor influencing labor productivity in the construction industry. Erhard et al. (2013) intended to highlight the importance of this factor for increasing performance in the construction industry in the way people reaches their commitments acquired when their word is given to someone else. As explained by these authors, integrity means keeping your word, or as soon as you know that you will not, you say that you will not be keeping your word to those who were counting on your word and clean up any mess you caused by not keeping your word.

The “**number of breaks and their duration**” factor ranked 5th in the human related factor's category and in position 32 among all 35 studied factors, with a relative importance index of 62.67%. Working without making any pause creates an adverse effect on the motivation and physical conditions of laborers, thus decreasing their productivity. However, the influence of this factor on construction labor productivity in Spain is considered limited due to its average effect. This finding is in consonance with the results of Jarkas and Bitar (2012) which ranked “late arrival, early quits, and frequent unscheduled breaks” factor 33th among all 45 surveyed factors.

Finally, **working overtime** obtained the lowest relative importance index of the factors grouped under the human category. Moreover, taking into account the 35 factors considered for this research, working overtime ranks 33th among all with a RII of 59.82% which suggest that working overtime does not affect significantly on labor productivity. Although this effect may cause causes physical fatigue to laborers decreasing their agility, stamina, and motor skills, related investigations support this finding as Enshassi et al. (2010) ranked this factor with a relative importance index of 62.37% as the less significant within the time category and in

position 31 for all the 45 surveyed factors. Furthermore, working overtime obtained a RII of 64.84% in the study conducted by Jarkas and Bitar (2012). Thus, working overtime is not likely to have high impact on labor productivity.

To conclude with this category, RII is also calculated by using an average measure of the RII of each factors included within the category. For this human related factors' category, a RII of 73.16% is attained.

5.3. Management or organizational related factors' category

The relative importance indices and ranks of the 14 factors grouped under the management/organizational category are shown in Table 41 below.

Rank	Factor	Overall RII (%)
1	Clear and daily task assignment	85.53
2	Delays in payments to workers	82.47
3	Coordination between crews	82.00
4	Improper coordination of subcontractors	81.59
5	Insufficient supervision of subcontractors	81.03
6	Communication problems	80.88
7	Inadequate planning	78.10
8	Delays in payments to suppliers	76.99
9	Unrealistic scheduling	75.07
10	High congestion	73.94
11	Rework	73.19
12	Reallocation of laborers	70.80
13	Lack or delay in supervision	70.22
14	Incentive policies	69.65

Table 41. Overall RII and ranking of factors in the management/organizational category

Clear and daily task assignment, was ranked with the highest relative importance index within this category. In fact, with a RII of 85.53% it is considered by the respondents the third factor among all surveyed factors which more impacts on construction labor productivity in Spain. Since one of the main objectives of the project manager is to maintain a constant workload for all workers, daily task assignment according to the needs of the construction site becomes crucial so as to reach optimum levels of productivity. Abdul Kadir et al. (2005) ranked the same factor 24th among all 50 surveyed factors. Providing more support to this result, Alinaitwe et al. (2007) classified it 30th among all 36 surveyed factors. Enshassi et al. (2007) ranked it second in the project category and 24th among all 45 surveyed factors. Jarkas and Bitar (2012) ranked it ninth in the management category and 25th among all 45 surveyed factors.

“**Delays in payments to workers**” factor represents with a relative importance index of 82.47% the second factor with more implications on labor productivity within the management or organizational category. In addition, it is ranked in 6th position among all the factors surveyed. Enshassi et al. (2007) also noticed that payment delay has negative effect on laborers mood, and consequently decreases its productivity. In their study carried out in the Gaza Strip, payment delay was ranked 6th of all 45 factors negatively affecting labor productivity considered. In the same way, Durdyev et al. (2013) ranked 8th among the 23 surveyed factors constraining labor productivity in Turkmenistan.

Practitioners who filled in the questionnaire ranked “**coordination between crews**” as the third most important factor affecting labor productivity within this category, with a relative importance index of 82.00%. This factor was ranked 7th in its effect among all the factors evaluated in this study, which indicates the high effect of this factor on construction labor productivity in Spain. This lack of coordination between crews may cause interference between gangs and workers due to mismanagement on construction sites.

“**Improper coordination of subcontractors**” and “**Insufficient supervision of subcontractors**” factors were ranked 4th and 5th with RIIs of 81.59% and 81.03%, respectively under the management or organizational category. When considering all the 35 surveyed factors, improper coordination ranks 8th and insufficient supervision to subcontractors is classified in 9th position. These effects are meant to have great implication in labor productivity in the Spanish construction industry since the proportion of work subcontracted may far exceed 50% of the total workload. Basically, subcontracting work packages or certain trades means offer sums to subcontractors to accomplish and hand over, in accordance with contracts’ specifications and within specified durations. Consequently, any additional costs required to making good on faulty or nonconforming work, along with any associated liquidated damages incurred, would be borne directly by the related subcontractors. This finding further supports the results obtained by Horner et al. (1989), reporting this factor among the most significant to labor productivity in the British construction industry. Additionally, Jarkas and Bitar (2012) ranked “proportion of work subcontracted” second in the management category with a relative importance index of 80.64%, and fifth among all the 45 factors explored. As they argue, such a practice encourages subcontractors to be more organized, committed, and focused; paying more attention to technical details and contracts’ specifications. However, due to the peculiarities of the Spanish construction industry, this factor is strongly related to the integrity factor previously explained. Great proportion of work subcontracted linked with improper coordination and supervision of subcontractors may lead to misleading situations moreover when lack of integrity exists from subcontractors or site managers. When given these situations, decreases in efficiency levels are induced and thus lower labor productivity is achieved.

With a relative importance index of 80.88%, **communication problems** between site management and workers ranks 6th in this category and 10th compared to all factors surveyed.

Makulsawatudum et al. (2004) ranked poor communication sixth among all the 23 factors surveyed in Thailand. Respondents from this study advised that, instead of using informal verbal communication, documentation such as work procedures, manuals, charts and guidelines should be used. Further support it is provided by El-Gohary and Aziz (2014) who ranks clarity of instructions and information exchange 6th within the management category and in position 10th among all the factors explored with a relative importance index of 80.73%. Enshassi et al. (2007) also sustain these findings since misunderstandings between labour and superintendent was ranked in position 4th among all 45 factors negatively affecting labor productivity in Gaza Strip.

“Inadequate planning” factor ranks 7th under the management and organizational category and in position 12th among all the factors explored in this research. This inadequate planning refers to the incompatibilities and restrictions coming about when planning. El-Gohary and Aziz (2014) expose that the application of modern concepts and systems such as the last planner system (LPS) can help to control and drive the management factors that affect construction labor productivity. Moreover, the “planning, work flow and site congestion” factor, with a relative importance index of 84.54%, was ranked fifth in the management category and eighth among all 30 factors in the study conducted by El-Gohary and Aziz (2014). Liu et al. (2011) concluded that productivity is not improved by completing as many tasks as possible regardless of the plan, nor from increasing workload, work output, or the number of work hours expended. In contrast, productivity does improve when workflow based in an adequate planning is made more predictable.

Practitioners who took part in the survey rated **“Delays in payments to suppliers”** factor as the 8th under the management and organizational category with a RII of 76.99% and in 14th position of all the factors considered for this investigation. Impact on labor productivity may come because of late payment to providers can bring delays in delivering the materials or a reduction in the quality of materials delivered, leading to lower efficiency levels of construction labor productivity. In this regard, it must be added that frequently, the responsibility for these late payments cannot be exclusively attributed to the contractor but also to the public administrations which pay main contractors out of the deadlines and thus these delays in payments falls from main contractors to subcontractors and suppliers.

Unrealistic scheduling due to overconfidence from project managers of labor performance was ranked 9th among all the factors included under the management or organizational related factors category with a relative importance index of 75.07%. In the same way, it was ranked 16th among the 35 factors explored. Previous research developed by Jarkas and Bitar (2012) ranked this factor 24th among the 45 factors surveyed and eighth under the management category with a relative importance index of 55.13%. Also they suggest that this kind of management practices may lead to overcrowding, interference between activities, overtime, hastiness, and messiness on laborers’ part, resulting in rejection, and rework, and consequently discouragement and low labor productivity. Moreover, Chang et al. (2007) pointed that attempting to reduce the time available to complete a project through schedule compression not only negatively impacts the efficiency of labor but also becomes a source of dispute between employers and contractors.

Practitioners ranked “**High congestion**” factor 10th among all the factors considered within this category. In the overall classification taking into account all the factors selected for this research, this factor is in position 18th with a relative importance index of 73.94%. El-Gohary and Aziz (2014) further corroborates this finding since they ranked this factor fifth in the management category and eighth among all the 30 factors studied with a RII of 84.54%. Furthermore, other studies conducted by Jarkas and Bitar (2012) who ranked this same factor nine within its category and 25th overall, with a relative importance index of 54.65%; Horner et al. (1989); Kaming et al. (1997); Makulsawatudom et al. (2004); Alinaitwe et al. (2007); Enshassi et al. (2007), and Hanna et al. (2007) further sustain that this factor’s effect is significant to labor productivity. This factor is usually attributed to mismanagement of the work sequence and overcrowding of the laborers and machinery in some workplaces, which can cause impediments to the desired productivity and quality. The overcrowding of workers and machinery is normally caused by inappropriate general planning of construction site activities but also may be linked with the size of the construction site. Kaming et al (1998) recommended that a labor density higher than 1 worker per 30 m² would lead to decrease in labor efficiency. Hinze (1999) also supports this finding.

Rank eleventh within the management or organizational category and 19th overall, is attained by **rework**, with a relative importance index of 73.19%. As Makulsawatudom et al. (2004) pointed, the more rework, the more time and cost needed for construction. Also Kaming et al. (1997); Makulsawatudom et al. (2004); Alinaitwe et al. (2007), and Enshassi et al. (2007), reported research studies which recognized the influence of this factor on construction labor productivity. Causes of rework can be attributed to unclear drawings and specifications, incompetent laborers, design complexity, lack of supervision and overtime work. Insufficient working skill and knowledge of drawings are examples of an incompetent laborer, while lack of experience, leading to deficient supervision, is an example of incompetent supervisors. Other causes of rework advised where change orders and incomplete drawing.

With a relative importance index of 70.80%, **reallocation of laborers** depending of the working needs was ranked 12th in this factors related category and 21th among all the factors investigated with an average-high effect on labor productivity. Moving laborers from one activity to other activity in short periods of time may decrease labor productivity since workers need time to get used to the new job site and the new activity they have to develop. This effect can be explained by the Learning curves (Lam et al. 2001) which can provide support to get a better comprehension of this phenomenon.

Lack or delay in supervision was ranked 13th within the management or organizational category with a relative importance index of 70.22%. Additionally, it was ranked in position 22 along of the factors surveyed. This factor regarding lack of supervision or delay in inspecting the activities executed was also considered by Makulsawatudom et al. (2004), who ranked this issue ninth among the 23 factors explored in the research developed in Thailand. Continuous supervision of labor is essential to optimize the productive input, especially on those tasks or activities on the critical path. Lack of supervision encourages operatives, to engage in unproductive activities, take regular unscheduled breaks, or even leave the job sites during working hours to attend to personal issues (Jarkas and Bitar 2012). Direct supervision of labor is required to avoid these situations and non-conforming work to contractual specifications and thus minimize the expensive incidents of rework.

Finally, the last factor of this category is presented. Influence of **incentive policies** on worker performance was ranked in 14th position with a RII of 69.65%. Considering all the factors among all the categories, “incentive policies” factor is classified 23th. This factor was considered as the less influencing factor of the management or organizational category. However, this finding defers substantially from results obtained by El-Gohary and Aziz (2014), Jarkas and Bitar (2012), Enshassi et al (2007) and Horner et al. (1989). The ranking of this factor by its RII in their studies reflects that motivation provided by incentive policies is essential to laborers, as it gives site workers satisfaction such as achievement, sense of responsibility and pleasure of the work itself.

Due to the nature of most of the management or organizational factors, they cannot be predicted in advance, specifically at the bidding phase. Hence, they cannot be used in developing forecasts and can only be controlled during the construction phase, based on the quality and efficiency of the project and construction management during the time of execution. Finally, RII of this category is computed by using an average measure of the RII of each factors included within the category. Management or organizational related factors’ category obtained a RII of 77.25%.

5.4. Materials and tools related factors’ category

The relative importance indices and ranks of the 3 classified factors under the materials and tools category are shown in Table 42.

Rank	Factor	Overall RII (%)
1	Shortage or late supply of materials	87.40
2	Tools or equipment shortages	85.20
3	Unsuitability of materials storage location	75.36

Table 42. Overall RII and ranking of factors in the materials/tools category

The most important factor of this category was **shortage or late supply of materials**, with a RII of 87.40%. But it was also classified in first position among all the 35 factors considered for the survey. As any work cannot be accomplished without necessary materials, this factor has very high impact on labor productivity in the construction industry. Moreover, this finding is further substantiated by many construction labor productivity studies conducted in the US, UK, Indonesia, Nigeria, Singapore, Gaza Strip, Kuwait, Egypt and Gaza Strip (Horner et al. 1989; Yates and Guhathakurta, 1993; Lim and Alum, 1995; Olomolaiye et al, 1996; Abdul Kadir et al. 2005; Enshassi et al. 2007; Jarkas and Bitar, 2012 and El-Gohary and Aziz, 2014). This result might be justified in Spain, since a very high proportion of the materials needed are provided for external providers which not always fulfill with their delivery agreements in terms of quality and time. Also an improper planning from site manager of the activities that have to be executed may lead to a shortage of materials or a delayed delivery of needed construction materials with the consequent loss of efficiency and consequently, a decrease in labor productivity.

The second factor classified under this category was **tools or equipment shortages**, with a relative importance index of 85.20%. Similar results also show that tool and equipment shortages have a high effect on labour productivity as Enshassi et al. (2007) ranked this factor in position 10 among all 45 studied factors negatively affecting labor productivity. Indeed, “tools or equipment shortages” factor is ranked in 4th position among all the factors surveyed. This fact confirms the high influence of this factor on labor productivity in Spain. In addition, tool and equipment shortages also have a high effect in the US, UK, Indonesia, Nigeria, Thailand and Gaza Strip (Guhathakurta et al, 1993; Olomolaiye et al, 1996; Makulsawatudom et al. 2004; and Enshassi et al. 2007). These results might be substantiated by inadequate management since laborers need a minimum number of tools and equipment to work effectively. Moreover, a lack of maintenance programs from companies might lead to inefficient use of tools or equipment, the use of old and obsolete equipment or shortage of spare parts. Finally overestimating the capacity of the equipment may result in insufficient number of equipment employed for a given activity which will lead to an equipment shortage. If there is lack of equipment and/or tools, productivity will decrease (Enshassi et al. 2007).

Finally, the “**Unsuitability of materials storage location**” factor ranked third within the materials and tools related factors’ category with a RII of 75.36% and 15th among all 35 explored factors. Unsuitability of materials storage location has an average-high effect influencing construction labor productivity in Spain. This result is further sustained by Thomas and Sanders (1991) and Enshassi et al. (2007) who reported that size and disposition of materials storage have a noteworthy influence in masonry productivity. This is justified by as either workers or machinery have to move long distances from their workplace to these unsuitable storage locations in order to get the materials or tools they will use for their activities, this entails a waste of time and therefore productivity will decrease. To avoid this, it becomes important to plan where storages will be placed before the construction work begins.

So as to finish with this category, RII is also quantified, and a value of 82.65% is achieved.

5.5. Environmental related factors’ category

The RIIs and ranks of factors under the environmental category are shown in Table 43.

Rank	Factor	Overall RII (%)
1	Motion’s limitation in the jobsite	72.08
2	High/low temperatures	69.53
3	Performing work at night	67.93
4	Rain	64.39
5	Influence of working at height	64.36
6	High winds	63.25
7	Distance between construction sites and cities	54.23
8	Air humidity	53.56

Table 43. Overall RII and ranking of factors in the environmental category

Motion's limitation in the jobsite was ranked first within this category with a relative importance index of 72.08% and classified in position 20 among all the factors considered for this research. Poor site conditions like limitation of motion at jobsites may be responsible for laborers cannot work effectively, and consequently, they may have negative impacts on labor productivity. However, it is not always possible to avoid these working environments since site conditions depend mainly of nature of the construction work and its location.

The second factor ranked in the environmental related factors category was **high/low temperatures** with a RII of 69.53%. This same factor was ranked 24th of all surveyed factors. Temperature depends basically of the geography, weather conditions and location of the country. In this case in Spain, temperature conditions can vary greatly depending on the region in which you are within Spain. As it can be extracted from findings, the effect of temperatures affecting labor productivity is less influencing in regions with moderate weather conditions such as the North coast than in South part of Spain where extremely high temperatures are reached during the summer months with the consequent impact on laborers productivity. The effect of high temperatures was also observed in the Mediterranean coast and the middle part of Spain. This weather conditions affect particularly external work activities since laborers have to face with these adverse factors. Previous studies developed in Kuwait (Jarkas and Bitar 2012) also reflect the importance of this factor regarding labor efficiency. Figure 13 shows similarities between the average temperatures reached in Spain and the values of high/low temperature factor obtained for different provinces.

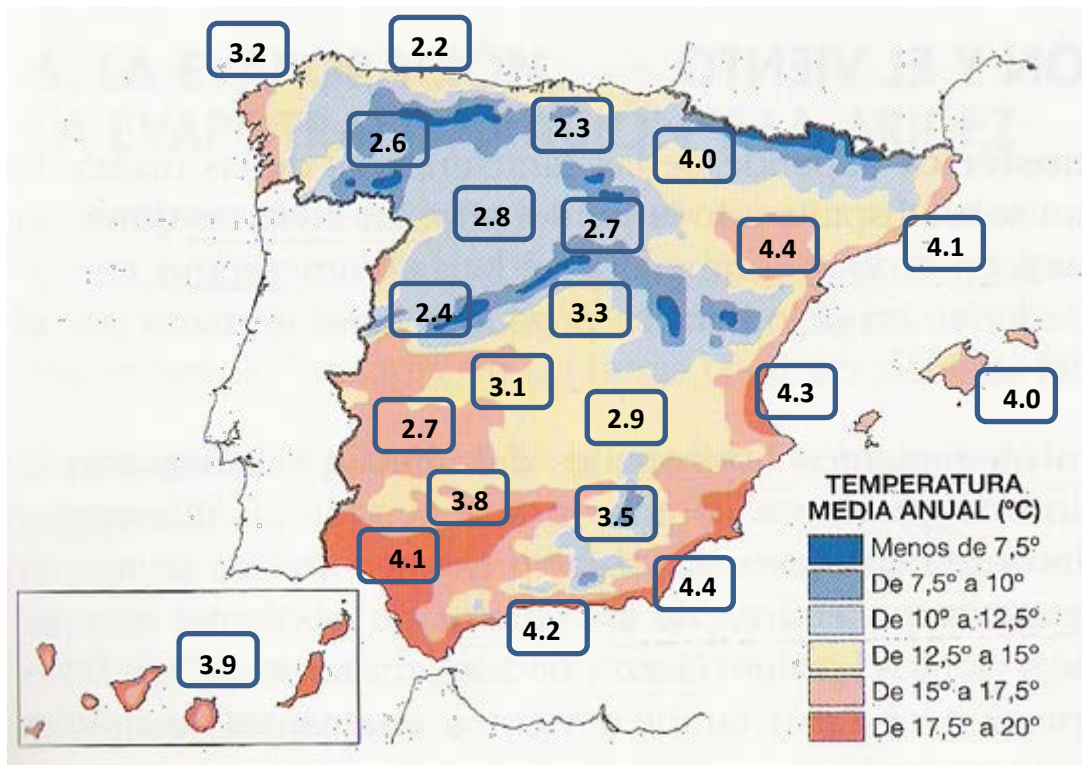


Figure 13. Map of average temperatures in Spain and values obtained by high/low temperature factor for different provinces. Map source: AEMET

Respondents ranked “**performing work at night**” factor as the third most influencing factor within this category to labor productivity. In addition, this factor is further ranked 25th in its effect among all factors considered for this investigation with a relative importance index of 67.93%. This average impact on labor productivity may be explained since laborers need a proper and sufficient lighting to develop their work in an effective way, and performing activities at night leads in most of cases to have an insufficient lighting, and therefore, this lack of proper lighting has a negative impact on labor efficiency, especially on those tasks or activities which have to be carried out in the outside. The relative importance of this factor to labor productivity is easily understandable and was also recognized as a factor with a noteworthy influence affecting labor productivity in the Gaza Strip. (Enshassi et al. 2007)

Rain factor was ranked fourth in its influence within the environmental related factors category, with a relative importance index of 64.39%, and 28th overall. This environmental factor is linked with adverse weather conditions that reduce labor productivity; particularly in activities developed in the outside such as formwork, steel work, concrete casting, external plastering, external painting, and external tiling. Adverse weather sometimes stopped work totally. The findings obtained by this factor regarding efficiency in labor productivity reflect that those provinces which higher impact of this factor mostly coincide with the provinces with more annual rainfalls as it is shown in Figure 14.

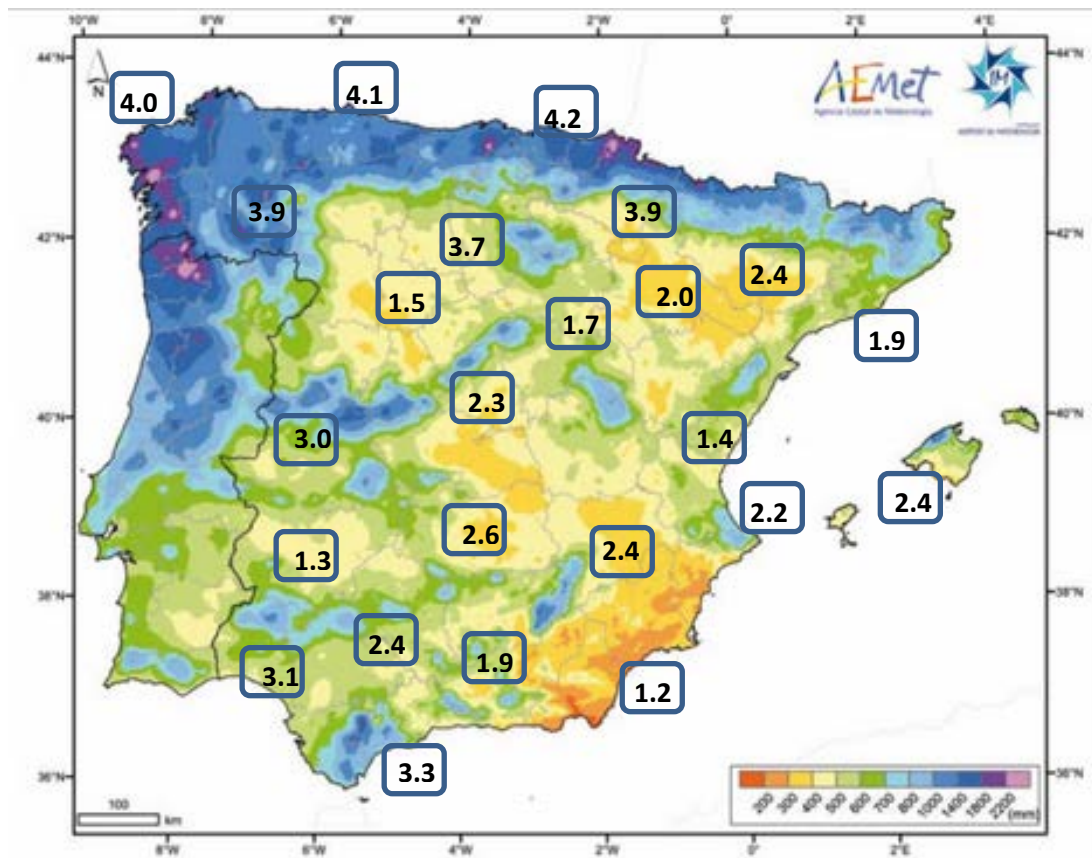


Figure 14. Map of average rainfalls in Spain and values obtained by rain factor for different provinces. Map source: AEMET

With a relative importance index of 64.36%, the **influence of working at height**, was ranked fifth within this category and in position 29 among all 35 factors explored. This factor mainly depends of the nature of the construction work and construction method used to execute it. In this manner, working at high places becomes an effect with an average impact may be responsible for laborers cannot work effectively, and consequently, a decrease in labor productivity due to this negative impact may be attained. Similar findings were obtained by El-Gohary and Aziz (2014) in Egypt, who ranked this factor in position 23 among the 30 factors surveyed with a RII of 73.60%.

The **“high winds”** factor ranked sixth in the environmental category and 31th among all 35 rated factors by practitioners, with a relative importance index of 63.25%. This factor has average effect on labor productivity since it limits operations and thus has negative impacts on labor efficiency. High winds affect particularly to activities carried out in the outside such as formwork, steel work, concrete casting, external plastering, external painting, and external tiling. Adverse weather sometimes stopped work totally, for instance, the use of cranes when the speed of the wind reaches a given value. Figure 15 shows the values of the basic speed of the wind used for building design and the values of the “high winds” factor. As it can be observed, most of the provinces located in zone “C” also present high effect for this factor influencing labor productivity, and those located in zone “A” displays limited effect for this factor.

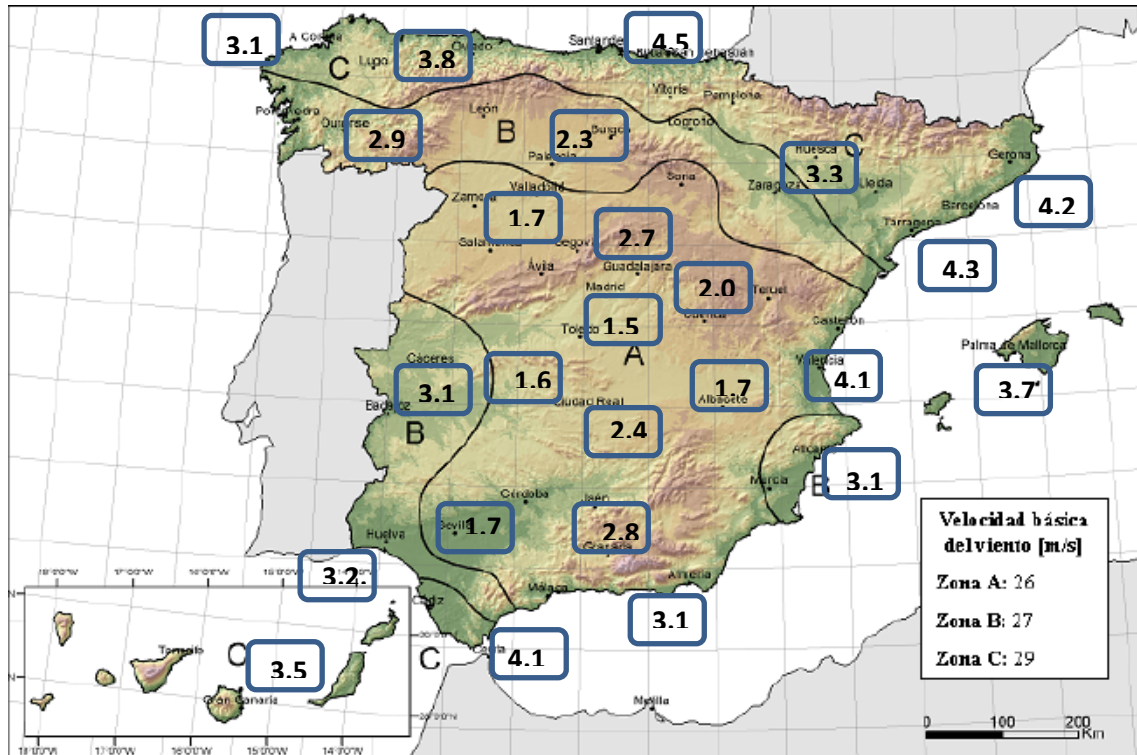


Figure 15. Map of basic speed of the wind in Spain and values obtained by “high winds” factor for different provinces. Map source: DB-SE-AE

With a relative importance index of 54.23%, **distance between construction sites and cities**, was ranked seventh with the environmental related factors category and 34th when considering all factors rated by respondents. Although the impact of this factor on labor productivity in Spain is limited, El-Gohary and Aziz (2014) also observed that distance between construction sites and cities may be an impediment to achieve good productivity because of the difficulties and transport time of both materials and workers.

Finally, **air humidity factor**, with a relative importance index of 53.56% was ranked in last position (8th) within this category but also among the 35 factors explored. While low effect for this factor was observed inside the peninsula, high effect regarding labor productivity was noticed in those provinces close to the seaside, since the sea provides a higher level of humidity.

In order to conclude with the last category in which each of the 35 surveyed factors were grouped; RII of the environmental related factors' category was also estimated by the same way used in the rest of categories. For this category, a relative importance index of 63.67% is attained.

6. Ranking by categories and overall classification of all factors surveyed

6.1. Ranking by categories

Importance indexes for each category were quantified in previous sections by using an average measure of the RII of the factors included in each category so as to determine their relevance and so, comparison between them could be conducted. Table 44 presents the overall ranking of the five categories, under which all the considered factors affecting construction labor productivity were classified.

Rank	Category	Overall RII (%)
1	Materials and tools category	82.65
2	Management or organizational category	77.25
3	Human category	73.16
4	Project category	70.73
5	Environmental related factors category	63.67

Table 44. Ranking and overall RII by categories

The outcomes obtained indicate that materials and tools category ranks first with an average RII of 82.65%, further supporting the high effect of the factors within this category. Secondly, with a RII of 77.25%, management or organizational category is ranked. In third and fourth position, human and project category are ranked with RIIs of 73.16% and 70.73%, respectively, and finally, the quantified RII of the environmental category, that is, 63.67%, indicates that also factors under this category has average effect on labor productivity in Spain.

6.2. Overall classification of all factors surveyed

Then, the overall ranking and relative importance index of the factors surveyed are summarized in Table 45.

Rank	Factor	Overall RII (%)
1	Shortage or late supply of materials	87.40
2	Clarity of the drawings and project documents	86.41
3	Clear and daily task assignment	85.53
4	Tools or equipment shortages	85.20
5	Level of Skill and experience	83.16
6	Delays in payments to workers	82.47
7	Coordination between crews	82.00
8	Improper coordination of subcontractors	81.59
9	Insufficient supervision of subcontractors	81.03
10	Communication problems	80.88
11	Ability to adapt to changes and new environments	80.84
12	Inadequate planning	78.10
13	Labour motivation	77.47
14	Delays in payments to suppliers	76.99
15	Unsuitability of materials storage location	75.36
16	Unrealistic scheduling	75.07
17	Worker's integrity	75.00
18	High congestion	73.94
19	Rework	73.19
20	Motion's limitation in the jobsite	72.08
21	Reallocation of laborers	70.80
22	Lack or delay in supervision	70.22
23	Incentive policies	69.65
24	High/low temperatures	69.53
25	Performing work at night	67.93
26	Complexity of the design	66.86
27	Construction method	65.49
28	Rain	64.39
29	Influence of working at height	64.36
30	Project scale	64.17
31	High winds	63.25
32	Number of breaks and their duration	62.67
33	Working overtime	59.82
34	Distance between construction sites and cities	54.23
35	Air humidity	53.56

Table 45. Ranking and overall RII for all factors surveyed

As displayed in Table 45 above, the top ten ranked factors affecting the construction labor productivity in Spain are as follows: (1) shortage or late supply of materials, with a RII of 87.40%; (2) clarity of the drawings and project documents, 86.41%; (3) clear and daily task assignment, 85.53%; (4) tools or equipment shortages, 85.20%; (5) level of skill and experience of laborers, 83.16%; (6) delays in payments to workers, 82.47%; (7) coordination between crews, 82.00%; (8) improper coordination of subcontractors, 81.59%; (9) insufficient supervision of subcontractors, RII value of 81.03%; and (10) communication problems with a relative importance index of 80.88%. It is an interesting finding that within the top ten ranked factors, there exist 6 factors directly related with the management or the organization of the construction work, whereas the remaining factors, 2 are related with the materials and tools shortages, 1 with the project characteristics and the last one, with human characteristics. On the other hand, results indicate that (31) high winds; (32) number of breaks and their duration; (33) working overtime; (34) distance between construction sites and cities; and (35) air humidity were the lowest factors negatively affecting labor productivity in Spain, with RIIs values of 63.25%, 62.67%, 59.82%, 54.32% and 53.56%, respectively.

Chapter 9

**CONCLUSIONS AND FUTURE
LINES OF INVESTIGATION**

1. Conclusions

As part of the main objective of this research and with the aim of improving construction labor productivity, an identification and recognition of the primary factors influencing productivity was developed. This study has identified, and, based on the quantified RIIs, assessed the influence ranks of 35 factors affecting construction labor productivity in Spain. The factors studied were, furthermore, grouped under the following five categories: (1) project category; (2) human category; (3) management or organizational category; (4) materials and tools category; and (5) environmental category. In order to rank the factors in a consistent way, the effect of respondent's experience in the construction industry on the results was considered, for this purpose, data from questionnaires was analyzed taking into account the category of level of experience of the practitioners.

This research reports the importance of the materials and tools category which could be considered related to the second ranked category: management or organizational group since the responsibility of providing and ensuring supplying both materials and tools to workers lies on site manager. In addition, due to the nature of most of the management or organizational factors, they cannot be predicted in advance, hence, they cannot be used in developing forecasts and thus they can only be controlled during the construction phase, based on the quality and efficiency of the project and construction management during the execution phase. Additionally, main findings of this research are mostly in consonance with the results of previous studies related with labor productivity.

According to the Pareto principle (also known as the 80–20 rule) which states that, for many events, roughly 80% of the effects come from 20% of the causes; recommendations are proposed in order to improve productivity levels by mitigating the effect of factors with higher impact on labor productivity. Also recommendations addressing the findings from the Lean Construction point of view will be exposed and several tools are presented which could be easily implemented in order to mitigate the effects of these top ranked factors.

A predictable factor identified, "clarity of the drawings and project documents" is the most influencing factor within the project category. Tender documents are most often incomplete, unclear, or contain serious conflicts among the various disciplines involved. This fact further supports that the design phase needs much more effort and consideration in the Spanish construction industry since a lack of cohesion between designers/engineers and contractors was observed. The outcomes furthermore expose their incapacity to see the whole construction process through each other's eyes. This inability occasionally leads to incomplete drawings or technical specifications which need to continuous requests for clarifications, hence consecutive interruptions and/or disruptions to work progress. Loss of efficiency may reach 30% when work changes are being carried out during execution confirming the importance of the relationship between designers/engineers and contractors. Achieving higher constructability level of designs is definitely the first step in the right direction. This can be accomplished by increasing the designers' awareness of the significant impact of this concept on the productivity of the construction process. In fact, a change in the way the design phase is managed should be also considered since choices and implications made during this phase not only have crucial impact on its constructability, but also dictates its viability, cost, and

durations. Suggestions might include encouraging procurement methods that allow the involvement of contractors during the design stage of projects, such as design/build (DB), design/build/operate/transfer (DBOT), or turnkey/engineering, procurement, and construction (EPC), and thus expedite the incorporation of the construction experience at the early stage of the project development process so that the desired benefits can be achieved during the construction phase. Considering the results, also further control and revision of the documents comprising the project should be developed by the policy makers or the offices of supervision, in order to minimize the number of omissions, unclear features or conflicts among the various disciplines involved. It could be considered to stipulate a formal value engineering assessment before the project was delivered to bidders, in which minimum requirements of constructability and quality must be satisfied before the project starts up the tender's phase.

Also, the findings discussed the importance of the "shortage or late supply of materials" as well as the "tools or equipment shortages" factors which were ranked first and fifth, respectively among all 35 factor surveyed, further revealing the need for the contractor to prepare a careful delivery plan for the required materials/equipment providing a materials/machinery supply schedule for each supplier. Also, it reflects the need for proper selection of suppliers and efficient selection of the location of material storage avoiding wastage of labor time. Occasionally, overestimating the capacity of the equipment may result in insufficient number of equipment employed for a given activity which will lead to an equipment shortage. Construction project and site managers should pay more attention to the quality of construction materials, tools and equipment used in their projects, as using appropriate materials, tools and machinery reduces the time taken to finish the work, which consequently improves labor productivity. Moreover, implementing maintenance programs in construction companies might lead to an efficient use of tools or equipment.

"Clear and daily task assignment" and "coordination between crews" factors are the most important ones within the management or organizational category. It is highly recommended to use project scheduling techniques (such as computer-aided construction project management) during the construction phase to optimize the times of related activities and to ensure that work allow continuous task performance and hence, reducing idleness of the labor force to a minimum. Additionally, communication problems between site management and workers and also between crews may be mitigated through all-foreman meetings, which could help to identify overlapping activities and address potential problems on the job site. Furthermore laborers should meet at the beginning of each workday for 5 to 10 minutes to review the work to be done that day as well as scheduling, safety or housekeeping issues. Involving laborers in decisions affecting their jobs leads to a *creative thinking* offering process improvements and thus continuous improvement through feedback from laborers. Also, it is common that laborers are not regularly informed of completion dates, for this purpose and aiming workers to feel more involved in the execution of the project, it is suggested to plot all completion dates and middle project milestones throughout the project and post them in different job sites so laborers can feel themselves important to the organization.

The outcomes of this research regarding the result of “level of skill and experience” factor reveals the importance of developing construction labor skills and experience in all levels of the organization. On the one hand, it becomes necessary to conduct training courses and seminars in management topics for the site managers, on the other hand, contractors should provide strong assistance and support regarding the continual training of their laborers. Thus, these actions can improve the construction industry and the overall economy. In this regard, the governmental policy should pay more attention to formal secondary technical education and training programs.

Results obtained, also points that “Delays in payments to workers” represents nowadays a high influencing factor affecting the productivity of laborers in Spain. Although this factor can be considered conjunctural and might be explained by the financial difficulties that many small construction companies are suffering due to the crisis and thus increasing the hopelessness of their workers, it is expected a gradual improvement in the volume of bidding for public works for the next years, thus helping small companies to overcome their financial and liquidity problems and hence, supporting to mitigate this factor.

Finally, on the basis of the outcomes of this study, factors related with the coordination and supervision of subcontractors also have high effects on labor productivity. In the Spanish construction industry the proportion of work subcontracted may far exceed 50% of the total workload. Additional costs incurred, would be borne directly by the related subcontractors. This fact linked with improper coordination and supervision of subcontractors as well as when lack of integrity exists from subcontractors or site manager may lead to misdealing situations. In this context, it becomes desirable the application of modern approaches and concepts such as the *Last Planner System* (LPS) which can help to control and drive the management factors that affect the labor productivity in the Spanish construction industry. This management factors further includes coordination and communication between crews and between crews and site managers as well as assignments and supervision from site managers. LPS is a set of principles and tools designed to enhance work flow reliability through better planning strategies. LPS consists in different planning stages including phase scheduling, lookahead planning phase and lastly, commitment work planning phase. These planning phases identify the work that “should” be done, “can” be done, and “will” be done, respectively (Liu et al. 2011). In order to effectively implement this technique, transparency as well as trust and reliance on others becomes decisive. These attitudes aim to improve reliability between construction agents. Furthermore, cost variance analysis is frequently the only performance indicator introduced in the companies in order to know the deviation respect the planned budget. However, it could result interesting to complement this analysis implementing also the variance of assignments as a meaningful performance measure. As soon as the assignments are not completed on the scheduled time, the construction manager provides the immediate cause, i.e. weather conditions or improper scheduling. Providing the root causes of variances, construction manager is able to set action plans to deal with delays and limit the flow variability. Consequently, implementing these sort of lean techniques can certainly help minimizing the effects of these factors previously exposed and thus, improving labor productivity in the Spanish construction industry.

Thus, improvement's efforts for increasing labor productivity levels inside construction companies in Spain should then be focused on these high ranked factors, since this will not only make the construction companies more profitable, but also more competitive and thus increasing the chances of survival within the sector, especially nowadays that there exists a strong competition due to the economic crisis. In conclusion, it is believed that the outcomes of this research can provide a starting point from which recommendations and especially Lean techniques could be implemented in order to improve labor productivity and also and guide contractors and construction managers for the effective management of the labor forces.

2. Future lines of investigation

In this section, future lines of investigation will be presented in order to provide reliability, overcome its limitations and validate the findings presented in this research.

Although the sample size is representative for national level, it is not wide enough to provide reliable data when differences between Autonomous Communities or Provinces are studied. For this purpose, a possible future research could consider increasing the number of respondents in those regions where more accurate data was desired. Interesting findings could be displayed when comparing the effects between different regions in Spain, since there exist many differences between regions such as people character, geography, weather conditions and availability of materials among others. This fact was indeed, the biggest limitation of this research as no comparisons were allowed between regions within Spain since findings would not be representative. Nevertheless, due to the objectives of this Master thesis and its scope, and also the limitation of available time to accomplish it, target population was selected and determined in order to get a representative sample throughout the national territory.

This study focused only in responses from practitioners and made no difference regarding the agent involved in the construction phase, so that is why future studies should make differences between contractors, subcontractors, providers and designers since each of them have diverse interests and see the construction project from different points of view. In addition, it would be also desirable to differentiate levels of responsibility among practitioners when collecting data for posterior analysis since decisions have not the same consequences when they have been taken by a site manager rather than a foreman or craftsman. In this way, perceptions extracted from these groups could be useful to corroborate the findings of this research. Inviting contractors, consultants, subcontractors, providers and designers to assess the level of agreement among the 35 studied factors could be also helpful to support the results of this investigation.

Other point for further consideration is that there was lack of feedback from clients. Additional studies should also seek to reflect opinions from all stakeholders involved in the procurement and construction process since they have significantly influence on-site performance outcomes.

Finally, it would be also recommendable that future studies should explore other affecting factors influencing construction labor productivity at all stages of the procurement process.

Chapter 10

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ANNEXES

Index of Annexes

1. Planning Schedule
2. Introductory letter inviting construction companies to take part in the research
3. Example of the questionnaire in Spanish
4. Example of the questionnaire in English



Valencia, 28 de abril de 2014

Estimada empresa:

Mi nombre es Guillermo Robles, responsable del proyecto de investigación que se viene desarrollando desde la Universidad Politécnica de Valencia (España) y el Instituto de Tecnología de Karlsruhe (Alemania) para identificar los factores que afectan a la productividad laboral en la construcción en España.

Nos ponemos en contacto con su empresa para solicitar su adhesión y colaboración con el proyecto. En las líneas inferiores os explicamos en qué consiste el proyecto y los beneficios para su empresa por la colaboración en el mismo.

¿En qué consiste el proyecto?

El proyecto consiste en un estudio para identificar los factores, así como cuantificar su importancia, que afectan a la productividad laboral en el sector de la construcción en España.

¿Qué ventajas obtiene la empresa por cumplimentar y enviar la encuesta?

Compromiso por nuestra parte con aquellas empresas que cumplimenten y reenvíen el cuestionario, de enviar por correo electrónico una copia de los resultados y conclusiones obtenidos en dicha investigación. Así mismo aparecerán como empresas colaboradoras de este proyecto en congresos y foros de ámbito nacional e internacional y en aquellas revistas científicas en el que los resultados de este estudio sean publicados.

¿Cuánto tiempo me llevará cumplimentar el formulario?

Aproximadamente entre **5-8 minutos**.

¿Cómo colaborar con el proyecto?

Para colaborar solo tiene que clicar en el enlace adjunto y cumplimentar el cuestionario, una vez haya terminado, tan solo tiene que pulsar el botón “enviar resultados” situado en la parte inferior del cuestionario. La dirección que se indique en el cuestionario será aquella a la que se envíen los resultados y conclusiones del estudio.

Link al cuestionario:

<https://adobeformscentral.com/?f=zXsdumLHHAXRt4FLXONneQ>

Desde aquí animamos a su empresa a colaborar con este estudio, de esta manera su empresa podrá beneficiarse de los resultados del mismo así como de publicidad gratuita.

Para cualquier cuestión o aclaración, no duden en ponerse en contacto con nosotros.

¡Muchas gracias por su colaboración!



Cuestionario sobre los factores que afectan a la productividad laboral en la construcción en España.

En primer lugar nos gustaría agradecerle su participación en este estudio. El cuestionario consta de 2 apartados, el primero tiene como finalidad estratificar los resultados y el segundo apartado tiene como objetivo conocer sus percepciones sobre los factores que pueden influir en el rendimiento de los trabajadores afectando a la productividad laboral en su organización.

APARTADO I: Información personal y profesional de interés

1. Empresa u organización a la que pertenece

2. Tamaño de la empresa u organización por número de empleados.

3. Ámbito de actuación geográfica de la empresa u organización.

4. Provincia donde desempeña su función en la empresa u organización actualmente.

5. Edad

6. Sexo

Hombre

Mujer

7. Máximo nivel de estudios alcanzado

8. Años de experiencia en el sector de la construcción

9. Ámbitos profesionales donde ha obtenido la experiencia mencionada en el apartado 8.

Empresa constructora

Proveedor

Consultoría

Despacho arquitectura

Asistencia técnica

Dirección facultativa

Otros

(marcar máximo dos)

APARTADO II: Valoración de las percepciones sobre la influencia de los siguientes factores en la productividad del trabajo

A continuación, usted deberá valorar el grado de influencia que, en su opinión, cada una de estas afirmaciones tienen sobre el rendimiento de los trabajadores en su empresa u organización.

Leyenda:

"1" Muy poco efecto; "2" poco efecto; "3" efecto medio; "4" efecto moderado; y "5" elevado efecto.

	1	2	3	4	5
1. El proceso constructivo utilizado para ejecutar el proyecto diseñado.					
2. Influencia del diseño de una infraestructura a la hora de ejecutarla.					
3. Calidad en los planos o documentos del proyecto constructivo.					
4. Tamaño del proyecto. (extensión)					
5. Nivel de capacitación y experiencia previa de los trabajadores.					
6. Capacidad de adaptación a los cambios y nuevos entornos de trabajo por parte de los trabajadores.					
7. Motivación de los operarios a la hora de realizar su trabajo.					
8. Trabajar más horas de las correspondientes durante la jornada laboral. (horas extra)					
9. Influencia del número de descansos y duración de los mismos durante la jornada laboral.					
10. Influencia de la honestidad y comportamiento ético de los trabajadores en el desempeño del trabajo y el valor del proyecto.					
11. Influencia de las políticas de incentivos en el desempeño de los trabajadores.					
12. Asignación clara y diaria de las tareas a los trabajadores.					
13. Insuficiente supervisión de los subcontratistas.					
14. Incorrecta coordinación de los subcontratistas.					
15. Incorrecta planificación de los tajos de trabajo debido a incompatibilidades o restricciones.					
16. Elevada congestión en la obra.					
17. Retrasos en los pagos a los trabajadores.					
18. Retrasos en los pagos a los proveedores.					
19. Planificación poco realista debido al exceso de confianza por parte de los responsables del proyecto.					
20. Problemas de comunicación entre los responsables de proyecto y los trabajadores.					
21. Reasignación de los operarios a nuevos tajos de obra en función de las necesidades.					
22. Coordinación entre equipos de trabajo durante la ejecución de la obra.					

Leyenda:

"1" Muy poco efecto; "2" poco efecto; "3" efecto medio; "4" efecto moderado; y "5" elevado efecto.

	1	2	3	4	5
23. Inadecuada supervisión de las actividades ejecutadas.					
24. Necesidad de volver a realizar una actividad debido a una incorrecta ejecución.					
25. Escasez o suministro tardío de los materiales necesarios para ejecutar una actividad.					
26. Falta de idoneidad en la ubicación del acopio de los materiales.					
27. Escasez de herramientas o maquinaria necesaria para ejecutar una actividad.					
28. Realización de trabajos durante la noche.					
29. Influencia de la realización de trabajos en altura.					
30. Limitación del movimiento debido a las condiciones del puesto de trabajo.					
31. Influencia de la humedad del aire en el desempeño de los trabajadores.					
32. Influencia de altas/bajas temperaturas en el desempeño de los trabajadores.					
33. Influencia de la lluvia en el desempeño de los trabajadores.					
34. Influencia de vientos de intensidad en el desempeño de los trabajadores.					
35. Distancia desde la localización de las obras a la residencia de los trabajadores.					

¡Muchas gracias por su participación!

Por último, si desea recibir una copia de los resultados obtenidos en este estudio, indique su Correo electrónico al cual desea que sea enviada.

No olvide pulsar el link inferior "**Enviar cuestionario**" para enviar las respuestas

Nota Legal:

Los datos proporcionados serán tratados de acuerdo con la protección y especificaciones contenidas en la Ley 15/1999, de 13 de Diciembre, de Protección de Datos de Carácter Personal así como su normativa de desarrollo.

NO se utilizarán dichos datos para el envío de comunicaciones comerciales por correo electrónico no solicitadas o no autorizadas expresa y previamente por el interesado, según lo estipulado en la Ley 34/2002 de Servicios de la Sociedad de la Información y de Comercio Electrónico (LSSI).



Questionnaire regarding factors affecting labor productivity in construction in Spain.

Firstly, we would like to thank you for participating in this study. The questionnaire consists of two sections, the first one is intended to stratify the results and the second section aims to determine the perceptions about the the factors that might influence the performance of laborers affecting labor productivity in your organization.

SECTION I: Personal and professional information of interest

1. Name of the company or organization
 2. Size of the company or organization by number of employees
 3. Geographic scope of the company or organization
 4. Province where you perform your work at present
 5. Age
 6. Gender
 - Male
 - Female
 7. Maximum level of studies reached
 8. Years of experience in the construction industry
 9. Fields where professional experience indicated in question 8. was acquired
 - Construction company
 - Supplier
 - Consultancy
 - Architecture office
 - Support
 - Project management
 - Others
- (tick two options as maximum)
-

SECTION II: Assessment of the perceptions about the influence of the following factors on labor productivity

Next, you should assess the degree of influence that, in your opinion, each of these statements have on the performance of the laborers in your company or organization.

Scale:

"1" Very little effect; "2" Little effect; "3" Average effect; "4" Moderate effect; y "5" High effect.

	1	2	3	4	5
1. The construction method used to execute the project designed.					
2. The complexity of the design when executing a construction project.					
3. Quality on the drawings or construction project documents.					
4. Project scale.					
5. Level of skill and previous experience of the laborers.					
6. Ability to adapt to changes and new working environments by the laborers.					
7. Labour motivation when performing their work.					
8. Working overtime.					
9. Influence of the number of breaks and their duration during the workday.					
10. Influence of worker ´s Integrity as a set of moral principles, honesty and ethical behavior on labour performance and project value.					
11. Influence of incentive policies on worker performance.					
12. Clear and daily task assignment to laborers.					
13. Insufficient supervision of subcontractors.					
14. Improper coordination of subcontractors.					
15. Inadequate planning of the work due to incompatibilities or restrictions.					
16. High congestion in the construction site.					
17. Delays in payments to workers.					
18. Delays in payments to suppliers.					
19. Unrealistic scheduling due to overconfidence from project managers.					
20. Communication problems between site management and workers.					
21. Reallocation of laborers depending of the working needs.					
22. Coordination between crews during execution of the construction project.					

Scale:

"1" Very little effect; "2" Little effect; "3" Average effect; "4" Moderate effect; y "5" High effect.

	1	2	3	4	5
23. Lack of supervision or delay in inspecting the activities executed.					
24. Rework.					
25. Shortage or late supply of needed materials to accomplish an activity.					
26. Unsuitability of materials storage location.					
27. Tools and equipment shortages when needed to accomplish an activity.					
28. Performing work at night.					
29. Influence of working at height.					
30. Limitation of motion due to the conditions at the jobsite.					
31. Influence of air humidity on laborer´s performance.					
32. Influence of high/low temperatures on laborer´s performance.					
33. Influence of rain on laborer´s performance.					
34. Influence of high winds on laborer´s performance.					
35. Distance between construction sites and residences of the workers.					

¡Thank you very much for your participation!

Finally, if you would like to obtain copy of the results obtained in this study, please indicate your email.

Do not forget to click on the link below "**Submit Questionnaire**"

Legal note:

The data provided will be treated in accordance with the protection and specifications contained in Law 15/1999 of December 13, Protection of Personal Data and its implementing regulations.

These data will **not** be used for sending commercial communications by email unsolicited or unauthorized expressly and previously by the applicant, as provided in Law 34/2002 of the Information Society and Electronic Commerce (LSSI).