ANALYZING BARRIERS TO CONSTRUCTION PRODUCTIVITY IMPROVEMENT IN THE DOMINICAN REPUBLIC

Bolivar A. Senior[1] and Tulio A. Rodríguez[2]

ABSTRACT

The present study examined the perceived importance, easiness to overcome and criticality of 29 barriers to productivity improvement in the Dominican Republic. It surveyed 134 construction professionals with 5 or more years of experience, who provided their assessment in the dimensions of importance and easiness to overcome on a Likert scale from 1 to 5. Barriers were grouped into environment driven, top-management driven and field-management driven. Two secondary questions explored attitudes towards education in productivity improvement.

Respondents gave high average grades of 4.01 to 4.69 to all questions in the dimension of Importance. Average responses for Easiness to overcome were lower, had a broader range, from 2.31 to 3.74 and showed a more nuanced deliberation of possibilities. The criticality of some barriers seems difficult to justify using Lean Construction principles, and need further examination. Barriers with high criticality tended to be driven by field management, and those with low criticality tended to be driven by top management. Results point to an overall perceived need for improvement which is not followed by optimism for achieving it.

The present study is the first of its kind in the Dominican Republic. Its results provide a roadmap for educational and managerial action in the immediate future. It can also serve as a foundation for similar studies in other developing countries.

KEYWORDS

Productivity improvement, benefits realization Dominican Republic, survey.

INTRODUCTION

The barriers to construction productivity improvement in the Dominican Republic are poorly understood, and have led to inaction or wasteful attempts to implement management techniques. While many construction management issues are shared by projects in many countries (Koskela, 1992), a rational effort to improve construction productivity in this Latin American country must be grounded on an objective basis for assessing what factors are perceived as important by local stakeholders and which ones are perceived as easy to overcome.

The Dominican construction sector has enjoyed a notable increase in volume and complexity in the last decade. In the residential sector alone, 56% of new housing

[1] Associate Professor, Department of Construction Management, Colorado State University. 102 Guggenheim Hall, Fort Collins, CO 80523-1584, USA. Phone +1 (970) 491-7337. Bolivar.senior@colostate.edu.

[2] Associate Professor, Department of Civil Engineering, Instituto Tecnológico de Santo Domingo, Santo Domingo, Dominican Republic. Phone +1 809-866-1530. tulio@intec.edu.do.

units in 2002 were individual residences and 44% were buildings with at least 4 levels. By 2010, 93% of new housing units consisted of buildings of at least 4 levels and only 7% were individual residences (ONE, 2012). The heavy and industrial construction sectors have experienced a comparable growth.

Lean Construction is emerging as a management alternative in the Dominican Republic. The Construction Management Innovation Group (Grupo de Innovación en la Gestión de la Construcción, GIGC) at the Instituto Tecnológico de Santo Domingo (Intec), for example, tested field management tools similar to The Last Planner System™ (Ballard, 2000) as well as seminars for middle and upper level managers.

There have been several studies addressing issues related to barriers to construction quality and productivity improvement in industrialized countries (e.g. BICE, 2009, Arditi and Mochtar, 2009), as well as in developing countries such as the ones discussed in this section. These studies are generally specific in their claimed geographic scope, and use a wide variety of indicators and analysis tools. Their conclusions emphasize different aspects of the industry, and are affected by the economic and political forces of the country. The following studies provided guidance in the development of this survey's methodology, and offer insight into typical productivity issues examined throughout the world.

- Makulsawatudom et al. (2004) surveyed 34 Thai project managers and explored productivity factors at the site level. The analysis included a Critical Factor Index, found by multiplying the importance given by respondents to each factor in a Likert scale by their potential for improvement on a similar scale. The study ranked and discussed the 10 main factors to improve in the industry, including lack of materials, incomplete drawings and incompetent supervisors.
- Alinaitwe (2009) conducted 45 interviews to Ugandan contractors, classifying their responses to 31 identified barriers to the success of lean construction using a Likert scale. Many factors were internal to the construction production process. For example, he found that the factor with highest calculated strength was having inputs exactly when required, and the easiest to overcome was keeping needed items in the right places.
- Serpell et al. (2002) conducted a total of 45 interviews to a mix of stakeholders in the Chilean construction industry, including owners, designers, contractors, unions, inspectors and suppliers. With an extensive use of Ishikawa diagrams, they showed that improvements required the coordinated effort of all stakeholders, including educational institutions and the government.
- Other studies include Abdel-Razek (1998), who surveyed 159 construction professional representing owners, consultants, and academicians using multiple rounds of questionnaires to reach consensus for the main factors affecting construction quality in Egypt. Enshassi (2009) explored the problems of construction projects and the construction industry in general in the Gaza Strip using a questionnaire distributed to owners, consultants and contractors. They found that industry problems, although strongly related to the political situation of the area, also had local components such as quality of materials and project leadership skills. Al-Momani (2000) surveyed 138 construction owners and contractors in Jordan, emphasizing overall satisfaction issues. He found, among other high-level issues, that local contractors did not give enough emphasis to owner satisfaction.

OBJECTIVES

The study reported in this article had the objective of identifying the perceived relative importance of a group of barriers to construction productivity improvement identified by experienced Dominican construction stakeholders, and identifying the perceived easiness with which these barriers could be overcome.

As a secondary objective, this study sought to quantify the local interest for formal instruction about productivity improvement.

HYPOTHESES

The following hypotheses formulate in testable form the objectives of this study. The Methodology section offers details on how these hypotheses were investigated

1. There are significant differences in the perceived importance of barriers to construction productivity by Dominican construction professionals.
2. There are significant differences in the perceived easiness to overcome barriers to construction productivity by Dominican construction professionals.
3. There are significant differences in the criticality of barriers to construction productivity by Dominican construction professionals. Criticality is defined for this study as an indirect property derived from the responses to each question's importance and easiness to overcome.
4. There are differences in the criticality of driving categories for barriers to productivity. Driving categories were defined as Environment, Top Management and Field Management. A driving category was assigned to each question, according to the main locus of its underlying barrier.

METHODOLOGY

Data for this study was provided by a survey administered in 2010 to construction-related individuals sponsored by Intec, and administered by graduate student members of the GIGC. It was geared to experienced Dominican construction professionals with 5 or more years of field experience. Participants were a convenience sample selected from the registry of the Dominican Professional Engineers, Architects and Surveyors. Preliminary individual interviews were performed to a small group of potential participants by graduate students to refine the survey questions. A total of 149 professionals were contacted, of which 134 answered the questionnaire. Participants were initially contacted by email. The survey was administered by hand-delivering a printed copy of the questions. Completed surveys were collected directly from each participant. This method allowed a turnaround time of 2 months from the start of the distribution to the end of the start of data processing.

A preliminary list of questions was refined through interviews with an opportunity sample of 5 construction professionals, who provided advice on the scope and wording of the questions included in the final version of the questionnaire. A survey similar in objectives and administered in Uganda (Alinaitwe, 2009) was used as a point of reference for structuring the questionnaire.

The final version consisted of 29 questions. A Likert scale from 1 to 5 was used for the responses. A 5 in the Importance dimension signified that the factor was a very significant barrier. A 5 in the Easiness dimension meant that the factor was very easy to overcome. Participants were offered the option of providing their responses in

anonymity. Seventy-one of the 134 participants (i.e., 53%) chose to remain anonymous. This article discusses the responses of all 134 participants.

Respondents rank each question in two aspects, which addressed the first two hypotheses tested by this study:

- The *Importance* of the factor as a barrier to the improvement of project productivity, and
- The *Easiness to overcome* the barrier to productivity improvement posed by the factor.

The third hypothesis of this study tested the criticality of each barrier. The Criticality of each barrier was computed as the product of its scores for the Importance and Easiness to Overcome. It was normalized into a 1-5 scale by dividing by 5 the product of the two scores, thus making this computed score fall in the same range (1 to 5) of its two combined factors. In summary:

Criticality = Importance score * Easiness score / 5)

An item's criticality is defined in general by its significance relative to a given aspect (e.g.,VM-1997). The above formula indicates that a highly critical barrier to productivity for this study would be one combining a high importance and a high easiness to overcome. Criticality in this case is an indication of opportunity for change.

The fourth hypothesis tested by this study required the grouping of questions into three categories according to their driving factors:

- *Environment driven (EV).* This category included factors external to the participants' ability for influencing significantly, such as the quality of materials, worker skills and the price of commodities.
- *Top-management driven (TM).* These questions addressed factors difficult to control by mid and lower level managers in a construction company. Examples of factors in this category include reward systems based on team goals, organizational culture supporting teamwork and provision of benchmarks.
- *Field-management driven (FM).* Communication within teams, well-defined focus of teams, defect prevention and similar questions in this category were considered to be realistic targets for improvement by the middle and lower level personnel in the field.

The Appendix contains the 29 barriers to productivity included in the survey, along with their respective driving category.

The questionnaire also included two additional questions addressing the respondents' interest in investing time and money on a hypothetical method that could prove effective in improving project productivity. These two questions are briefly considered here because they further clarify the rationale and contribution of the present study.

DATA ANALYSIS AND DISCUSSION

Results for the average Importance, Easiness to overcome and Criticality of each barrier to productivity are summarized in Table A.1 of the Appendix, and are examined in detail in this section.

Table 1 shows the top five and bottom five barriers ranked by Importance. The top ranking barriers would be expectable to many experienced construction professionals, such as alignment among project teams and quality materials. The top bottom, includes barriers such as component standardization and group culture, shared vision and consensus. In the experience of the authors, most Lean construction practitioners in industrialized countries would rank much higher these factors. Their average could indicate that project management in the Dominican Republic is subject to a substantially different context from the context encountered in industrialized countries, or that there is a misperception of the significance of factors among experienced construction professionals.

The importance dimension showed a narrow range of scores. Respondents gave high marks in the Likert scale to virtually all questions in this dimension. The average mark for all 29 questions was 4.36 of 5.00, with high agreement in assigning these scores reflected in a standard deviation for the entire sample was just 0.73 points.

Table 1: Top 5 and bottom 5 barriers by Importance

Q#	Description	Cate-gory	Importance		
			Average	Std Dev	Rank
2	Alignment among project teams	FM	4.69	0.53	**1**
24	Quality materials	EV	4.66	0.55	**2**
19	Keeping needed items in the right places	FM	4.62	0.59	**3**
25	Steady work engagement	TM	4.60	0.54	**4**
29	Complete designs	EV	4.60	0.72	**4**
12	Reward systems based on team goals	TM	4.13	0.73	**24**
8	Good pre-planning	TM	4.09	0.86	**25**
18	Transportation and communication infrastructure	EV	4.08	0.76	**26**
22	Provision of performance benchmarks	TM	4.07	0.78	**27**
17	Group culture, shared vision and consensus	TM	4.05	0.73	**28**
27	Component standardization	TM	4.01	0.82	**29**

In contrast to the Importance dimension, there was much less agreement in assessing the Easiness for overcoming each barrier. The overall average was 3.31, a full point below the Importance dimension, with a standard deviation of 1.06 points. Table 2 shows the top 5 and bottom 5 barriers ranked by Easiness to overcome, varying from 2.31 to 3.74.

Table 2: Top 5 and bottom 5 barriers by Easiness to overcome

Q#	Description	Cate-gory	Easiness to overcome		
			Average	Std Dev	Rank
16	Documenting agreements and procedures	FM	3.74	1.09	**1**
27	Component standardization	TM	3.69	0.99	**2**
28	Well-defined team focus	FM	3.63	0.91	**3**
4	Ability to measure performance	FM	3.63	0.89	**3**
7	Constructability of design	EV	3.60	1.06	**5**
12	Reward systems based on team goals	TM	3.14	1.01	**25**
9	Certainty in the supply chain	EV	2.97	1.07	**26**
1	Organizational culture and teamwork	TM	2.96	1.01	**27**
8	Good pre-planning	TM	2.61	1.12	**28**
10	Stable commodity prices	EV	2.31	1.07	**29**

Well-defined team focus is ranked near the top in terms of Easiness to overcome. As with the Importance dimension, it is difficult to assess with the available data whether respondents were aware of the available alternatives to overcome these barriers, and particularly with the options offered by Lean Construction.

The top 5 and bottom 5 barriers ranked by criticality are shown in Table 3. This ranking shows a combination of Importance and Easiness to overcome, and therefore, barriers ranked 1 to 5 are the best candidates for improvement. Responses varied from 1.94 to 3.30, with an average of 2.91. The range and average are affected by the formula used to compute this dimension, and cannot be directly numerically compared to the averages for the other two dimensions. Results are much aligned with the expectations of a construction professional aware of Lean Construction principles, in the opinion of the authors. In this table, key terms to Lean Construction such as communication, customers and needs are included in the top ranked barriers. The bottommost factor is *Stable commodity prices*, which very likely reflects the perception that an individual contractor has little influence over this point. Still, there are seemingly illogical rankings, such as placing *Good pre-planning* near the bottom of the list. As with the previously discussed dimensions, this result may be due to unique circumstances or lack of information about alternatives. Further research is required to clarify this point.

The terms *Importance* and *Criticality* are relatively close in meaning. As previously discussed, while each barrier's Importance was directly assessed by respondents, Criticality was computed from their responses. Both terms, in turn, are close to key words for Lean Construction: *value* and *waste*. From a Lean Construction perspective, the importance of each barrier reflects its built-in waste; its criticality reflects its relative value for improvement.

Table 3: Top 5 and bottom 5 barriers by Criticality

Q#	Description	Cate-gory	Criticality		
			Average	Std Dev	Rank
24	Quality materials	EV	3.30	1.12	**1**
16	Documenting agreements and procedures	FM	3.29	1.26	**2**
26	Understanding needs of internal, external customers	TM	3.27	1.16	**3**
28	Well-defined team focus	FM	3.24	1.06	**4**
14	Communication within teams	FM	3.19	1.11	**5**
12	Reward systems based on team goals	TM	2.63	1.12	**25**
1	Organizational culture and teamwork	TM	2.60	1.11	**26**
9	Certainty in the supply chain	EV	2.52	1.05	**27**
8	Good pre-planning	TM	2.15	1.11	**28**
10	Stable commodity prices	EV	1.94	1.02	**29**

Figure 1 shows the average Criticality scored by barriers in each driving category: Top-management driven (TM), Field-management driven (FM), and environment driven (EV). The differences in average shown in Figure 1 point to the validation of the fourth hypothesis tested in this study, namely that there were differences in the average criticality of factors depending on their driving category. It can be seen that barriers in the EV category averaged the lowest Criticality score, while FM barriers scored the highest. Three out of the top 5 factors by criticality are field management driven, and none of the bottom 5 is field management driven. These results suggest that respondents were aware of the importance of problems concerning field management, and the relative easiness with which some of them could be addressed from the viewpoint of traditional construction management. A more troubling possibility is that individuals at the top management level cannot (or will not) see their own contribution to the barriers.

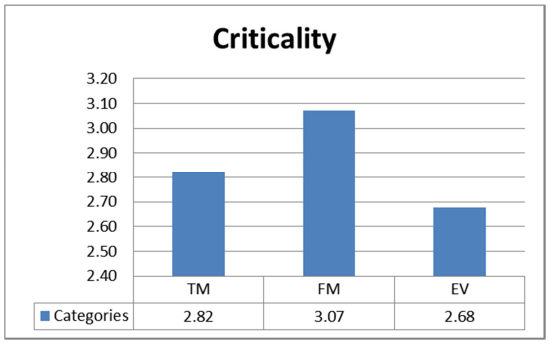

Figure 1. Average criticality by category

ATTITUDES TOWARDS A HYPOTHETICAL IMPROVEMENT METHOD

Two secondary questions included in the survey sought the stance of participants to the possibility of investing time and money to improve the barriers identified in the survey using a hypothetical management method. Lean Construction deliberately was

not mentioned to avoid bias from previous knowledge about this management approach.

The first question's wording was: "Would you be willing to invest time and money in a methodology for reducing the hindrances to productivity improvement?" 112 respondents (85%) stated that they were willing to commit resources into this unnamed methodology, while 20 (15%) responded negatively.

The second question was: "If you answered yes to the previous question, how much time would you be willing to commit for this purpose? The responses were as follows:

2 to 4 hours:	29 respondents (26%)
4 to 16 hours:	44 respondents (39%)
16 to 24 hours:	16 respondents (14%)
24 to 40 hours:	23 respondents (21%)

These results show a definite willingness for improving the current state of construction productivity in the Dominican Republic. This willingness in in line with the high marks given to each barrier's importance, and points to the potential for introducing Lean Construction techniques in the near future.

CONCLUSIONS

The understanding of a problem is an important step towards its solution. This study contributes to the enhancement of the construction industry in the Dominican Republic by offering insight into the barriers to construction productivity in three crucial dimensions: importance, easiness to overcome and criticality. The Data Analysis and Discussion section addresses in detail each of these dimensions. In brief, results point to an overall perceived need for improving productivity, which is not followed by optimism to achieve this improvement. Specific issues are briefly recapitulated below, addressing each hypothesis for this study.

- The Importance of all barriers was consistently highly rated by respondents, which could reflect the urgency for improvement that the authors have anecdotally recognized in many Dominican construction professionals.
- The Easiness of overcoming scores were lower on average and more spread across the various barriers, pointing to a nuanced view of the effort required by each barrier.
- There was a wide range of Criticality scores computed for each barrier's Importance and Easiness to overcome. Some of the ranked barriers seem illogical from a Lean Construction perspective. Further study is needed to elucidate whether these results reveal unique characteristics of the Dominican market.
- The driving categories showed a tendency to rank more highly the criticality of barriers driven by field management, and to place the criticality of barriers driven by top management near the bottom of the ranking. These tendencies could originate in the characteristics of Dominican construction projects, but also could be the result of bias from respondents.

Few of the studies in developing countries reviewed here have taken into account any Lean context (exceptions include Alinaitwe, 2009 and Serpell, 2002, both of great utility for the structuring of this strudy). There is a need to frame construction management issues in a Lean context for a full recognition of the appropriateness of

Lean Construction to solve them. Although this study did not address specific Lean Construction solutions to the problems posed by the various barriers to productivity, its methodology could serve as a basis for further research in other developing countries.

Based on the results of this study, the following actions are recommended:

- Examine solutions to the most critical barriers to productivity identified here. For example, the most critical identified barrier is the quality of materials. What constraints prevent the overcoming of this barrier? What changes need to be introduced to the design, contracting and execution phases of local projects? Lean methods such as the *Five Whys* (e..g., Senge, 1990) can be very helpful in this step.
- Investigate the reasons underlying the seemingly illogical ranking received by some barriers. For example, this study sought the perceptions of experienced construction professionals who, partly as a result of their experience, are at the top management levels of their companies or their projects. Their success may have introduced a bias in this study, which could help to explain the results discussed in this article. There are many similar issues examined in this paper that this investigation uncovered but did not clarify. Each one merits further research.
- Disseminate the information revealed by this study about barriers to construction productivity, and the opportunity offered by Lean Construction for overcoming them.

REFERENCES

Abdel-Razek, R. (1998). Factors affecting construction quality in Egypt: identification and relative importance. *Engineering, Construction and Architectural Management*, 5 (3), 220-227.

Alinaitwe, H. (2009). Prioritising Lean Construction Barriers in Uganda's Construction Industry. *Journal of Construction in Developing Countries*, 14 (1), 15-30.

Al-Momani ,A. (2000). Examining service quality within construction processes. *Technovation* 20, 643–651.

Arditi, D. and Mochtar, K. (2009). Trends in productivity improvement in the US construction industry. *Construction Management and Economics*, 18 (1), 15-27.

Ballard, G. (2000). *The Last Planner System of Production Control*. Doctoral thesis, University of Birmingham, UK.

Board on Infrastructure and the Constructed Environment , BICE (2009). *Advancing the Competitiveness and Efficiency of the U.S. Construction Industry*. The National Academies Press. Retrieved March 30, 2012 from http://www.nap.edu/openbook.php?record_id=12717&page=19.

Central Bank of the Dominican Republic (2012). *Estadísticas Económicas.* Retrieved March 30, 2012, from http://www.bancentral.gov.do/sipard.asp.

Enshassi A., Mohamed S. and Abushaban, S. (2009). Factors affecting the performance of construction projects in the Gaza strip. *Journal of Civil Engineering and Management*, 15 (3), 269-280.

Koskela, L. (1992). *Application of the New Production Philosophy to Construction*. Technical Report 72, CIFE, Stanford Univ., CA, Sept., 75 pp.

Makulsawatudom A., Emsley M. and Sinthawanarong, K. (2004). Critical factors influencing construction productivity in Thailand. *Journal of KMITB*, 14 (3), 1-6.

Oficina Nacional de Estadística, ONE (2012). *Dominicana en Cifras 2011*. Secretariado Técnico de la Presidencia, República Dominicana.

Senge, P (1990). *The fifth discipline : the art and practice of the learning organization*. Milsons Point, NSW: Random House Australia, 1992, c. 1990.

Serpell, A., de Solminihac H. and Figari C.(2002). Quality in construction: the situation of the Chilean construction industry. *Total Quality Management*, 13 (5), 579-587.

VM-1997, (1997). V-Model 1997, *Lifecycle Process Model -Developing Standard for IT Systems of the Federal Republic of Germany.* General Directive No. 250.

APPENDIX

Table A.1 Barriers to improvement, average responses and rankings

Barriers to Improvement included in survey			Survey results					
Q#	Description	Cate-gory	Criticality		Importance		Easiness to overcome	
			Average	Rank	Average	Rank	Average	Rank
1	Organizational culture and teamwork	TM	2.60	**26**	4.24	**21**	2.97	**26**
2	Alignment among project teams	FM	3.00	**14**	4.05	**28**	3.37	**14**
3	Worker skill and knowledge levels	EV	2.95	**17**	4.40	**14**	3.31	**17**
4	Ability to measure performance	FM	3.12	**7**	4.66	**2**	3.54	**7**
5	Management leadership	TM	3.07	**13**	4.60	**4**	3.40	**13**
6	Commitment to continuous improvement	TM	2.95	**16**	4.62	**3**	3.32	**16**
7	Constructability of design	EV	3.08	**11**	4.58	**6**	3.46	**11**
8	Good pre-planning	TM	2.15	**28**	4.09	**25**	2.61	**28**
9	Certainty in the supply chain	EV	2.52	**27**	4.34	**16**	2.96	**27**
10	Stable commodity prices	EV	1.94	**29**	4.19	**23**	2.31	**29**
11	Client and supplier involvement	EV	2.72	**23**	4.30	**17**	3.16	**23**
12	Reward systems based on team goals	TM	2.63	**25**	4.13	**24**	3.14	**25**
13	Reliability of production process	EV	2.94	**18**	4.48	**10**	3.28	**18**
14	Communication within teams	FM	3.19	**5**	4.22	**22**	3.60	**5**
15	Defect prevention	FM	2.89	**19**	4.07	**27**	3.27	**19**
16	Documenting agreements and procedures	FM	3.29	**2**	4.01	**29**	3.69	**2**
17	Group culture, shared vision and consensus	TM	2.75	**21**	4.45	**11**	3.24	**21**
18	Transportation and communication infrastructure	EV	2.85	**20**	4.50	**8**	3.26	**20**
19	Keeping needed items in the right places	FM	3.09	**10**	4.08	**26**	3.48	**10**
20	Working in parallel multidisciplinary teams	FM	3.07	**12**	4.44	**13**	3.42	**12**
21	Project team skills	FM	3.12	**8**	4.30	**17**	3.52	**8**
22	Provision of performance benchmarks	TM	2.70	**24**	4.26	**19**	3.15	**24**
23	Provision of inputs when required	TM	2.73	**22**	4.69	**1**	3.19	**22**
24	Quality materials	EV	3.30	**1**	4.36	**15**	3.74	**1**
25	Steady work engagement	TM	3.12	**6**	4.56	**7**	3.56	**6**
26	Understanding needs of internal, external customers	TM	3.27	**3**	4.45	**11**	3.63	**3**
27	Component standardization	TM	2.97	**15**	4.60	**4**	3.37	**15**
28	Well-defined team focus	FM	3.24	**4**	4.26	**19**	3.63	**3**
29	Complete designs	EV	3.09	**9**	4.48	**9**	3.49	**9**