The Use of Mobile Technologies in the Monitoring and Control of Projects

Completed Research Paper

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Abstract

The development of projects is fundamental to the daily functioning of any organization. However, many projects do not always have the expected results. Amongst the factors that influence the performance of projects is their effective and efficient monitoring and control. The aim of this paper is to investigate the way in which the use of mobile technologies in the processes of project monitoring and control affects project performance. The results obtained indicate a positive relation between the use of mobile technologies in monitoring and control of projects and project performance, particularly in terms of working within the planned schedule.

Keywords

Mobile Technologies, Monitoring and Control of Projects, Project Performance

Introduction

In order to reach their goals, organizations allocate resources for the implementation of projects. However, many companies are dissatisfied with projects results (Ika, Diallo, and Thuillier, 2012). For instance, on 10,000 information technology projects carried worldwide out in 2010, only 37% were completed successfully (Gale, 2011).

Many organizations have intensively used information and communication technologies to improve the results of projects, with a growing use of mobile technologies. It constitutes 'enterprise mobility', which involves the use of mobile/wireless technologies in various processes and projects within organizations (Saccol, and Reinhard, 2006, Sorensen, 2011).

Given the importance of the success of projects and the growing use of mobile technologies in organizations, this research proposes the following question:

How does the use of mobile technologies in the process of monitoring and control of projects affect project performance?

The relationship between mobile technologies and project management performance has not often been the subject of academic studies. Amongst the studies found on this subject, five of them (Lee, Kang, and Kim, 2006; Lee, and Bernold, 2008; Lee, and Park, 2008, Kim et. al., 2011; Ika, Diallo, and Thuillier, 2012) discuss the use of mobile technologies for improving performance in project implementation processes. Just two (Chan, and Chung, 2002; Hampe et al., 2012) are related to project management, focusing more specifically on defining mobile systems for managing activities.

It is therefore important to deepen our understanding of the elements linked to the mobility of project managers and to project performance, to fill the theoretical and practical gaps concerning how the use of mobile technologies influences project performance. The article is structured as follows: the next two sections review the literature on project management and on enterprise mobility. The subsequent section will present the conceptual model and the research hypotheses. Then the method of research will be detailed, followed by an analysis of the results and conclusions.

Project Management

Project management is the application of knowledge, skills, techniques and tools in order to achieve outlined aims. It is organized into five groups: initiating, planning, executing, monitoring/controlling, and closing (PMI, 2008).

Implementation of activities outlined by a project involves the use of a set of resources, which might be human, monetary, temporal, material and structural (Webster, and Knutson, 2004). These resources are not necessarily all found in the same place, and the implementation of activities, including those of the project manager can take place in various places (PMI, 2008).

This research focuses on the processes that take place in the *monitoring and control* of projects, because activities involved in this phase may require greater mobility of project managers. The aim of monitoring and control of projects is to guarantee that the execution of activities takes place as outlined in the planning. In addition to this, it identifies potential needs for change and promote necessary changes. The main processes included in the monitoring and control of projects are (PMI, 2008):

1. Monitoring and controlling project work
2. Carry out integrated control of changes
3. Verify scope
4. Control scope
5. Controlling the project schedule
6. Controlling costs
7. Carrying out quality control
8. Performance reporting

Control of a project is set of factors that influence performance (Lauras, Marques, and Gourc, 2010). Project performance includes three variables: time, cost and scope. Time refers to keeping to the schedule of the project, and delivering the resulting product within the agreed schedule. In relation to cost, performance is based on the spending that was necessary for carrying out the project. If the real cost is equal to the planned cost, performance is positive. Finally, scope is related to the characteristics of the product. If it possesses all the elements outlined in the project planning stage, performance is adequate (Yeton et. al., 2000).

Enterprise Mobility

Yuan et al. (2010) shows that the mobility of work is related to the frequency with which the worker carries out his/her activities outside of his/her fixed workplace. In this context, time and location are fundamental. With this in mind, in order to observe mobile activities, three aspects need to be considered; worker mobility (percentage of time spent outside of fixed workplace), dependence on location (dynamic information obtained according to the place) and criticality of time (flexibility and urgency of activities being performed).

This research will adopt the definition of enterprise mobility as the use of mobile technologies in carrying out organizational processes, both in terms of operation and in terms of project management. Mobile technologies can support the mobility of project managers.

Enterprise mobility can generate benefits such as increased computerization of processes, improved access to information, increased efficiency of activities and flexibility in the work routine. Mobile technologies use can also facilitate the spread of information and interaction between workers (Scornavacca, and Barnes, 2008). Other benefits include immediate access to resources regardless of location, reduction of costs, reduction of errors in gathering and communicating information and an increase in productivity (Basole and Rouse, 2006). On the other hand, the use of mobile technologies can also entail also negative consequences, such as information overload. In addition, respect for limits between personal and professional life can be overlooked, reducing the privacy and quality of life of workers (Saccol, and Reinhard, 2006).

Conceptual Model and Research Hypotheses

The literature suggests that the use of mobile technologies enables workers to carry out activities without restrictions of time and place, allowing them to be more productive (Kalakota and Robinson, 2002). In this study, we explore how project managers use mobile technologies in order to help them to improve project performance, focusing on the process of monitoring and control of projects.

Yuan et al. (2010) evaluated the adjustment of mobile technologies to the activities of a mobile worker, suggesting that the degree of use of this technology is influenced by mobility, regarded as the portion of time in which the employee carries out his/her activities outside of the fixed workplace. Therefore, the first research hypothesis is:

H1: the degree of mobility of the project manager increases his/her use of mobile technologies.

Dependence on location, which addresses the need to have access to resources (human or otherwise) that are located in different places, also can influences the use of mobile technologies (Yuan et al., 2010). Therefore, the second research hypothesis is:

H2: the degree of dependence on location increases the use of mobile technologies by project managers.

Another aspect discussed by Yuan et al. (2010) is the criticality of time, which evaluates the need for the worker to carry out activities away from his/her workplace. Based on this, the third research hypothesis is:

H3: the degree of criticality of time increases the use of mobile technologies by project managers.

The fourth research hypothesis is:

H4: the use of mobile technologies contributes positively to the effectiveness (efficiency and efficacy) of processes of monitoring and control of the project.

The monitoring and control of project activities aids the management of variables that influence project performance, such as time, cost, quality and risks (Lauras, Marques, and Gourc, 2010). Based on these statements, the final research hypothesis is:

H5: the use of mobile technologies in processes of monitoring and control of projects positively influences project performance.

Project performance is multidimensional, and many different factors influence it (Shenhar et al., 2001). However, since it is an exploratory study, and the control of all the project performance antecedents is a very complex endeavor, we chose to focus on the influence of mobile technology use related specifically with the processes of monitoring and control of projects, since we have as an assumption that this phase is the one that implies a greater mobility of project managers. The Figure 1 presents the conceptual model.

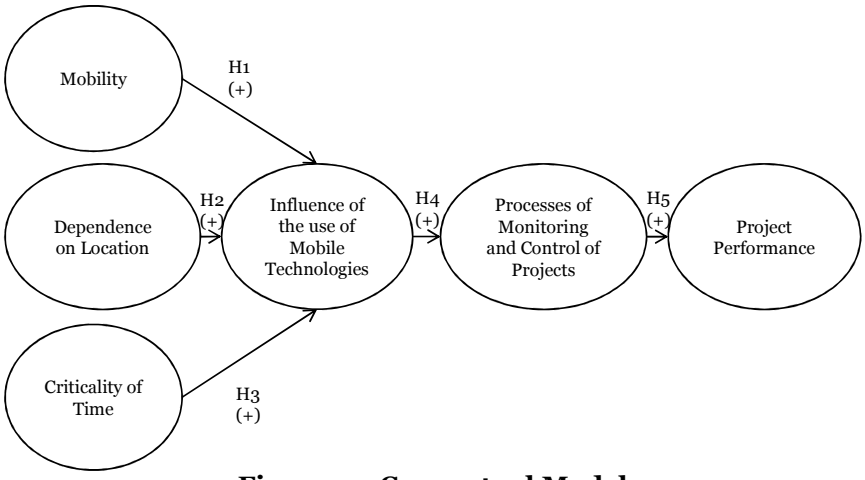

Figure 1 – Conceptual Model

Method

After a literature review, an exploratory research was carried out via interviews with five project managers. The completed literature review and the exploratory study made it possible to develop the conceptual model and the research hypotheses. The definition of constructs and their respective units of measurement is in Appendix A.

The research used a convenience sample (accessibility to participants) and a 'snowball sampling' method with members of the Brazilian branches of the Project Management Institute (PMI), and with members of discussion groups of project management professionals in the Internet.

Data collection occurred through an online questionnaire available from October 2012 to January 2013. A total of 223 project managers responded to the survey, representing a return of 2.23%.

The first step in analyzing the results focused on using SPSS v. 20 to check the missing values, which according to Kline (1998), cannot go beyond 10%. The initial research sample was made up of 223 respondents, though 41 of them registered a number of absent answers above 10%, being excluded from the research database. Next, the presence of outliers was examined (Hair, 2005). The measure of Mahalanobis distance was used. As a result, no respondents were withdrawn from the base. After having purified the base, the non-probabilistic sample of this study is made up of 192 Brazilian project managers.

The statistical technique selected for analyzing the data is the Partial Least Squares model (PLS) as it has formative units of measurement, it is not a large sample, and the research hypotheses are not strongly based in theory (Chin, 2010; Yuan et al., 2010). In agreement with Chin (2010) for the correct use of the PLS technique, statistical procedures should be used to firstly guarantee the validity of information, and secondly to evaluate the relationships between the elements of the structural model. Reliability and validity analyses were performed (Chin, 2010). Furthermore, an analysis of discriminant validity was also carried out. These analyses are presented in the next section.

Data Analysis

The research sample is mainly formed of male project managers (81.25%) aged between 30 and 39 (48.96%), with up to five years of experience (51.04%), with a post-graduate degree (73.96%) educated in the area of computer science (34.90%) and with a specialization in project management (67.71%). Concerning the projects that were evaluated, the sample of the study is in large part characterized by IT projects and software development (38.02%), with a team composed of up to 9 people (43.23%) and a duration of between 6 and 12 months (39.58%).

Firstly we present the results of the validity and reliability tests of the research tool, and subsequently the results of the evaluation of the conceptual model and research hypotheses.

In relation to the reflexive constructs of the conceptual research model, which were: Mobility of project managers, Dependence on location, Criticality of time, Mobile technologies (software applications), Monitoring/control of project (M/C projects) and Performance (of projects), the analysis observed the values of factor loadings which should preferably be higher than 0.7, but which are also acceptable as of 0.6. Checking of the Average Variance Extracted (AVE), for which the ideal value is above 0.5, the combined consistence, which is accepted with values above 0.7, and Cronbach's Alpha with a lower limit of 0.7 (Hair, 2005), can be added to this test.

In the domain of the formative constructs, the construct of Mobile technologies (devices), the values used in reflexive constructs are not applicable. The weight of the items (not factor loadings, which should be greater than 1,960 for a significance of p-value less than 0.05 (Jarvis et al., 2003), should be observed. Furthermore, the formative constructs should be evaluated with the tolerance values, that should be near to 1, and the Variance Inflation Factor (VIF) which should be less than 3.3 (Diamantopoulos and Siguaw, 2006).

During the evaluation of structural elements that was carried out using values of reliability, validity and extracted variance, the need to adjust the units of measurement of the constructs of mobility and criticality of time became clear. In addition, the construct of dependence on location did not present satisfactory results, and was eliminated. After making these alterations, the conceptual model presented statistical validity.

On the first analysis of discriminant validity, a correlation between the constructs (excluding the construct of mobile technologies (applications), as this is formative) was observed.

This process is based on the AVE, which is compared between the constructs. It is desirable for the AVE of the construct to be greater than the correlation with the other constructs (Chin, 2010). The correlations between the constructs examined, are, in all cases less than the AVE of the construct in question. The AVE of the constructs are greater than the minimum limit of 0.5.

Concerning the discriminant validity between the constructs, Table 1 presents the squared correlation between them. The squared correlation between all the constructs is less than the squared correlation of the construct itself.

Constructs	Criticality of Time	Performance (of projects)	M/C Projects	Mobility (of Project manager)	Mobile Technologies use (applications)
Criticality of Time	**0,871**				
Project Performance	-0,033	**0,546**			
M/C Projects	0,210	0,160	**0,770**		
Mobility	0,074	0,031	0,256	**0,572**	
Mobile Technologies-(applications)	0,039	0,079	0,656	0,227	**0,704**

Table 1 – Squared Correlation between Constructs

The next step in analyzing discriminant validity is the evaluation of the relation of units of measurement between constructs. It is hoped that the standardized factor loading is greater than 0.6 in the construct itself, and that the factor loadings of the same indicator should be less in the other latent variables. Again, the construct of Mobile technologies (devices) use is not included in the analysis, as it possesses a formative characteristic. Table 2 presents the results calculated for the units of measurement in each construct.

Units of Measurement	Criticality of Time	Performance (of projects)	M/C Projects	Mobility (of Project manager)	Mobile Technologies Use (applications)
Dont_Begin_Fast	**0,917**	-0,007	0,183	0,091	-0,001
Dont_Finish_Fast	**0,949**	-0,050	0,207	0,052	0,067
Performance_Cost	-0,090	**0,632**	0,067	-0,059	-0,015
Performance_Team	-0,034	**0,736**	0,108	0,006	0,066
Performance_General	0,019	**0,838**	0,092	0,043	0,027
Performance_Time	-0,031	**0,793**	0,192	0,042	0,123
Performance_Scope	0,023	**0,657**	0,044	0,082	-0,007
Performance_Stakeholders	-0,020	**0,755**	0,092	0,016	0,038
MobTech_Management_ Acquisitions	0,234	0,096	**0,818**	0,163	0,410
MobTech _Controlling_Schedule	0,142	0,148	**0,907**	0,240	0,614
MobTech _ Controlling_Costs	0,198	0,161	**0,890**	0,253	0,569
MobTech _ Controlling_Scope	0,181	0,144	**0,913**	0,218	0,596
MobTech _ Controlling_Changes	0,183	0,185	**0,900**	0,217	0,540
MobTech _ Controlling_Quality	0,149	0,125	**0,864**	0,221	0,496
MobTech _ Controlling_Risks	0,191	0,186	**0,901**	0,219	0,536
MobTech _Monitoring_Work	0,191	0,099	**0,829**	0,242	0,682
MobTech _Reporting_Perfomance	0,200	0,120	**0,870**	0,226	0,650
Time_Inside_City	0,075	0,020	0,237	**0,744**	0,117
Time_Outside_City	0,046	0,036	0,220	**0,861**	0,249
Time_Outside_Country	0,061	-0,008	0,028	**0,649**	0,088
Mobile_Text_Editors	0,052	0,117	0,533	0,144	**0,850**
Mobile_Eletronic_Spreadsheets	0,025	0,105	0,555	0,096	**0,817**
Mobile_applicaticons_sharing	0,048	-0,014	0,520	0,132	**0,844**
Mobile_Communication_Systems	0,003	0,068	0,575	0,304	**0,847**
Mobile_Business_Systems	0,042	0,053	0,561	0,249	**0,836**

Table 2 – Discriminant Validity between Units of Measurement

The results demonstrate that the units of measurement have a greater standardized factor loading in the constructs to which they are related (values in bold). For the other constructs the standardized factor loadings are smaller.

After carrying out this set of analyses, it can be stated that the structural model is appropriate for testing the relation between the constructs that it is made up of.

The first analysis of results relating to the structural model is centered on the values obtained from R squared (R^2) for the constructs. Figure 2 presents the model (without the construct of criticality of time, which presented inappropriate statistical values) with its respective R^2, represented inside the circles. This diagram also demonstrates the paths between the constructs, which represent the precedence of the structural model. For each path, that is designated by an arrow, the respective coefficients are displayed and the final one, with the significance between brackets.

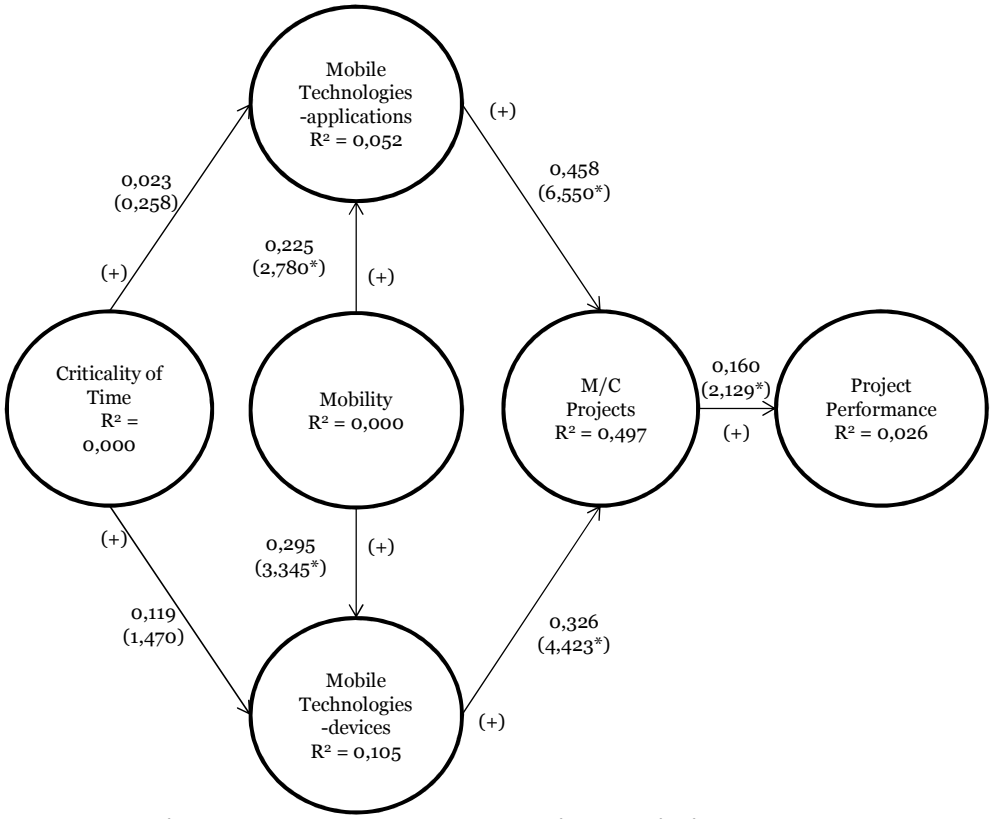

Figure 2 – Structural Model with Statistical Results

As can be seen, the R^2 of the Mobile technologies (devices) use, that is preceded by latent variables of Mobility of project manager and Criticality of Time, is of 0.105, which in agreement with Cohen (1977), adopted as a rule for this study, is considered low. Also, in relation to the Mobile technologies (applications) use, the R^2 value presents a result of 0.052, defined as low. Following this, in terms of the Monitoring and Control of projects construct (M/C Project), the calculated R^2 is 0.497, classified as medium. Finally, aware of the latent variable Performance (of projects), an R^2 of 0.026 was identified, which is considered statistically low.

In analyzing the coefficients of the paths and their significances, it can be observed that only the construct Criticality of time presents a statistically insignificant result (for $p > 0.05$), with values of the significances of the paths with Mobile technologies (applications) use of 0.258 and with Mobile technologies (devices) use of 1.470, both lower than 1.960 (limit of analysis).

For the other paths, the values obtained are statistically significant (for $p < 0.05$). The significance of 3.345 was obtained by the path between the Mobility of project manager and the Mobile technologies (devices) use. The other path between the Mobility of project manager and the Mobile technologies (applications) use has a significance of 2.780. Moving the focus to the M/C Projects construct and its

predecessor latent variables, it can be seen that the path with Mobile technologies (devices) use presents a significance of 4.423 and that the path with Mobile technologies (applications) use has a significance of 6.550. Finally, the relation between the constructs M/C Projects and Performance (of projects) has as path with a significance of 2.129.

The results obtained in the analysis of the structural model presented low values for the R^2 of the constructs, with the exception of M/C Projects at 0.497, considered medium. In other words, the structural model proposed explains a low percentage of variation of the evaluated constructs. Analyzing other studies related to adopting information technologies and the consequences of this, and also given the low R^2 values (Chellappa, and Saraf, 2010; Santos et al., 2012), the complexity of the latent variables makes it difficult to define all the influencing factors. In this situation, the constructs of the structural model that present low (R^2) indexes can be understood, in particular the Project performance construct, as the other elements, in addition to the processes of monitoring and control, which influence project performance. With this in mind, for example, the PMI (2008) suggests other groups of processes such as planning, which certainly influence project performance. Therefore, the low R^2 is understandable as it derives from the analysis of just the monitoring and control processes of the project.

After analyzing the structural model and the additional analyses, there was an evaluation of the research hypotheses based on the results obtained from the statistical procedures carried out with the structural model that was considered valid.

The first verified research hypothesis is the positive relation between the degree of Mobility of project manager and the use of mobile technologies. The validation of the hypothesis is based on the coefficient of the path between the constructs of Mobility of project manager and the constructs of Mobile technologies (devices) use and Mobile technologies (applications) use, and the statistical significance of these coefficients. The relationship between Mobility of project manager and Mobile technologies (devices) use has a coefficient of 0.295, which is statistically significant, as a T Statistic value of 3.345 (for $p < 0/05$) was registered. The path between Mobility of project manager and Mobile technologies (applications) use showed a coefficient of 0.225, which is also statistically significant (T Statistic = 2.780). Thus, the results support H1.

The next research hypothesis was the positive relation between Dependence on location and the use of mobile technologies. The Dependence on location construct presented low factor loadings for its units of measurement. The AVE indicators, combined reliability and Cronbach's Alpha also presented unsatisfactory results. Thus, the construct was eliminated and H2 cannot be properly tested.

The next tested research hypothesis is the positive relation between the Criticality of time and the use of mobile technologies. The validation of this hypothesis is based on the coefficient of the path between the constructs of Criticality of time, Mobile technologies (devices) use and the construct Mobile technologies (applications) use, and the statistical significance of these coefficients. The relation between Criticality of time and Mobile technologies (devices) use has a coefficient of 0.119, which is not statistically significant as it presented a T Value statistic of 1.470 (below the lower limit of 1.96 for $p < 0.05$). The path between Criticality of time and mobile technologies (applications) use presented the coefficient of 0.023, which is also not statistically significant (T Statistic = 0.258). As a result, H3 is not supported.

The next tested research hypothesis is the positive relation between the use of mobile technologies and effectiveness (efficiency and efficacy) in the processes of monitoring and control of a project. The validation of this hypothesis is based on the coefficient of the path between the constructs of Mobile technologies (devices) use, Mobile technologies (applications) use and Processes of monitoring and control of projects (M/C of projects), and the statistical significant of these coefficients. The relationship between Mobile technologies (devices) use and M/C of projects has a coefficient of 0.326 which is statistically significant, as it presented a T Statistic value of 4.423 (above the lower limit of 1.96 for $p < 0.05$). The path between Mobile technologies (applications) use and M/C of projects presented a coefficient of 0.458, which is also statistically significant (T Statistic = 6.550). With this in mind, it is considered that hypothesis H4 is supported.

The final research hypothesis was the influence between the processes of monitoring and control of projects and project performance. The validation of this hypothesis is based on the coefficient of the path between the constructs ¨M/C of projects¨ and "Project Performance". The coefficient is 0.160, which is

statistically significant, as it presented a T Statistic value of 2.129 (above the lower limit of 1.96 for p > 0.05). Therefore, hypothesis H5 was supported.

The figure 3 presents the conceptual model after the statistics tests.

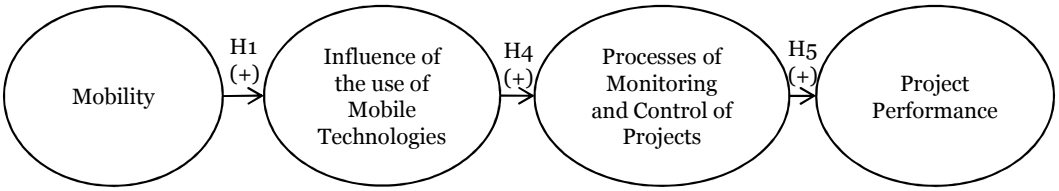

Figure 3 – Resulting Conceptual Model

Conclusion

The aim of this study was to analyze the influence of the use of mobile technologies on processes of monitoring and control of projects and its impact on project performance. The hypothesis that relates the degree of mobility of projects managers to the degree of use of mobile technologies was supported. Also upheld were the hypotheses addressing the use of mobile technologies in processes of monitoring and control of projects and its relation with project performance, suggesting a contribution of mobile technologies use to activities related to controlling project time/schedule. However, the hypotheses suggesting the influence of criticality of time and dependence of location on the degree of use of mobile technologies by project managers were not supported.

In summary, the general analysis of the research results suggests that there is a positive relation between the use of mobile technologies in processes of monitoring and control of projects and project performance.

The conclusion of the research allows some theoretical observations to be made. The results demonstrate, even if only initially, the relation between the use of mobile technologies and project performance, paving the way for new studies to be carried out with the aim of broadening our knowledge of the subject and testing relations in other contexts. In terms of practical contributions, this study makes it possible to suggest the use of mobile technologies to improve project performance with specific characteristics. The project managers who use mobile technologies with greater frequency for carrying out processes of monitoring and control can be able to obtain better results in terms of project performance, particularly in the question of time/schedule.

For future research, we suggest improving the measurement of the degree of mobility of project managers, inclusion of other groups of processes related to project management, the evaluation of project performance through secondary data (not exclusively through the perception of managers) and, finally to include project managers from other countries. Since our work was exploratory, we have not controlled all the project performance antecedents in our conceptual model, which is a limitation that also needs to be addressed in future research.

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APPENDIX A – QUESTIONNAIRE ITEMS*

*We did not included here the profile questions due to the lack of space

Degree of Mobility of the Respondent

The following questions are to assess your degree of mobility in executing work. Use the scales to respond to each question.

Scale: 1-none 2-a little 3-average 4-a lot 5-a very large part 0-n/a

*What **portion of your work time** takes places in the following locations?*
In your fixed work office
In other areas near to your fixed office (such as in the same building)
In other locations in the same city
In locations outside of your city
In other locations outside of your country

Scale: 1-totally disagree 2-disagree 3-sometimes agree/sometimes disagree 4-agree 5-totally agree 0- n/a

There is a negative impact on how well you perform your work if you:
don't begin tasks within the schedule
don't finish tasks within the schedule
don't begin tasks as soon as is possible
don't finish tasks as soon as is possible

Scale: 1-no dependency 2-low dependency 3-moderate dependency 4-high dependency 5-total dependency 0-n/a

*To what extent the good performance of your work **depend on the information available** when you are…?*
at your place of work
at someone else's physical location (e.g. project team or stakeholders)
at the physical location of a piece of equipment of information system/application related to the project
at the physical location of a document related to the project

Mobile Technologies used in Monitoring and Control of Project

Scale: 1-Never 2-rarely 3-sometimes 4-frequently 5-always 0-n/a

*Specify the **degree of your personal use of mobile technologies in processes of monitoring and control of projects.***
Cellphone
Smartphone
Tablet

Notebook used outside of fixed place of work
Communication systems/applications accessed by mobile devices.
Business systems/applications accessed by mobile devices
Systems/applications for sharing data or documents accessible by mobile devices
Text editors accessible by mobile devices
Electronic Spreadsheets accessible by mobile devices
Others

Scale: 1-never 2-rarely 3-sometimes 4-frequently 5-always 0-n/a

*Based on **the project you managed most recently**, indicate below your use of mobile technologies (as described in the previous question) in processes of monitoring and control.*
Use of Mobile Technologies for monitoring and controlling work on the project
Use in carrying out integrated control of changes
Use in verifying and controlling scope
Use in controlling schedule
Use in controlling costs
Use in carrying out quality control
Use in reporting on performance
Use in monitoring and controlling risks
Use in administering acquisitions

Project Performance

Scale: 1-totally disagree 2-disagree 3-sometimes agree/sometimes disagree 4-agree 5-totally agree 0-n/a

*Based on the **most recent project that you managed, and that has already been completed**, respond to the following statements:*
The client's requirements were met
The project was completed within the planned schedule
The project was finished according to the estimated cost
The stakeholders were satisfied with the results of the project
The work team was satisfied once the work had been completed
Project performance was, in general, satisfactory