

Appliances' New Product Development: Exploring the Influence of Fuzzy Front End Phase on Time to Market

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Abstract

The purpose of this study was to identify the main uncertainties involved in the fuzzy front end phase of a new product development and to determine the weight of factors that define the time to market a product. The focus of this study has emerged from the need to explain the complexity of the fuzzy front end of a project and to understand and establish a treatment for the variables involved. Although literature covers the existence of difficulties in managing the fuzzy front end of projects, there is no reference to the identification of those variables and to the determination of their influence on the time to market. The interest in the fuzzy front end is justified due to the doubts that occur at that point of the development process of a new product. The fuzzy front end mentioned by some authors covers project management difficulties that occur at the very beginning of a project due to the lack of more precise data and to the possibility that the project team may face unknown situations and tasks. This paper proposes the use of systemic modeling tools in the fuzzy front end of a new product and the use of linear regression and variance analysis to determine the time to market. A study to be used as the database has been carried out with a home appliance company.

Index terms— time to market; conceptual design; new product development; fuzzy front end.

he search for differentiated products and for better cost has accelerated the reduction of product life in the market, made people rethink product design and create platforms and strategies. That context creates a new challenge to companies, that is, to get competitive advantage generated by earlier launching of new products to the market. In this strategy, companies need to reduce the number of direct competitors and to avoid price erosion, traditional in a competitive market. Having that differentiation and using it by making products available to the market before competitors do is the strategically objective of most of the companies inserted in this context. Earlier availability of a product to the market may increase the profitability of a company due to the extension of its sales life, and also to the qualification of their product development (NPD) area to launch products within the timing required by the market. Fast development of a product leads to superior performance according to empirical studies (Mascitelli, 2006); (Bascle et al, 2012); (Shankar et al., 2013).

Time to market (TtM) expresses the speed a company moves from the concept of a product to initial market sales. The time to market (TtM) is defined as the total development time of a new product. It is obtained by adding the concept generation time (T_{cet}) to the conversion time (drawings/prototypes/tests) and to the execution time (moulds and tools execution) (Whirlpool, 2012). To Mascitelli (2006), in the past, the TtM was less important than innovation and the cost of new products. However, in the last decade, speed and efficiency have been considered to be at the same level of priority as price and cost. Actually, today, many companies clearly know the difference in the total profit generated by being the first to launch a product. Although many companies use the fast follower strategy for a product already launched in the market, one should observe that an excellent TtM usually offers profitability gains for having a differentiated product before their competitors. Given the above scenario, and looking for that strategic advantage, there is a concern that the development lead

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44 time of a new product may be affected in its initial concept generation phase due to the uncertainties experienced
45 by the project team regarding the new product. One of the well known factors about the development process of
46 a product is that the degree of uncertainty in the beginning of the process is very high, decreasing with time (see
47 figure 1). However, most of the constructive solutions are chosen at the beginning. Decisions among alternatives
48 at the beginning of the development cycle are responsible for 85% of the end product cost. Modification costs
49 increase along the development cycle as every change may invalidate a greater number of decisions already made
50 (Rozenfeld et al, 2006).

51 This work uses the new product development model called C2C to demonstrate the uncertainty level along
52 the stagedgates (Whirlpool, 2012). The figure 1 shows the project phases and the uncertainty level associated.
53 The conceptualization phase is the momentum of the project that the uncertainties are in the highest level. This
54 is the phase that the project team is selecting the concept for a new product. Also picture 1 show the tollgates:
55 IST or Idea Selection tollgate when theT Global Journal of Researches in Engineering XIII Issue v v v V Version
56 I

57 Concept Evaluation tollgate when the final concept of the new product is defined and locked, BET or Business
58 Evaluation tollgate when the investments are approved for tooling execution and finally LCT or Launching
59 Tollgate when the product is approved to produce and commercialize.

60 Figure 1 : Uncertainty level along the project phases Smith and Reinertsen (1997) calls fuzzy front end the
61 initial development phase or the new product concept generation phase, mentioning the lack of attention of
62 managers to that initial phase as it does not have the traditional management control, that is, neither time scale
63 nor established goals. Therefore, it is not possible to detect whether actions are deviating from the plan in the
64 fuzzy front end. Also, the lack of controlling mechanisms is aggravated by the fact that most managers only pay
65 partial attention to that phase. As managers are more involved with finances, they tend to ignore that phase
66 as it seems to have a fuzzy financial impact. In view of what has been exposed, the present paper proposes to
67 identify the main uncertainties within the fuzzy front end, and to determine the weight of factors that define the
68 product concept generation time during the fuzzy front end and the time to market, that is, which variables shall
69 be early identified to avoid delays to the concept generation time (T_{cet}) and to the time to market (T_{tM}).

70 The article is divided into five sections. The second section, which follows this introduction, is devoted to a
71 literature review on T_{tM} . The third section describes the proposed model. This section begins by addressing the
72 conceptualization of a new product as the focus of this study. A research within the NPD of a home appliance
73 industry is made to identify the main critical factors (uncertainties) in the fuzzy front end phase. The critical
74 factors identified help to create the theoretical construct. This section ends with the presentation of the proposed
75 model. In the fourth section, a case study is made inside the same NPD with two purposes: to validate the
76 critical factors identified in the previous research and to understand the influence of the uncertainties on the
77 T_{tM} of the projects developed in these NPD. Also empiric data are analyzed through the use of linear regression
78 to probabilistically determine concept generation times (T_{cet}) and the time tomarket (T_{tM}). The fifth section
79 of the study shows the results, limitations and implications.

80 Some authors (Montoya-Weiss and Tatikonda, 2001, Eisenhardt and Tabrizi, 1995; Song and Montoya -Weiss,
81 2001, Kerzner, 2003) reported in their study, concerns with excessive changes during the development of a product
82 as well as the impact of new developments in technology and marketing and its effect on the design of a new
83 product. Crawford (1994) highlighted that imperceptible costs may be generated due to acceleration in NPD to
84 ensure rapid development. These costs include errors resulting from unfulfilled milestones, risks related to non-
85 dominated technology and marketing uncertainties on the designing of the product to be developed on account
86 of the pressure regarding speed in development. Datar et al. (1996) reports that the excess of information
87 on consumers may create confusion and subsequent duplication of effort by the project team that may cause
88 impairment of T_{tM} . Cooper and Kleinschmidt (1995) Brown and Eisenhardt (1995) the main factors affecting
89 the performance of the PDP are: the project team, the project leader, the role of the managers and the involvement
90 of suppliers and customers during project execution. In the research made about which approach is given by
91 product development reference models to the fuzzy front end of a new project showed that the main decisions and
92 commitments are made in the initial stage, when the concept of a new product is generated. Future corrections
93 to a decision made may imply in launching delays due to reprocesses.

94 The identification of the variables of research starts by examining the product development process as shown
95 in Figure 2. . For this study we will be considering only the design or conception stage for the formulation of
96 the forecasting model. The conversion and execution phases of this study will be considered as dependent on
97 the design phase and predictabilities. That is, it is understood that the expected results for these two phases
98 depend more on the excellence of its execution and standardization of procedures. This is on the principle that
99 the critical factors are inherent in the early stages of conception, since this is the stage where there is a greater
100 lack of accurate information for the project team, therefore this phase becomes critical for defining T_{tM} . Since
101 T_{tM} (ideal or standard) = $st1 + st2 + st3$, but taking into account the actual time we can write the equation
102 as follows:

103 Each ? has its own characteristics depending on the activity to be performed within the project phases within
104 the NPD. As mentioned earlier in this chapter only the variations inherent in the design phase or $t1$ will be
105 considered in this study. It is understood that the definition, knowledge and management of critical success
106 factors of the project in the early stages of new product conceptualization will assist the project team in meeting

107 the deadlines. Failure to comply with the schedule or delay in launching a new product is linked to the lack of
108 knowledge of critical success factors.

109 Below some examples of traditional delays and impact on TM described by Smith and Reinertsen (1997), Chen
110 et al. (2012) and Griffin (1997) are cited:

111 ? Delays due to the understanding of the project problem, or level of complexity of the project. In this case
112 the project team does not have the usual experience in developing tasks.

113 ? Delays due to unknown mental processes of generating or creating solution. In this case there is training in
114 order to solve problems related to the activities.

115 ? Delays in decision making, the need to "hit the gavel"

116 for the delivery of results. The latter can be defined in two ways, the first being when the information requested
117 or required for a definition does not reach the project team, and the second when the information arriving to the
118 project team is incomplete or inaccurate.

119 a) Identification of project uncertainties in the fuzzy frontend of home appliance sector

120 As a continuation of this study we propose a complementary study to identify the critical success factors in
121 the new product project performance. This research aims at identifying specific critical factors on the particulars
122 of a given NPD. To better understand the reality existing in a project environment subjected to the pressures
123 of a competitive market, we chose to interview a group of people who work in the NDP of a large multinational
124 company leader in the sector of household appliances in Brazil. The target of the research consists solely of
125 experts and project leaders with extensive experience in new product development. Therefore, in this study, we
126 used intentional sampling, by selecting a group of 15 professionals having a cumulative experience of 10 to 25
127 years on projects. The objective was to identify the main insights of these experts regarding the causes and factors
128 causing delays in the project (for refrigerators, washer machines, free standing ranges, room air conditioners and
129 micro-wave ovens) that are compromising TtM on the last 10 years. This is on the assumption that the public
130 interviewed has enough skill and competence to perform a specific task of the project within the stipulated time,
131 as long as provided with the adequate means for its execution. The questions asked were: ? What does the word
132 "doubt" represent at the beginning of a project?

133 ? What is your view on the complexity involved at the beginning of a project? ? What are the main
134 uncertainties involved at the beginning of a project?

135 ? What affects the speed of development of a project conception?

136 The first part of this research involved collecting data through survey sent over the Internet where we obtained
137 the answers (written). With the answers provided by the project leaders (experts), we synthesized and classified
138 them by clusters with common factors (see figure 3). The definition of the critical success factors of a project in
139 NPD is obtained from the correlation of data from field research conducted with the theoretical framework on
140 TtM.

141 1 b) Theoretical Construct

142 To quantify the impact of the critical success factors of a project on project performance it is important to show the
143 relationship between information, uncertainty and project performance (TtM). Figure ?? shows the theoretical
144 construct proposed to solve the problem showing the relationship between input factors, middle factors (in this
145 case the critical success factors) and output factors. -What will be the final performance of the product and
146 whether it will be approved -Aesthetics developed after the deadline, losing the launch date.

147 2 CLUSTER 2: MARKETING PROFICIENCY

148 -Scope changes in the initial proposal, generate rework and delay in the launch.

149 -Uncertainties cause loss of resources focus and generate rework causing launch delays.

150 -Non availability of information at the right time leads to delays in delivery of tasks and consequent delay in the
151 TtM -How to address the unresolved requirements as well as wide and constant variation on project objectives.

152 -In answers to be provided due to the lack and/or little information.

153 -If the marketing briefing was complete.

154 3 CLUSTER 3: CONCURRENT ENGINEERING

155 -Regarding the commitment of the functional areas in providing the best resources for the project.

156 -If all areas involved in the project are aligned with the end goal.

157 -What will be the team's commitment to the challenges of the project.

158 -Who can we count on for the project (competence and ownership).

159 4 CLUSTER 4: CONSUMER TRANSLATION TO PROD- 160 UCT AND PROCESS SPECIFICATION

161 -How to transform the consumer's desires into product specification -What are the benefits to be delivered to the
162 consumer that reflect a winning product.

163 -How to meet cost and final quality goals for the product.

7 B) RESULTS FOUND

- 164 -What will the product's final performance be and whether it will be approved.
- 165 -Delivery of the project goals without generating overestimation of investments, budgeting etc.
- 166 -How to address unresolved requirements as well as wide and constant variation on project objectives.
- 167 -Regarding the understanding of cost, quality and innovation goals to be made available in the project.

168 5 CLUSTER 5: RESOURCES ALLOCATION

- 169 -Who can we count on for the project (competence and ownership).
- 170 -Lack of resources creates delays.
- 171 -If the investment in the new project will be approved throughout development.
- 172 CLUSTER 6: TECHNICAL SKILLS -How to transform the consumer's desires into product specification.
- 173 -What will the product's final performance be and whether it will be approved.
- 174 -Lack of competence of project team members generates delays in carrying out tasks.
- 175 -Delay in reconciling project demands (marketing, cost, quality and legal requirement) generates delays in the
- 176 TtM. It presents a whole series of steps that should be implemented for the identification and formatting of data.
- 177 This formatting is for the purpose of carrying out the simulation of TtM for a given project. This simulation will
- 178 allow the project group an understanding of the likelihood of this project being launched within the estimated
- 179 TtM.
- 180 Step 1 begins with the formation of the team that will work throughout the process of determining TtM. It is
- 181 desirable

182 6 d) Modeling Tools Employed

183 The linear regression analysis through software JMP/Anova (2011) is used to quantify the impact of each variable
184 on the project development time, and then to obtain a general equation that represents the impact of a set of
185 variables on the total time of product development.

186 To check whether the result of the TtM simulation presented good adherence to the reality of the project
187 environment, the simulation results were confronted with the actual data obtained from the projects already
188 carried out by the researched company. Data and records of 15 projects carried out by the company were
189 collected by means of workshops with project leaders (specialists). A set with the same leaders was also carried
190 out to assess the impact of each variable (uncertainty) on the projects researched. The purpose was to check
191 whether the simulated results were coherent with those found in the records of the finished projects, and to ensure
192 the precision of the models chosen to estimate projects TtM.

193 The field study involved the NPD of the home appliance industry. In this study, a survey was conducted with
194 the senior project leaders. They answered a questionnaire sent via internet with questions about projects already
195 undertaken. The approach applied was to understand the influence of the critical success factors on projects
196 delivered and also to validate the proposed model for new projects. The survey was conducted between February
197 and March 2012. The sampling profile of the NPD is reported in Table ???. To apply the linear regression, a
198 study of the main projects carried out by the researched company, leader in the segment of home appliances, is
199 suggested. This research resulted in a sample of 15 projects already carried out in the four main businesses of the
200 researched company. The seven factors (uncertainties), present in the fuzzy front end of a project, identified by
201 the specialists as those that impact the most the TtM, comprise the group of variables x knowing the uncertainties
202 (x), a workshop with those specialists (project leaders) was carried out to individually attribute the degree of
203 impact of each variable on the product concept generation phase (Tcet) and on the time to market TtM (Y) in
204 each of the projects developed by the team. This paper used a more intuitive approach in the evaluation of the
205 results over more objective variables. The critical factors were deployed through specific questions and where the
206 final averages were obtained.

207 7 b) Results Found

208 The normal probability graph shown in figure 6 identifies the most significant uncertainties after the analysis of
209 variance (ANOVA), that is, the uncertainties that are further away from the diagonal straight line, those that
210 have the greatest significance or impact on Tcet and TtM. This analysis can be confirmed with the Pareto plot
211 represented in figure ??, which shows the effects of factors TDI (impact of product and/or process new technology
212 development time within project), SCM (project scope clearness and maintenance), and FAC (functional areas
213 commitment with project objectives) as being the most influential on Tcet and TtM. It is important to point out
214 that variable LC (leader competence as a manager G experienced in leading projects. The later stages of the model
215 for determining TtM require a proven experience of these professionals for a good reading and interpretation of
216 data. In step 2 the characterization of the project being assessed is performed. The classification should be
217 carried out so that you can identify the particularities of the project in relation to novelty and or the complexity
218 demanded. In step 3 a survey is conducted through a questionnaire (see Appendix 1) administered to a group of
219 experts for the assessment of projects undertaken by the NPD study. The goal of this step is to generate sample
220 data for subsequent simulation. In step 4 is made the simulation using the software JMP/Anova (2011) software
221 to identify the most influent critical factors to achieve TtM. In the step 5 are analyzed the results of simulation

222 and also defined a plan to manage the most influent variables in order to guarantee that the TtM objective will
223 be achieved.

224 that the composition of this team be with professionals of activities) stood out in the product concept generation
225 phase (Tcet) graph. The same factor is not significant for TtM, suggesting that the leader capability at that
226 point of the project is important to manage the project team. The next step in the analysis of the results was
227 to make a regression analysis with the most significant factors only, TDI and SCM, analyzing their residues and
228 generating a model (equation). In the graphs shown in figure 7, the value of Rsquare adj shows that these factors
229 (TDI and SCM) represent 78.21% of the variation found in the data, a value greater than when factor FAC
230 is added (variation = 74.75%). The analysis of variance shows that the probability of such factors to happen
231 at random is of 0.01%. As a result, it becomes clear that the two uncertainties (TDI and SCM) were the most
232 significant to influence Tcet and TtM.

233 8 d) Prevision Model Validation

234 The validation of the model was done for 4 projects that were not involved on the case study. The table ??
235 shows the previewed TtM obtained through the use of the equation (1). The table 2 also shows the real TtM
236 occurred by project. The comparison between previewed TtM and real TtM expresses the accuracy of the model.
237 The score used to simulate TtM comes from an interview conduct with project team members. The project
238 team members attributed scores to TDI and SCM in according with: not satisfactory (1) -little satisfactory (2)
239 -satisfactory with minor restrictions (3) -satisfactory (4) -above expected (5).

240 9 Table 2 : Methodology validation for new projects

241 The case study shows that the evaluated NPD should be concerned with prior identification, development and
242 certification of new technologies to be introduced in their appliances (e.g.: Refrigerators, Washing Machines and
243 Ranges) once the lack of knowhow about those factors in terms of product and/or process has generated delays
244 to the latest launchings. The NPD need to take care about product or process innovation for new products that
245 are not tested and certified before the conceptualization phase in order to avoid delays on TtM. Another finding
246 that caused delays on project launching is regarding the "non-maintenance" of the original proposal of the new
247 product along the project. In other words, the briefing generated by marketing has not been consistent, being
248 changed during the development of the project, leading to process re-loops and launching delays. Although, all
249 uncertainty factors are present within (NPD), the simulation evidences shows greater concern with (TDI) and
250 (SCM) in the projects to come as they have the most impact on the projects launched in the last years. The
251 prevision model was validated with projects that not participated on the case study. The simulation presented
252 results very near with the reality. The comparison between the simulated results with the practical results shows
253 5 to 10% of error. This level of error is quite acceptable with respect to TtM variation. It means that the
254 prevision model is adequate to preview the TtM. The NPD participant in G the sampling followed the boundary
255 conditions or limitations of the model for this evaluation. As boundary conditions for this study we established
256 that NPD assessed should possess: -a project leader appointed at the beginning of the project, managing the team
257 project until the release of the product, -a reference model of product development with staged-gates defined,
258 -the application of simultaneous engineering practices; -NPD maturity on new product development, project team
259 having previous experience of over 5 years -strong technological base.122 Finally the results of this study suggest
260 that the development time performance of new products is linked with complex set of variables and the lack of
261 understanding and management of these variables during the conceptualization of a new product may affect the
262 development time performance of a new product. This research could be extended and expanded in several ways
-for example by studying other models of NPD in companies of Different branches. ^{1 2 3}



Figure 1:

263

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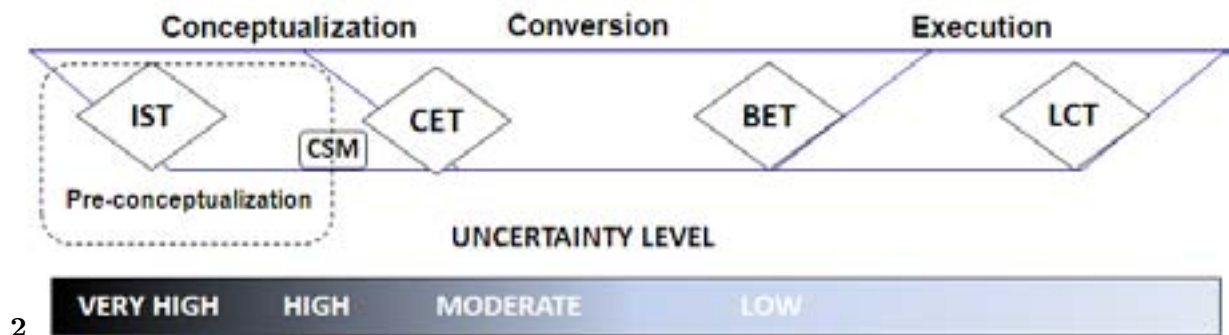


Figure 2: Figure 2 :

$$TtM \text{ real } (TtM + \Delta TtM) = (st1 + \Delta st1) + (st2 + \Delta st2) + (st3 + \Delta st3) \quad (1)$$

Figure 3: ?

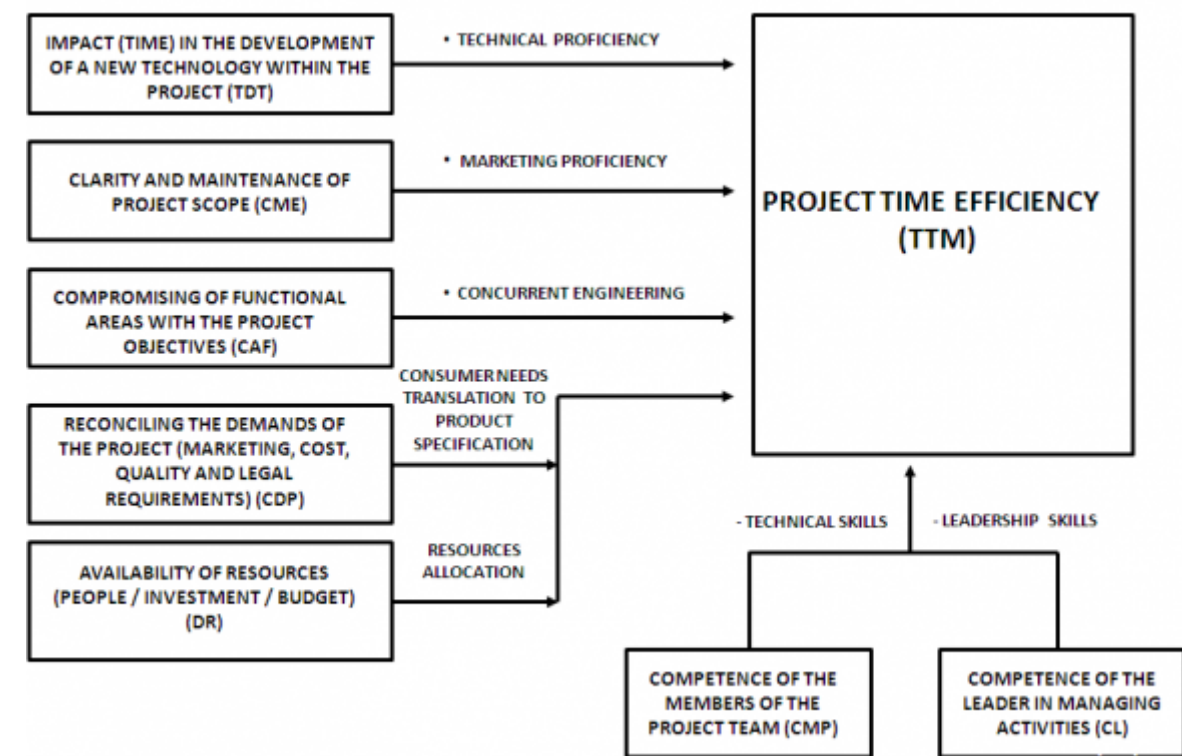


Figure 4: Figure 3 :

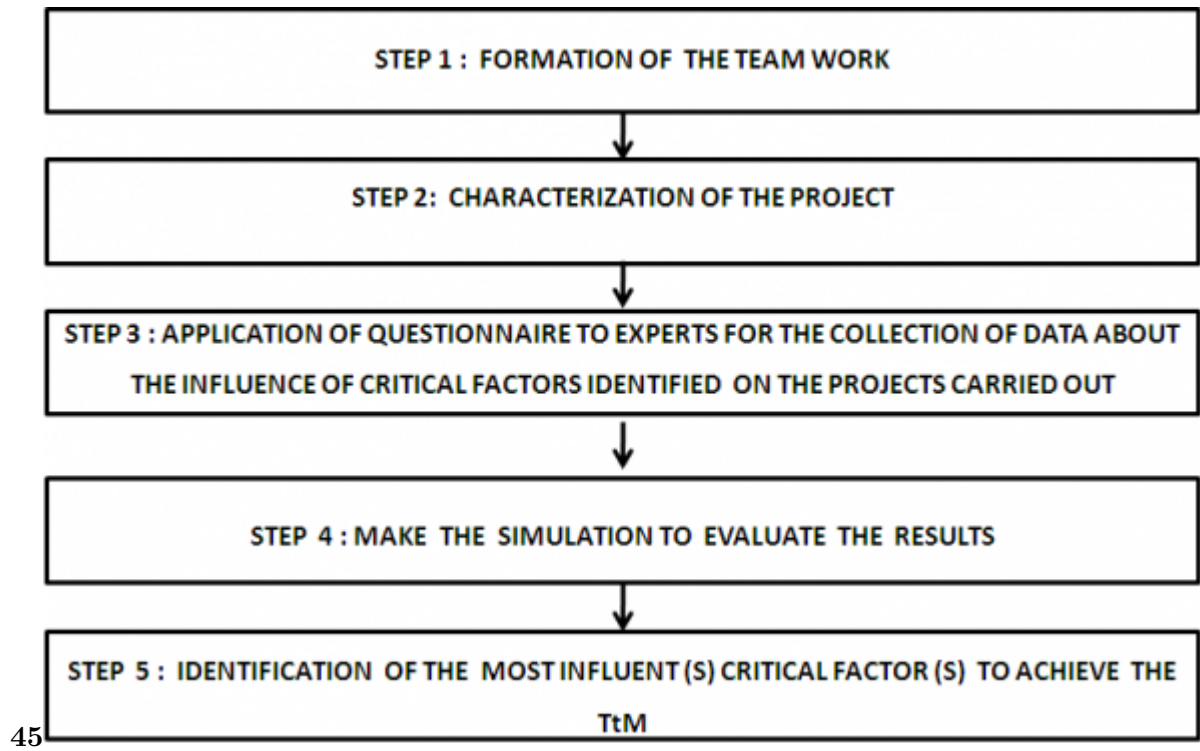


Figure 5: Figure 4 : 5 -

7

COMPANY	COMPANY DESCRIPTION	PROJECTS (SAMPLE) EVALUATED	PROFILE OF EXPERTS
APPLIANCES	IT HAS 4 TECHNOLOGY CENTERS (NPD) IN BRAZIL WHERE REFRIGERATORS / FREEZERS / COOKERS / WASHING MACHINES / AIR CONDITIONERS AND MICROWAVES ARE DEVELOPED	18 MEGA PROJECTS (7 PROJECTS FOR NEW REFRIGERATORS AND FREEZERS, 5 PROJECTS FOR NEW STOVES, 5 PROJECTS FOR NEW WASHING MACHINES, 1 PROJECT FOR AN AIR CONDITIONER, 1 PROJECT FOR A WATER DISPENSER	18 PROJECT LEADERS HAVING 10 TO 25 YEARS OF EXPERIENCE

Figure 6: CLUSTER 7 :

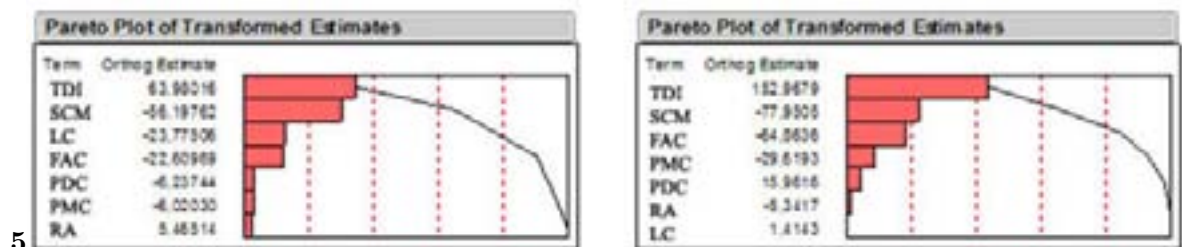


Figure 7: Figure 5 :

9 TABLE 2 : METHODOLOGY VALIDATION FOR NEW PROJECTS

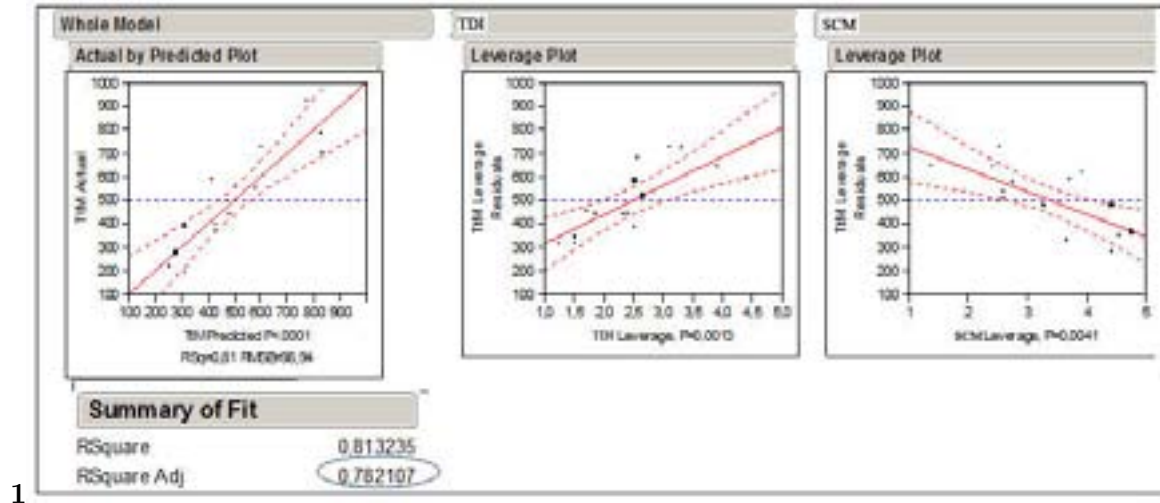


Figure 8: Table 1 :

6

SIMULATION				REAL TBM	
TDI	SCM	Tcct	TtM	Tcct	TtM
1	3	148,34	348,31	128	363 (Project 17)
1	5	27,66	154,99	35	165 (Project 16)
3	3	231,46	595,45	252	630 (Project 19)
5	3	314,58	841,15	350	890 (Project 18)

Figure 9: Figure 6 :

264 Finally, on identifying the factors that have influence on defining TtM we believe that we have contributed to
265 future studies on performance improvement of NPD projects.

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