NEW PRODUCTS PORTFOLIO SELECTION: A TEACHING CASE

Abraham Sin Oih Yu [1]
Av. Prof. Luciano Gualberto, 908
CEP: 05508-900 São Paulo/SP Brasil
Tel.: (11) 37674749
E-mail: abraoyu@ipt.br

Alceu Salles Camargo Júnior [2]
Av Caramuru, 732
CEP: 14030-000 Ribeirão Preto/SP Brasil
Tel.: (16) 39117389
E-mail: alceu@usp.br

Edgard Monforte Merlo [2]
Av Caramuru, 2200
CEP: 14030-000 Ri beirão Preto/RP Brasil
Tel.: (16) 6208824
E-mail: edgardmm@usp.br

[1] Universidade de São Paulo – USP/FEA
Faculdade de Economia, Administração e Contabilidade
Departamento de Administração
CEP: 05508-900 São Paulo/SP Brasil

[2] Universidade de São Paulo – USP
Faculdade de Economia, Administração e Contabilidade de Ribeirão Preto FEA-RB
Departamento de Administração
CEP: 14040-900 Ribeirão Preto/SP Brasil

Abstract:

Competitive forces, technological changes and more segmented demands and dynamics in the globalized markets have imposed revolutions to businesses environment so that the modern organizations face the new product development management nowadays as a essential competence in these markets. The organizations no longer invest in R&D (Research and Development) as an obligation or as a percentage of their revenue, but as a strategic element to gain or to keep at the market. It is with the new products portfolio selection and management that the organization has the opportunity to build or correct technological or market strategies. Portfolio management is a decision process that seeks to select a group of projects of new products that, within a certain scenery, would constitute the best choice for the organization, considering its business strategies or balance towards multiple criteria.

This paper aims at giving a didactic presentation allowing to illustrate the aid that quantitative tools can give to the decision making in the selection of portfolio of new products when the

organization presents multiple strategies such as technological and market ones. The case can be used as support to the learning in disciplines of New Products Development Management Strategy in Administration courses. Didactic applications of Cluster Analysis together with Linear Programming (using the Solver/MS-Excel routine) were implemented to obtain the portfolio of maximum profit but it also considers the balance strategy among the technological segments of the organization. It was initially considered a group of 16 projects of new products, each one with its technological and market potentialities. The work presents the theoretical foundations as well as the necessary instructions to obtain the projects portfolio by using the SPSS and MS-Excel softwares.

Key Words: new product; portfolio selection; market and technological strategies; linear programming; cluster analysis.

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1 INTRODUCTION.

This paper presents a very practical methodology to obtain a new products portfolio so that considers the principal criteria found in the literature on this matter. The objective is to present an application that is interesting through a didactic approach and which can be, eventually, used in disciplines of Management of Innovation in college or graduation courses of administration as illustration to the theory.

Papers such as those developed by Cooper, Edgett and Kleinschmidt (1997, 1998 and 2000), Kruglianskas (1989), Yu and Azevedo(2000), Murphy and Kumar (1997), Clark and Wheelwright (1993) are just a small example of papers that have investigated the most important criteria in the process of selection of projects for the constitution of a portfolio of new products. These papers point out, in a general, the importance for the contemplation of aligned criteria with key strategies of the businesses of the organizations as well as the search of a balance of different types of portfolio projects.

The paper uses, therefore, this theoretical reference to develop a practical application of obtaining a portfolio of projects of new products by using quantitative tools such as the cluster analysis to obtain the requirement of balance of the portfolio in terms of technological segments that the company develops and later, the modeling of a simple problem of linear programming to seek the maximization of profit of the portfolio. With such development, it is supposed to have reached the objective of the work: the one of accomplishing a didactic and very practical presentation of obtaining of a portfolio of projects of new products, as it is proposed in the literature. The paper is structured in four sections. This first one presents the introduction to the object and objective of the study. The second section presents Theoretical Reference with brief bibliographical review on the products innovation management, new products projects selection and portfolio management, linear programming and clusters analysis. The third section presents the development of the obtaining of the new products projects portfolio, the main objective of this paper, and the forth and last section presents the final considerations and suggestions of future work.

2 LITERATURE REVIEW

This section presents a literature review related to this research. It is constituted by four sub-sections. The first one presents a brief discussion on new products and processes R&D, while the second one brings a revision on new products portfolio selection and management. The

third and fourth sub-sections presents brief discussions on linear programming problems and cluster analysis respectively.

2.1 NEW PRODUCTS AND PROCESSES DEVELOPMENT MANAGEMENT

Much changes in the last three decades have been making the organizations go under great revolutions in the lucky internal ambit to face the changes in the businesses environment. Starting from the 70's, the companies had to adapt to the new atmosphere that began to appear. Such atmosphere was not calmer and placid as the one of the beginning of the 20th century. There were a lot of changes in the businesses environment until it became as competitive, dynamic, globalized and extremely demanding as it is now. The amount of models of offered products has increased a lot in the last decades. This was a consequence or diversification of the demand, appearing niches differentiated with needs, desires and different requirements for the products. The companies had to create competences to come up to such businesses environment changes. To Clark & Wheelwright (1993), it no longer regards companies that simply increase the percentile of the revenue reverted to the development process nor of getting scientific progresses with more investments in R&D (Research and Development) but, it regards the process has been oriented to great forces such as the increases in the international competition, in the segmentation and fragmentation of the markets and in the rotation and diversification of new technologies.

Bolwijn and Kumpe(1990) have created a model of phases to explain the relationship between growth and demands diversification and changes in the businesses environment with the cycles of competences creation for the organizations after researching some organizations in Europe. To them, the companies have been developing and accumulating competences throughout the last decades. The companies that survive keep on accumulating all the previous competences. The authors say: "Each new group of competences is an extension of the old ones. The evolution of the market requirements in price, quality and diversified line of products corresponds, respectively, to the efficiency, quality and flexibility competences in the production. Such evolutions should be faced as new market requirements that arise from the previous ones and that contain them". The authors above relate the market requirements with the competences and the performances that the companies had to develop as an answer to their evolutions throughout the time, as presented below in chart 2.1.

Chart 2.1: Evolution of the market requirements and strategies (competences) that the companies had to develop.

	Requirements of Market	Strategies
1960	Price	Efficiency
1970	Price, Quality	Efficiency + Quality
1980	Price, Quality, Line of Products	Efficiency + Qual.+Flexibil.
1990	Price, Quality in the Line of Products, Innovations	Efficiency +Qual+Flex+ Inovation

Source: Bolwijn and Kumpe, (1990).

This is one of the reasons why the innovation process or new products development in the organizations presents a high degree of importance as well as complexity. Nowadays, to think and to manage for the innovation is the vital point of survival of the companies in dynamic and demanding settings, since it presupposes the incorporation of all the previous competences, according to the authors above.

Nowadays, the organization should present competences to manage the new product development process to fulfill all the requirements of dynamic settings, from quickly launching at the market a product of high quality at low costs as well as diversifying it to the point of presenting a portfolio of derived products (additional improvements) while it also develops a new product platform (radical innovation), within a relatively short period of time, closing, thus, an entire development cycle. The management of the products innovations process involves a complex range of decisions. It is during the process that decisions about functional characteristics and quality of the products should be made. Besides, decisions should be made towards how the product will reach the consumers, that is to say, the logistic issues and distribution channels in addition to the production cost issue that is closely related to the decisions of the manufacture, choice of processes, materials, suppliers etc.

2.2 NEW PRODUCTS PORTFOLIO SELECTION AND MANAGEMENT

The new products portfolio selection is one of the most complex themes for the organizations, being the target of a lot of researches and investigations. McDonough III and Spital (2003) draw the attention to the difference between the new products portfolio selection and management processes.

> "It is important to distinguish between project portfolio selection and what we are calling project portfolio management. Although the distinction is somewhat arbitrary, project portfolio selections primarily concerned with the processes used by firms to include projects in the portfolio. Work that has focused on mathematically-

> based optimization models that seek to maximize profits subject to a set of resource constraints, and more recently the work of Cooper, Edgett and Kleinschimdt, and Graves, Ringuest and Case, fall into this camp." MCDONOUGH III e SPITAL (2003, p. 40).

Effective R&D centers should present not only investments in laboratories and researches but also a group of qualified and geared professionals with the technology and organization marketing strategies to generate ideas continually. Thus, at this moment, in order to decide which projects to develop, there are more ideas than resources (labor, capital, equipments, laboratories etc). In this sense, the selection of the portfolio of projects is one of great importance, because it is the process that will choose the projects in detriments of others. KRUGLIANSKAS (1989, p. 37). Besides the arduous task of selecting the projects, it is to be done in a way to reduce the risk, that is to say, to develop more projects that, in the future, will become unfeasible through the technical approach or not profitable and to discard projects that could bring great benefits to the organization.

The process is quite dynamic. According to Kruglianskas (1989): "Brandenberg (1966), based on empiric research about evaluation of practices and selection of projects in quite differentiated companies, it is concluded that the process is quite interactive, involving additions and intermittent exclusions in the portfolio of the projects in execution, through re-directing, re-programming and incorporating of new suggestions of projects in its list".

The process of ideas generating cannot be completely disentailed from a certain strategy. According to Murphy and Kumar (1997): "With the objective of establishing credibility, the idea should be tuned with the course of the strategy that the management established for the company. 'The Management establishes the strategic direction of the company and then, it draws a course for the innovations' (Prahalad and Hamel, 1990)."

Good part of the main problems that the new products development managers often find is caused by considering each project in separate. Thus, problems of internal gaps (allocated resources) and external (position of the company, dynamic atmosphere etc) to the company often appear. Clark and Wheelwright (1993) point: "As a consequence, individualized projects reduce the potential of implementation of technological and market strategies so as to capture market position; they demand more resources besides making organizational alterations easier".

Clark and Wheelwright (1993) have developed an structural model for the development strategy where the managers have the possibility "to limit the scope of the individual projects

and, therefore, to facilitate the refinement and obtain improvements in the processes of project management".

Such approach treats the management of innovation as a process that should be considered with an wide view of the technologies strategies and market positioning must be related with the goals and objectives of the firm. Still, there must be a group view of all the development projects, that is to say, the projects portfolio management and its consequences to the aggregated plan that supports it. The model is known as the "process development funnel" that still foresees the learning feedback as another element of great importance for the process. The figure 2.1 below presents the funnel model.

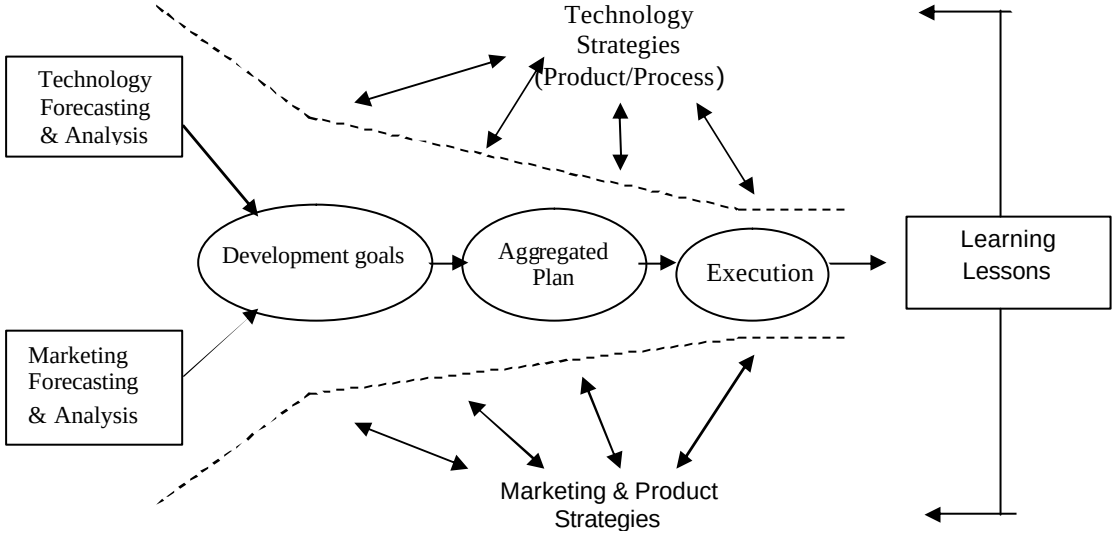


Figure 2.1: New product development management model guided to the technology and market organization strategies, proposed by Clark and Wheelwright (1993).

Source: Clark and Wheelwright (1993).

According Clark and Wheelwright (1993), the organizations should have a much defined strategy in relation to the technology performance: "For a lot of companies, there is a great number of important areas of technological know-how but they should choose those few ones where they will create superior competences indeed. Technological competences can be developed internally through investments in people, equipments and processes or through the development of a certain product through an advanced project. But the technology can also be acquired out of the company through the sponsorship of researches in universities, joint-ventures, license purchase. Managing internal and external sources of technologies is not mutually excluding. In fact, the true dimension of the technological strategy is exactly the management of such mix of internal and external sources of technologies".

Yu and Azevedo (2000) reported that, based on their experiences with the management of technological projects together with DEES/IPT (Economy and Systems Engineering Division), the innovation projects could be classified in three great groups or phases, considering two of them of great importance for this theoretical reference:

- Group 1 would be constituted by projects that are already very advanced, being enough deepening and analysis of the technical and economical viability, as in a front-end.
- Group 2 of projects is still in a much more initial phase. Basically, it would be pre-conceived ideas or opportunities which were noticed that they need first studies capable to raise alternatives or feasible solutions to perform them, so that more deepened studies can be made.

Yu and Azevedo (2000) draw, therefore, the attention so that the problems of investment on technology assessment would be characterized basically by two dimensions: the number of generated and assessed alternatives and the depth or the detailing that each alternative is evaluated. For the authors, group two problems are shown in a first instant where the company knows that it has found an opportunity or a business and has to be made real through feasible alternatives. At this time there are a lot of alternatives; however some ones are presented as unfeasible before previous analyses. In a second moment, there is the need of deepening and more detailed viability analysis of the few alternatives that remained. YU AND AZEVEDO (2000, P. 115).

Cooper, Edgett and Kleinschimdt (1997) have found, in their study on new products portfolio management together with 35 top organizations from several industrial sectors around the world, three great objective groups for the portfolios selection in these companies. One of them presents the search for the maximization of value, where the allocation of resources considers the profitability maximization, market share or other strategic result. Still, the portfolio balance also represented as another objective, where the companies have sought to balance the portfolio with long and short term projects or then to balance it in relation to the technology types, different markets, high and low risk level projects, among other characteristics. Alignment with the strategy of the company was also found as an objective for the process of portfolio selection, where the projects should reflect the global strategy of the organization. Thus, investments be it in several markets, areas or technologies, they should always be aligned with the business strategy of the organization.

> "What becomes clear is the potential for conflict between these three high-level goals. For example, the portfolio that yields the greatest NPV or IRR may not be a balanced one (it might contain a majority of short-term, low risk projects,

> or be overly focused on one market). Similarly, a portfolio that is primarily strategic may sacrifice other goals (such as short-term profitability)".
>
> COOPER, EDGETT e KLEINSCHIMDT (1997, p. 19).

Kruglianskas (1989) researched, among 51 big brazilian companies, to identify the employed criteria for the new products projects selection. The sample had been classified under several aspects as national or foreign capital, as high or low emphasis to the activities of R&D, being questioned on the procedure of projects selection. The author found significant difference when it compared the procedures of portfolio selection. Companies with emphasis in activities of R&D tend to privilege the character criteria more related to the business strategy while the low emphasis ones, just consider more tactical aspects, such as those related to the technical or commercial success.

Cooper, Edgett and Kleinschimdt (1998) developed a research with 205 companies in cooperation with IRI (Industrial Research Institute) along with the one found by Kruglianskas (1989). Cooper, Edgett and Kleinschimdt (1998) questioned the types of methods or techniques that they have used in procedures of portfolio selection. The most frequent result was related to financial aspect, where usually is calculated aspects like VPL, TIR, ROI or payback period. Another technique group quite found are those that seek to gain punctuations or scoring for each project so as to order them. Check-List techniques, where the projects are assessed with yes/no type of answers for some characteristics and, still, graphic techniques as the bubble diagrams or portfolio maps. Techniques that privilege the businesses strategy of the organization were also found, where the investments are made in a way to privilege different market types or technology according to strategic determinations.

The authors above also found a lot of similar results to those obtained in the research of Kruglianskas (1989). Cooper, Edgett and Kleinschimdt (1998) made an ordination in their sample in relation to the performance with the new product projects and they discovered that the companies that represent the 20% top leading use more aligned techniques with the businesses strategies for new product portfolio selection in detriment of the financial techniques or scoring simple criterion. These latter ones are techniques used in larger degree by the low performance companies.

3 A PROPOSED METHODOLOGY TO OBTAIN A NEW PRODUCTS BALANCED PORTFOLIO

This is the section that presents the practical and didactic methodology to obtain a new products balanced portfolio. The main aspects of the proposed methodology are discussed.

3.1 INTRODUCTION AND PRESENTATION OF THE PROBLEM

Theoretical Reference about new product portfolio selection presented in section 2.2 above have brought some interesting results with relationship to the deciding process for the products innovation projects selection. Authors as Kruglianskas (1989) and Cooper, Edgett and Kleinschmidt (1998) have showed results pointing the alignment with the businesses strategy as being the main criterion used in the process of new products projects selection by high performance companies or with greater emphasis in activities of R&D.

The alignment with the businesses strategy guarantees that projects are not only chosen based on short term criteria from which she would not be extracting all the results or contributions that the same ones could generate for the organization in a long term.

> For instance, having decided the business's strategy, money is allocated across different types of projects and into different envelops or buckets… The dimensions of these buckets vary greatly by business, but the most popular splits or buckets, according to the study, are by:
>
> - Market;
> - Development Type (maintenance, exploratory, frontier research, line extensions, and so on);
> - Product line;
> - Project magnitude (major or minor);
> - Technology area;
> - Technology platform types;
> - Area of strategic thrust;
> - Competitive need.
>
> Cooper, Edgett e Kleinschimdt (1998, p. 27).

Another important aspect, in the researched literature, is the one of balance that should exist in the portfolio, as pointed by Cooper, Edgett and Kleinschimdt (1997): "Market, products and technologies provide another set of dimensions across which managers sought balance. The question face is: Do you have the appropriate split in R&D spending across your various product lines? Or across the markets or market segmentation in which you operate? Or across the Technologies you possess?".

Thus, this paper seeks to present a relatively simple methodology of obtaining of a new products portfolio considering the main three criteria simultaneously for the selection of the projects found in the literature: the search for maximization result, though considering a balance in the portfolio and alignment with some key strategy of the organization. So, we adapted and extended an example found in Martino (1995). The problem could be enunciated as the search for a portfolio among 16 new products projects, each one with its need of allocation of resources and predictions of financial results (profit) besides the types of technologies that would be using, among the 29 developed or available technologies for the organization. Such technologies, somehow, are complemented when it relates to the execution of new products projects.

The problem could be presented, then, as maximizing the total profit of the portfolio, though seeking a balance in the portfolio due to a commitment imposed by the executives and shareholders would be contemplated by the two projects, of each great technology group that the company develops, due to a strategic choice, for instance, that the company wants to continue researching and developing products in all the 29 technological bases.

Thus, the work presents a practical application of obtaining of a portfolio using a technique of clusters formation for the obtaining of groups of projects with similar technologies, to fall back on the linear programming afterwards in order to find the portfolio that maximizes the profit, respecting the restrictions that all the groups of technologies would be contemplated besides the one regarding the aggregated plan, that is to say, the availability of resources. We began with the development of a modeling of linear programming for the obtaining of a portfolio of maximum profit without the restriction of the balance among the groups of technologies that were contemplated. For this, the SPSS software was used to obtain technology clusters and MS-Excel Solver routine for the resolution of the problem of linear programming. In the sequence, the comments and necessary procedures are presented for the obtaining of the portfolios.

The table 3.1 below presents the 16 projects of development of new products that the company, supposedly, considers as viable for future perspectives. For each one of the 16 projects, the development costs, profit possibility, necessary computer consumption hours and laboratories tests hours are also presented.

Table 3.1: Development Costs ($ 1.000), profits possibilities (1.000.000), necessary computer consumption hours and laboratories tests hours of each one of 16 new products projects considered.

	PROJECTS	COST ($1000)	MARKET SHARE %	PROFIT MARKET $ MILLION	PROFIT POSSIBILITY $ MILL.	TESTS HOURS	COMPUT. HOURS
1	DIGITAL SIGNAL PROCESSOR	48	11	430	47,3	60	29
2	DIGITAL IMAGE PROCESSOR	38	12	340	40,8	189	48
3	VOICE SINTETIZER	40	10	180	18	105	51
4	COMPUTER CHIP	43	13	290	37,7	174	23
5	SOLAR CELULAR PHONE	35	28	1220	341,6	191	20
6	DIG-ANALOG. CONVERSOR	25	28	1340	375,2	55	51
7	ANALOG.-DIG CONVERSOR	26	20	610	122	196	47
8	FREQUENCY CONVERSOR	41	15	1010	151,5	120	34
9	PHASE ANTENNA	53	10	810	81	208	51
10	FREQUENCY RADIO MIXER	81	12	560	67,2	59	33
11	SIGNAL CONVERSOR	97	10	710	71	224	28
12	HIGH VELOCITY CIRCUIT	51	13	1180	153,4	82	40
13	ELECTRIC CONVERSOR	89	16	460	73,6	66	52
14	HIGH ENERGY BATTERY	78	16	180	28,8	176	24
15	ADVANCED ALGORITHM	97	23	270	62,1	109	28
16	OPTIC MATERIALS FOR SOLAR CELLS	90	21	430	90,3	235	50

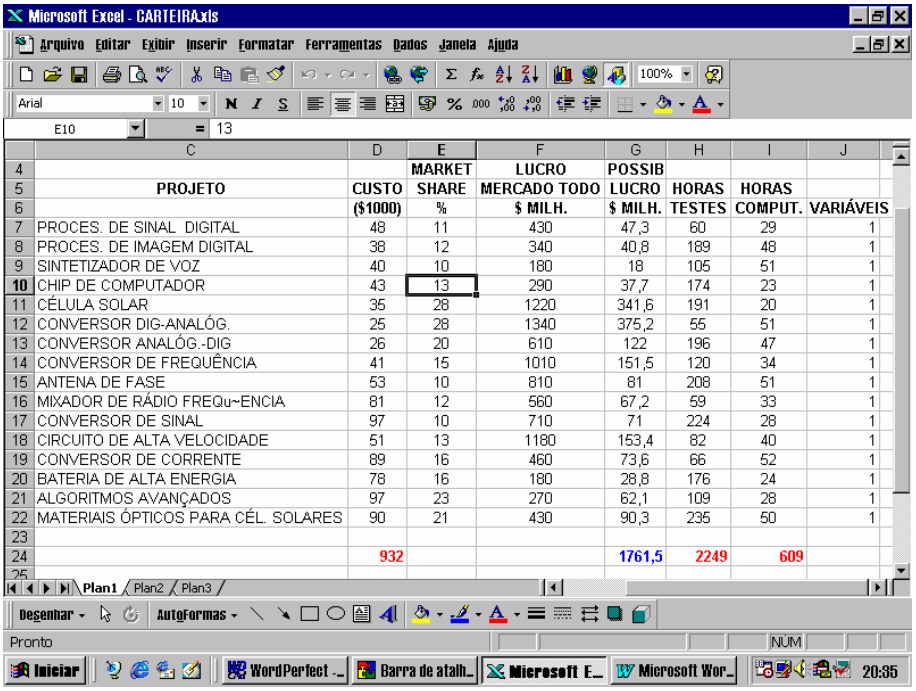
Fonte: Martino (1995).

3.2 OBTAINING THE MAXIMUM PROFIT PORTFOLIO

Imagine that the aggregated plan for the R&D resources of the company presented a certain availability of resources that will be disputed by these 16 projects. Thus, such availabilities are the restrictions for the problem of profit maximization that will be solved with the help of lineal programming, in the sequence. The restrictions are:

- $500 thousand to be invested in the development;
- 1300 hours to be used in laboratories for tests and
- 390 hours for the use of computers.

For the obtaining of the maximum profit portfolio, we can use the MS-Excel Solver routine, using a quite spread designation problem in lineal programming. Thus, the modeling variables are of the dichotomous type (0,1) that indicate, respectively, veto or acceptance to any project. Figure 3.1 below presents the Solver spreadsheet with the disposition of the problem data and with the decision variables (initially inserted as 1) in the column J.



	C	D	E	F	G	H	I	J
4			MARKET	LUCRO	POSSIB			
5	PROJETO	CUSTO	SHARE	MERCADO TODO	LUCRO	HORAS	HORAS	
6		($1000)	%	$ MILH.	$ MILH.	TESTES	COMPUT.	VARIÁVEIS
7	PROCES. DE SINAL DIGITAL	48	11	430	47,3	60	29	1
8	PROCES. DE IMAGEM DIGITAL	38	12	340	40,8	189	48	1
9	SINTETIZADOR DE VOZ	40	10	180	18	105	51	1
10	CHIP DE COMPUTADOR	43	13	290	37,7	174	23	1
11	CÉLULA SOLAR	35	28	1220	341,6	191	20	1
12	CONVERSOR DIG-ANALÓG.	25	28	1340	375,2	55	51	1
13	CONVERSOR ANALÓG.-DIG	26	20	610	122	196	47	1
14	CONVERSOR DE FREQUÊNCIA	41	15	1010	151,5	120	34	1
15	ANTENA DE FASE	53	10	810	81	208	51	1
16	MIXADOR DE RÁDIO FREQu~ENCIA	81	12	560	67,2	59	33	1
17	CONVERSOR DE SINAL	97	10	710	71	224	28	1
18	CIRCUITO DE ALTA VELOCIDADE	51	13	1180	153,4	82	40	1
19	CONVERSOR DE CORRENTE	89	16	460	73,6	66	52	1
20	BATERIA DE ALTA ENERGIA	78	16	180	28,8	176	24	1
21	ALGORITMOS AVANÇADOS	97	23	270	62,1	109	28	1
22	MATERIAIS ÓPTICOS PARA CÉL. SOLARES	90	21	430	90,3	235	50	1
23								
24		932			1761,5	2249	609	

Figure 3.1: MS-Excel Spreadsheet with the data disposition.

For the modeling to capture the designation possibility (veto or acceptance) of each one of the 16 projects, it is necessary that the totals (initials) for the development cost ($932) of the profit (1761.5) of hours spent with computers (2249) and with laboratory tests (609), in line 24, respectively in the columns D H and I, consider the dichotomous variables in column J, according to Figure 3.1 above. For this, such totals should be the result, each one, of the product of the respective value for each variable in column J. In a next step, we should open the Solver routine in the menu Tools and indicate the maximization of the cell of profit destiny G24, with

the cells (J7:J22) as being the variable cells. The restrictions are 4: the cost (500), the two of time (1330 for computers and 390 for tests) and that the variable cells (of designation or choice) have to be of the "binary" type. Figure 3.2 below displays the open window of the solver at this time, ready to receive the order of "solve".

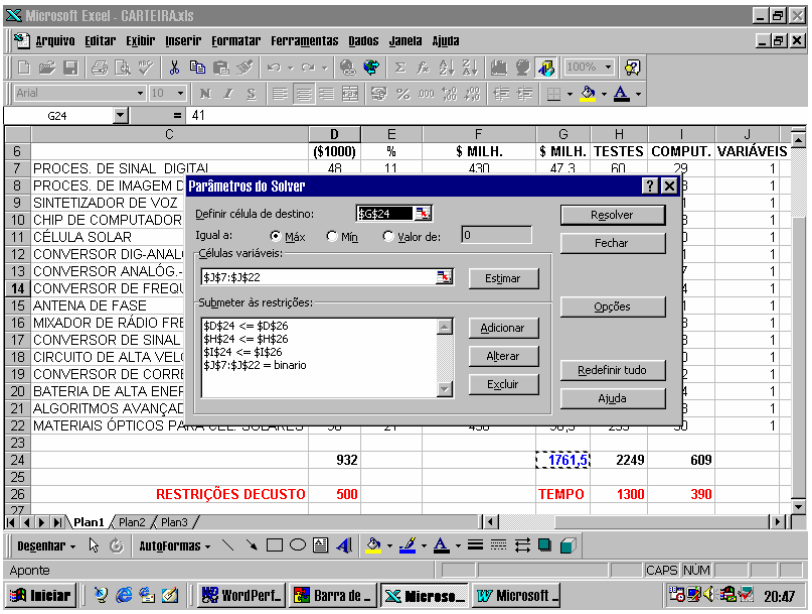
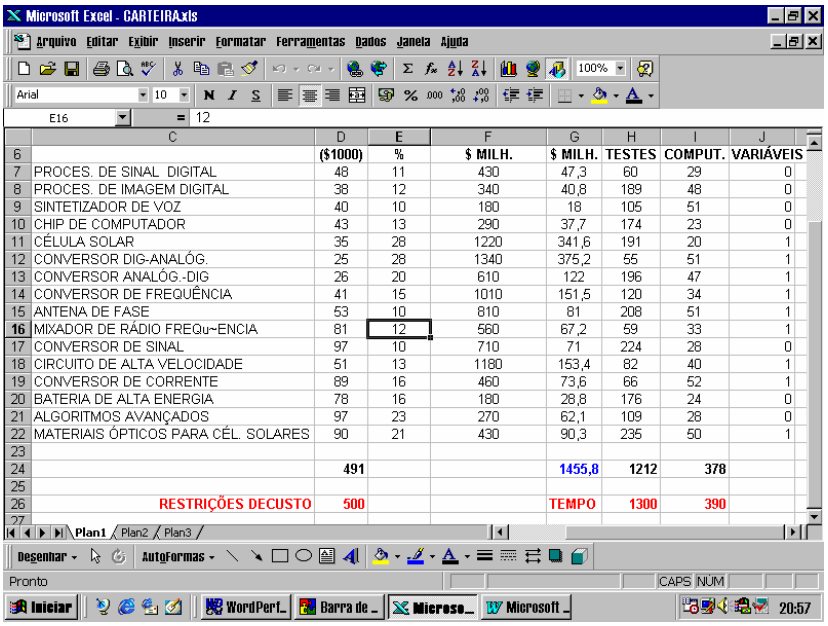


Figure 3.2: Spreadsheet with the routine Solver window complete.

Having inserted all the necessary information to solve the problem, we can order it to "Solve" it so that the MS-Excel starts to seek the solution that will maximize the profit. We cannot forget that the solution will come out in column J, that is to say, the solution will be the group of binary variables that point out the projects that should be chosen (1), and also the rejected ones (0). the solution is presented below in Figure 3.3.



	C	D	E	F	G	H	I	J
6		($1000)	%	$ MILH.	$ MILH.	TESTES	COMPUT.	VARIÁVEIS
7	PROCES. DE SINAL DIGITAL	48	11	430	47,3	60	29	0
8	PROCES. DE IMAGEM DIGITAL	38	12	340	40,8	189	48	0
9	SINTETIZADOR DE VOZ	40	10	180	18	105	51	0
10	CHIP DE COMPUTADOR	43	13	290	37,7	174	23	0
11	CÉLULA SOLAR	35	28	1220	341,6	191	20	1
12	CONVERSOR DIG-ANALÓG.	25	28	1340	375,2	55	51	1
13	CONVERSOR ANALÓG.-DIG	26	20	610	122	196	47	1
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17	CONVERSOR DE SINAL	97	10	710	71	224	28	0
18	CIRCUITO DE ALTA VELOCIDADE	51	13	1180	153,4	82	40	1
19	CONVERSOR DE CORRENTE	89	16	460	73,6	66	52	1
20	BATERIA DE ALTA ENERGIA	78	16	180	28,8	176	24	0
21	ALGORITMOS AVANÇADOS	97	23	270	62,1	109	28	0
22	MATERIAIS ÓPTICOS PARA CÉL. SOLARES	90	21	430	90,3	235	50	1
23								
24		491			1455,8	1212	378	
25								
26	RESTRIÇÕES DECUSTO	500			TEMPO	1300	390	

Figure 3.3: Spreadsheet with the profit maximization results.

As presented above in Figure 3.3, we can notice that the great portfolio would be constituted of the projects number: 5, 6, 7, 8, 9, 10, 12, 13 and 16. Such portfolio is the one that it maximizes the profit of the company (in the value of $1,455.8 million), according to Figure 3.3 above. We can also conclude that the cost and time restrictions were satisfied.

3.3 OBTAINING TECHNOLOGICAL SEGMENTATION FOR THE 16 NEW PRODUCTS PROJECTS

We seek to establish, in this sub-section, a segmentation of the 16 projects for common technological platforms, among the 29 ones that the company is has been developing in the last few years. The objective is to know how the projects are allocated in each great technological segment (or technological "bucket", using the term of Cooper, Edgett and Kleinschimdt (1998, p. 27)), to impose that at least two projects, of each technological segment, can be contemplated in the final portfolio of the company, that will be obtained in the next section 3.4. The idea is to obtain groups of technologies that, somehow, are complemented in the execution and development of a new product.

Table 3.2 below present the technological constitution, that is to say, the group of technologies (among 29) that would be necessary in the development of each one of the 16 projects. Such presentation is made with dichotomous variables (0.1), being 1 to demonstrate that a given project would be using a certain technology in its development.

Table 3.2: Information about the 29 developed technologies to be considered to the portfolio selection problem.

Projects	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**T11**	**T12**	**T13**	**T14**	**T15**	**T16**	**T17**	**T18**	**T19**	**T20**	**T21**	**T22**	**T23**	**T24**	**T25**	**T26**	**T27**	**T28**	**T29**
DIGITAL SIGNAL PROCESSOR	1	0	1	0	0	0	1	1	1	1	1	1	1	1	0	1	0	1	0	0	1	1	1	1	1	1	1	1	1
DIGITAL IMAGE PROCESSOR	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	1
VOICE SINTETIZER	1	0	0	0	0	0	1	0	0	1	1	1	1	1	0	0	0	1	0	0	0	1	0	1	1	1	0	0	0
COMPUTER CHIP	0	1	1	1	1	1	1	0	0	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SOLAR CELULAR PHONE	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
DIG-ANALOG. CONVERSOR	0	0	1	0	0	1	1	1	0	1	1	1	1	1	0	1	1	1	1	0	0	0	0	1	1	1	1	1	1
ANALOG.-DIG CONVERSOR	1	0	1	0	0	1	1	1	0	1	1	1	1	1	0	1	1	1	1	0	0	0	0	1	1	1	1	1	1
FREQUENCY CONVERSOR	1	0	1	0	0	0	1	0	1	1	1	1	1	1	0	0	0	1	1	0	1	1	0	1	1	1	0	0	0
PHASE ANTENNA	1	0	1	0	0	0	0	0	0	1	1	0	0	0	1	0	0	1	1	0	0	0	0	1	1	1	0	0	0
FREQUENCY RADIO MIXER	1	0	1	0	0	0	1	0	1	1	1	1	1	1	1	0	0	1	1	0	1	1	0	1	1	1	0	0	0
SIGNAL CONVERSOR	1	0	1	0	0	0	1	0	1	1	1	1	1	1	1	0	0	1	1	0	1	1	0	1	1	1	0	0	0

HIGH VELOCITY CIRCUIT	0	0	0	0	1	0	1	0	1	1	1	1	1	1	0	0	1	1	0	0	0	1	0	1	1	1	0	0	0
ELECTRIC CONVERSOR	1	1	1	0	0	0	1	0	0	1	1	0	0	1	0	0	1	1	1	1	1	0	0	1	0	1	0	0	0
HIGH ENERGY BATTERY	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	1	1	0	0	0	1	0	1	0	0	0
ADVANCED ALGORITHM	0	1	0	0	0	0	1	0	0	1	1	1	1	1	0	0	0	1	0	0	1	1	0	1	1	1	0	0	0
OPTIC MATERIALS FOR SOLAR CELLS	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	1	0	0	0	1	0	1	0	0	0	0	0

Fonte: Martino (1995).

Thus, we can enter with this matrix of data in a multivariate statistics software (like SPSS used here) to obtain a technological segmentation through the use of a clusters analysis. Figure 3.4 below presents the open window of hierarchical cluster in SPSS. The 29 technologies are the variables. We asked, for instance, that the segmentation to be made with 2 or 6 groups at the most.

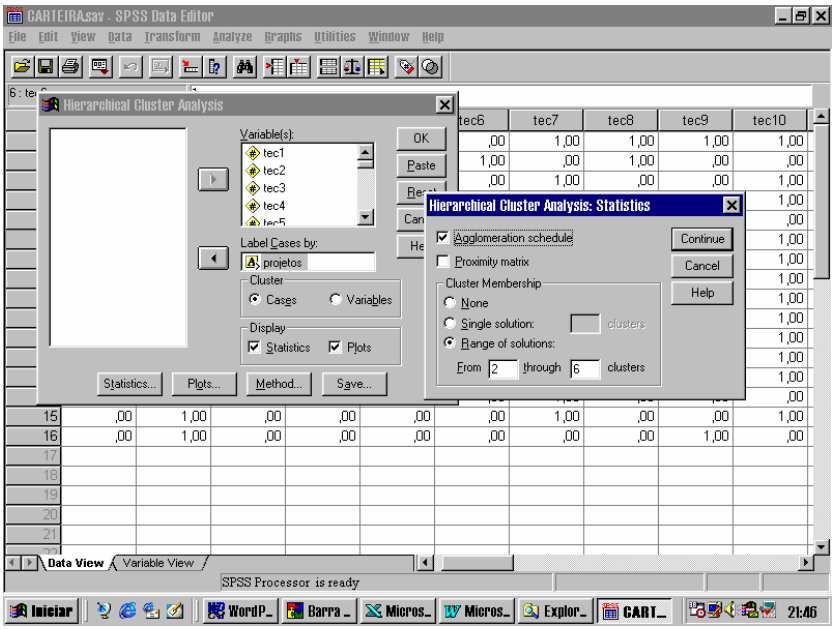

Figure 3.4: Hierarchical cluster analysis on SPSS window.

In the sequence, Figure 3.5 displays the window of the method for the formation of the hierarchical cluster in the moment of the choice of the centroid and Jaccard methods for the variable of binary type.

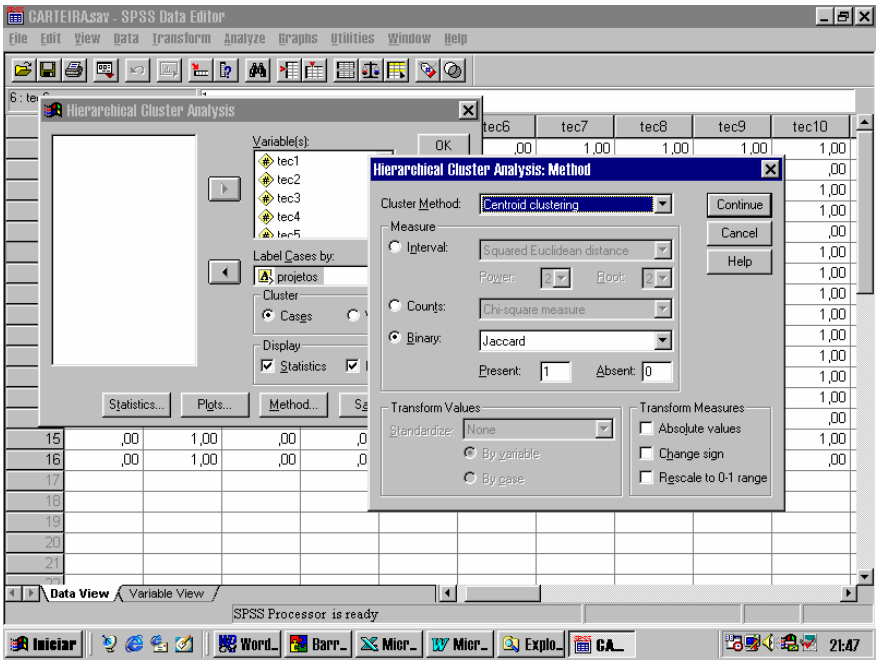

Figure 3.5: Window with the methods for the hierarchical cluster.

Figure 3.6 below presents the results through the dendrogram, while, in the sequence, Table 3.1 presents the constitution of clusters.

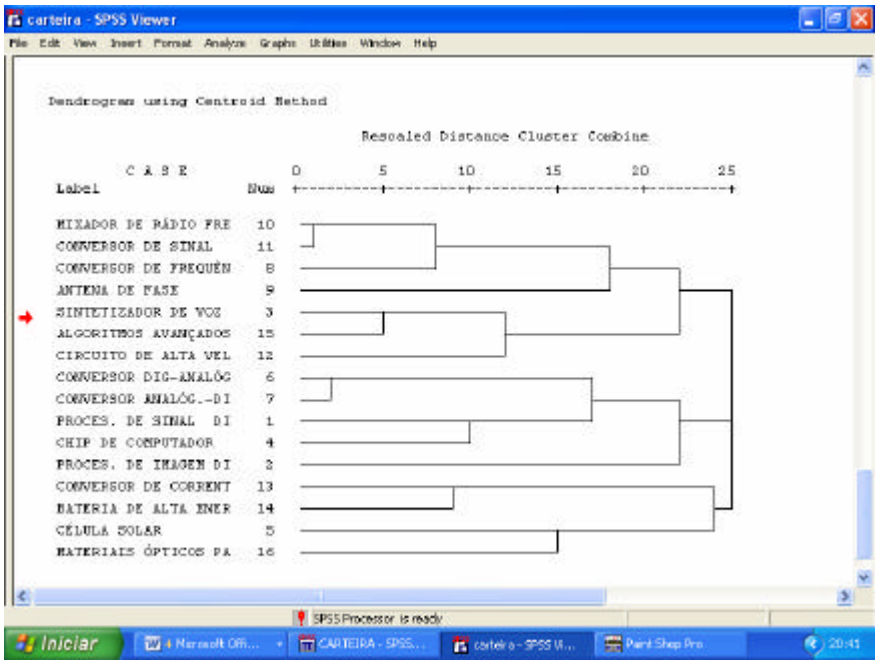

Figure 3.6: Technological segmentation Dendrogram.

Table 3.1: Cluster analysis solution

Case	6 Clust.	5 Clust.	4 Clust.	3 Clust.	2 Clust.
DIGITAL SIGNAL PROCESSOR	1	1	1	1	1
DIGITAL IMAGE PROCESSOR	2	2	1	1	1
VOICE SINTETIZER	3	3	2	2	1
COMPUTER CHIP	1	1	1	1	1
SOLAR CELULAR PHONE	4	4	3	3	2
DIG-ANALOG. CONVERSOR	1	1	1	1	1
ANALOG.-DIG CONVERSOR	1	1	1	1	1
FREQUENCY CONVERSOR	5	3	2	2	1
PHASE ANTENNA	5	3	2	2	1
FREQUENCY RADIO MIXER	5	3	2	2	1
SIGNAL CONVERSOR	5	3	2	2	1
HIGH VELOCITY CIRCUIT	3	3	2	2	1
ELECTRIC CONVERSOR	6	5	4	3	2
HIGH ENERGY BATTERY	6	5	4	3	2
ADVANCED ALGORITHM	3	3	2	2	1
OPTIC MATERIALS FOR SOLAR CELLS	4	4	3	3	2

The solution with four clusters is the best for the analysis of the gathering coefficient. Therefore, this information of the technological segmentation in four great groups will be

important for the obtaining of the portfolio of maximum profit, though balanced and aligned with the strategy of the company.

3.4 OBTAINING OF MAXIMUM PROFIT PORTFOLIO, BALANCED AND ALIGNED WITH THE TECHNOLOGICAL STRATEGY

Now, let us turn to the obtaining of the portfolio of larger profit, however, the one that guarantees a balance among the four technological groups found in the previous section and that constitutes an alignment with the strategy in the area of technology of the company. For this, we need to introduce in the MS-Excel spreadsheet the summations of the dichotomous (decision) variables for the projects of each one of the four groups, according to Figure 3.7 below. Notice that the spreadsheet is already ordinate according to the groups of technological segmentation (column K). Column L contains the summations of 5, 7, 2 and 2 projects in each one of the technological segment.

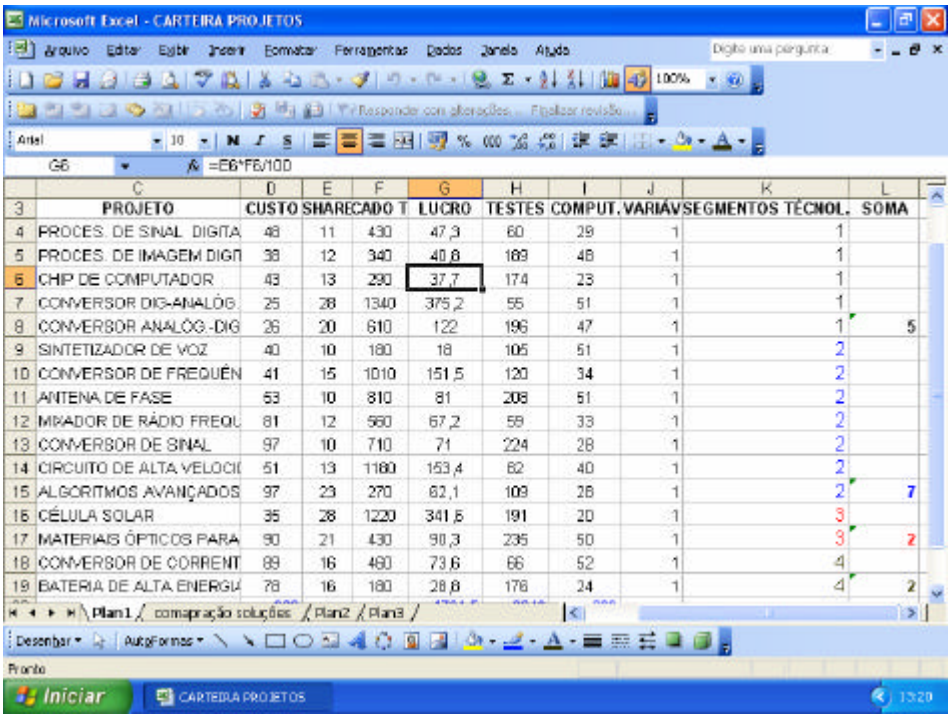

Figure 3.7: Spreadsheet with the disposition of the data for the obtaining of the Portfolio of maximum profit and balanced in terms of the technological segments.

Figure 3.8 below presents the open window of Solver with the request of profit maximization, however with the restriction of balance of the portfolio among the four technological segments. Such restriction is inserted so that at least two projects of each segment are contemplated in the portfolio of new products.

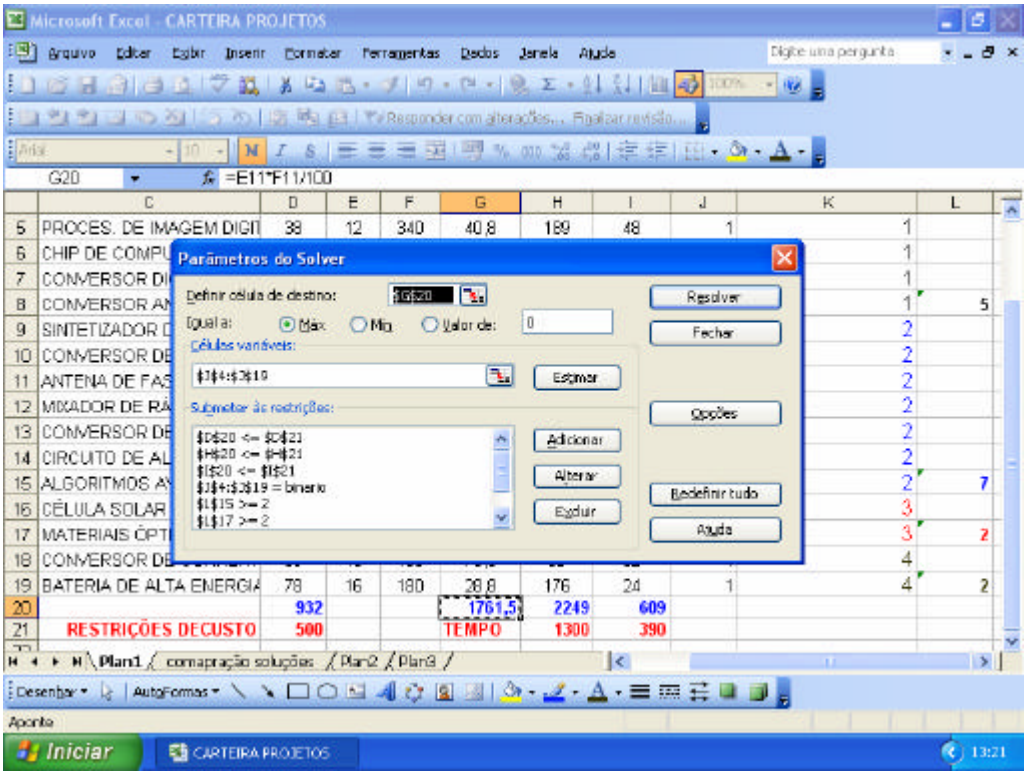

Figure 3.8: Solver Window with the order to maximize the profit and restrictions for the balance of technological segments and resources allocation.

Figure 3.9 below presents the found solution.

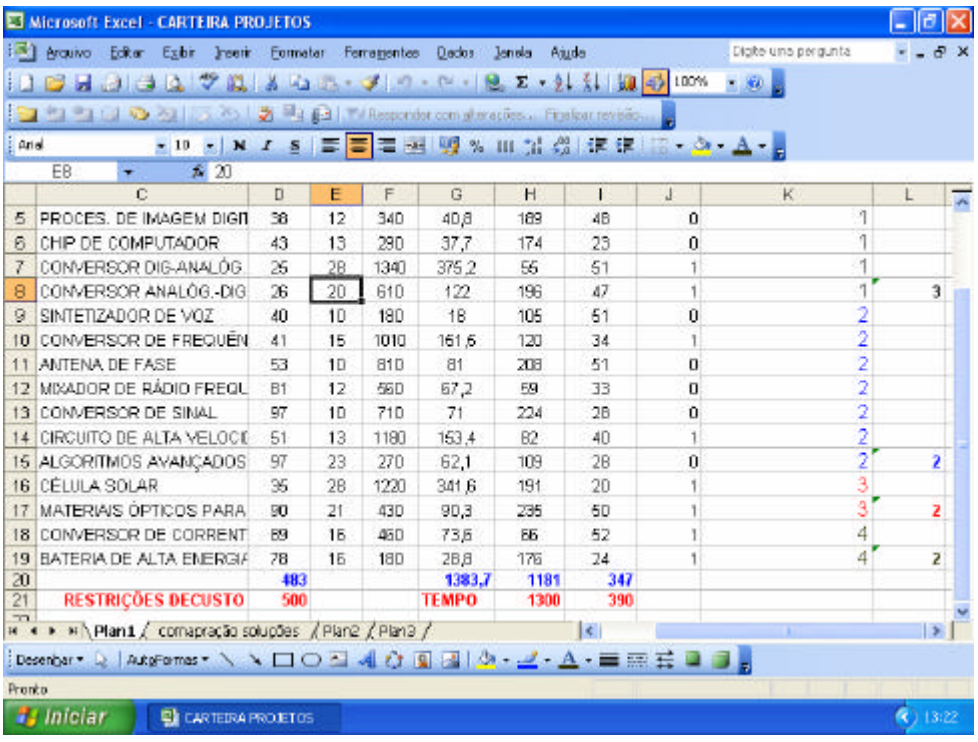

Figure 3.9: Solution found for the maximum profit portfolio and the balance among the technological segments.

Table 3.3 below presents a disposition of the two solutions found in the work, allowing, therefore, a comparison.

Table 3.3: Comparison among the two solutions of maximum profits portfolios, with and without the balance of projects among the four technological segments.

PROJECT NUMBER	Technologic Segments	Without technology balance solution	With technology balance solution	Profit	Develop. Costs	Tests Hours	Comp. Hours
1	1	0	1	47,3	48	60	29
2	1	0	0	40,8	38	189	48
4	1	0	0	37,7	43	174	23
6	1	1	1	375,2	25	55	51
7	1	1	1	122	26	196	47
3	2	0	0	18	40	105	51
8	2	1	1	151,5	41	120	34
9	2	1	0	81	53	208	51
10	2	1	0	67,2	81	59	33
11	2	0	0	71	97	224	28
12	2	1	1	153,4	51	82	40
15	2	0	0	62,1	97	109	28
5	3	1	1	341,6	35	191	20
16	3	1	1	90,3	90	235	50
13	4	1	1	73,6	89	66	52
14	4	0	1	28,8	78	176	24
			Without technology balance solution	1455,8	491	1212	378
			With technology balance solution	1383,7	483	1181	347
			Restrictions		500	1300	390

For Table 3.3 or Figure 3.9 above, we can observe that the portfolio that maximizes the profit of the company with the balance contemplates at least two projects of each one of the four technological segments. However, the maximum profit that could be of $1,455.8 million without the commitment of the balance, it ended up being in $1,383.7 million due to the introduction of the restriction of the Balance. What happens is that some trade-offs were made.

Some more profitable projects (as the one of n. 09 and 10) entered left the portfolio while, other less profitable ones (the ones of n. 01 and 14) entered (in the new portfolio with balance), expecting to bring better contributions in medium and long term periods, for being aligned to the policies and technological strategies of the company. On the other hand, there is

idleness in the resources. Even in the great portfolio without the balance we could find a certain sub-utilization of the resources, though a minor one, basically due to the fact that we are working with whole programming (binary). However, the commitment of the portfolio to present balanced in relation to the technological segments, it ends up imposing one more restriction to the problem and still decreasing even more the viable area for the resolution of the problem. In this sense, there is a little larger sub-utilization of resources than when compared to the career without the balance.

4. FINAL CONSIDERATIONS AND SUGGESTIONS FOR FUTURE WORKS

This paper presented a quite simple, practical and at the same time didactic approach of application to the selection of portfolio of projects of new products. The development of the obtaining of the portfolio of new products presented here brings a quantitative approach by using lineal programming and of clusters analysis. Great part of the literature about selection and portfolio management of projects of new products brings considerations regarding the acting of companies showing that the best practices consist of obtaining portfolios that maximize some result such as the profit, though it presents a commitment with the technological strategic line or with the company market.

This work sought to present, therefore, an application that could serve as illustration to the theory of selection of portfolio of projects of new products in disciplines of innovation Management in college or graduation courses in administration. The problem to be solved was to find a portfolio, among 16 projects of new products of a company which maximized the profit, though it could also present the commitment with the strategic orientation in technology of the company. The organization, in the study, has at its disposal 29 types of technologies that, in a way, complement each other, and it intends, therefore, to continue developing and researching them. Thus, the organization has a guideline of selecting projects that contemplate the great groups of technologies that are complemented the most.

The paper also presented a comparison among the portfolios of maximum profit obtained and with and without the balance. The portfolio with the balance commitment among the less similar groups of technologies presented a decrease of the maximum profit in relation to the portfolio without the balance. Besides a lower profit, the portfolio with balance presented a little larger level of sub-utilization of resources, basically due to the decrease of the viable area imposed by the introduction of the restriction that at least two projects of each group of technologies should be contemplated in the portfolio, seeking the balance.

New papers could present mix of other analysis tools and selection of portfolios of projects of new products in a didactic approach. Scoring techniques to obtain ordering of performance analysis in technology and market, as the BCG matrix or still, the research in marketing as joined analysis to grasp the structure of the consumers' values; it could be applied aiming at obtaining the balance of projects in the portfolio of projects. Techniques of market segmentation or still, risk analysis as ones about approaches by Markowitz (1959) or real options in decision trees, as found in Howard (1996) could also be used to seek a balance and align the portfolios with company strategies.

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