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Application of 0-1 Fuzzy Programming in Optimum Project Selection

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Abstract—In this article, a mathematical programming model for choosing an optimum portfolio of investments is developed. The investments are considered as investment projects. The uncertainties of the real world are associated through fuzzy concepts for coefficients of the proposed model (i. e. initial investment costs, profits, resource requirement, and total available budget). Model has been coded by using LINGO 11.0 solver. The results of a full analysis of optimistic and pessimistic derivative models are promising for selecting an optimum portfolio of projects in presence of uncertainty.

Keywords—Fuzzy Programming, Fuzzy Knapsack, Fuzzy Capital Budgeting, Fuzzy Project Selection

I. INTRODUCTION

SELECTION of an optimum portfolio when an organization is involved in a set of projects with a pre-determined net present value and initial investment cost has both practical and theoretical importance which has made it attractive to the researchers in last decades. This selection should contain a set of projects in order to meet a high level profit margin. The problem of choosing an optimal set of project subject to some constraints such as available budget for investment and optimizing a measurement function like maximizing the returns of selected projects is an essential and practical problem. Formally it's a decision making problem which results in selecting some projects and rejecting others subject to organization resources and targets. Generally, this is interpreted as capital budgeting which is a common paradigm with enough flexibility for standing in many areas. A great amount of researche works have been reported in the literature of this area.

As mentioned before, fuzzy/crisp capital budgeting and project selection have also attracted a large variety of research efforts due to its adaptability to real case conditions. Chance Programming Models for Capital Budgeting in Fuzzy Environments [19], Mean-variance model for fuzzy capital budgeting [15], Optimal project selection with random fuzzy parameters [16], Chance-constrained programming models for capital budgeting with NPV as fuzzy parameters [13],

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Credibility-based chance-constrained integer programming models for capital budgeting with fuzzy parameters [14], A goal-seeking approach to capital budgeting [6], An R&D options selection model for investment decisions [8], Multiple criteria decision making combined with finance: A categorized bibliographic study [25], Capital budgeting and compensation with asymmetric information and moral hazard [3], A comprehensive 0–1 goal programming model for project selection [22], Optimal project selection when borrowing and lending rates differ [23], Capital budgeting under uncertainty: An extended goal programming approach [26], A general form for the capital projects sequencing problem [27], An empirical study of capital budgeting practices for strategic investments in CIM technologies [24], Capital budgeting model with flexible budget [21], Dependent-Chance Programming Models for Capital Budgeting in Fuzzy Environments [20], Credibility-based chance-constrained integer programming models for capital budgeting with fuzzy parameters [9] and On some optimization problems under uncertainty [4] are some illustrative examples of research works in this area.

Knapsack problem and its extensions, well-known NP-hard problems [25], are fitted properly to the lots of optimization and engineering problem as well as capital budgeting and project selection. Some impressive efforts about this concept are: an improved interactive hybrid method for the linear multi-objective knapsack problem [7], a dynamic programming based reduction procedure for the multidimensional 0–1 knapsack problem [1], Local and global lifted cover inequalities for the 0–1 multidimensional knapsack problem [17], On separating cover inequalities for the multidimensional knapsack problem [1], Solving the Multidimensional Multiple-choice Knapsack Problem by constructing convex hulls [28], Improved results on the 0–1 multidimensional knapsack problem [11], The multidimensional 0–1 knapsack problem: An overview [12], a scheme for exact separation of extended cover inequalities and application to multidimensional knapsack problems [26], partially ordered knapsack and applications to scheduling [18], and Approximate and exact algorithms for the fixed-charge knapsack problem [10], Exact solution of a class of nonlinear knapsack problems [29].

In this paper we attack the capital budgeting problem as a multidimensional knapsack in fuzzy environment. Total available budget, the net present value of a project and the associated project profit are assumed to be positive Trapezoidal Fuzzy Numbers (TrFNs) which will be define in section 2. The objective is optimum portfolio selection with lowest cost and maximum profit from available investment situations in an ambiguous environment.

The following sections of this paper are arranged as below. Section 2 is allocated to define the problem scope which contains multidimensional knapsack and its application for project selection problem. The crisp model and proposed fuzzy model are also represented in section 2. Experimental results are outlined in section 3. Finally in the 4th section the paper will be ended with a brief summery and conclusion.

II. Problem Description

In this section the classical multidimensional knapsack problem is reviewed briefly. Then it will be related to an application like investment in a set of investment projects with fuzzy conditions.

A. Zero-One Multidimensional Knapsack Problem

We are given a set of n objects numbered 1, 2,…,n and a knapsack of total volume and weight capacity which are represented by W and V, respectively. Each object i has weight wi, volume vi and utility pi. Let X = [x1, x2… xn] be a solution vector in which xi = 0 if object i is not in the knapsack, and xi = 1 if it is in the knapsack. The goal is to find a subset of objects to put into the knapsack so that the total available volume and weight capacity is obeyed and the total utility of this set is maximized concurrently. Several exact methods as well as heuristic and meta-heuristic one are reported in literature for solving this problem. It is a NP-hard one and the optimal solution of it is hard to find when the dimension is increased [25]. It is notable that if the objects are assumed to have one attribute like weight the problem is converted to a simple knapsack problem. It is clear that, the dimension of objects can be increased subject to problem properties.

B. Fuzzy Zero-One Multidimensional Knapsack Problem

In real world problems, it is often impossible or non-realistic to gather a crisp value for the coefficient of the model. Such data are mixed with a notable amount of vagueness as well. Researchers try to represent this ambiguity through fuzzy concepts. The knapsack model can be developed in a fuzzy environment as below.

$$Max \sum_{i=1}^{n} \tilde{p}_i x_i \qquad (1)$$

$$s.t.$$

$$\sum_{i=1}^{n} \tilde{w}_i x_i \le \tilde{W} \qquad (2)$$

$$\sum_{i=1}^{n} \tilde{v}_i x_i \le \tilde{V} \qquad (3)$$

$$x_i = 0,1 \qquad (4)$$

In this model the expected profit of a project, weight of objects, objects volume and total available resources are assumed to be a fuzzy number with defined attributes. For instance, they could be assumed as TrFNs.

C. Proposed FuzzyOptimal Project Selection Model

Consider an organization which is facing with the portfolio selection of exclusive project with predefined profits as well as initial project investment requirement in a way that the total profit of investment is maximized and the total available budget for investment is obeyed. It is a decision making problem which can be solved optimally by multidimensional knapsack formulation.

In this section, the fuzzy optimal project selection model will be developed. Suppose that an organization is facing with several investments opportunities in the form of industrial, building and service sector projects. The organization should select at least one project for investment. Without lose of generality, the main requirements of a project are human resources, facilities/machines and row materials. The output of a project is all of its tangible and intangible and probable losses as well as its profits. In real conditions, managers have not a clear sense about the amount of these requirements or outputs in a deterministic way. A manager has vague information about project resource availability. Moreover, the sources requirements are mixed with ambiguity. This vagueness can be reported in TrFNs. The output of a project obeyed these concepts. In the other words, the total net profit of a project is surveyed in fuzzy environment. Let, describe the notations and fuzzy parameters as TrFNs. Suppose, we are faced n project with following properties:

j : number of projects, $j = 1, 2,..., n$
i : type of human resources, $i = 1, 2,..., m$
k : machine kind, $k = 1, 2,..., s$
o : type of raw material, $o = 1, 2,..., z$
$\tilde{H}_i$: maximum available human resource of type i (person/hour)
$\tilde{h}_{ij}$: requirement of human resource i in project j (person/hour)
$\tilde{M}_k$: maximum available machine - hour of type k
$\tilde{m}_{ij}$: requirement of machine - hour of type k in project j
$\tilde{R}_o$: maximum available raw material of type o
$\tilde{r}_{oj}$: requirement of raw material o in project j
$\tilde{B}_j$: maximum available budget for project j
$\tilde{C}_i$: per hour cost of human resource i
$\tilde{C}_k$: per hour cost of machine type k
$\tilde{C}_o$: unit cost material o
$\tilde{p}_j$: total net profit of project j

The decision variable of the model is considered as below:

$$x_j = \begin{cases} 1 & \text{if project j is selected for investement} \\ 0 & \text{otherwise} \end{cases}$$

By these definitions the proposed fully fuzzy 0-1 programming will be:

$$Max\ \Phi = \sum_{j=1}^{n} x_j \left[\tilde{p}_j - \left(\sum_{i=1}^{m} \tilde{h}_{ij}.\tilde{C}_i + \sum_{k=1}^{s} \tilde{m}_{kj}.\tilde{C}_k + \sum_{o=1}^{z} \tilde{r}_{oj}.\tilde{C}_o \right) \right] \quad (5)$$

$s.t.$

$$\sum_{j=1}^{n} \tilde{h}_{ij} x_j \le \tilde{H}_i, \qquad i = 1,2,...,m \quad (6)$$

$$\sum_{j=1}^{n} \tilde{m}_{kj} x_j \le \tilde{M}_k, \qquad k = 1,2,...,s \quad (7)$$

$$\sum_{j=1}^{n} \tilde{r}_{oj} x_j \le \tilde{R}_o, \qquad o = 1,2,...,z \quad (8)$$

$$(\sum_{i=1}^{m} \tilde{h}_{ij}.\tilde{C}_i + \sum_{k=1}^{s} \tilde{m}_{kj}.\tilde{C}_k + \sum_{o=1}^{z} \tilde{r}_{oj}.\tilde{C}_o) x_j \le \tilde{B}_j, \quad j = 1,2,...,n, \quad (9)$$

$$(\sum_{i=1}^{m} \tilde{h}_{ij}.\tilde{C}_i + \sum_{k=1}^{s} \tilde{m}_{kj}.\tilde{C}_k + \sum_{o=1}^{z} \tilde{r}_{oj}.\tilde{C}_o) x_j < \tilde{P}_j, \quad j = 1,2,...,n, \quad (10)$$

$$\sum_{j=1}^{n} x_j \ge 1 \quad (11)$$

$$x_j = 0,1 \quad j = 1,2,...,n \quad (12)$$

The objective function which is presented in equation (5) is a multi-objective function which tries to maximize the net profit of selected projects and minimize the cost of selected project simultaneously. These objectives are assumed to have the same weights and priorities so they have been combined with a simple additive weight method. The set of constraints (6), which should be held for all projects and all human resources of the projects, insures that human resources availability is met during the procedure of project selection. The sets of constraints (7) and (8) have the same description of constraints (6) but they are applied for machine-hour and raw materials, respectively. The set of constraint (9) holds the budget availability for each project in the project selection procedure. Constraint (10) checks if total cost of a selected project is less than its profit. Constraint (11) insures that at least one project is selected and finally the zero-one orientation of decision variable of the model is reserved in constraint (12).

More formally, the proposed model is a semi-multidimensional knapsack problem in which an organization is faced with different investement opportunities. Each investement opportunity is represented as a project with three classes of fuzzy required resources (i.e. human, machines and raw material). Each resource classe has different type with a fuzzy availability. The recruitment costs of all resources differ in each resource class and in each resource kind. These costs are also represented with TrFNs. The outcomes like total profits and monetary cost of a project as well as total available budget for a project are fuzzy numbers. Selecting a project is related to indefeasibility of three major constraint types. The first type is allocated to the resource constraint which implies the number of resources. The second one takes the recruitment cost into consideration. Third one ensures that only the projects which their profit is bigger than their cost are candidated to be in the optimum porfolio. On the other hand in this problem the organizations are imposed the number of or assignment of resources and cost of hiring these resources, simultaneously. This is the direct result of given upper bound for available budget for each project. Considering the α-cut concept, terms 9-16, will be transformed and the result will be an interval 0-1 programming represented as follows:

Following the interval programming will cause two models in optimistic and pessimistic situations. The proposed models should be solved for a predefined α-cut level in order to complete a full analysis. In the next section the full analysis will be represented for an illustrative instance.

III. RESULTS

In this section, the proposed algorithm is tested. A full analysis is performed with both optimistic
and pessimistic model at a predefined α-cut level.Consider 10, 5, 5, and 5 as available projects, human resource kinds, machine kinds and raw material types, respectively. The full data of test instance is presented in appendix A.

The described problem was solved optimally by LINGO 11.0 solver, through a Branch & Bound algorithm. The optimistic and the pessimistic model were solved for different α-cut levels. The obtained results are summarized in following tables.

TABLEVII OPTIMISTIC PROGRAMMING

Run	α-cut	O.F.V.	State	Iteration
1	0	42923.00	Global Optimum	0
2	0.1	41657.67	Global Optimum	0
3	0.2	40449.68	Global Optimum	0
4	0.3	39204.03	Global Optimum	0
5	0.4	37920.72	Global Optimum	0
6	0.5	34744.50	Global Optimum	0
7	0.6	33536.60	Global Optimum	0
8	0.7	32296.10	Global Optimum	0
9	0.8	31023.00	Global Optimum	0
10	0.9	29717.30	Global Optimum	0
11	1	28379.00	Global Optimum	0

TABLE VIII RUNS OF OPTIMISTIC PROGRAMMING

		Project No.									
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Runs	*1*	1	1	1	1	1	1	1	1	1	1
	2	1	1	1	1	1	1	0	1	1	1
	3	1	1	1	1	1	1	0	1	1	1
	4	1	1	1	1	1	1	0	1	1	1
	5	1	1	1	1	1	1	0	1	1	1
	6	1	1	1	1	1	1	0	1	0	1
	7	1	1	1	1	1	1	0	1	0	1
	8	1	1	1	1	1	1	0	1	0	1
	9	1	1	1	1	1	1	0	1	0	1
	10	1	1	1	1	1	1	0	1	0	1
	11	1	1	1	1	1	1	0	1	0	1
TOTAL		11	11	11	11	11	11	1	11	5	11

The results show that some projects lie in optimum portfolio for all α-cut levels in boths proposed models. These projects have high priority for investement in these ambiguous conditions. Some projects don't lie in optimum portfolio at any condition. These projects are not proposed for investment at all. All remained project are ranked subject to decreasing order of their total selection frequency in both table8 and table10, respectively. These projects are selected for invesment due to their calculated ranks.

TABLE IX PESSIMISTIC PROGRAMMING

Run	α-cut	O.F.V.	State	Iteration
1	0	3280.000	Global Optimum	0
2	0.1	4475.890	Global Optimum	0
3	0.2	5652.560	Global Optimum	0
4	0.3	6881.970	Global Optimum	0
5	0.4	8246.880	Global Optimum	0
6	0.5	9588.250	Global Optimum	0
7	0.6	10906.08	Global Optimum	0
8	0.7	12200.37	Global Optimum	0
9	0.8	13471.12	Global Optimum	0
10	0.9	14718.33	Global Optimum	0
11	1	15942.00	Global Optimum	0

TABLE X RUNS OF PESSIMISTIC PROGRAMMING

		Project No.									
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Runs	*1*	1	1	0	1	1	0	0	1	0	0
	2	1	1	0	1	1	0	0	1	0	0
	3	1	1	0	1	1	0	0	1	0	0
	4	1	1	0	1	1	1	0	1	0	0
	5	1	1	0	1	1	1	0	1	0	0
	6	1	1	0	1	1	1	0	1	0	0
	7	1	1	0	1	1	1	0	1	0	0
	8	1	1	0	1	1	1	0	1	0	0
	9	1	1	0	1	1	1	0	1	0	0
	10	1	1	0	1	1	1	0	1	0	0
	11	1	1	0	1	1	1	0	1	0	0
TOTAL		11	11	0	11	11	8	0	11	0	0

IV. SUMMARY & CONCLUSION

In this paper we have developed a 0-1 programming model for project selection in which the process of project selection has been accommodated in a full fuzzy environement. We developed a full fuzzy 0-1 programming for project seletion in a situation which an organization is faced several investment opportunities. The developed model consisted of two major kinds of constraints. The first one guaranteed the requirement resources for a candidate project would not exceed the quantity of total available resources while the second one held on the spended cost for each project under total available amount of considered budget for that project. The objective funtion of the model were a multi one with two major parts (profit and cost) which were combined by simple additive weight method fairly.

Due to adaptation with real world ambiguous conditions all parameters of the projects were assumed to be fuzzy. They include expected profit of project, all cost oriented values, total available resources and total available budgets. We used TrFNs to represent the vagueness. Using α-cut level concepts, we developed 2 different models, one for optimistic and the other for pessimistic condition. The proposed models were coded in LINGO 11.0 solver. The obtained results show that the proposed procedure is efficient and viable.

The procedure helps decision makers to select an investment plan among several ones in full ambiguous conditions. By selecting different α-cut levels, decision maker may gain a suitable vision about the outcome of his/her chosen investment.

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TABLE I AVAILABLE RESOURCES

Human Resource	H.R Type1	(5, 7, 11, 15)
	H.R Type2	(32, 40, 44, 50)
	H.R Type3	(41, 43, 47, 48)
	H.R Type4	(8, 16, 26, 32)
	H.R Type5	(10, 18, 23, 32)
Machines	Machine Type1	(35, 44, 52, 59)
	Machine Type2	(47, 53, 55, 63)
	Machine Type3	(32, 35, 36, 42)
	Machine Type4	(9, 17, 23, 24)
	Machine Type5	(37, 45, 48, 48)
Raw Materials	Raw Material 1	(43, 43, 50, 57)
	Raw Material 2	(3, 5, 12, 15)
	Raw Material 3	(6, 9, 13, 20)
	Raw Material 4	(25, 27, 28, 33)
	Raw Material 5	(18, 21, 26, 35)

TABLE IIUNIT COST FOR RESOURCES

Human Resource	H.R Type1	(5, 7, 11, 15)
	H.R Type2	(32, 40, 44, 50)
	H.R Type3	(41, 43, 47, 48)
	H.R Type4	(8, 16, 26, 32)
	H.R Type5	(10, 18, 23, 32)
Machines	Machine Type1	(35, 44, 52, 59)
	Machine Type2	(47, 53, 55, 63)
	Machine Type3	(32, 35, 36, 42)
	Machine Type4	(9, 17, 23, 24)
	Machine Type5	(37, 45, 48, 48)
Raw Materials	Raw Material 1	(43, 43, 50, 57)
	Raw Material 2	(3, 5, 12, 15)
	Raw Material 3	(6, 9, 13, 20)
	Raw Material 4	(25, 27, 28, 33)
	Raw Material 5	(18, 21, 26, 35)

TABLE III AVAILABLE BUDGET & NET PROFIT

Project No.	Available Budget	Net Profit
Project 1	(39304, 39307, 39363, 39372)	(7238, 7260, 7265, 7284)
Project 2	(14140, 14151, 14152, 14192)	(7065, 7110, 7143, 7188)
Project 3	(5789, 5857, 5894, 5913)	(3559, 3602, 3620, 3627)
Project 4	(47219, 47237, 47239, 47251)	(7977, 8018, 8033, 8045)
Project 5	(26336, 26340, 26418, 26419)	(8558, 8567, 8580, 8607)
Project 6	(40169, 40180, 40186, 40186)	(6770, 6774, 6836, 6892)
Project 7	(22964, 22987, 23002, 23038)	(1607, 1669, 1687, 1752)
Project 8	(24694, 24728, 24735, 24780)	(8209, 8262, 8274, 8284)
Project 9	(2239, 2250, 2312, 2331)	(4275, 4309, 4312, 4313)
Project 10	(22029, 22068, 22069, 22092)	(4573, 4575, 4581, 4598)

TABLE IV HUMAN RESOURCE REQUIREMENTS

Project No.	H.R. Type 1	H.R. Type 2	H.R. Type 3	H.R. Type 4	H.R. Type 5
Project 1	(1, 5, 7, 9)	(3, 5, 5, 7)	(5, 13, 20, 26)	(7, 8, 11, 12)	(6, 14, 15, 17)
Project 2	(3, 7, 8, 8)	(3, 11, 16, 17)	(4, 6, 11, 12)	(0, 3, 10, 12)	(1, 2, 5, 6)
Project 3	(2, 3, 9, 9)	(2, 2, 5, 12)	(9, 12, 13, 13)	(5, 12, 16, 22)	(1, 4, 10, 10)
Project 4	(8, 14, 15, 19)	(9, 11, 17, 17)	(8, 8, 9, 11)	(8, 12, 12, 13)	(1, 3, 4, 5)
Project 5	(1, 2, 2, 4)	(2, 2, 3, 6)	(9, 17, 23, 26)	(3, 7, 9, 10)	(3, 6, 10, 11)
Project 6	(8, 8, 10, 18)	(4, 6, 9, 14)	(3, 9, 11, 11)	(1, 3, 8, 14)	(0, 1, 8, 10)
Project 7	(8, 9, 9, 10)	(9, 9, 14, 14)	(3, 3, 11, 13)	(3, 7, 8, 12)	(9, 10, 11, 12)
Project 8	(8, 12, 12, 13)	(7, 9, 13, 17)	(3, 4, 4, 8)	(0, 2, 8, 13)	(5, 11, 11, 15)
Project 9	(3, 6, 8, 15)	(4, 9, 9, 14)	(2, 3, 3, 3)	(10, 17, 17, 20)	(0, 5, 9, 14)
Project 10	(4, 5, 5, 9)	(8, 8, 11, 13)	(8, 11, 11, 12)	(3, 10, 10, 13)	(10, 19, 24, 26)

H. R. Type 1: Human Resource Type 1

TABLE V MACHINE REQUIREMENTS

Project No.	Machine Type 1	Machine Type 2	Machine Type 3	Machine Type 4	Machine Type 5
Project 1	(0, 1, 1, 1)	(6, 6, 6, 12)	(9, 10, 11, 11)	(3, 3, 4, 4)	(7, 10, 18, 19)
Project 2	(3, 4, 6, 8)	(1, 1, 6, 9)	(2, 11, 18, 18)	(7, 8, 12, 13)	(1, 1, 1, 4)
Project 3	(6, 8, 14, 18)	(2, 4, 9, 9)	(6, 8, 9, 10)	(10, 13, 15, 16)	(3, 5, 8, 13)
Project 4	(7, 10, 11, 11)	(4, 5, 9, 16)	(8, 16, 18, 22)	(1, 1, 3, 3)	(1, 3, 4, 6)
Project 5	(7, 9, 9, 12)	(4, 5, 5, 6)	(3, 7, 9, 10)	(9, 15, 15, 15)	(9, 10, 12, 13)
Project 6	(5, 9, 9, 11)	(10, 13, 14, 17)	(9, 12, 12, 13)	(8, 14, 17, 17)	(5, 11, 16, 20)
Project 7	(2, 9, 9, 16)	(2, 4, 9, 15)	(8, 9, 11, 16)	(4, 6, 7, 7)	(7, 7, 10, 14)
Project 8	(9, 9, 12, 17)	(9, 16, 20, 20)	(5, 7, 9, 10)	(5, 10, 14, 16)	(9, 12, 12, 20)
Project 9	(1, 6, 7, 12)	(6, 9, 10, 15)	(7, 8, 8, 12)	(0, 2, 3, 5)	(7, 7, 8, 9)
Project 10	(7, 9, 9, 13)	(1, 2, 9, 11)	(2, 9, 10, 14)	(5, 7, 15, 17)	(7, 12, 19, 20)

TABLE VI RAW MATERIAL REQUIREMENTS

Project No.	R. M. Type 1	R. M. Type 2	R. M. Type 3	R. M. Type 4	R. M. Type 5
Project 1	(5, 6, 10, 10)	(8, 8, 8, 9)	(7, 8, 10, 11)	(5, 7, 7, 8)	(5, 9, 15, 21)
Project 2	(2, 5, 5, 7)	(1, 1, 9, 10)	(8, 10, 13, 15)	(2, 2, 3, 11)	(6, 8, 13, 19)
Project 3	(6, 7, 8, 14)	(3, 9, 13, 17)	(9, 13, 14, 14)	(1, 2, 2, 2)	(4, 6, 8, 10)
Project 4	(8, 9, 15, 22)	(8, 13, 15, 15)	(2, 3, 3, 5)	(0, 8, 10, 12)	(6, 7, 8, 10)
Project 5	(10, 12, 13, 13)	(7, 15, 20, 21)	(7, 9, 12, 16)	(7, 11, 16, 16)	(0, 3, 3, 7)
Project 6	(4, 5, 8, 9)	(2, 6, 14, 15)	(3, 7, 8, 11)	(2, 2, 2, 7)	(2, 2, 9, 9)
Project 7	(2, 5, 5, 7)	(5, 10, 10, 13)	(9, 10, 15, 16)	(6, 13, 15, 21)	(4, 9, 9, 10)
Project 8	(3, 4, 4, 10)	(7, 9, 10, 11)	(4, 7, 9, 10)	(1, 6, 10, 11)	(7, 9, 9, 15)
Project 9	(10, 12, 15, 20)	(4, 7, 14, 17)	(6, 7, 13, 13)	(5, 8, 12, 21)	(4, 8, 8, 9)
Project 10	(6, 7, 8, 11)	(10, 12, 21, 22)	(1, 4, 4, 9)	(9, 10, 11, 11)	(10, 11, 12, 16)

R. M. Type 1 : Raw Material Type 1