MARMARA UNIVERSITY

INSTITUTE FOR GRADUATE STUDIES IN PURE AND APPLIED SCIENCES

ASSOCIATION RULES FOR INNOVATIVE SME ALLIANCES

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Ph.D. THESIS

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ISTANBUL, 2015

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Director of the Institute
Prof. Dr. Uğur YAHŞİ

To my family…

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ASSOCIATION RULES FOR INNOVATIVE SME ALLIANCES

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TABLE OF CONTENTS

ACKNOWLEDGEMENT i

TABLE OF CONTENTS ii

ÖZET v

ABSTRACT vi

CLAIM OF ORIGINALITY vii

SYMBOLS viii

ABBREVIATIONS ix

LIST OF FIGURES x

LIST OF TABLES xiii

1 INTRODUCTION 1

2 LITERATURE REVIEW 4

2.1 Innovation in SMEs 4

2.2 SME Alliances for Innovation 5

2.2.1 Technoparks (TPs) 7

2.2.2 Technoparks in Turkey 9

2.3 Areas of Interest in SME Innovation 11

2.3.1 Literature taxonomy 12

2.4 Multi Criteria Decision Making and Innovation 24

2.5 Association Rules in Collaboration Innovation 26

3 METHODOLOGY 32

3.1 Criteria Ranking Methodology 32

3.1.1 Analytic Network Process 32

3.2 Association Methodology 38

3.2.1 Multinominal Logistic Regression Analysis 40

3.2.2 Association Rule Mining 45
4 CRITERIA CHOICE AND THE MODEL OF THE STUDY 55
4.1 Criteria Ranking 55
4.1.1 Evaluation network hierarchy 55
4.1.2 Construction of supermatrix 56
4.1.3 Pairwise comparisons and calculate relative – importance weight 57
4.1.4 Calculation of stable weights from the normalized super-matrix 60
4.1.5 Final relative importance weights 61
4.1.6 Influential criteria in SME alliances for innovation 63
4.2 Proposed Model 64
5 APPLICATION & RESULTS 65
5.1 Target SMEs 65
5.2 Survey 65
5.2.1 Survey Preperation 65
5.2.2 Questionnaire 66
5.2.3 Survey application 76
5.2.4 Results 76
5.3 Application of Multinomial Logistic Regression 89
5.3.1 Reconstruction of categorical data 89
5.3.2 Application of MLR in SPSS 91
5.3.3 Cross-relations tables 99
5.4 Association Rules Achieved 103
5.5 Model Testing 126
5.5.1 Reading data files into Clementine 127
5.5.2 Creating test data 133

5.5.3 Verification of models with test data 135
5.5.4 Results 138
5.6 Cross Validation of Rules 139
5.6.1 Application in RapidMiner 5.3 139
5.6.2 Association Rules achieved from RapidMiner 146
5.7 Discussion 148
6 CONCLUSION 151
REFERENCES 154
APPENDICES 167

ÖZET

YENİLİKÇİ KOBİ'LER İÇİN İŞBİRLİĞİ KURALLARI

Kurumlar arasındaki işbirliğinin güçlenmesiyle yenilikçi çalışmalar ve sanayideki gelişim hızı artmıştır. Küçük ve Orta Büyüklükteki İşletmeler (KOBİler) rekabetçi pazarlarda yenilikçilik için işbirliği yapmayı amaçlarken, iş ortaklarıyla üstlendikleri riskler başarılı işbirliği için yol haritası gereksinimini artırmaktadır. KOBİler diğer KOBİler ile olduğu kadar üniversiteler, araştırma kuruluşları ve küresel firmalarla da işbirliği yapmalıdırlar. Rastgele seçilen işbirliklerinin başarısızlıklarından oluşan deneyimler yeni işbirlikleri oluşturmada korku yaratmaktadır.

Bu çalışma yenilikçilik konusunda başarı ölçütlerini belirlemek için KOBİlerin yaptığı işbirliklerinin niceliksel ve niteliksel araştırmasını yapmayı amaçlamaktadır. Bu ölçütler tezin ana hedefi olan, yenilikçilikte başarıya götürecek olan işbirliği kurallarını oluşturacaktır.

KOBİlerin yenilikçi işbirliklerini hedefleyen işbirliği kurallarını anlamak için bu çalışma içerisinde öncelikle 70 bilimsel makale taranmış, incelenmiş ve Analitik Ağ Süreci yöntemi ile derecelendirilmiştir. Bu analiz sonuçlarında elde edilen kriterlerle hazırlanan anket Teknoparklar içinde kurulu 122 firma tarafından değerlendirilmiştir. KOBİlerin yenilikçi işbirliği kurallarını belirlemek için Çok Değişkenli Lojistik Regresyon Analizi kullanılarak bir model oluşturulmuştur. Kurallar karşılıklı ilişkilerin önemine göre oluşturulmuş, önemsiz görülenler elenmiştir. Sonuçlar, firma büyüklüğü ve ortak çalışma türünün yenilikçilik boyutunda önemsiz olduğunu göstermiştir. Firmaların mikro ölçütten orta boya büyümesi ile daha dengeli özellikler talep edildiği gözlenmiştir. Ayrıca, teknoloji ve finans kriterlerinde eşitlik talep edilirken fiyatın işbirliği için en önemli etkenlerden biri olmaya devam ettiği saptanmıştır.

Şubat, 2015 **İrem DÜZDAR**

ABSTRACT

ASSOCIATION RULES FOR INNOVATIVE SME ALLIANCES

Industrial improvements are currently based on innovation in alliance, which constructs a forceful coordination. Small and Medium Enterprises (SME) are obliged to progress in collaborative innovation to create competitive advantages; however, the risks observed in alliances increase the need for a success roadmap. SMEs have to construct alliances with universities, research organizations, global companies as well as other SMEs. Experiences with randomly chosen collaborators have shown failures that caused the fear of new collaborative work.

This study attempts to perform qualitative and quantitative analysis of the SME collaborations in order to depict the criteria causing failures and success in innovation. These criteria will allow realizing the main objective of the dissertation, which is to construct the association rules leading the success of innovative collaboration.

In order to understand the association rules in business application through innovative SME collaboration 70 scientific articles are analyzed to select and rank the business criteria using Analytical Network Process (ANP) method. The questionnaire prepared using the results ANP analysis is responded by 122 SMEs established in Turkish Technoparks. Multinomial Logistic Regression Analysis is used to construct the model for association rules. Rules are extracted based on the significance of attribute in cross relations; where, inattentive rules are eliminated. Results indicate that innovation has no significance with the firm size and collaborator types. It is observed that balanced shares are requested as the company is aged. Technology criteria and finance is requested to be balanced, whereas price is seen as the most important reason for collaboration.

February, 2015 **İrem DÜZDAR**

CLAIM OF ORIGINALITY

ASSOCIATION RULES FOR INNOVATIVE SME ALLIANCES

In order to understand the business rules targeting innovative collaboration of SMEs, more than 70 scientific articles are analyzed. The factors which are effective on the collaborative innovation in SMEs are extracted from this literature review. The questionnaire for the survey is constructed in accordance with the results of the above analysis.

There are a few studies about innovation with Multinomial Logistic Regression Analysis Technique, but there is no study to our knowledge, using Multinomial Logistic Regression Analysis Technique in "Collaborative Innovation". Hence, the subject-technique couple will be a new approach in the field of Innovation studies. Furthermore, Association Rules for the success of Collaborative Innovation is a unique application for Multinomial Logistic Regression.

The fact that application is realized with the technology SMEs in technoparks creates the great interest for the high potential of collaborative innovation. Extracting the "business rules in alliance" for successful innovation will be supporting the development of technology SMEs.

Association rules achieved by statistical application in SPSS are compared with the Association Rules explored by RapidMiner, a Machine Learning tool, to give an applicable list of rules resulting from the cross validation.

To our knowledge "Collaborative" is the keyword without result, when a search is run for "multinomial logistic regression in collaboration innovation" is searched.

February, 2015 Assoc. Prof. Dr. Bahar SENNAROĞLU İrem DÜZDAR

SYMBOLS

α **:** Cornbach's alpha

a_{ij} **:** Matrix value assigned

C.I. **:** Consistency Index

C.R. **:** Consistency Ratio

D_f **:** Degrees of freedom

$L **:** Predicted probability

$LP **:** Associated probability

Exp **:** Exponential

FP **:** Frequent Pattern

G **:** Geometric mean

H_0 **:** Null Hypothesis

H_1 **:** Alternative Hypothesis

λ_{max} **: S**um of the assesstment values

ln **:** Natural logarithm

log **:** Logarithm

n **:** Number of items

N **:** Frequency number

p (x) **:** Probability

R.I. **:** Random Index

σ **:** Support count

Sig. **:** Significance

ABBREVIATIONS

AHP **:** Analytic Hierarchy Process

ANP **:** Analytic Network Process

AR **:** Association Rules

IBM **:** The International Business Machines Corporation

KOSGEB **:** Turkey Small and Medium Enterprises Development Organization

LC **:** Large Companies

MADM **:** Multi Attribute Decision Making

MCDA **:** Multi Criteria Decision Analysis

MCDM **:** Multi Criteria Decision Making

MLR **:** Multinomial Logistic Regression

OECD : Organization for Economic Co-operation and Development

R&D **:** Research and Development

SME **:** Small Medium Enterprises

SPSS **:** Statistical Package of Social Sciences

TGBD **:** Association of Turkish Teknology Parks

TP **:** Technopark

TÜBİTAK **:** The Scientific and Technological Research Council of Turkey

TTGV **:** Technology Development Foundation of Turkey

LIST OF FIGURES

Figure 2.1. Number of technology improvement zones and firms 10

Figure 2.2. The number of published applications about association rules methodology in all areas – Year analysis 27

Figure 2.3. The number of published applications about association rules methodology in engineering area – Year analysis 28

Figure 2.4. Distribution of method used in association rules targeting the innovative synergy 30

Figure 2.5. Frequency of method utilization in association rules targeting the innovative synergy 30

Figure 3.1. Likert scale 36

Figure 3.2. Random Index 37

Figure 3.3. An illustration of Apriori Principle – Frequent Item set 48

Figure 3.4. An illustration of Apriori Principle – Infrequent Item set 49

Figure 3.5. Illustrating Apriori Principle – A generation example 49

Figure 3.6. Listing subsets of three Items form transaction f. 52

Figure 3.7. An illustration for lattice of rules 53

Figure 3.8. Relationships of Item sets 53

Figure 4.1. Network model view form Super Decision 56

Figure 4.2. Respect to competitive 58

Figure 4.3. Pair wise comparisons of Structural & Cultural Attributes 59

Figure 4.4. The weighted supermatrix of clusters – Super Decision image 61

Figure 5.1. View of the survey at the LimeSurvey. 65

Figure 5.2. The form of data transferred from LimeSurvey to Excel 66

Figure 5.3. The form of data transferred from LimeSurvey to MS Excel 70

Figure 5.4. The sizes SMEs answered the questionnaire 77

Figure 5.5. The types of collaborators 77

Figure 5.6. Types of preferred collaborators 78

Figure 5.7. Numbers of employees 79

Figure 5.8. Age-classification of the firms 80

Figure 5.9. The presence of collaboration for innovation 80

Figure 5.10. Duration of innovative collaboration 81

Figure 5.11. Duration of collaboration for innovation 81

Figure 5.12. Frequency chart for collaboration and the size of the firm 82

Figure 5.13. The choice of collaboration for innovation 83

Figure 5.14. The choice of collaboration for innovation – Frequency distribution 84

Figure 5.15. Bar chart of company field frequencies 86

Figure 5.16. Collaborated industry frequencies 88

Figure 5.17. SPSS view of survey data 89

Figure 5.18. Coding for size factor 90

Figure 5.19. Coding for communication technology factor 90

Figure 5.20. Coding for firm age factor 91

Figure 5.21. SPSS view of multinomial logistic regression analysis tool 93

Figure 5.22. SPSS view of the observed and predicted frequency table - Firm Size – Firm Age – Technology Related Criteria 100

Figure 5.23. Variable file reads data form delimited column text files 127

Figure 5.24. Selection of train data set 127

Figure 5.25. A view of building stream and setting the target and input fields with the type node. 128

Figure 5.26. Filter allows fields to be renamed and removed 129

Figure 5.27. Filter fields for Firm Size – Firm Age based on Technology Related Criteria model. 129

Figure 5.28. Logistics constructs a predictive logistic regression model 129
Figure 5.29. Choosing model options in MLR 130
Figure 5.30. Choosing output options in MLR 130
Figure 5.31. Executing MLR modeling 131
Figure 5.32. MLR model for Firm Size – Firm Age for Technology Related Criteria 131
Figure 5.33. Screenshot of structure of the model 131
Figure 5.34. Model fitting information table from Clementine 12.0 132
Figure 5.35. Model summary showing output and input fields 133
Figure 5.36. Sample node: obtains different methods for sampling data 134
Figure 5.37. Open Excel node 134
Figure 5.38. Open a variable file for test data 135
Figure 5.39. Add a type node 135
Figure 5.40. Add a filter node for testing data 136
Figure 5.41. Connect test data to the MLR model 136
Figure 5.42. Add a table node 136
Figure 5.43. Connect MLR model to the table node 137
Figure 5.44. View of result table 137
Figure 5.45. View of training data in RapidMiner 5.3 140
Figure 5.46. View of Main Process screen in RapidMiner 141
Figure 5.47. Frequent item set output for Technology Related Criteria 143
Figure 5.48. Design perspective from RapidMiner 144
Figure 5.49. Association rules output table view –Technological Related Criteria 145
Figure 5.50. Association rules output text view – Technological Related Criteria 145
Figure 5.51. Association rules graph view – Technological Criteria: Connectivity = All ways 146

LIST OF TABLES

Table 2.1. Technopark approach in different countries (2011) 8

Table 2.2. Alliance criteria frequency 13

Table 2.3. Relationship criteria frequency 14

Table 2.4. Synergy criteria frequency 15

Table 2.5. Communication criteria frequency 16

Table 2.6. Trust criteria frequency 16

Table 2.7. Managerial skills criteria frequency 17

Table 2.8. Technological criteria frequency 18

Table 2.9. Operational criteria frequency 19

Table 2.10. Personnel criteria frequency 20

Table 2.11. Innovation capacity criteria frequency 20

Table 2.12. Competitive advantage criteria frequency 21

Table 2.13. Structural & Cultural criteria frequency 22

Table 2.14. Financial criteria frequency 22

Table 2.15. Marketing criteria frequency 23

Table 2.16. Demographical criteria frequency 23

Table 2.17. Classification of methods 28

Table 3.1. Market basket transactions example 45

Table 3.2. Market Basket Transaction – Binary representation 46

Table 3.3. An illustration of Apriori Principle – Logic of generation example 50

Table 4.1. Submatrix of initial supermatrix 56

Table 4.2. Pair wise Comparisons of Structural & Cultural Attributes 59

Table 4.3. The weighted supermatrix 60

Table 4.4. Priorities of sub targets 61

Table 4.5. Priorities of clusters 61

Table 4.6. Priorities of attributes 62

Table 4.7. Flow of the study 64

Table 5.1. Crosstabulation of innovative collaboration and company age 79

Table 5.2. Frequency and percentage of company field 85

Table 5.3. Frequency and Percentage of Collaborated Industry 87

Table 5.4. Case processing summary 92

Table 5.5. Model fitting information 94

Table 5.6. Parameter Estimates Table – Firm Size = 2 95

Table 5.7. Parameter Estimates Table – Firm Size = 3 97

Table 5.8. Model fitting Information - Firm Size – Firm Age – Technology Related Criteria 99

Table 5.9. Cross – relations table: Firm Size – Firm Age – Technology Related Criteria 101

Table 5.10. Model fitting information – SPSS 21 132

Table 5.11. Ratio of threshold value for test data 138

1 INTRODUCTION

In1970s, SMEs were theoretically presented as the main accelerators of the economic growth and development. The main advantage of the SMEs is the flexibility because of low investment level and creativity. As the time passed SME role is evolved from employment generator to regional information creator with the contribution in development models and technological improvement (Bayülken and Kütükoğlu, 2012).

The main business issue for SMEs is to improve the innovative capacity; the solution is found to be the research and learning (Armatlı and Köroğlu, 2004).

Organizations must establish an information/ knowledge asset for innovation. This asset is to shared and used to produce added value. The knowledge asset can be seen as a contradiction to the global competition in the SME world, since, the creation of knowledge is only possible with the cooperation with other large and small firms and institutional or academic research organizations as the Helix theory defines (Leydesdorff & Etzkowitz, 1998). Hence, the capital created by knowledge accumulation must be achieved through the innovation networks (Laperche et al., 2006).

SMEs are obliged to collaborate for innovating in competitive markets, but the fact that they have risks in alliances they would like to define a success roadmap. SMEs have to construct alliances with universities or other research organizations, global business companies as well as other SMEs. Each type of alliance has specific risk and success criteria to be studied. Strategic decision of alliances can be constructed based on association rules targeting the innovative synergy.

SMEs need to construct successful alliances in order to have sustainable business in a competitive environment. The recent experiences with the randomly chosen collaborators have shown failures that caused the fear of new collaborative work. Experiences in different countries show a variety of causes and results in different types of alliances (Kakabadse et. al, 2004). Pre-analysis of the path for successful alliances will lead improvements in innovative power.

This study attempts to perform qualitative analysis of the SME alliances in order to depict the criteria causing failures and supporting the success in innovation. These criteria will allow realizing the main objective of the dissertation, which is to construct

the association rules leading innovative success. Association rules constructed will support strategic choice of the collaborators. The implication of the study is generic enough to help any SME or research organization or large business to reduce risks in future alliances.

Association Rules have become a global tool in knowledge management. Applications are currently found for technology firms and product development but not yet applied for business collaborations. Fundamentally, knowledge exchanges based on pre-determined rules are necessary for efficient resource utilization. SMEs with restricted funds and resources for innovative sustainability will benefit from the successful collaboration rules. Literature shows performance studies and success criteria to develop the innovative synergy. Strategic decision makers are expected to reevaluate these criteria to define the roadmap for a specific company, that does not allow using the knowledge accumulated through global experiences. This study will allow structuring strategic decisions based on association rules extracted through global analysis. Logical analysis and rule mining in global knowledge bases will be used to facilitate defining association rules.

Originality of this dissertation is first the survey that is prepared in accordance with the results of the literature taxonomy. The second novelty is extracting the "business rules in alliance" for successful innovation using Multinomial Logistic Regression Analysis Technique. This study also contributes to the literature by studying the "Collaborative Innovation" using both statistical and machine learning approaches.

In this scope, second section of this dissertation includes the literature review of the study. This section consists of literature survey about collaborative innovation in SMEs and its attribute analysis from former studies. The third section of this dissertation gives the details of methodologies consisting of the criteria ranking methods and association methods. The next section includes criteria ranking results and proposed model. The fifth section includes the application of the proposed methodology, results of the Multinomial Logistic Regression application in SPSS and validation of these results with Clementine. The results of model are compared with Association Rules in RapidMiner which is a Machine Learning tool. The final section is reserved for the concluding remarks and recommendation for future research.

This study will certainly improve the vision of decision makers of the technology SMEs. Achievements of this study will create a new vision on the collaborative innovation and lead for further studies in data mining and expert systems.

2 LITERATURE REVIEW

2.1 Innovation in SMEs

Numerically, 99.9% of the business organizations can be defined as SMEs in Turkey. These SMEs are employing 81% of the workers in manufacturing industries, producing 59% of the economic value added, and exporting 60% of the goods. SMEs may be introduced as the driving force of the Turkish economy. The role of SMEs is getting more important in Turkish economy concurrently all over the changing economic world (MÜSIAD, 2012).

Besides, SMEs can be seen as the main barrier for unemployment problem in Turkey by employing the two third of the total employment. It is proven statistically that SMEs represent more than 85% of the gross domestic product (Apak and Atay, 2014).

The rate of increase in the development has been affected by the development of new technologies during the last decades. These developments triggered the increase in the competition among the companies (Daim and Kocaoglu, 2008).

The greatest effect of increasing competition on the small and medium size enterprises (SMEs) is of two main pressures. One of them is the external pressure from their large size customers. The other is the internal pressure of limited resources (Bayraktar et al., 2009).

The main objective of all business organizations is to get profit from their business activities. In the competitive business media, it is obviously seen that developing an innovation strategy is the optimal solution. When establishing the strategy, and monitoring the innovation process, SMEs must try to satisfy the customer needs and expectations by collaborating with the customers. There is another objective waiting to be achieved is the improvement of the organization by enlarging the knowledge stocks. The business organizations can manage the enlargement action by building more effective systems to transfer the information and technology for improvement of the organization instead of palliative daily problem solving methods. In the last decade, innovation was on the focus of the management, and paid attention from the state with various support programs, industry with research and development (Apak and Atay, 2014).

Innovation is defined in the 3rd Oslo Manual as the realizing a considerable improvement for process, product, marketing technique, supplier and/or customer relations, organization and layout. The four types (product, process, marketing, and organizational) of innovation are described in that definition (OECD, 2009).

> *Product innovation* means a significant modification and/or new improved good and/or service in its features or uses. These improvements may be in its technical qualifications, parts, and materials, ease of use, environmental effects or software.
>
> *Process innovation* defines the application of a considerable improvement in manufacturing or distribution methods of the product including modifications in methods, equipments, software.
>
> *Marketing innovation* denotes the employment of considerably improved marketing and/or delivery method, product promotion or pricing, and product and/or package design.
>
> *Organizational innovation* defines the significant improvement and application in organizational structure including the relations between staff people, plant organization or supplier/consumer relations.

2.2 SME Alliances for Innovation

It is frequently seen that the innovation is produced easily in networks than individually (Pittaway et al., 2004). Innovative networks are more necessary for SMEs, since they are fragile, coming from their sizes, and need an environment to support (Szarka, 1990). SMEs may increase their restricted sources knowledge assets by the way of associating the networks and the sources of collaborators (Lefebvre et al., 2014). There is the risk of arising the problems from the organizational, cultural and institutional differences between the networking/and or collaborating SMEs (Boschma, 2005).

SMEs have a variety of management tools to construct the innovation process. Widely accepted ones are investing in research and development, the state funding, building structures and systems to reach information, linking to the knowledge producers, collaboration with suppliers and customers (Keizer et al., 2002).

The 2008 and 2009 reports of Trendchart about Innovation in Turkey, emphasized are four main strategies applied (Uslu, 2012):

Obtaining financial support for innovation, and the research and development operations;

Improving the cooperation of SMEs and the public organizations and universities leading the research and development;

Increasing the number of innovative actions and supporting them to survive.

Supporting the R&D studies of the educational organizations and pioneering them to have the studies to be converted into commercial products.

The relation among the universities, the government and the industry can be defined as the triple helix, the common way, for evolution of communication networks (Etzkowitz and Leydesdorff, 1997). To build and motivate the innovation and entrepreneurship in the national scale requires triple helix. The knowledge is generated and distributed to the community by the universities. The added value and profit on commercialization are produced by the industry. The state must organize and motivate these two for communication to manage the social improvement (Yalçıntaş, 2014).

Different Universities established University – Industry Cooperation Centers to enable the cooperation between the industrial organizations and the academicians. Their effectiveness can be measured by the success of such cooperation (Kaymaz and Eryiğit, 2011). The university – industry cooperation is legalized with identification of "Technology Improvement Zone" or shortly "Technopark" or "Technocity" in Turkey (Yalçıntaş, 2014).

The techno parks are trying to establish the university – industry cooperation that will supply the scientific knowledge to the industry. The third part of triple helix, in technoparks is integratesd by the supports given by the state organizations. In Turkey, those organizations are The Scientific and Technological Research Council of Turkey (TÜBİTAK), Republic of Turkey Small and Medium Enterprises Development Organization (KOSGEB), Ministry of Science, Industry and Technology, Technology Development Foundation of Turkey (TTGV). Techno parks are developing and progressing with the participation of the new firms. The financial and R&D contributions of the firms in the techno parks are very important (MÜSİAD**,** 2012).

SMEs can increase the competitive advantages only by growing technology transfer potential and research and innovation investments. That is why the technoparks where R&D culture grows, are the favorable land of innovation. The technology centers have initially provided opportunities for the highly educated entrepreneurs and the corporate firms. In the last decade, the fruit of the cooperation was seen inaccessible for most of the SMEs (Uslu, 2012). This issue is overcome today by the project approach of the Universities.

2.2.1 Technoparks (TPs)

The technoparks have taken a very important role of triggering the development in the developed countries since the early 1950s (Aydoğdu, 2012). The effects of technoparks can be listed as;

The university – industry relations have been established as regular cooperation,
Incorporation of new firms having high technology and improvement of the old firms,
The conversion of the academic knowledge from the universities to technological products and the occurrence of technological transfer,
Increase in local products in manufacturing industry,
Increase in R&D studies and the rate of return,
Increase in exportation and external investment,
Decrease in external dependency,
Reconstruction of the regional and local economy with the R&D investments,
Increase in the variety of local economic operations, and economical productivity,
Remove the unbalanced investments in innovation and R&D,
Create new employment opportunities and prevent the brain migration.

The minimum requirements for an ideal technology improvement zone are:

The need for re-organization in the region,
Enough R&D and industry investments in the region,
The zone must be placed in or near the campus areas of the universities to keep the synergy high with the university,
The zone must have high living and working standards,
The incubation centers must be built and run,
The technology transfer center must be established and run successfully,
R&D studies must be promoted,

The outputs of these R&D studies must be supplied to domestic or external markets,

The foreign trade notion must be built,

The integration with the business community must be constituted.

The main goal of the development is the transfer of the modern technology from universities via industrial organizations. The interest of the universities in the technopark projects is fed by the need for income raising; monetary value is created by selling the intellectual properties and R&D studies, receiving support for graduate and postgraduate students in the lodger firms, and the rental revenues of the zone (Kalkınmada Anahtar Verimlilik**,** 2012). Table 2.1 shows that different technopark approaches in different countries (Kalkınmada Anahtar Verimlilik**,** 2012).

Table 2.1. Technopark approach in different countries (2011)

Countries	Organization Structure	Provided support and incentives	Activities	Services	R&D /GNP
USA	University, professional institutions, firms	Low-interest credit, risk capital, tax incentive	R&D, prototype creating, technology transfer office, incubation center	Office, laboratory, conference and education center, cafeteria, hotels and dormitories, gymnasium, etc.	2,67%
South Korea	State, University grant, tax incentive	Low-interest credit, grant, tax incentive	R&D, prototype creating, technology transfer office, incubation center	Office, laboratory, conference and education center, consulting, cafeteria, hotels and dormitories, gymnasium, etc.	2,85%
Israel	Firms	Tax exemption, tax incentive. low-interest credit, risk capital	R&D, prototype creating, technology transfer office, incubation center production	Office, laboratory, conference and education center, consulting, cafeteria,	4,6%
France	State, University, Municipality	Low-interest credit, risk capital, tax incentive, grant	R&D, prototype creating, technology transfer office, incubation center, production	Office, laboratory, conference and education center, consulting, cafeteria, hotels and dormitories, gymnasium, etc.	1,8%
Turkey	University, Municipality, Banks, Firms	Tax exemption, grant, build-operate-transfer	R&D, prototype creating, technology transfer office, incubation center	Office, laboratory, conference and education center, consulting, cafeteria	0,9%

Technoparks have many advantages like the discounts in office rents, all of the support services handled by a single management, the advisory of the academic staff and the employment of youngest university students. The first technopark in history have been established in United States in 1952. The idea of technopark has been presented in 1950 by a group of researcher studying in Stanford University to commercialize the output of their studies. This is the best known technopark of the World, called as "Silicon Valley" (Başalp and Yazlık, 2006).

International Association of Science Parks defines the technopark as; "An organization with a basic goal to create value by increasing the competitive capacity and innovation culture, and managed by a professional manager" (Kayalıdere, 2014).

2.2.2 Technoparks in Turkey

Small and Medium Enterprises Development Organization (KOSGEB) is established in early 1990s. Then, in the second half of 1990s, very important financial supports have been provided for SMEs to support the innovation, R&D, technology transfer studies (Alparslan et al., 2008). The technopark concept has started at the end of 1990s. T.C. Industry and Trade Ministry has made some legal arrangements to motivate the cooperation within industry and universities. The Law for Regulating the Technology Improvement Zones, law number 4691, is effected in 2001, and the legal infrastructure is established (MÜSİAD, 2012). There are 43 technoparks in Turkey, established according to this law at the end of 2014. There are 1,698 firms and 14,308 R&D workers in those 43 technoparks, and the average number of workers per firm is 8.42 (Figure 2.1).

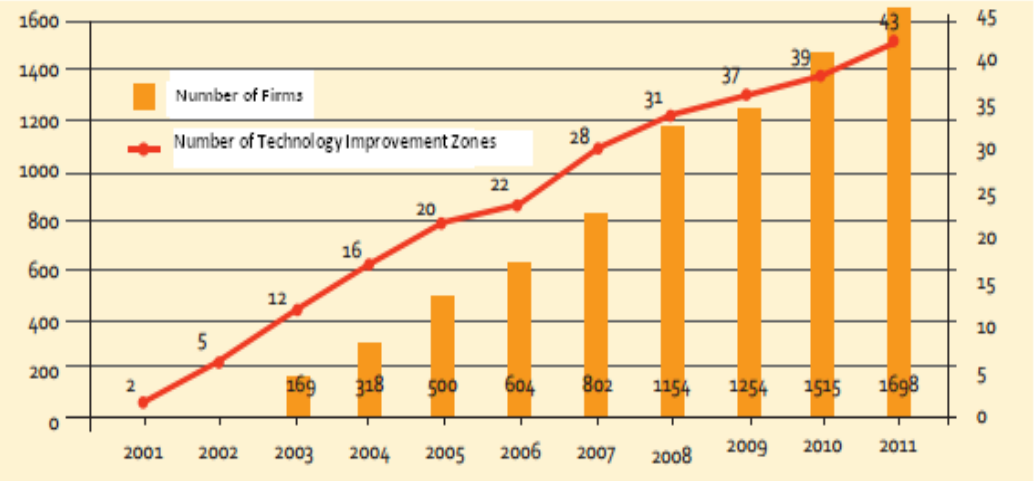


Figure 2.1. Number of technology improvement zones and firms

Law for Technology Improvement Zones (TIZ)

Technopark firms started as corporate taxpayers have exemption for the income taxes earned through software and R&D operations in the Technology Improvement Zones (Url-3, 2014). There are exemptions also for the R&D employees for income tax and incentive for 50% of social security premium of employers until the end of 2013. Public or university staff is allowed for working in Technology Improvement Zones part time or full time with the acceptance of their organization.

The stakeholders of Technology Improvement Zones are;

Industrial organizations,
State,
Higher education institutions,
Academic staff,
University students,
R&D personnel.

The aim of the law is to produce technological knowledge, to commercialize this knowledge, to raise the quality and standard of both product and production process, to create the innovation for increasing the productivity and decreasing the production costs, to integrate SMEs to new and advanced technologies, to create employment potential for researchers, to accelerate the external capital to entrepreneur on advanced technology, and to raise the competition potential of Turkish Industry (TGBD, 2014).

2.3 Areas of Interest in SME Innovation

In this study, association rules for strategic alliances will be used in order to sharing development costs and activities and utilizing collaboration and communication with current and potential stakeholders for innovation during the SME collaboration process.

First, the criteria are described which affect the innovation in SMEs. At the beginning through literature review, most of the criteria are defined and then some of them are proposed. The impressing criteria on the innovation in SMEs are shown as follows.

Effective criteria for innovation in SMEs:

a) Relationships: The quantity of resources which exchanged between firms highlights the number of contacts between the firms (Youli & Huiwei, 2011).

b) Synergy: The success of strategic alliances depends on the communication between the alliances. The confusion is the main problem in communication between partners. Basically communication can be defined as; picking up the phone and asking them how they are doing it (Baregheh et al., 2012).

c) Communication: The 'Communication' criterion covers communication technology, network density, level of network position strength, connectivity, and language.

d) Trust: The collaboration has also power conflicts and coordination type handicaps; the dominant reason is trust or personal relations (Casals, 2011).

e) Managerial Skills: One of the major problems in SME sector is the insufficient managerial skills and scarce technological effort (Albaladejo, 2001).

f) Technological: The benefits of collaboration will be limited, if the technologic knowledge and technological capacity are scarce (Albaladejo, 2001).

g) Operational: The 'Operational' criterion covers Operational Management, Processes, Production & Manufacturing Style, Service Style, Outsourcing Experience, Demand & Supply Management, Inventory management, Quality management, Design operations and, Sales Management.

h) Personnel: The collaboration has also power conflicts and coordination type handicaps; the dominant reason is trust or personal relations (Casals, 2011).

i) Competitive advantage: Some of the firms may get the competitive advantage by using their power to exploit the environmental opportunities and to disregard the environmental limitations (Barney, 1995).

j) Innovation capacity: The 'Innovation Capacity' criterion covers Innovations, Publishing, Unconstrained creativity, Number of patentees, R&D approach, Number of new products, Number of process, Number of product or process, Innovation strategy.

k) Structural & Cultural: The success of collaboration will be reached easily if shareholders have a common organizational culture and world vision (Casals, 2011).

l) Marketing: In the older researches it is seen that the emerging new markets being more impressive on the technological innovation (Maguire et al., 2007).

m) Financial: The 'Financial' criterion covers expenditures, impact of the capital, purchasing rate, selling rate, price, sales amount and Return on Investment.

n) Demographical: The 'Demographical' criterion covers firm age, business experience, firm size, industry and geographical.

2.3.1 Literature taxonomy

Through literature survey, the criteria found are studied in three different dimensions. The first of these is industry internal, the second is within industry and the third is the supplier/customer. These dimensions are divided to two groups according to the relationships in each one; SME – SME and SME – Large Company.

As the found 14 alliance criteria are searched in between the papers of the literature, and grouped in 4 classes according to their frequencies; the competitive advantage and relationships are the most popular criteria respectively. Then the managerial skills and technological and operational criteria take place in the second group. According to their frequencies, marketing and demographical, synergy, structural & cultural, innovation capability is seen in the third group respectively. The other 4 criteria were seen less than these (Table 2.2.).

Table 2.2. Alliance criteria frequency

	Industry Internal		Within Industry		Supplier / Customers		**Total**
Alliance Criteria	**SME-SME**	**SME-LC**	**SME-SME**	**SME-LC**	**SME-SME**	**SME-LC**	
Relationships	6	12	9	10	14	7	**58**
Synergy	5	10	4	6	5	2	**32**
Communication	4	2	4	4	5	3	**22**
Trust	3	2	2	0	7	1	**15**
Managerial Skills	7	8	16	5	8	3	**47**
Technological	7	4	15	9	8	4	**47**
Operational	3	6	10	9	9	3	**40**
Personnel	6	4	8	2	2	0	**22**
Competitive advantage	6	15	16	16	12	4	**69**
Innovation capacity	7	6	7	6	3	0	**29**
Structural & Cultural	3	6	11	5	5	1	**31**
Marketing	5	7	13	4	4	1	**34**
Financial	0	5	2	2	4	2	**15**
Demographical	3	8	4	5	11	3	**34**

The frequencies of between several SMEs and between SME and Large Company in industry internal are studied. Then the frequencies of SME – SME and SME – LC in between industries are searched. At the end, the frequencies of SME – SME and SME – LC in customer/suppliers, which are the most important shareholder, are studied.

Table 2.3. Relationship criteria frequency

Relationships	Industry Internal		Within Industry		Supplier / Customers		**Total**
	SME-SME	SME-LC	SME-SME	SME-LC	SME-SME	SME-LC	
Risk sharing	1		1				**2**
Financial Interests	1	1					**2**
Relationship style	1	1	2		3	1	**8**
Social capital in relationships		1			1		**2**
Partner selection		1	1	1		1	**4**
Number of competitors					1		**1**
Number of companies in relation		4		1	3	1	**9**
Network of organizations			1	1	1	2	**5**
Reasons for collaboration	1			1	1		**3**
Development of alliances				2		1	**3**
Complementarity	1	1	1	2	1		**6**
Cooperation	1	1		1	2		**5**
Flexibility		1	2	1	1		**5**
Information & Knowledge sharing		1	1			1	**3**
Total	**6**	**12**	**9**	**10**	**14**	**7**	**58**

The frequencies of the dimension and type of relationship are seen at the tables below. The mostly seen two of the sub criteria that covered by the relationships criterion is number of companies in relation and relationship style (Table 2.3). The distribution of this criterion is approximately equal according to various areas in the relationship

criterion. The relationship criterion is more frequent in SME – LC the industry internal and between industries and supplier/customers SME – SME is more frequent.

Resource balance and joint actions is the most frequent sub criteria of Synergy criterion (Table 2.4). In the sight of different areas; the frequencies of this criterion is decreasing from industry internal to within industry and supplier/customers respectively. It is most frequent in SME –SME of industry internal and, in the other two areas SME – LC is more frequent.

Table 2.4. Synergy criteria frequency

Synergy	Industry Internal		Within Industry		Supplier / Customers		**Total**
	SME-SME	SME-LC	SME-SME	SME-LC	SME-SME	SME-LC	
Synergy	1			1	1		**3**
Resource balance	1	1	2	1	1	1	**7**
Joint actions	2	3		1	2		**8**
Joint teams		1					**1**
Complementarity of resources	1	1		1		1	**4**
Technology balance		2					**2**
Performance and competitiveness		1	1	2	1		**5**
Equality		1	1				**2**
Total	**5**	**10**	**4**	**6**	**5**	**2**	**32**

Between the papers searched to generate the criteria, the sub criterion ‘communication’ of communication criterion is the most frequent of all. The distributions of communication criterion between the different areas are similar. The most frequent is SME – SME (Table 2.5).

Table 2.5. Communication criteria frequency

Communication	Industry Internal		Within Industry		Supplier / Customers		**Total**
	SME-SME	SME-LC	SME-SME	SME-LC	SME-SME	SME-LC	
Communication	1	2	2	1	2		**8**
Communication technology	1		1			1	**3**
Network density				1	1	1	**3**
Level of network position strength	1		1			1	**3**
Connectivity	1			2	1		**4**
Language					1		**1**
Total	**4**	**2**	**4**	**4**	**5**	**3**	**22**

The sub criterion ‘trust’ of trust criterion, has the highest frequency. The most frequent is the SME –SME of supplier/customers, there is any occurrence SME – LC of between industries (Table 2.6).

Table 2.6. Trust criteria frequency

Trust	Industry Internal		Within Industry		Supplier / Customers		**Total**
	SME-SME	SME-LC	SME-SME	SME-LC	SME-SME	SME-LC	
Honesty					1		**1**
Loyalty			1		1		**2**
Reliability	1						**1**
Trust	2	2	1		4	1	**10**
Inter-personal trust					1		**1**
Total	**3**	**2**	**2**	**0**	**7**	**1**	**15**

The managerial skills and technological criteria is the second most frequent of basic 14 criteria. The strategy management has the highest frequency in this criterion. The leadership, monitoring & control, and planning are seen frequently. The most frequent area is the between industries. The SME – SME is the most frequent one (Table 2.7).

Table 2.7. Managerial skills criteria frequency

Managerial Skills	Industry Internal		Within Industry		Supplier / Customers		**Total**
	SME-SME	SME-LC	SME-SME	SME-LC	SME-SME	SME-LC	
Leadership		1	2	2		1	**6**
Business understanding	2		1		1		**4**
Professionalism					1		**1**
Risk taking					1		**1**
Decision making		1					**1**
Strategy Development	2	3	5	1	2	1	**14**
Planning			2		1	1	**4**
Monitoring & Control		1	4		1		**6**
Coordination & Cooperation		1	1				**2**
Empowerment			1				**1**
Multi National Companies				1			**1**
External economies	1			1			**2**
Social Responsibility	1						**1**
Commitment		1			1		**2**
Change management	1						**1**
Total	**7**	**8**	**16**	**5**	**8**	**3**	**47**

Management information systems and technological skills of technological criterion are the most frequent in this criterion. As the managerial skills, the technological is also has a high frequency in the basic criteria. It is also frequent in SME – SME of between industries like managerial skills (Table 2.8).

Table 2.8. Technological criteria frequency

Technological	Industry Internal		Within Industry		Supplier / Customers		**Total**
	SME - SME	SME-LC	SME-SME	SME-LC	SME-SME	SME -LC	
Management Information Systems	3		2	3	3	1	**12**
Technological activities		3	4			1	**8**
Technology skills	3		3	3	2	1	**12**
Technology management			1		1		**2**
Physical infrastructure and machinery	1	1				1	**3**
Software			2	2	2		**6**
Technological performance			1	1			**2**
Access to technological know-how			2				**2**
Total	**7**	**4**	**15**	**9**	**8**	**4**	**47**

Design, supply chain management and production & manufacturing of operational criterion are frequent. The most frequent of this criterion is the SME – SME of between industries like technological and managerial skills criteria (Table 2.9).

Table 2.9. Operational criteria frequency

Operational	Industry Internal		Within Industry		Supplier / Customers		**Total**
	SME-SME	SME-LC	SME-SME	SME-LC	SME-SME	SME-LC	
Operational Management		1	1	1			**3**
Processes Style	1		1			1	**3**
Production & Manufacturing Style		1	1	1	4		**7**
Service Style		1	1		2		**4**
Outsourcing Experience			2			1	**3**
Demand & Supply Management	1	2	1	2	1		**7**
Inventory m anagement					1		**1**
Quality management		1		2			**3**
Design operations	1		3	2	1	1	**8**
Sales Management				1			**1**
Total	**3**	**6**	**10**	**9**	**9**	**3**	**40**

The specialized skills have the highest frequency in the personnel criterion. There is low number of occurrence for supplier/customer and SME – LC (Table 2.10).

Table 2.10. Personnel criteria frequency

Personnel	Industry Internal		Within Industry		Supplier / Customers		**Total**
	SME-SME	SME-LC	SME-SME	SME-LC	SME-SME	SME-LC	
Number of executives			1				**1**
Employment rate				1			**1**
Working conditions	1						**1**
Specialized skills	3	1	5	1	2		**12**
Innovative skills	1						**1**
Human resources	1	3	2				**6**
Total	**6**	**4**	**8**	**2**	**2**	**0**	**22**

The innovation realization of innovation capacity criterion has the highest frequency, and the numbers of occurrences are similar for the others. There are also similar frequencies in the areas of internal industry and between industries. The SME – SME relations are more frequent in all areas (Table 2.11).

Table 2.11. Innovation capacity criteria frequency

Innovation capacity	Industry Internal		Within Industry		Supplier / Customers		**Total**
	SME-SME	SME-LC	SME-SME	SME-LC	SME-SME	SME-LC	
Innovations	1	2	5	4	2		**14**
Publishing			1				**1**
Unconstrained creativity	1		1				**2**
Number of patentees	1	1					**2**
R&D approach	1	2		1			**4**
Number of new products	1				1		**2**
Number of process	1						**1**
Number of product or process	1						**1**
Innovation strategy		1		1			**2**
Total	**7**	**6**	**7**	**6**	**3**	**0**	**29**

The competitive advantage criterion is the most frequent of basic 14 criteria. Learning & training, knowledge management, competitive specialties and R&D capability of this criterion are the most frequent. Between different areas the occurrence in the descending order, respectively, is between industries, internal industry and supplier/customers. The SME – SME of internal industry has the highest frequency (Table 2.12).

Table 2.12. Competitive advantage criteria frequency

Competitive advantage	Industry Internal		Within Industry		Supplier / Customers		**Total**
	SME-SME	SME-LC	SME-SME	SME-LC	SME-SME	SME-LC	
Competitive specialties		3		2	2	1	**8**
Quality	1	1	3		1		**6**
Exceptional product and services					1		**1**
Exceeding customer expectations		2	1		1		**4**
Sustainability		2					**2**
Dominance	1			1			**2**
Understanding of requirement			1		2		**3**
Uniqueness		2					**2**
Learning and Training	1	1	3	6	2	2	**15**
Previous experience		1	1	1			**3**
R&D capability	2	2	1	2			**7**
Realistic goals		1	1				**2**
Knowledge Management	1		5	3	3	1	**13**
Special processes				1			**1**
Total	**6**	**15**	**16**	**16**	**12**	**4**	**69**

Organizational culture and structure criteria are more frequent in the surveyed papers. As it is seen at Table 2.13 the number of occurrence of internal industry and between

industries is more than the others. It is observed that in the area of between industries SME – SME relationships has the maximum number of occurrence.

Table 2.13. Structural & Cultural criteria frequency

Structural & Cultural	Industry Internal		Within Industry		Supplier / Customers		**Total**
	SME-SME	SME-LC	SME-SME	SME-LC	SME-SME	SME-LC	
Organizational structure	1	1	3	2	2	1	**10**
Culture	1	2	5	3	3		**14**
Cultural differences		1					**1**
Integrative spirit			1				**1**
Innovation culture	1	2	2				**5**
Total	**3**	**6**	**11**	**5**	**5**	**1**	**31**

The criterion financial exhibits an increasing order beginning from the right side of the Table 2.14. It is seen frequently in SME – SME of between industries and supplier/customers and of SME – LC of internal industry.

Table 2.14. Financial criteria frequency

Financial	Industry Internal		Within Industry		Supplier / Customers		**Total**
	SME-SME	SME-LC	SME-SME	SME-LC	SME-SME	SME-LC	
Expenditures		1	1	2			**4**
Capital Impact		1	1				**2**
Purchasing rate					1	1	**2**
Selling rate						1	**1**
Price					1		**1**
Sales amount		1			1		**2**
Return on Investment		2			1		**3**
Total	**0**	**5**	**2**	**2**	**4**	**2**	**15**

Penetration, activities and environment of marketing criterion are more frequent criteria, and the frequencies of the others are similar. The between industries area is the most frequent area here; the frequencies of internal industry is greater than that of the customer/suppliers. SME – SME is more frequent in all areas (Table 2.15).

Table 2.15. Marketing criteria frequency

Marketing	Industry Internal		Within Industry		Supplier / Customers		**Total**
	SME-SME	SME-LC	SME-SME	SME-LC	SME-SME	SME-LC	
Market Penetration	1		2	1	1	1	**6**
Exportation		1		1	1		**3**
Market development perspective		2	2				**4**
Core competencies			2				**2**
Environment	1		2	2			**5**
Marketing activities	1	1	3				**5**
Competition		2	1				**3**
Customer request	1	1	1		1		**4**
Loss of power	1				1		**2**
Total	**5**	**7**	**13**	**4**	**4**	**1**	**34**

The least frequent in the demography criterion is the industry. In the searched areas SME – SME of supplier/customers is more frequent than the others. There is similarity between the frequencies in industry internal and between industries of SME – LC and SME – SME (Table 2.16).

Table 2.16. Demographical criteria frequency

Demographical	Industry Internal		Within Industry		Supplier / Customers		**Total**
	SME-SME	SME-LC	SME-SME	SME-LC	SME-SME	SME-LC	
Firm age	1				3		**4**
Business experience		1		2	1		**4**
Firm size	2	1	1			1	**5**
Industry					1		**1**
Geographical		1	1	1	2		**5**
Total	**3**	**3**	**2**	**3**	**7**	**1**	**19**

2.4 Multi Criteria Decision Making and Innovation

The study for finding the best choice between various effective factors and solution alternatives to satisfy the expectations and objectives of the organization can be named as decision making. A decision environment is necessary for every decision, which consists of the gathering required information, alternative solutions, the preferences, predictions and values of the organization (Mateo, 2012).

The alternative solutions of the problem are arranged in an order, shortly ranked under the light of many criteria and subcriteria. Evaluation of these criteria and subcriteria is necessary for to create the priorities, to develop better alternative solutions, and to reach higher objectives. Human brain is suffering to measure and understand the effects of intangible factors on their decisions. The tangible factors can be measured and defined by numbers easily. The mathematics depends on the measurements and numbers, which is the essential of the science. The other more important factors for the decisions cannot be measured, since anybody knows anything how to measure them. The other more important factors for the decisions cannot be measured, since anybody knows anything how to measure them. To have the knowledge for their measurement will direct the human being to demonstrate and prove the new theories (Saaty, 2008).

The requirement of formal method helping to solve the multiple criteria problems, led to the Multi Criteria Decision Making (MCDM) techniques (Mateo, 2012). The problems which have contradicting objectives, various types of data, interests with complex social, economic or biologic situations, concern more than one subjects at the same time, and need high uncertainty can be solved by using the MCDM techniques; an application of Operations Research (Wang et al., 2009). The Multi objective decision making and Multi attribute decision-making (MADM) techniques are derived from this method later. MCDM or MADM technique is for deciding between the discrete alternatives (Mateo, 2012).

By using both of these methods complex managerial decisions can be made. These methods help to realize the distinctive aspects of the problem, to encourage the decision making staff. They are also useful to ease the conciliation on decisions and to understand the decision making process in the realistic manner. The needs for clearness, efficiency and rationality for decisions can be obtained and improved by these

techniques. The precedence about the problem can consulate, discuss and state easily by employing them (Pohekar & Ramachandran, 2004).

The most common methods of MADM problems are Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), analytic hierarchy process (AHP) and outranking. The PROMETHEE (Preference Ranking Organization METHod for Enrichment Evaluation) is one of the most used outranking techniques (Bozbura et al., 2007; Yoon and Hwang, 1995).

Feng et al. (2011) used an integrated method includes AHP, scoring method and weighted geometric averaging method for collaborative innovation research teams selection.

To evaluate the inclinations and choices of the stakeholders a specific AHP model application is used by Álvarez et al. (2013) in a distinctive social infrastructure projects.

An interactive selection model based on AHP was developed by Chan (2003) to ease the selection of suppliers by decision makers. The objective of the model was to state the relative weight of the criteria away from the human subjectivism. In that model AHP was employed only to produce the total grade of suppliers on the base of the relative weights. AHP has been used for analysis and selection of suppliers by Liu & Hai (2005) and Ho & Dey (2010). The pairwise comparison of AHP has not been employed, as Chan, to decide the relative weight grades between the criteria.

Decision making trial and evaluation laboratory technique (DEMATEL) have been used by Chang & Tzeng (2010), to decide the effects of innovation performance on the management skills of high technology businesses in the scope of adsorptive and dynamic abilities. An analytical network process (ANP) methodology was used to relate the intangible values and organizational performance in balanced scorecard nature, by Boj et al. in 2014.

A MCDM new application has been proposed by Tsai et al. (2010), to success the effective problem solving. This new approach was the combination of ANP, DEMATEL and zero-one goal programming.

Innovation decision ability is necessary to the knowledge management innovation and to decrease the indefiniteness and the risk activities, can be related to the R&D

capability. Where the goal of the study is to evaluate the intricate hierarchical relations, ANP and DEMATEL will be the best applicable methods.

A hybrid MCDM model has been used to analyze the environmental knowledge management of an organization in uncertainty by Tseng (2011). Fuzzy multi-criteria decision making (FMCDM) approach can be helpful to produce awareness of the critical effective factors. The factors affecting the success of implementation of knowledge management not only measure the probability of achievement of the project but also define the required operations for start performing the knowledge management. To measure the possibility of successful knowledge management, the fuzzy multi-criteria decision making approach is used by Chang and Wang (2009).

Fuzzy TOPSIS method has been proposed by Sun (2014) to analyze R&D strategic alliances problem in Taiwan Biotechnology Industry.

Environmental management performances of suppliers are evaluated by using VIKOR (VIseKriterijumska Optimizacija I Kompromisno Resenje) method among many of MCDMs by Büyüközkan and Feyzioğlu (2008).

2.5 Association Rules in Collaboration Innovation

The researches on the relationships between the industrial shareholders started at the beginning of the 21St century. This implies that the importance of this subject has been realized with the widespread of the outsourcing.

The first survey is made on literature for studies of Association Rule Mining and Methods in Web of Science Database. The first research is found in 1997 and the time line is detected to reflect the increasing interest in the subject.

In order to understand the usage of association rules targeting innovative collaboration of SMEs 70 scientific articles are analyzed. Analysis allowed perceiving the basic areas of interest for the relations varying as with SMEs and with Large Companies, which can be observed in a single industry, between industries or suppliers and customers. Furthermore, methods used to define association rules with the aim of innovative collaboration of SMEs survey pool is extended to the 112 articles which are used for method based classification.

Timeline of Association Rules Applications in Literature

The researches on association rule started in 1997 and the number of publications increased until 2007, most of the studies were done about general subjects in this period. Then the general purpose studies reduced because the specification starts (Figure 2.2).

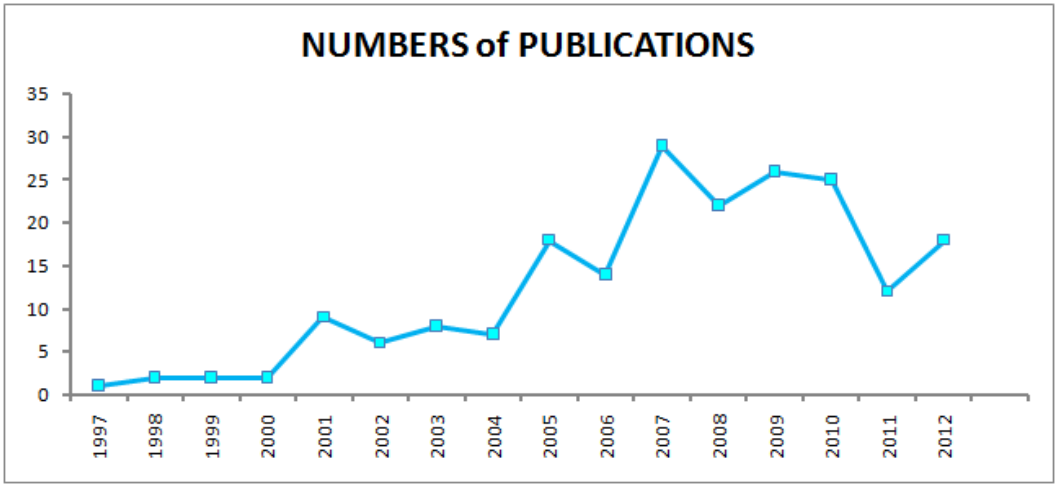


Figure 2.2. The number of published applications about association rules methodology in all areas – Year analysis

The usage of association rule in engineering is analyzed and the numbers of publications, the starting time seems 1999, but the reel beginning time is 2005 (Figure 2.3). This matches the starting time of specialization on association rule studies.

The annual distribution of the published studies on 'Association Rule Methodology in Data Mining' is researched. The number of published applications about this subject increased until 2006. Between 2009-2011 years there is slight decrease, and then, last year an increasing trend is observed (Figure 2.2). The analysis in engineering branch shows that beginning from 2005, it takes its place increasingly reached 8 researches on annual average (Figure 2.3). The 25% of these researches were done in 2010, and the maximum number is reached in this year.

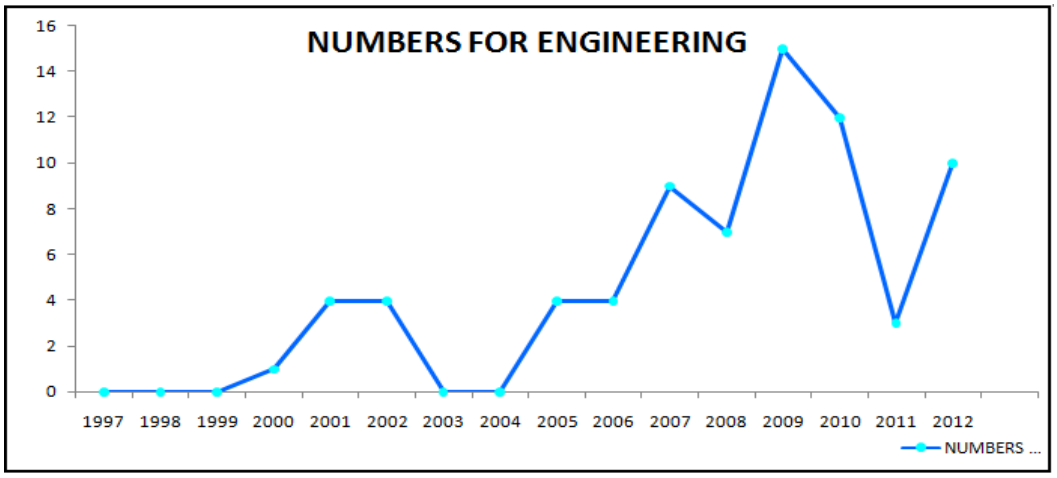


Figure 2.3. The number of published applications about association rules methodology in engineering area – Year analysis

When the methods of 112 papers written on 'Strategic alliances in SMEs for innovation' are studied; basically 12 methods were used. The classified methods and the numbers of usage are shown at Table 2.16 for the studied articles.

Table 2.17. Classification of methods

Methods	**Frequency**
Management methods	**5**
SWOT Analysis	
VRIO Analysis	
Cross-tabulation	
Basic Statistics	**16**
Frequency - mean – variance	
Graphical analysis	
Statistical and analytical techniques	
Experimental Design	**35**
Hypothesis testing	
Least Squares	
Correlation	
R - square test	
Chi-square test	
Logit model	

Table 2.16 (Continue)

Variance Analysis	
The causal-effect analysis	
Quantitative methods	**7**
Factor analysis	
Multivariate analysis	
Data mining	**5**
Rough set theory	
Clustering	
Association rule mining	
Classification	
Regression	**25**
Multi-criteria analysis	**4**
AHP	
Fuzzy AHP	
Fuzzy	**10**
Fuzzy AHP	
Fuzzy Association classification	
Fuzzy Association rule mining	
Fuzzy clustering	
Intelligent algorithms	**2**
Neural Network algorithm	
Genetic algorithm	
Case study	**7**
Qualitative methods	**5**
Empirical study	**<5**

The biggest part of the pie is covered by the experimental design methods with 35.28%; followed by regression methods with 25.20% and basic statistical methods with 16.13% (Figure 2.4). Most of the researchers preferred the numerical methods in general (Figure 2.5). As association rule mining is improved new state of the art methods are used to

make more detailed analysis from several dimensions. Since the competition in the globalized industries forced the firms toward outsourcing.

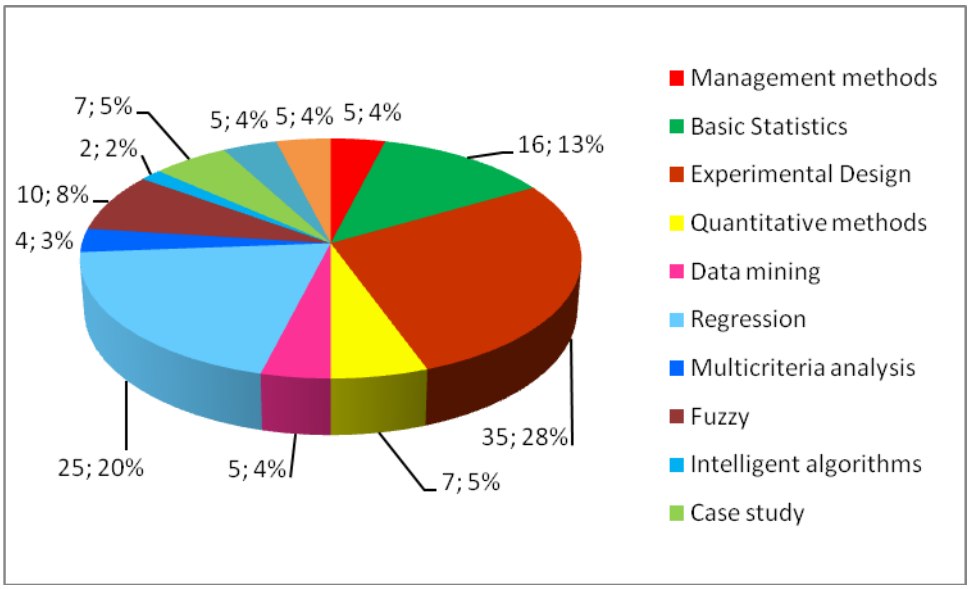


Figure 2.4. Distribution of method used in association rules targeting the innovative synergy

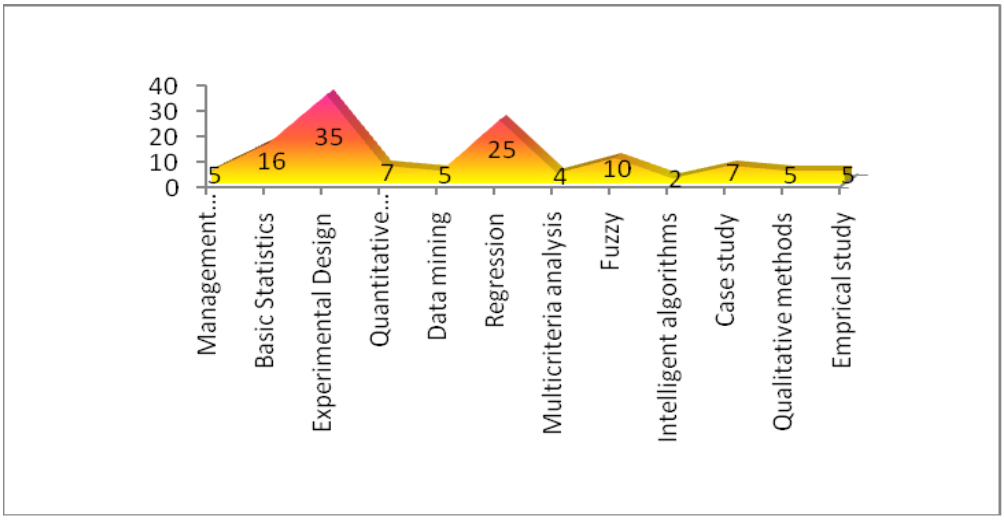


Figure 2.5. Frequency of method utilization in association rules targeting the innovative synergy

Binary Logistic regression method has been employed by De Mattos et al. (2013) in the study about the impact of R&D-specific factors on the attractiveness of SMEs. Theory-based hypothesis testing and multiple logistic regression methods have been used by Pullen et al. (2012) to increase innovation performance through the SME network characteristics vs. product innovativeness. The hypothesis testing and multinomial logit

models have been used by Romero (2011) in the study about analyzing the composition of the SME sector in high- and low-income regions. In the study of Navarro et al. (2007) about the factors affecting the use of e-government in the telecommunications industry of Spain the multinomial logistic regression method has been used. Logistic regression method has been used in the study of Clarke and Costello (2005) about the failure of SMEs in Ireland prediction. Bougrain and Haudeville (2002) has used the logistic regression of the likelihood model and Chi-square test techniques in the study about innovation collaboration and SMEs internal research capacities.

Fuzzy association rule mining technique has been used in the study about the expert systems with applications by Ho et al. (2012). In the study of Shengnan et al. (2011) on the effects of innovation alliance on network structure and association rules with apriori algorithm and predictive apriori algorithm methods have been used.

3 METHODOLOGY

3.1 Criteria Ranking Methodology

The main steps of MADM technique are definition of the criteria, development of alternatives, rating the weights of criteria, and ranking them (Vincke,1992). In the determined scope of decision every single criteria is associated to an objective, and transformation of criteria into an appropriate measurement is done by normalizing them (Jahan and Edward, 2013).

3.1.1 Analytic Network Process

The Analytic Hierarchy Process (AHP) brings a method to sort the alternatives of a problem according to the derived priorities. In practice it is interested to find the best arrangement of alternative solutions having the largest sum of priorities and satisfying the constraints of the problem. This type of problems can be solved easily by using the AHP technique. In AHP model the priorities of the alternatives are the coefficients of the variables of objective function in an linear programming problem. The constraints of the problem are expressions of the existing measurements. AHP can also be used to determine the coefficients of the constraints (Saaty, 2005).

The AHP is the theory of deriving priority grades by measuring with the pairwise comparisons under the light of the experts' decisions. The intangible relative factors can be measured in the priority scales. The pairwise comparisons are done by using a scale of absolute decisions to answer 'how much more'. Each compared element will dominate the other one with respect to the comparing attribute. The decisions of experts may be inconsistent. Measuring the inconsistencies and improving the decisions to decrease the inconsistencies are in the objectives of the AHP. The generated priority measures are evaluated with multiplication of them by their parents' priorities and adding on them (Saaty, 2008).

AHP method is very useful to find solutions for the decision making problems including multi criteria situations on various levels. The capacity of the method to built complex, multiple persons and multiple attributes problems make this method powerful and every level of hierarchy can be examined separately to integrate the results (Çakır et al.,

2009). The mostly used methods for pairwise comparisons are the questionnaire or contention of specialists (Ata and Sennaroğlu, 2008).

Analytic network process (ANP) supplies a general method to handle the decisions without making assumptions about the independencies of elements of upper level from that of lower level or the elements belong the same level. A network is used in ANP that the hierarchical priorities are not necessary (Saaty, 1990). ANP method is unique with the capability of evaluating multiple dimensions of data when analyzing. The quantitative, qualitative, tangible and intangible factors that affect the decision can be used in ANP, when evaluating the success attributes (Kayakutlu and Buyukozkan, 2011).

The ANP is selected among various MCDA techniques. ANP (Saaty, 1996; 2005) obtains the ability to show the defined links between intangible values and the strategic goals in a nonhierarchical network form including internal and external associations. Since these links between the elements are not hierarchical, the ANP has the advantage of it and this is the one of the conditions to apply other MCDA techniques. Both the quantitative and qualitative problems can be solved by using ANP; in the network most of the elements are assumed as intangible. Besides, the effects of the intangible elements, subjective part of the success of strategic goals, can be decreased by using ANP.

The need to make a decision starts with the human at earlier times. Everyone makes some decisions in daily activities. In the advanced societies the decisions have an important role. Managerial Decisions get more importance for the employees, societies and the governments. In decision making criteria and the alternatives are necessarily selected. Besides, measures are required to value the criteria and the convenience of judgment (Saaty, 2005). Therefore, to make a rational and optimal decision, which affects the future, it is necessary to use some decision making techniques and models. The most generally known multi criteria techniques are Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP).

Decision-making requires precedence of the ideas depending on the current or future circumstances. A main problem in decision-making is how to measure absolute criteria and how to evaluate measurements of tangible criteria correctly to yield sensible,

reasonable numerical results. A significant test is to ensure actual measurements can be used exactly as they are when needed.

ANP developed by Thomas L. Saaty (Saaty, 2005), obtains a method to input judgments and measurements to create ratio scale priorities for the distribution of influence among the factors and groups of factors in the decision. AHP is a forceful and deductive technique that permits groups or individuals to bring qualitative and quantitative elements in decision making process. The ANP has a very large extend that is available today to analyze social, governmental and corporate decisions.

This method permits to cover all the factors and criteria, which may be either physical or nonphysical, affecting making the best decision. The ANP evaluates both inner dependence (interaction and feedback within clusters of elements) and outer dependence (between clusters). The feedback best yields the unpredictable effects of interplay in human society, when there is risk and uncertainty. This process can be used for resource allocation according to their ratio-scale priorities, since it is based on derivation of ratio scale measurements. The AHP, a well-known decision theory, is a special case of the ANP. The AHP derives ratio scale priorities for elements and clusters of elements by making pairwise comparisons of elements on a common criterion like ANP. Many decision making problems can be best studied by using the ANP. When somebody wishes to compare the obtained results by using ANP with the results obtained by using the AHP or the obtained results of any other decision making technique with respect to time, the effort involved in making the decisions, and the convenience and certainty of the results.

Many decision making problems cannot be constructed hierarchically because of inner and/or outer dependencies, influences between and within criteria and alternative clusters. ANP is very useful to create solution for this kind of problems.

The ANP is mainly a method to measure absolute factors by using pair wise comparisons with judgments that describe the supremacy of one element over another with respect to a common feature (Saaty, 1999). It is a process of laying out a structure of all the necessary factors that affect the result of a decision. Numerical pairwise comparison decisions are then disclosed to define people's understanding of the importance, choice or likely effect of these elements on the result obtained by

synthesizing the priorities created from different sets of pair wise comparisons. Sensitivity analysis is done at the end to decide the stability of the result to broad disturbance in the judgments.

ANP models have two parts. The first part of it controls network of objectives and criteria that checks the interactions in the studied system. The second part is the sub-networks of interactions among the elements and clusters of the problem, one sub-network for each control criterion.

The reality of prediction by using ANP is appreciated in decisions that have been made to economic trends, sports and other events for which the outcome later became known. One of the major reasons for the strengths of the AHP is the employment of pair wise comparisons to derive precise ratio scale priorities, instead of using traditional approaches of "assigning weights" since it can also be difficult to justify. An Analytic Network Model of a problem may have a single network or a number of networks.

The ANP process has six major steps (Kayakutlu, & Büyüközkan, 2010):

Develop an evaluation network hierarchy showing the relationships among analysing factors.
Elicit pair-wise comparisons among the factors influencing the evaluation.
Calculate relative-importance-weight vectors of the factors.
Compose a supermatrix and normalize this supermatrix.
Calculate converged (“stable”) weights from the normalized super-matrix.
Determine overall weights of evaluation attributes

In this study to construct and analyze the ANP model, Super Decision software is used. The Super Decision is a software that developed for decision making with dependence and feedback, based on the mathematical theory of Thomas L. Saaty. It is a progressed version of his Analytic Hierarchy Process for decision making. AHP involves separating a problem into its decision elements, re-ordering them in a hierarchical structure, making decisions on the relative value of pairs of elements and combining the results. In the AHP this process follows a route from top to down. With the ANP, since there is a feedback between the elements in various and also between elements in the same levels of the hierarchy; the decision elements need to be organized into a network of clusters and nodes. The Super Decisions software is a package for creating decision

models with dependence and feedback and reaching results employing the supermatrices of the ANP. It is simple easy-to-use (Adams & Saaty, 2012).

Pairwise Comparisons and Calculate Relative – Importance Weight

These evaluations are answered according to the Saaty Scale to assign the precedencies. To rate the preferences of people different scales have been developed. The well known and most widely used of these scales is the Saaty Scale as seen in Figure 3.1 (Saaty, 2006). Likert (1932) developed the principle of rating the choices by asking people to answer to a series of questions on a special topic, their answers will be in terms of the extent to which they agree with them or not, and so tapping into the conceptual and impressive components of choices. Saaty has revised the Likert Scale to have even numbers as intermediate details (Yang, 2008).

Likert-type or frequency scales employ fixed answer formats and are prepared for rating attitudes or ideas. These ordered measures rates the levels of agreement/disagreement (McLeod, 2008).

1	equal importance
3	moderate importance of one over another
5	strong or essential importance
7	very strong or demonstrated importance
9	extreme importance
2,4,6,8	intermediate values
Use reciprocals for inverse comparisons	

Figure 3.1. Likert scale

Criteria which have weaker effect on another criterion, the score values vary between 1/9 and 1. If the value is 1 it means there is indifference; and 1/9 implies an extreme weight of column element on the row element. In scoring the pairs, the reciprocal of that value is input automatically to its corresponding element in the matrix. This means if a_{ij} is a matrix value assigned to the relationship of component i to component j, then

$$a_{ij} = 1/a_{ji}. \quad (3.1)$$

Also there is another important measurement for ANP model which is inconsistency value. The inconsistency is values related with the weights. Maximum consistency index:

$$C.I.=(\lambda_{\max}-n)/(n-1) \tag{3.2}$$

is the consistency index of a matrix. The ratio of C.I and the convenience of numbers given in Figure 3.2 is the consistency ratio (C.R). Each number is an average random C.I. that is calculated for very large population. Randomly produced reciprocal matrix can be created by using the scale starting with 1/9 and ending with 9. Produce the Random Consistency Index R.I. by computing average of their Eigen values.

Order	1	2	3	4	5	6	7	8	9	10
R.I.	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Figure 3.2. Random Index

The inconsistency measure is used to identify the potential errors in judgments as well as real inconsistencies in the judgments. Inconsistency measures the logical contradiction of the judgments. For example, if it is said that A is more important than B and B is more important than C and then C is more important than A this is not consistent (Saaty, 2003).

The geometric mean indicates the typical value of a set of numbers by using the product of their values. Since the arithmetic mean will work with the values themselves, it is advisable to use the geometric mean when working with percentages which are derived from values (MU, 2013). The main advantage of employing the geometric mean is that the actual values are not known, and presents fair comparisons of the same level of figure are realized.

Geometric mean can be defined technically as "the 'n' th root product of 'n' numbers", the mathematical formula for calculating geometric mean may be written as follows:

$$G=\sqrt[n]{x_1 x_2 \ldots x_n} \tag{3.3}$$

3.2 Association Methodology

Experimental design is a way to make a decision by using the data gathered from an experiment. This method is used if there are not enough samples to make a valid decision.

Hypothesis testing

A hypothesis in statistics can be defined as an assertion or an assumption about one or more populations. Before searching the whole population, it cannot be predicted the hypothesis is true or not. Since searching the whole population is impractical, a randomly selected sample is taken and the data of this sample is tested whether it supports the hypothesis. If it supports, accept the hypothesis, in another words, the hypothesis is true, otherwise reject it. The hypothesis that will be tested is named as ***null hypothesis*** and abbreviated with $\boldsymbol{H_0}$. If the null hypothesis is rejected, it means that another hypothesis – alternative hypothesis- $\boldsymbol{H_1}$ is true (Walpole et al., 2007).

Least Squares methods

Generally, in the real world everybody thinks that the relationships between variables are linear. The Least Squares Method is used to determine the best fit line to the studying data by the help of simple calculus and linear algebra. The aim is to find the best fit straight line.

The method easily generalizes to finding the best fit of the linear form. Here, the function of x may not be linear; but y has to be a linear combination of these functions.
For the dataset $\{(x_1, y_1), \ldots, (x_N, y_N)\}$, saying the linear relationship

$$\mathbf{y = ax + b} \tag{3.4}$$

The error of this expression can be calculated by

$$E\ (a,b) = \sum_{n=1}^{N} (y_n - (ax_n + b))^2 \tag{3.5}$$

Statistically this expression is N times of the variance of the data set;

$$\{y_1 - (ax_1 + b), \ldots, y_N - (ax_N + b)\} \tag{3.6}$$

The goal is to calculate the values for “a” and “b” that will minimize the error (Arun, 1992).

Correlation

The term correlation is used to describe the strength of a relationship between two variables. Correlation, as regression analysis is trying to find relationships among variables. The correlation coefficient is a measure of linear relationships between two variables and its value changes in between -1 and +1. Where the correlation coefficient is +1; it proves that there is a perfect positive correlation between these two variables; -1 correlation coefficient of shows that two variables have perfectly negative correlation. If the value of correlation coefficient is 0; it means that there is no correlation between the test variables.

The most common used correlation coefficient type is the Pearson r. This analysis assumes that the two variables being analyzed are measured on at least interval scales. The coefficient is calculated by taking the covariance of the two variables and dividing it by the product of their standard deviations (Ewans and Olson, 2007).

Chi - Square Test

This test is a nonparametric statistical analyzing method to measure the dependencies between the two or more datasets. It generally employed in experimental work where the data is consisted of frequencies or ‘counted values’ differing from quantitative data obtained from measurement of continuous variables. Chi-squared test can be applied to only discrete data. For testing the continuous data by using chi-squared test of course, continuous data must be converted into discrete form by the use of intervals on a continuous scale. The test is used frequently to define the probability of association or independence of facts (Maxwell, 1971).

Logit model

Logistic regression is used to show the effect of chronical presented multiple independent variables when determining membership of the two dependent variable categories. The logistic regression can be used effectively to solve the decision making

problems having the categorical, or a mix of continuous and categorical independent variables and categorical dependent variables.

Logistic regression has two main application areas: The first is deciding the group membership of a variable. Since logistic regression measures the probability of success over the probability of failure, the output of the analysis are in the form of ratio of probabilities. Logistic regression also gives information about the relationships and their strengths between the variables (Burns and Burns, 2009).

3.2.1 Multinominal Logistic Regression Analysis

A model is the configuration of information or ideas according to definite rules. The logistic regression analysis is used for the same goal with the other statistical model constructing methods. The main aim of this type analysis is to construct an acceptable model that will identify the relationships between the dependent and independent variables with the best conformity by using minimum numbers of variables. The logistic regression analysis is mainly focused on building an equality to predict an individual belongs to which group. The normal distribution of independent variables does not require the linearity and equality of variance and covariance matrices. Because of this the logistic regression analysis is known as more flexible than the other two methods. It is necessary big examples to get objective and accurate statistics with logistic regression analysis (Çokluk, 2010).

Mathematical models, that are constructed by using logistic regression analysis are known by the ease of interpretation .Since the aim of logistic regression analysis is to estimate the value of the dependent variable, people try to estimate the 'membership' of two or more groups. It may be said that one of the aims is classification, and the other is search for relationships between the independent variables (Çokluk, 2010).

Moreover, it is an alternative for linear regression analysis for the cases where the dependent variable has binary values as 0 and 1, or the cases having polychotomous (Özkan and Çamdeviren, 2000) variables because of unsatisfied normality condition.

The logistic regression analysis name comes from the logit transformation that is applied to dependent variable. This makes some differences through the processes of interpretation and prediction. The logistic regression analysis is split into three

according to the scale of dependent variables, and the number of choices of dependent variable. If the dependent variable is a categorical variable with only two choices, it is named as Binary Logistic Regression Analysis. If the dependent variable is a categorical variable having more than two choices, it is named as Multinomial Logistic Regression Analysis (Çokluk, 2010).

The reasons for the widely use of logistic regression analysis in the last years is defined as (Çokluk, 2010):

The dependent variable is categorical (discrete), at the same time, the independent variables are continuous, categorical or binary. Logistic regression analysis does not have any limitation about the continuity of independent variables.

The parameters of the logistic model can be interpreted easily and the generated mathematical functions can be used easily.

There are many of software (SPSS, SAS, etc.) to analyze the logistic model.

Various tests can be applied because there is any limitation on the distribution of the probability functions of independent variables.

Logistic regression analysis does not produce negative regression probabilities, all probability values are positive and their range varies between 0 and 1.

It is not required the relationship between the dependent and independent variables to be linear, it may be exponential or polynomial in logistic regression. It is assumed that there is a logit relationship between the dependent and independent variables; this implies the ability to generate non-linear models to logistic regression. In other words, logistic regression makes logarithmic transformations to make the relationship linear by keeping the non-linear relationship. Especially, logistic regression analysis is very useful, if it is known or estimated that the dependent variable has non-linear relationship with one or more independent variables.

The classified discrete variables are identified as categorical variables. If the dependent or independent variables are categorical; the outputs can be rearranged in the models. In the logistic regression models, the dependent variables are always categorical, and these

are called as binary or dichotomous variables if these have two levels and polychotomous variables if these have three or more levels. The independent variable or variables used in the model may be in the form of discrete or continuous (Özkan and Çamdeviren, 2000).

Logistic regression model provides an alternative approach to chi-square tests which can not be used for the cross tables' analysis when the precondition of normal distribution is not assured and importance tests for differences between ratios. The dummy variables which are generated for dependent and independent scaled variables, defines the comparison variables. Namely, the comparisons are made according to the selected reference categories. All the other possible comparisons out of these can be made according to different factors and variables as references (Özkan and Çamdeviren, 2000).

In the logistic regression, the maximum likelihood is used instead of ordinary least squares method to predict the model (Menéndez et al., 2009). Because of the nonlinear nature requiring logistic transformation, the maximum likelihood method is used. This method is used to find the maximum likelihood prediction of parameters. The logistic regression deals with the probability of an occurrence to maximize instead of to minimize the squares of deviations (Çokluk, 2010).

Probabilities are the ratio of number of a particular outcome to total number of outcomes. For example the probability of 3 in throwing a dice is 1/6, since there is only on face with three dots and there are 6 outcomes. This can be expressed as 0.167 or 16.70%. In logistic regression the odds is ratio of the probability of realization of an outcome to the probability of non realization of an outcome (Çokluk, 2010).

$$\text{Odds} = \frac{p(x)}{1 - p(x)} \tag{3.7}$$

Where p(x) is the probability of realization of x, and probability of non realization of x is 1-p(x). Then the Odds of probability of 3 in throwing a dice is:

$$\text{Odds} = \frac{p(\text{"3"})}{1 - p(\text{"3"})} = 0.1667 / 0.8333 = 0.200$$

The important point here is the probabilities are in the range between 0 and 1. But the odds value can be greater than 1. The effect of independent variable on the contradicting results is represented by odds ratio. Odds ratio is symbolized by Exp (***B***), is called Exponentiated Logistics Coefficient.

The resulting model (objective model) of the logistic regression analysis is a non-linear function. The key concept of the logistic regression is "***logit***" concept. Logit is the natural logarithm of odds. For the above example, logit is:

ln (0.200) = 1.609

Especially in logistic regression P_Y is the probability of an outcome or the other, depending on the non-linear model resulting with the best possible linear combination of regressing variables. If the probability, odds and logit concepts are gathered into a single equality:

$$P_{Y_i} = e^u / (1 + e^u) \tag{3.8}$$

Where, P_{Y_i} is the predicted probability about the ith subject belongs one of the categories.

e is a constant which is equal to 2.718.

u is the classical regression equality.

$$u = B_0 + B_1 X_1 + B_2 X_2 + ... + B_k X_k \tag{3.9}$$

Linear regression equality (***u***) is the natural logarithm of the ratio of probability of belonging a group to the probability of belonging another group. The linear regression equality creates the log or logit of the odds ratio.

$$\ln\left(P_Y / (1 - P_Y) \right) = B_0 + B_1 X_1 + B_2 X_2 + ... + B_k X_k \tag{3.10}$$

In the case of the dependent variable is categorical, the distribution of faults are binomial or multinomial. In the logistic regression analysis, the distribution of faults must be normal to apply the linear probability model. To convert the distribution of

faults to normal and to construct a linear model with the parameters, the natural logarithm (ln) of Odds ratio is taken.

The Transformation of a Probability to Odds and Logit Values:

Logistic transformation process do this in two steps.

The reexpression of Probability as Odds:

In its original structure, the range of probability is in between 0 and 1. But, the odds ratio range is not limited 0and 1. Because of this, the probability of a new variable is limited in the range of 0 and 1 is achieved by re-expression of the probability in terms of odds. Odds is the ratio of the probability of one of the two results. i.e. p/1-p. By using this expression any probability value is denoted as a predictable metric variable. Any odds value can be transferred to a probability between 0and 1. In this way, the problem of limitation of in 0 and 1 range for regressing values reaches a solution.

This shows that the 0.50 probability value implies that the odds value is 1. The odds value is greater than 1 if the probability of objective outcome is greater than 0.50, and the odds value is less than 1 if the probability of objective outcome is less than 0.50. In this way, a metric variable is created that can be transformed always to a probability value between 0 and 1.

Calculating the Logit Value:

Another problem waiting for solution is about prevention of the odds when value is negative. There is no upper limit for odds, where the lower limit is 0. Logit is the natural logarithm of odds. Logit is negative if odds is less than 1, and is positive if odds value is greater than 1. If odds value is 1 (probability is 0.50) logit is 0. The negative value can be transformed to a positive value by taking the antilog of it. By calculating the logit value, a metric variable is obtained that can be positive or negative, can be transformed to a probability between 0 and 1.

3.2.2 Association Rule Mining

Data mining is the process of extracting interesting (non-trivial, implicit, previously unknown and potentially useful information or patterns from large information repositories.

Given a set of transactions, define rules that will exhibit that the occurrence of an Item based on the occurrences of other Items in the transaction. This is the *association analysis*. It is useful to explore the interesting relationships which are embedded in the huge data sets. These hidden relationships can be stated in the form of *association rules* (Tan & Kumar, 2005).

For example about Market-Basket transactions:

Table 3.1. Market basket transactions example

TID	Items
1	{ Bread, Milk}
2	{Bread, Diapers, Milk, Eggs}
3	{Milk, Diapers, Beer, Cola}
4	{Bread, Milk, Diapers, Beer}
5	{Bread, Milk , Diapers, Cola}

According to the Table 3.1 (Tan & Kumar, 2005) one can state an association rule that there is a strong relationship between beer and diapers, because many customers bought beer with diapers at the same time. More rules can be stated from the above table as:

{Diaper} → {Beer},

{Milk, Bread} → {Eggs, Coke},

{Beer, Bread} → {Milk},

These association rules can be used by retailers to help the new promotion campaigns to sell products to customers. Association analysis is a very useful tool for bioinformatics, medical diagnosis, web mining, and scientific data analysis. One can find a relationship between the ocean temperature, land and the atmospheric pressure. This rule may help to understand better the changes in climatic conditions of the Earth.

To apply the association analysis to market basket data there are two key issues which must be addressed. One is the expensiveness of finding the relationships in the large dataset. Other is the falseness of discovered rule; the relationship between two occurrences may happen by chance.

Table 3.2. Market Basket Transaction – Binary representation

TID	Bread	Milk	Diapers	Beer	Eggs	Cola
1	1	1	0	0	0	1
2	1	0	1	1	1	0
3	0	1	1	1	0	1
4	1	1	1	1	0	0
5	1	1	1	0	0	1

Frequent Item set Generation

The market basket data is represented in the binary format above in Table 3.2 (Tan & Kumar, 2005). The rows show the transactions and the columns show purchased Items. If any Item is occurred in a transaction the value is "1", otherwise "0".

Item set is the collection of one or more Items. Example:

{Milk, Beer, Diaper}

k-Item set is an Item set that contains k Items

Support count (**σ**) is the frequency of occurrence of an Item set. Example;

σ ({Milk, Beer, Diaper}) = 2

Support (s) is the fraction of transactions that contain an Item set. Example:

$$s(X \rightarrow Y) = \frac{\sigma(X \cup Y)}{N} \qquad (3.11)$$

s({Milk, Beer, Diaper}/{Milk, Diapers, Beer, Cola, Eggs}) = 2/5

Frequent Item set is an Item set whose support is greater than or equal to a *minsup* threshold.

Confidence (c) measures how often Items in Y appear in transactions that contain X

$$c(X \rightarrow Y) = \frac{\sigma(X \cup Y)}{\sigma(X)} \quad (3.12)$$

C= σ ({Milk, Beer, Diaper})/ σ ({Milk, Diaper}) = 2/3

The strength of an association rule is measured with its support and confidence values. Support shows the how often that rule is applicable to a given dataset. The confidence is the occurrence frequency of the Item in that transaction.

Tasks

Given a set of transactions T, the goal of association rule mining is to find all rules having

support ≥ *minsup* threshold

confidence ≥ *minconf* threshold

Brute-force approach to association rule mining:

List all possible association rules

Compute the support and confidence for each rule

False rules that fail the *minsup* and *minconf* thresholds

Two-step approach:

Frequent Item set Generation; generate all Item sets whose support ≥ minsup.

Brute-force approach:

Each Item set in the lattice is a candidate frequent Item set,

Count the support of each candidate by scanning the database,

Match each transaction against every candidate.

Rule Generation: Generate high confidence rules from each frequent Item set, where each rule is a binary partitioning of a frequent Item set.

Strategies:

Frequent Item set generation strategies consist of reducing the number of candidates, transactions and comparisons.

Reduce the number of candidates (M)

Complete search for total number of Item sets.

Use pruning techniques to reduce M

Reduce the number of transactions (N)

Reduce size of N as the size of Item set increases

Used by DHP and vertical-based mining algorithms

Reduce the number of comparisons (NM)

Use efficient data structures to store the candidates or transactions

No need to match every candidate against every transaction.

Apriori Principle

To reduce number of candidate Item sets and transactions the Apriori Principle is an effective tool. Apriori Principle states that "*If an Item set is frequent, then all of its subsets must also be frequent*."

$$\forall X, Y \in J : (X \subseteq Y) \rightarrow f(X) \leq f(Y) \tag{3.13}$$

This means: if *X* is a subset of *Y*, then *f*(*X*) must not exceed *f*(*Y*).

Apriori principle holds due to the following property of the support measure: "*Support of an Item set never exceeds the support of its subsets."* This is known as the *anti-monotone property* of support. Hence, *Apriori relationship avoids f to be monotone.*

An illustration of Apriori Principle is shown at Figure 3.3 (Tan & Kumar, 2005). If {c, d, e,} is frequent, then all subsets of these Items are frequent also.

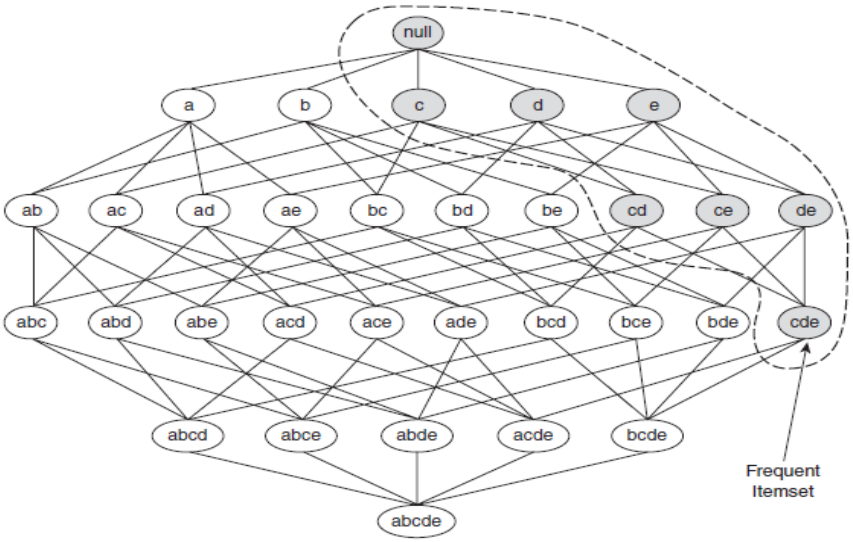


Figure 3.3. An illustration of Apriori Principle – Frequent Item set

The opposite of this statement is also valid. "*If an Item set is infrequent, then all of its subsets must also be infrequent*." For example in Figure 3.4 (Tan & Kumar, 2005); for {a, b}.

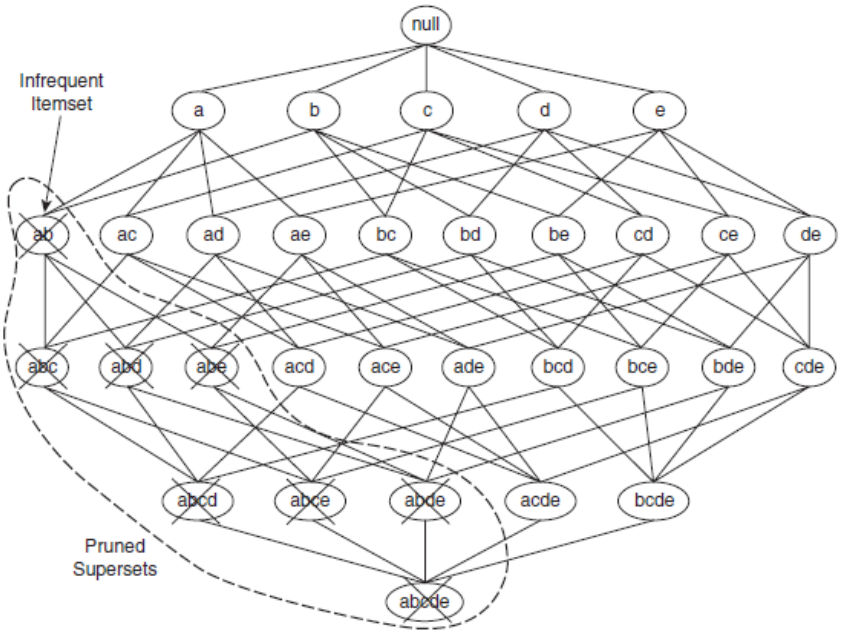


Figure 3.4. An illustration of Apriori Principle – Infrequent Item set

The first association rule mining algorithm is the Apriori, the use of support-based pruning to control the exponentially growing candidate Items. Figure 3.5 (Tan & Kumar, 2005) shows frequent Item set generation part of Apriori algorithm for the market basket example discussed at the beginning.

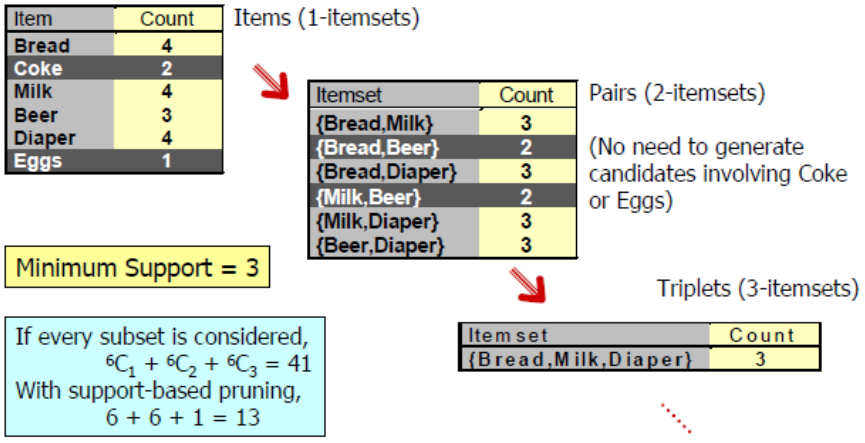


Figure 3.5. Illustrating Apriori Principle – A generation example

Table 3.3. An illustration of Apriori Principle – Logic of generation example

TRANSACTIONS	**ITEM SETS**						**NUMBER OF ITEM SETS**
Bread (1)	1						1
Coke (2)	2						1
Milk (3)	3						1
Beer (4)	4						1
Diaper (5)	5						1
Eggs (6)	6						1
NUMBER OF 1-ITEM SETS							**6**
	1	**2**	**3**	**4**	**5**	**6**	
1		12	13	14	15	16	5
2			23	24	25	26	4
3				34	35	36	3
4					45	46	2
5						56	1
6							
NUMBER OF 2-ITEM SETS							**15**
	1	**2**	**3**	**4**	**5**	**6**	
12			123	124	125	126	4
13				134	135	136	3
14					145	146	2
15						156	1
16							
23				234	235	236	3
24					245	246	2
25						256	1
26							
34					345	346	2
35						356	1
36							
45						456	1
46							
56							
NUMBER OF 3-ITEM SETS							20
NUMBER OF ALL ITEM SETS							41

Here, as shown in the above, there are 6 transactions having counts 1, 2, 3, and 4. The minimum support is chosen 3, and 2 Item sets are eliminated. The second iteration has 15 2-Item sets, and 2 of them are eliminated since their counts are less than 3. The third iteration has 20 3-Item sets, if any Item sets were not eliminated before. Total number of Item sets that would be iterated is 41. By elimination the Item sets having support less than 3, total number of Item sets that will be iterated is 13 (Table 3.3).

The Apriori algorithm has two important characteristics at frequent Item set generation. Apriori algorithm traverses the Items screen one level at a time, from frequent 1-Item set to the maximum size of frequent Item sets; this is the ***level-wise algorithm***. New candidate Item sets are generated in an individual iteration by using the frequent Item sets which are explored in previous iteration; this is the ***generate-and-test strategy***.

Candidate Generation and Pruning

The candidate Item sets are generated with Apriori generation function in two steps:

> Candidate Generation: **Generating** an Item set by employing the previous iteration.
>
> Candidate Pruning: Eliminating some of the candidate Item sets generated in the last iteration by employing the support based pruning strategy.

There are several candidate generation techniques, some of these are ;

Brute-Force Method:

In this method first step is listing all possible association rules, second step is to computing the support and confidence for each rule and last step is pruning rules that fail the minsup and minconf thresholds

Fk-1×F1 Method: An alternative method for candidate generation is to extend each (k-1) Item set with other frequent Item sets. For every candidate k-Item set which wins the pruning step, every Item in the candidate Item set have to be covered by at least k-1 of the (k-1) Item sets. If not, the candidate is infrequent.

Fk-1×Fk-1 Method: In this candidate Item set generation method, only if the first k-2 Items of a (k-1) Item sets pair is identical; the Apriori generating function will join the frequent (k-1) Item sets.

Support Counting

It is the process of calculating the frequency of occurrence for every candidate Item set that passed the candidate pruning step.

One of the several ways to do this is updating the support counts of candidate in the transaction after comparing each transaction with every candidate Item set. This way is expensive if there are large numbers of transactions and candidate Item sets.

Another way is using the transactions to update the support values of their respective candidate Items after enumerating the Items which are contained in each transaction.

The systematic way to enumerate the 3 Item sets belonging *t* is shown below in Figure 3.6 (Tan & Kumar, 2005).

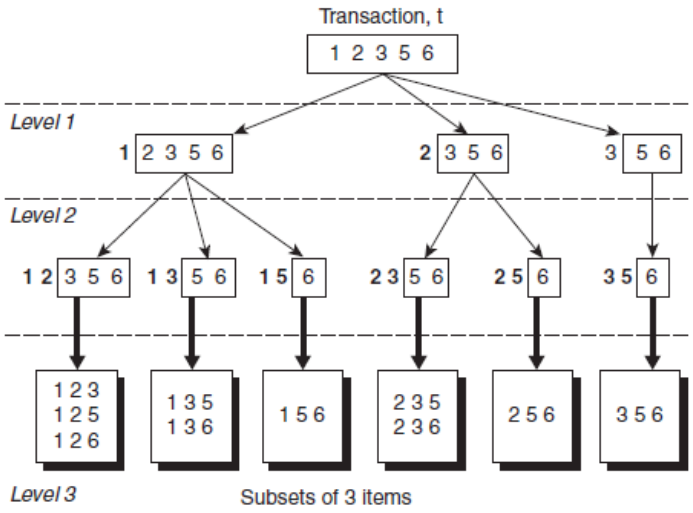


Figure 3.6. Listing subsets of three Items form transaction f.

An example of ruler generating: Given a frequent Item set L, find all non-empty subsets f ⊂ L such that f → L – f satisfies the minimum confidence requirement.

If {A, B, C, D} is a frequent Item set, candidate rules:

ABC →D, ABD →C, ACD →B, BCD →A,

A →BCD, B →ACD, C →ABD, D →ABC

AB →CD, AC →BD, AD →BC, BC →AD,

BD →AC, CD →AB,

The main approach in Apriori algorithm to generate association rule is level-wise approach, each level defines to the number of Items that belong to the rule consequent. New candidate rules will be generated from these rules.

Candidate rule is generated by merging two rules that share the same prefix in the rule consequent

join(CD=>AB, BD=>AC) would produce the candidate rule D => ABC

Prune rule D=>ABC if its subset AD=>BC does not have high confidence (Figure 3.7) (Tan & Kumar, 2005).

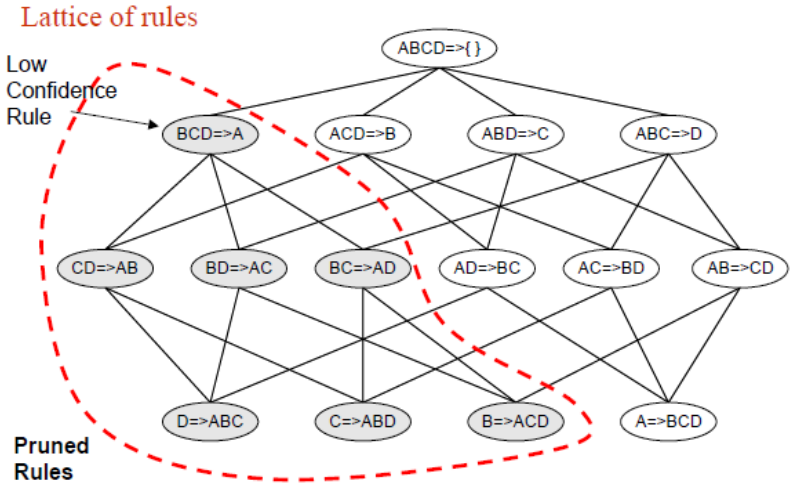


Figure 3.7. An illustration for lattice of rules

Maximal frequent Item set: An Item set is maximal frequent if none of its immediate supersets are frequent (Figure 3.8). An Item set is closed if none of its immediate supersets has the same support as the Item set. An Item set is closed frequent Item set if it is closed and its support is greater than or equal to minsup (Tan & Kumar, 2005).

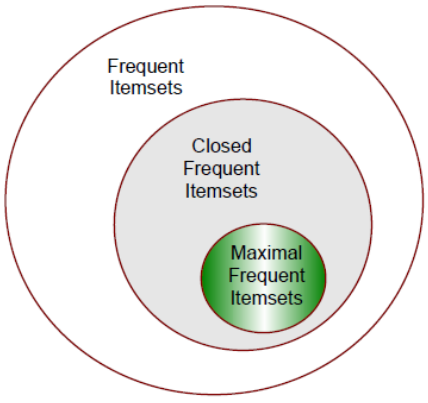


Figure 3.8. Relationships of Item sets

Computational Complexity

The Apriori Algorithm's computational complexity is affected by the below factors.

Support Threshold: If the support threshold decreases, the number of candidate Item sets will increase, because more Item sets will be frequent Item sets. Lowering support threshold results in more frequent Item sets, this may increase number of candidates and max length of frequent Item sets.

Number of Items: Larger numbers of Items require more space to store them. If number of frequent Items also increases, both computation and I/O costs may also increase.

Number of Transactions: Since Apriori makes multiple iterations, run time of algorithm may increase with larger number of transactions.

Average Transaction Width: The average transaction width will be larger if the data set is dense. This will affect the complexity of algorithm in two ways. The maximum size of frequent Item sets will increase as the average transaction width increases. And, as the transaction width increases, more Item sets belong to the transaction.

Aposteriori Algorithm

The aposteriori method starts by generating, as densely as possible, the tables of Sets and Rules and one main mining operation. Here the minimal support and the focus variables are adjusted as low as required. The second step is employing the actual data mining algorithm (Goethals, & Van den Bussche, 1999).

This method is filtered mining algorithm combined with the Reorder Direct algorithm having more distinctive notation and more effective than the antecedent algorithms. The filtering is not an excessive operation; since it does not generate any Item set explore a rule satisfying the filter.

An important characteristic of this algorithm is generated Item sets are not indexed by hashing. But, by using a tree, the standard data and ordered sets are indexed. The filters are incorporated naturally and directly because of the tree usage.

4 CRITERIA CHOICE AND THE MODEL OF THE STUDY

4.1 Criteria Ranking

Following the definition of collaborative innovation criteria extracted from the literature and generating the clusters of attributes in literature taxonomy, the Multi Attribute Decision Making (MADM) techniques can be employed to sort and select the optimal criteria for this study. The decision variables can be quantitative or qualitative.

The steps of the MADM are development of alternatives, establishment of criteria, evaluation of alternatives, appointing the weights to criteria, and the ranking system application (Vincke, 1992).

In order to understand the association rules in business applications through innovative SME collaboration scientific articles are analyzed to select and rank the business criteria using Analytical Network Process (ANP) method. The flow of ANP usage can be summarized as the following:

During the interviews with professionals, ranking and prioritizing methods are used.

In the information collection phase, three interviews are done with the innovation experts.

After these interviews the basic requirement is defined to be flexibility of multiple and conflicting criteria to enable the decision makers

The provision for incorporation of qualitative and quantitative measurements are evaluated in the ranking phase.

4.1.1 Evaluation network hierarchy

Through literature survey, the criteria are studied in three different dimensions as the targets. The first of these is industry internal, the second is between industries and the third is in supplier/customer relations. These dimensions are divided into two groups as the sub targets according to the relationships; Small and Medium-sized Enterprises (SME) – SME and SME – Large Company (LC). Figure 4.1 shows the network and interactions in the model.

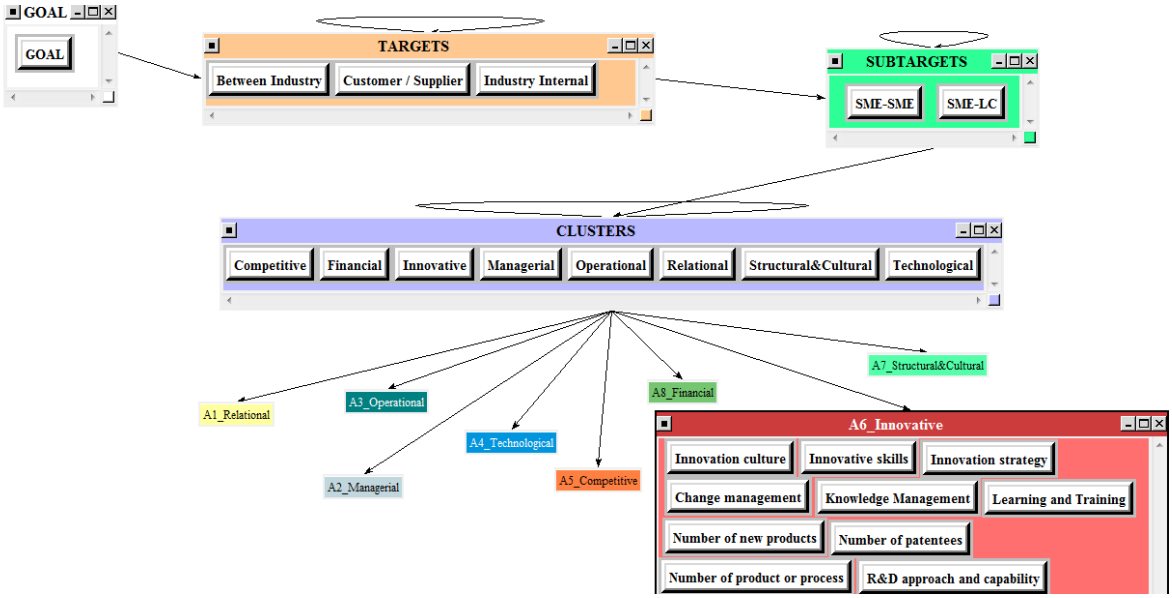


Figure 4.1. Network model view form Super Decision

4.1.2 Construction of supermatrix

Table 4.1 is the detailed submatrix of initial supermatrix of this proposed model; for instance, "C" is a submatrix and represents the effect between subtargets and targets.

Table 4.1. Submatrix of initial supermatrix

Sub matrix	GOAL	Targets	Sub Targets	Clusters
GOAL	0	0	0	0
Targets	**A**	**B**	0	0
Sub Targets	0	**C**	**D**	0
Clusters	0	0	0	**E**

4.1.3 Pairwise comparisons and calculate relative – importance weight

The precedencies and the interactions of Goal, Target, Sub-target and Clusters are determined by one expert in this model.

Inconsistency measures the logical contradiction of the judgments. For example, if it is said that A is more important than B and B is more important than C and then C is more important than A, this is not consistent. In this proposed model the inconsistency values are between 0.12 and 0.42. So these values are acceptable.

The evaluations of the experts are operated using the Super Decision tool to form pair wise comparisons tables. The weights are calculated from these pair wise comparisons in Super Decision software. Resultant weights are explained in the following sections.

Goal – Targets – Sub Targets:

In the evaluation of Target with the Goal it is perceived that the Customer/Supplier relation is more important than the Industry Internal and Between Industries (Within Industries).

In the analysis of cooperation between SME-SME and SME-LC it is accepted that Customer/Supplier and Industry Internal relations are more frequent than the Within Industries.

At the view of the Customer/Supplier, in the cooperation between SME-SME and SME-LC, the SME-LC is preferred. The Industry Internal view implied that the SME-LC relations have more importance than the SME-SME relations as it was Customer/Supplier factor.

The Managerial, Financial, and Operational clusters have precedence for SME-LC cooperation. Competitive and Innovative clusters are found more important than Relational and Structural &Cultural for SME-SME cooperation.

Clusters:

The main 8 clusters which were created from the attributes found in literature, are evaluated according to SME-SME and SME-LC alliances. These are:

Managerial

Financial

Operational

Competitive

Innovative

Relational

Structural &Cultural

Technological

These clusters are affecting each other since they have interrelationships. For Competitive balance, “Financial” is more important than “Innovative” (Figure 4.2); whereas “Financial” has more importance than “Structural &Cultural” for Innovative balance.

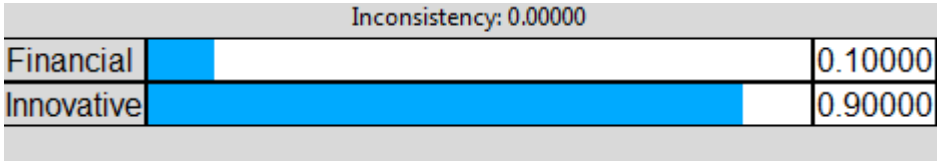


Figure 4.2. Respect to competitive

Managerial cluster has relationship with Competitive, Financial, Innovative, Structural&Cultural and Technological clusters. In the view of managerial cluster, Competitive, Structural&Cultural and Financial are important respectively.

Financial cluster has bigger precedence than Structural & Cultural in the sight of Operational criterion. Relational cluster has relevance with Competitive and Innovative. In this relationship Innovative is found more important than Competitive.

Attributes:

The five experts, who have publications on collaborative innovation, are asked to evaluate the attributes of 8 clusters. The evaluations are made according to Saaty Scale and the geometric means of these responses are calculated.

Where n>0 and represents the number of variables in the series. In this study n is equal to 5.

At the sight of Innovative Collaboration, Competition Style and Understanding of Requirements are found respectively important to assure the Competitive Balance. In the view of Financial criterion, the Impact of the Capital and Expenditures criteria are respectively important than the others. Innovation Culture, Unconstrained Creativity and Innovative Skill criterion has bigger precedence in the sight of Innovative criterion. Leadership, Commitment and Coordination & Cooperation criteria have approximate weights according to the Managerial point of view. Design Operations and Demand &

Supply Management have importance for the Operational criteria. In the Relational criterion, Honesty and Loyalty have more weights than the other criteria respectively. Communication Technology, Information & Knowledge Sharing and Connectivity criterion has bigger precedence in the sight of Technological criterion.

At the sight of Structural & Cultural cluster, Cultural Differences and Culture criteria have more importance according to the Managerial point of view as a result of pair wise comparison in Table 4.2. Figure 4.3 shows the weights and distribution of attributes in Structural & Cultural cluster.

Table 4.2. Pair wise Comparisons of Structural & Cultural Attributes

	Cultural differences	Culture	Firm age	Firm size	Geographical	Industry	Integrative spirit	Organizational structure
Business experience	0.58	1.53	0.48	0.28	1.22	3.27	1.71	2.54
Cultural differences		2.92	3.27	3.00	0.69	2.76	5.28	4.22
Culture			3.27	3.00	2.76	2.76	2.03	1.00
Firm age				1.22	1.00	2.08	0.41	0.41
Firm size					1.00	3.27	1.19	0.41
Geographical						1.00	3.00	0.27
Industry							0.75	1.22
Integrative spirit								4.22

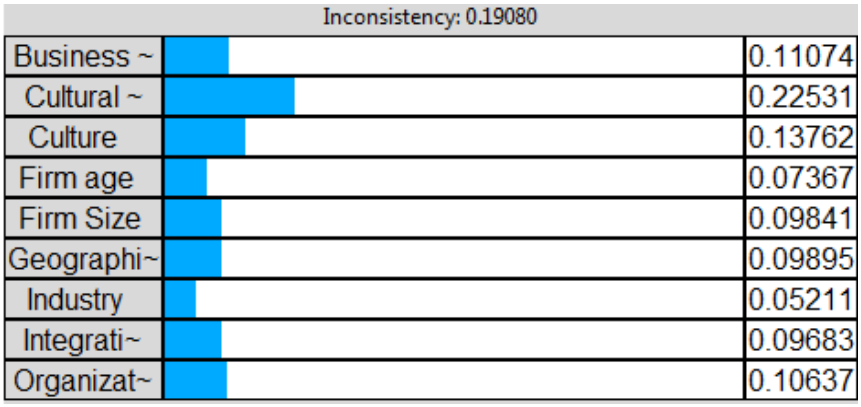


Figure 4.3. Pair wise comparisons of Structural & Cultural Attributes

4.1.4 Calculation of stable weights from the normalized super-matrix

In this step the goal is to determine the final relative importance weights of supermatrix elements. The need in convergence is to have each column to sum up to 1. To obtain this rule, each of the columns should be normalized by dividing the weight in the column by the sum of that column. Also to converge to the final weights, supermatrix is normalized to the power which is a large number. When the values in the supermatrix do not change, it is defined as convergence. For this model, the convergence is applied by Super Decision software.

As it is seen at Table 4.3 the effect of dimension Customer/Supplier on the goal has the greatest value. By the same way; the effect of SME-LC on Customer/Supplier and Industry Internal is more than the effect of SME – SME on the Within Industry.

Table 4.3. The weighted supermatrix

		GOAL	**TARGETS**			**SUBTARGETS**	
			BI	**C/S**	**II**	**SME-LC**	**SME-SME**
GOAL		0.000	0.000	0.000	0.000	0.000	0.000
TARGETS	**WI**	0.170	0.000	0.750	0.000	0.000	0.000
	C/S	0.739	0.000	0.000	0.000	0.000	0.000
	II	0.091	0.000	0.150	0.000	0.000	0.000
SUBTARGETS	**SME-LC**	0.00	0.000	0.875	0.875	0.000	1.000
	SME-SME	0.000	1.000	0.125	0.125	1.000	0.000

The weights of inter-effect of clusters are seen on Figure 4.4. The most influential clusters are;

Competitive on Relational,

Financial on Operational,

Innovative, Innovative on Competitive, and

Structural on Managerial.

Super Decisions Main Window: Most Effective Criteria_ver4_GK_010713__avr_5.sdmod: Weighted Super Matrix

Cluster Node Labels		CLUSTERS							
		Competitive	Financial	Innovative	Managerial	Operational	Relational	Structural& Cultural	Technological
CLUSTERS	Competitive	0.000000	0.000000	0.000000	0.160205	0.000000	0.416667	0.000000	0.500000
	Financial	0.050000	0.000000	0.416667	0.138663	0.450000	0.000000	0.500000	0.000000
	Innovative	0.450000	0.000000	0.000000	0.019316	0.000000	0.083333	0.000000	0.000000
	Managerial	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Operational	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Relational	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Structural& Cultural	0.000000	0.000000	0.083333	0.173184	0.050000	0.000000	0.000000	0.000000
	Technological	0.000000	0.000000	0.000000	0.008633	0.000000	0.000000	0.000000	0.000000

Figure 4.4. The weighted supermatrix of clusters – Super Decision image

4.1.5 Final relative importance weights

As it is seen in Table 4.4, SME-SME is found more important than SME-LC. Table 4.5 shows that the weights of clusters Financial, Innovative and Structural & Cultural in descending order.

Table 4.4. Priorities of sub targets

SME-LC	0.49673
SME-SME	0.50327

Table 4.5. Priorities of clusters

Financial	0.80277
Innovative	0.08972
Structural&Cultural	0.08121
Competitive	0.01918
Relational	0.00237
Managerial	0.00214
Operational	0.00173
Technological	0.00088

At the end of all iterations the calculated attribute weights are shown at Table 4.6. There are only 25 attributes having a weight more than %10, and these will be used in this study as a threshold of ranking the criteria. The Capital Impact and Cultural Differences criteria lead all 103 criteria.

Table 4.6. Priorities of attributes

Attribute	**Priority**	**Priority(Normalize)**
Capital impact	0.383	0.131
Cultural differences	0.225	0.077
Expenditure balance	0.185	0.063
Leadership	0.172	0.059
Connectivity	0.165	0.056
Design operations	0.161	0.055
Innovation culture	0.154	0.053
Communication technology	0.135	0.046
Price	0.129	0.044
Competitive specialties	0.123	0.042
Understanding of requirements	0.118	0.040
Management Information Systems	0.114	0.039
Coordination & Cooperation	0.112	0.038
Exportation	0.112	0.038
Commitment	0.111	0.038
Business experience	0.11	0.038
Business understanding	0.107	0.037
Organizational structure	0.106	0.036
Change management	0.105	0.036
Professionalism	0.100	0.034

4.1.6 Influential criteria in SME alliances for innovation

The objective of the classification is ranking the most effective criteria based on the previously implemented cases. It is detected that the management, innovation, technology and finance criteria have bigger values than the determined threshold value, when the assets were normalized and sorted. The criteria of the survey can be grouped as follows:

Finance Related Criteria

- Capital
- Expenditure balance
- Exportation
- Price

Management Related Criteria

- Cultural Differences
- Leadership
- Cooperation & Coordination
- Commitment
- Business experience
- Organizational Structure
- Professionalism

Innovation Related Criteria

- Design Operations
- Innovative Culture
- Competitive Specialties
- Understanding of requirements
- Business understanding

Technology Related Criteria

- Connectivity
- Communication technology
- Management Information Systems
- Change management

4.2 Proposed Model

The questionnaire is prepared using the results of ANP analysis. The survey is responded by Turkish technology SMEs. The data gathered from the survey are reconstructed. The statistical model is constructed by using multinomial logistic regression in SPSS. The hypotheses which were used to generate the association rules are:

H_0: There is no relationship between dependent variable (for example: firm size) and other factors (for example: Technology Criteria and firm age).

H_1: There is a relationship between dependent variable (for example: firm size) and other factors (for example: Technology Criteria and firm age).

Some of the generated models are selected and validated in Clementine by using multinomial logistic regression. Then, the rules which are deriven from the statistical model were constructed by using multinomial logistic regression in SPSS. They are cross-validatedwith the results of the Association Rule Mining technique in Rapid Miner software using machine learning. Figure 4.5 gives the flow of this study to create the alliances rules for collaborative innovation.

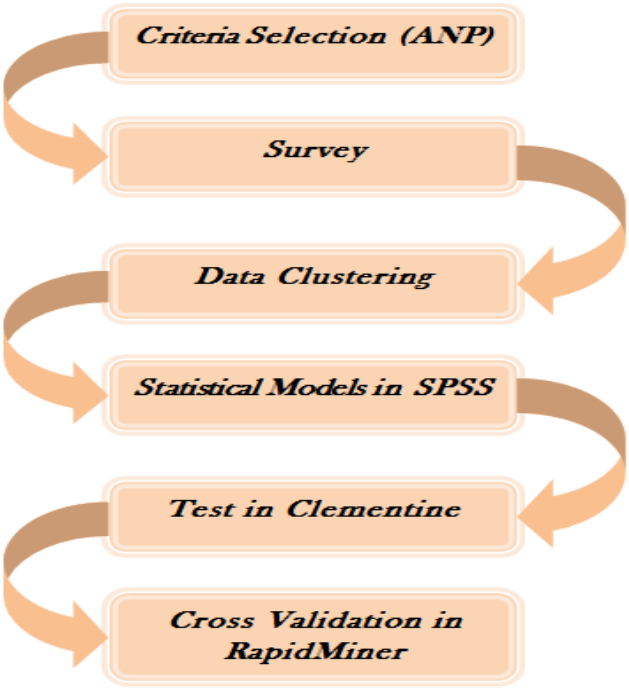


Table 4.7. Flow of the study

5 APPLICATION & RESULTS

5.1 Target SMEs

Currently, R&D studies are performed in the R&D laboratories of universities and also in the organizations like technoparks. Hence, SME alliances in helix relations can be encountered frequently in Turkish Technoparks. Indeed, most of the firms in technoparks are SMEs. The SMEs in technoparks are determined as the target of this study, because these firms have high potential for successful collaborative innovation as a result of their R&D studies. A questionnaire is prepared based on the results of the literature survey and on the direction of criteria prioritized with ANP. This questionnaire is applied to the firms which are in the technoparks. The aim is to get the rules of association for true collaboration for the true SME collaboration.

5.2 Survey

A survey is prepared for the technoparks to achieve the opinion of the SMEs in Technoparks.

5.2.1 Survey Preperation

LimeSurvey software application of Marmara University Questionnaire System Unit is used in surveys where the questionnaire is appealed on October 2013 and is approved on 25th October 2013 (Figure 5.1). 29 questions and answers are prepared for the application of survey by using LimeSurvey. LimeSurvey is an open-source online survey application and helps to generate, manage, publishing and receive the results of survey.



Figure 5.1. View of the survey at the LimeSurvey.

5.2.2 Questionnaire

The questionnaire has been obtained from the selected criteria, details of which are given below and the full questionnaire is presented in Appendix II. The survey has mainly 2 groups: demographic, composed of 9 and criteria effects consisting 20 questions. Figure 5.2 shows the form of data transferred from LimeSurvey to Excel.

	A	B	C	D	E	F	G
10	SIZE	COLL	Cust	Suppl	Compet	SMEs	BigFirms
11	1	12340	1	2	3	4	0
12	3	00005	0	0	0	0	5
13	3	12000	1	2	0	0	0
14	3	00005	0	0	0	0	5
15	3	12345	1	2	3	4	5
16	2	00005	0	0	0	0	5
17	1	02000	0	2	0	0	0
18	1	12040	1	2	0	4	0
19	1	10000	1	0	0	0	0
20	2	02000	0	2	0	0	0
21	2	12045	1	2	0	4	5
22	1	12345	1	2	3	4	5
23	1	12040	1	2	0	4	0
24	3	00005	0	0	0	0	5
25	3	12045	1	2	0	4	5
26	2	10005	1	0	0	0	5
27	3	12045	1	2	0	4	5
28	2	02000	0	2	0	0	0
29	2	10005	1	0	0	0	5
30	1	00005	0	0	0	0	5
31	3	12005	1	2	0	0	5

Figure 5.2. The form of data transferred from LimeSurvey to Excel

Size of Respondent Firm

Firm size will give information for the type of responder. This question has three choices as below.

Which one is the size of your firm as an SME?

Micro (1 – 9 worker) (1)

Small (10 – 49 worker) (2)

Medium (50 – 250 worker) (3)

If firm size is small, micro and medium then the choice is seen as 1, 2 and 3 respectively (Figure 5.2).

Types of Collaborators

Stakeholders have some contributions for innovation. Therefore, collaborators are to be selected carefully.

Which one is your collaborator? (More than one choice can be selected)

Customer (1)

Supplier (2)

Competitor (3)

SMEs (4)

Large Firms (5)

In the 2nd and the 8th questions, more than one choice can be selected. In these questions the choices are shown as 1, 2, 3, 4, 5, respectively and the others are 0. Since the choices can occur at the same time in both questions, the data is rearranged with "CONCATENATE" function (Figure 5.2). For example, 12040 in column B shows that choices 1, 2, and 4 are selected as seen in column from C to G.

Innovative Collaboration

Collaborations are for any kind of innovation or with another reason is to be defined here.

Choose the subjects which are successful for innovation. (More than one choice can be selected)

New Product (1)

New Process (2)

New Market (3)

New Organisation (4)

New Design (5)

Employee Size of Respondent Firm

Workforce of SMEs is demographic information. If responder SMEs has less than 50 employees, they are asked to select the first answer of this question.

How many employees do you have?

0-49 (1)

50-99 (2)

100-149 (3)

150-199 (4)

>200 (5)

Age of Respondent Firm

Firm age is another impact for the growth of the collaborative innovation

Which range shows the age of your firm?

< 1 year (1)

1-3 years (2)

3-5 years (3)

5-10 years (4)

> 10 years (5)

Reason of Collaboration

Reason for collaboration is asked to differentiate the innovation. If the respondent firms collaborate for innovative actions, they should select "Yes". Otherwise reasons are not related to innovation.

Are you cooperating for innovation?

Yes (1)

No (0)

Collaboration Duration

If SMEs collaborate for innovation, it is a process of time. This information is taken by the 5 ranges. If the firm has never made any collaboration then the response is expected to be "0".

How old is your cooperation for innovation?

< 1 year (1)

1-3 years (2)

3-5 years (3)

> 5 years (4)

0

Industry of Respondent Firm

The respondent SME will answer this question by giving the name of the industry. The choice is not given because technology is a dynamic field that evolves with new fields every other day.

What is your field of business?

…….

…….

Industry of Collaborator

This question might have multiple responses, since the firm might have more than one collaborator.

What is the industrial field of your collaborator?

…….

…….

After the demographic questions are finalized the criteria part starts.

Only one of the three choices will be answered for the questions about the criteria of this survey. There are 4 main groups for 20 criteria.

FINANCE RELATED CRITERIA

Capital Impact

Business capital is related size of collaborators that the respondent chooses to collaborate.

Which one of the following choices must be the capital of your cooperating firms for innovation?

It must be greater than the industrial average. (1)

It must be at least equal to the average of industry (2)

The capital has no importance. (3)

When the answer of this question is transferred from LimeSurvey to MS Excel, the choices will take the values 1, 2, and 3 respectively (Figure 5.3). If respondent choose first answer which means that his opinion is “capital must be greater than the industrial average”, then the choice is

seen as 1 (Figure 5.4). Since the Multinomial Logistic Regression Analysis needs data in binomial form, data must be reconstructed.

CAPITAL	CULT_DIF	INNOV_OF	LEADERS	COI
3	3	3	2	
3	3	2	2	
3	2	1	2	
1	3	2	3	
3	3	1	3	
3	2	1	2	
3	2	1	2	
3	2	2	2	
2	2	1	2	
1	2	2	2	
3	3	1	3	
3	2	2	1	
3	2	1	2	
2	3	1	2	
3	2	3	1	
3	3	2	2	
3	2	1	2	
2	2	1	2	

Figure 5.3. The form of data transferred from LimeSurvey to MS Excel

Costs of Innovative Operations

Sharing the investment in Innovative operations is a financial factor which influences the strength of collaboration.

The expenditures for innovative operations;

Must be shared equally. (1)

Must be shared proportionally. (2)

Does not affect the collaboration. (3)

If the respondent thinks that expenditure should be shared equally among the collaborators, first answer is chosen. But if firms think that expenditure should be shared proportionally based on rate of collaborator's partnership, second answer is chosen. The third choice indicates that sharing the cost of innovative operations has no impact for innovation.

Potential Price of Product

The importance of potential price expectation is indicated by choice influences.

The price of the improved product with innovation is;

One of the most important factors feeding the innovation. (1)

It is only a motivation for the innovation. (2)

It does not affect the innovation. (3)

Potential Exportation Facilities

The potential exportation facilities can be shared or left to the strongest collaborator.

For the success of innovative products

The activities to increase the exportation are to be performed equally by all of the cooperating firms. (1)

The activities to increase the exportation can be performed by one of the cooperating firms. (2)

The activities to increase the exportation have no effect on the success of the product. (3)

MANAGEMENT RELATED CRITERIA

Cultural Differences

Impact of cultural differences on collaborative innovation is summarized in this question

Among the collaborating firms;

There should be no cultural difference. (1)

The cultural differences can be tolerated, if they are not too wide. (2)

The cultural differences are not important. (3)

Leadership Properties

Existence of the leadership features for the innovation projects are evaluated.

For the successful innovation:

All collaborators must have leadership properties. (1)

At least one of them must have leadership properties. (2)

The leadership is not important for collaborative innovation. (3)

Cooperation & Coordination

Occurrence of the cooperation and coordination acts to improve the innovative culture is evaluated.

For the success and improvement of innovation culture in collaborations;

All of the firms in cooperation must have the coordination and cooperation acts. (1)

Only one firm, which starts the collaboration, must have the coordination and cooperation acts. (2)

The absence of the coordination and cooperation acts can be tolerated. (3)

Commitment

Importance of loyalty to achieve the desired quality of collaboration for innovation is asked.

Commitment between collaborators;

Is one of the most important factors to improve innovation. (1)

Can motivate the innovation. (2)

Have no effect on the innovation. (3)

Business Experience

Priority of industrial experience to realize the objectives of innovative collaboration is evaluated.

For the success of innovative collaboration;

All of the collaborators must have relevant industrial experience. (1)

There may be some firms having relevant industrial experience. (2)

The industrial experiences of the firms are not obligatory. (3)

Organizational Structure

Impact of organizational structure of collaborator firms is determined.

For an effective collaboration organizational structure of Collaborators is;

One of the most important factors for the success of innovation. (1)

Only motivates the innovation. (2)

Has no significance for innovation. (3)

Professionalism

The impact of professionalism of the collaborator is evaluated for the success of innovation.

The professionalism of the collaborator is;

One of the most important factors for the improvement of innovation. (1)

Only a motivator for the innovation. (2)

Not effective on innovation. (3)

INNOVATION RELATED CRITERIA

Design Operations

Share of design abilities can have an impact on success.

During the collaborative innovation;

All the collaborating firms must have the designing skills. (1)

At least one of the firms must have the designing operations. (2)

Designing skills are not required for collaborating firms. (3)

Innovative Culture

Occurrence of innovation culture to collaborate is evaluated.

For achievement of success in collaboration for innovation:

All collaborating firms must have advanced innovation culture. (1)

At least one of the firms must have advanced innovation culture. (2)

Innovation culture is not required for collaboration for innovation. (3)

Competitive Advantages

Impact duration of working together for the competitive advantages is evaluated for the success of collaborative innovation;

Collaboration for competitive advantages makes a positive effect in a short period. (1)

Collaboration for competitive advantages makes a positive effect in 1to 3 years. (2)

Collaboration for competitive advantages makes a positive effect more than three years. (3)

Understanding of requirements

Priority of understanding market demand for successive innovation is evaluated through

For achievement of success in collaboration for innovation;

All of the firms must understand the market requirements well. (1)

More than one of the firms must understand the market requirements well. (2)

Only one of the firms must understand the market requirements well. (3)

Business understanding

Impact of sharing business approach to choose collaborator for innovation is indicated

For a successful collaboration for innovation;

It is important that all of the firms must have similar industrial/business approach. (1)

It is enough that at least one of the firms have the business understanding of the industry. (2)

The industrial/business approach of the firms does not make any contribution. (3)

The third choice allows having initiators to be part of collaboration.

TECHNOLOGY RELATED CRITERIA

Connectivity

Impact of communication ways is evaluated.

How important is the connectivity among the collaborators for innovation?

All potential communication ways must be used easily. (1)

Only one possible communication way is enough. (2)

The connectivity has no impact for innovation. (3)

Communication Technology

Existence of communication technologies in the potential collaborators for innovation is evaluated through the 17th question of questionnaire in Appendix II.

For improving the innovation potential;

All of the communication technologies have to be used effectively. (1)

Existing communication technologies of the firms at the beginning of collaboration are satisfactory. (2)

Communication technologies do not have any role on innovative improvement. (3)

Management Information Systems

Management information systems including Enterprise Resource Planning (ERP), Decision Support systems might be important.

It is important to use the management information systems effectively for innovative success;

All the collaborators must use effectively. (1)

Only one of the firms, the decision making firm has to use it effectively. (2)

MIS effectiveness has no impact on Innovative Success. (3)

Change Management

Importance of change management application is evaluated.

For the success of innovative collaboration;

Realization of change management by the collaborators in parallel is important. (1)

Actualizing change management independently by each collaborator is satisfactory enough. (2)

The change management has no effect on innovation. (3)

5.2.3 Survey application

The survey was activated on November, 29th 2013 and announced through some network channels. Responses were received either by face to face interviews or on-line by filling the survey in LimeSurvey. 90% of the firms take place in the university techno parks. In descending order, the firms of Yıldız Technical University, Kocaeli University, Istanbul Technical University (ITU) ARI and Middle East Technical University (METU) techno parks participated in the survey. 105 firms from various industries shared information by answering all the questions whereas; another 25 firms answered only a part of the questionnaire.

5.2.4 Results

5.2.4.1 Statistical analysis of demographic questionnaire

The first 10 questions of this questionnaire have been analyzed for reliability; with a Cornbach's alpha value of 0.702. The statistics calculated by using the split half method is the correlation between the two halves of the data; where the big correlation values require the reliability. This technique has a problem coming from having more than one ways for splitting the data into two parts. This implies that results can be the product of number of ways of splitting the data. Cornbach (1951) used a measure to overcome this problem. This measure was approximately equal to the possible numbers of splitting the data in two parts, and computing the correlation coefficient for every split part. The average of these coefficient values is named as Cornbach's alpha, α, which is the most common measure of scale reliability. Most of the articles and research papers declare that the Cornbach's alpha is in between 0.7 and 0.8 value is acceptable. 0.8 is applied commonly for cognitive tests, whereas 0.7 is acceptable for ability tests (Field, 2005). α is found to be in between 0.7 and 0.8, and this can be approved as acceptable value. Responses for the firm size are evaluated to have the shares as seen in Figure 5.4 where 43 of the firms are micro sized, 47 of the firms are small sized, and 15 are medium sized firms.

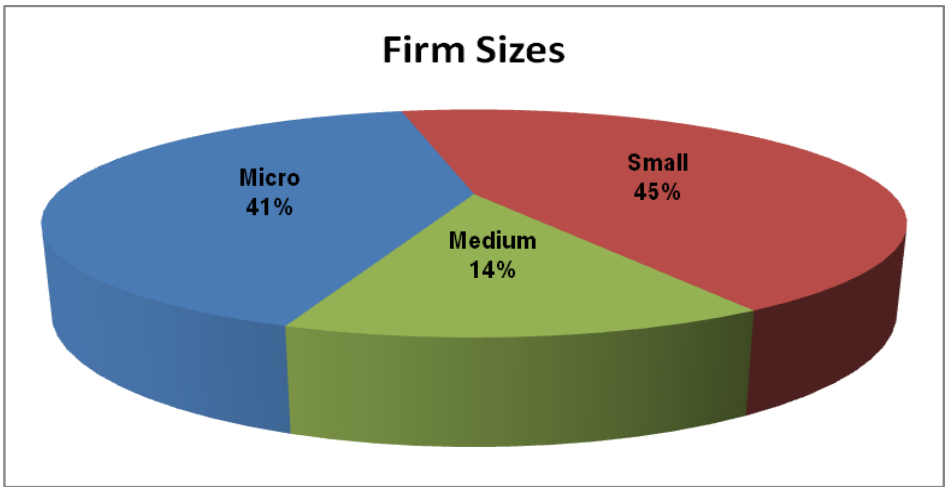


Figure 5.4. The sizes SMEs answered the questionnaire

When the collaborated firms are classified, only 2 firms are seen to collaborate with all kinds of relations. The respondents can choose more than one answers and therefore each response is analyzed. It is observed that 78 firms are cooperating with the customers, 66 firms are cooperating with the big firms, 54 firms are cooperating with the SMEs, 39 are cooperating with the suppliers, and 6 of the firms are cooperating with their competitors. 1 micro and 1 medium sized firm are cooperating in all types. The values are shown in percentages in Figure 5.5 below.

It is discussed during face to face interviews that most of the firms are cooperating with the customers and/or big firms, to satisfy customer demands exactly or to share the costs of innovation investments. The cooperation between competitors is rare, with the need to keep industrial secrets.

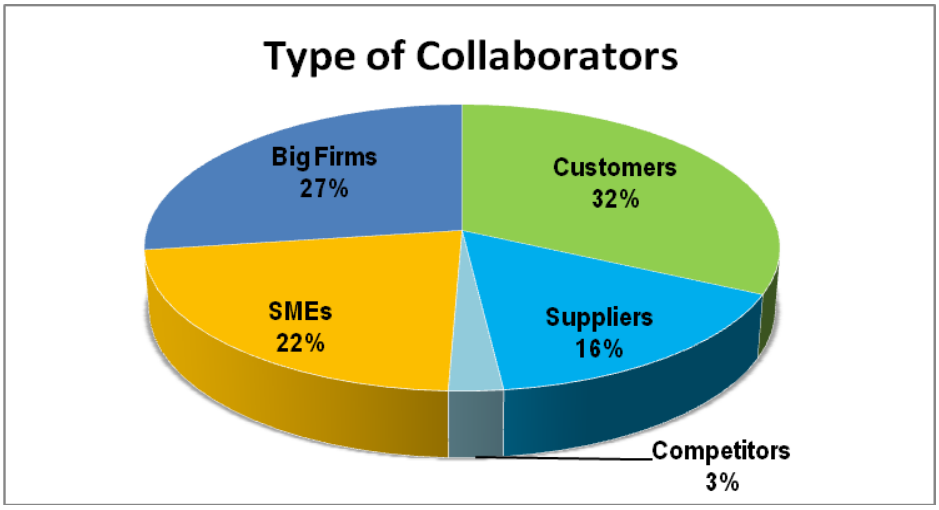


Figure 5.5. The types of collaborators

The frequency of the type of collaborators is shown in Figure 5.6 below. The firms collaborating with customers mostly prefer the big firms for collaboration. In the second group, it is observed that both suppliers and customers can be preferred, either Big (Large) Firm or SME.

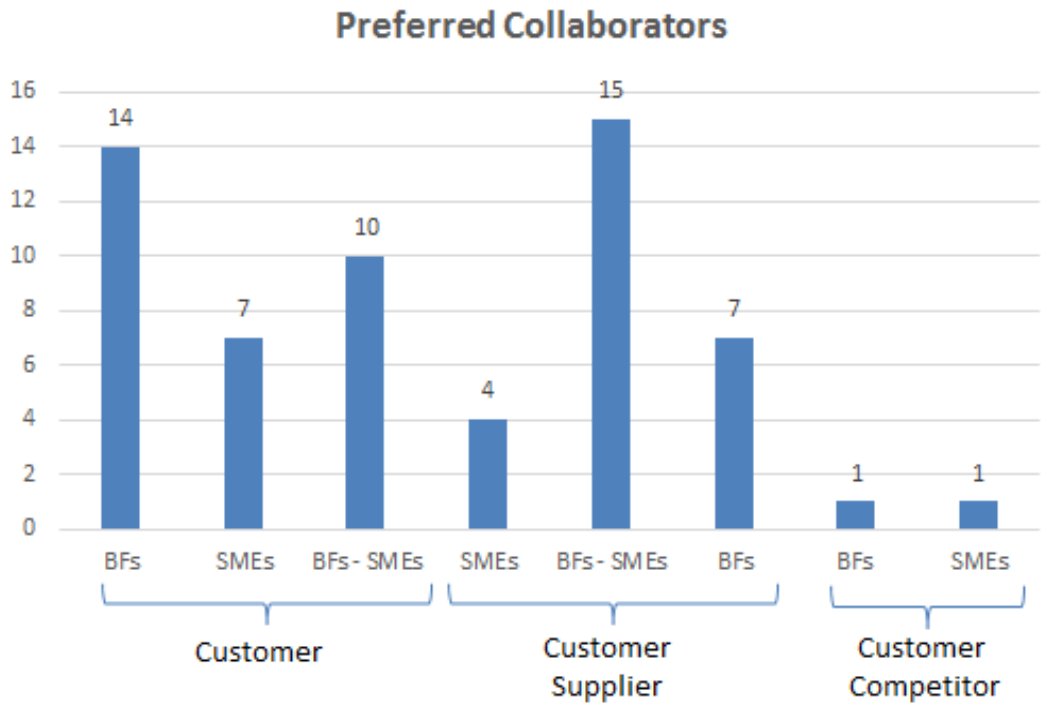


Figure 5.6. Types of preferred collaborators

The fifth question gives the number of employees. There are 5 groups: 87 firms have 0-49 employees, 10 firms have 50-99 employees, 5 firms have 100-149 employees, 0 firms have 150-200 employees, and 3 firms have more than 200 employees on 105 respondents. The percent distribution of the SMEs on the basis of numbers of employees is shown in Figure 5.7 below. Similarly, it is seen easily that in the size of the firms, micro and small sized firms have the majority in this survey. On the other hand, answers about the number of employees match the size of companies.

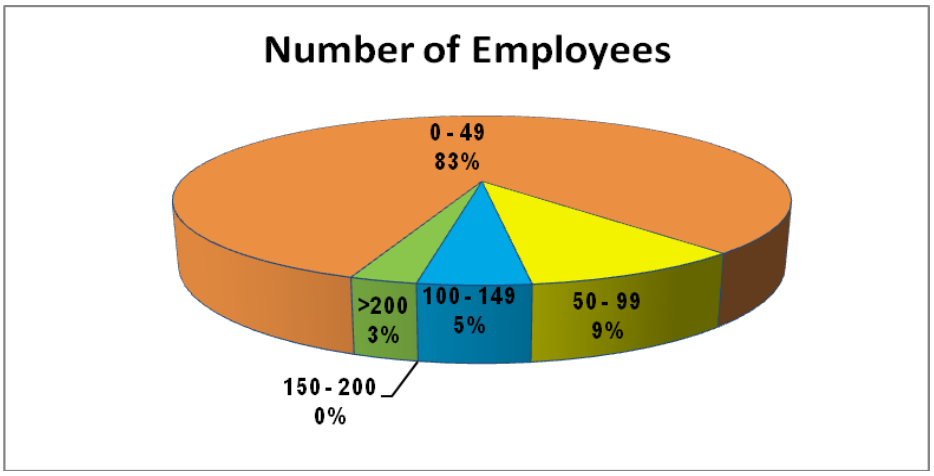


Figure 5.7. Numbers of employees

It is observed that, small size firms are more enthusiastic to collaborate with respect to the big size firms. The reason may be the need for financial funds for innovation investments.

8.57%, of the respondent firms are younger than 1 year. The majority (59%) survived over 5 years. When the ages of the firms are analyzed, the firms older than 10 years have the majority in innovative collaboration (Table 5.1). This shows us that the older firms are more willing to share the information. This may be a result of the industrial experience.

Table 5.1. Crosstabulation of innovative collaboration and company age

		COMPAGE					Total
		1	2	3	4	5	
INNOV	0	3	9	10	6	7	35
	1	6	9	9	16	30	70
Total		9	18	19	22	37	105

The respondents are classified in three groups on the basis of their ages as young, intermediate (middle aged), and old. The percentages can be seen at Figure 5.8. 59 of the respondent firms are middle aged that are between 3 and 10 years old, 37 of them are older than 10 years, and 9 of the firms are younger than 1 year. As it is distinguished easily, since the respondents are in technology, 56% of them are in the intermediate group which is between 1 and 10 years old.

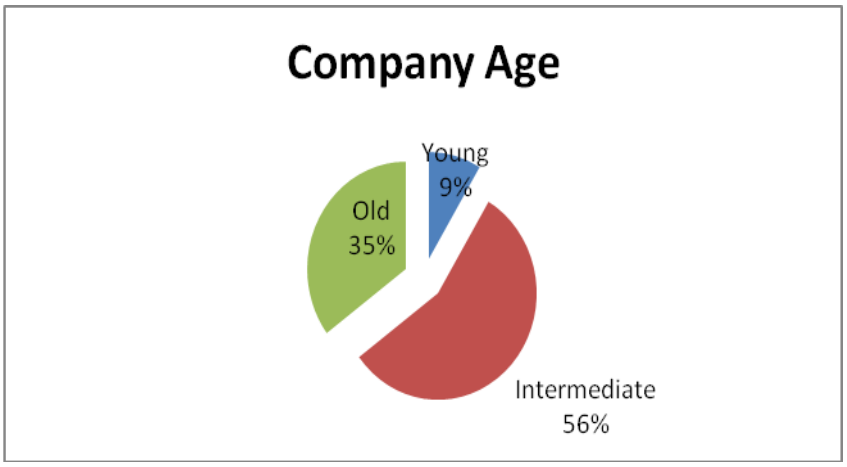


Figure 5.8. Age-classification of the firms

70 of the 105 respondent firms said "Yes, we collaborate for innovation" and 35 of all respondents on this survey said "No, we do not collaborate for innovation". The pie chart in Figure 5.9 shows the presence of collaboration studies for innovation.

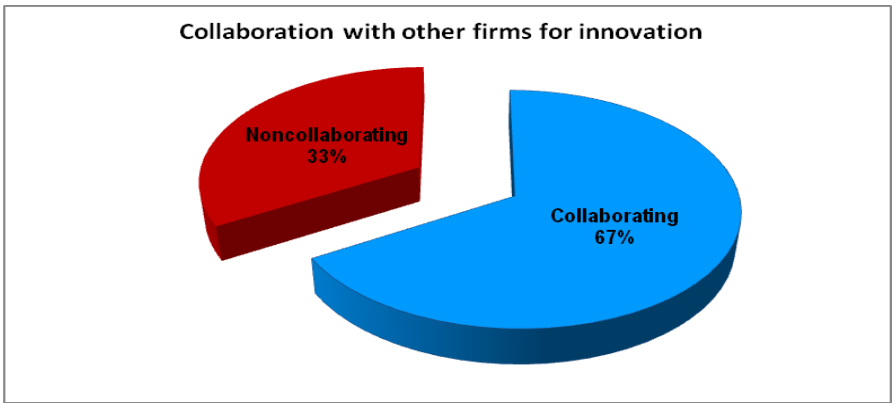


Figure 5.9. The presence of collaboration for innovation

Figure 5.10 shows the durations of innovation based cooperation as percentages. First group is the youngest collaborators, less than 1 year, 14 SMEs in 105 are in this group. The second group covers the collaboration ages in between 1 to 3 years, 22 of 105 SMEs are in this group. The third one is containing 3 to 5 years old collaborators, 13 of 105 firms took their places in this group. The last and older group covers the ages greater than 5 years, 22 of 105 collaborating firms are in this group.

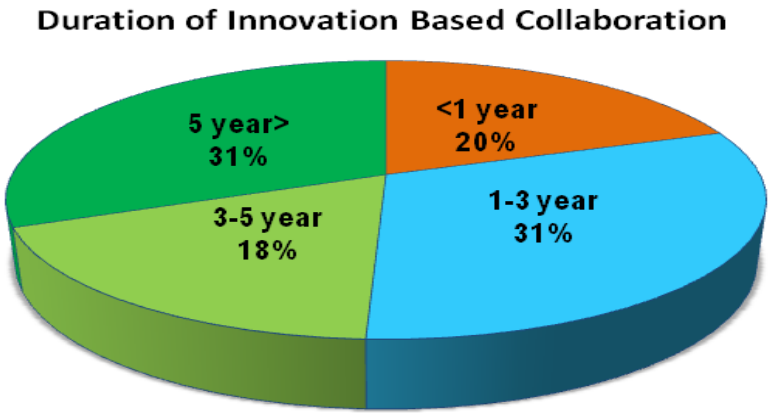


Figure 5.10. Duration of innovative collaboration

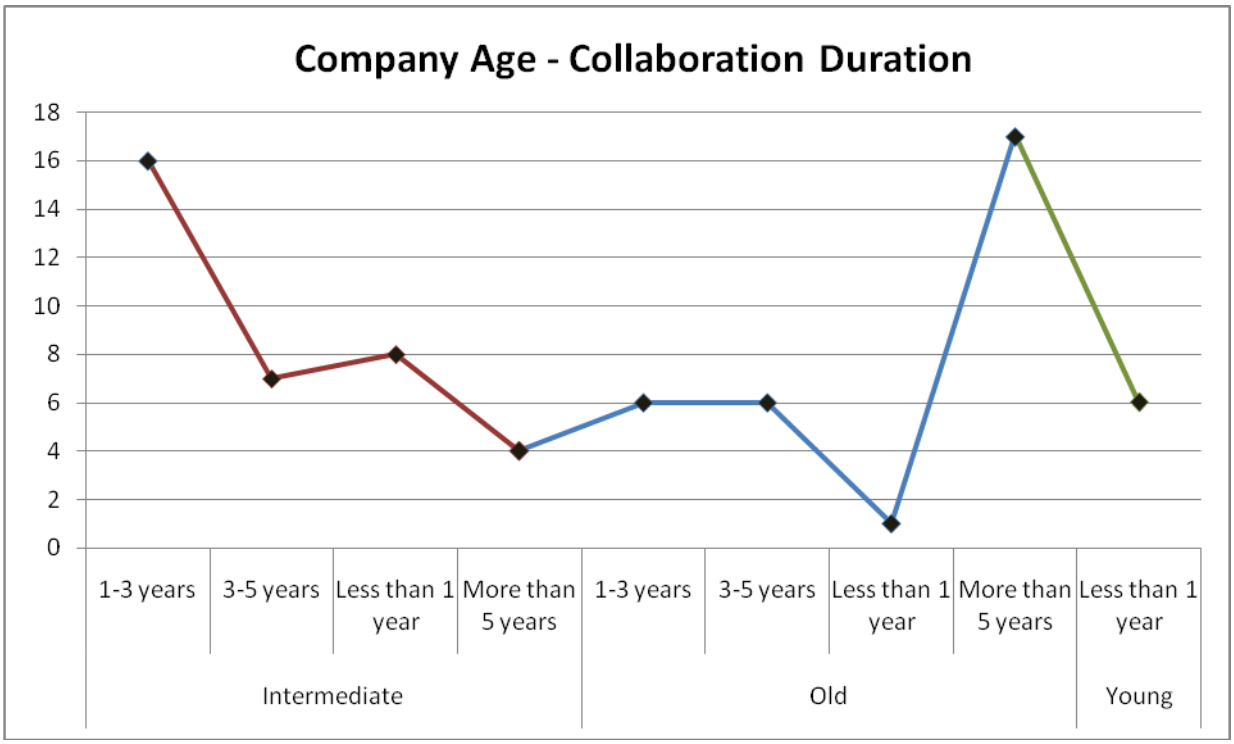


Figure 5.11. Duration of collaboration for innovation

The comparison between company ages and collaboration ages of respondents in Figure 5.11, it is easily seen that the companies older than 10 years are collaborating more than 5 years. Results imply that intermediate and old SMEs have realized the need for innovation studies to keep their positions in the competitive market conditions. The large majority of intermediate companies aged between 1 and 10 years, are collaborating for 1 – 3 years. This shows that the competitive market conditions urge them for corporation.

Results show that older SMEs have realized the need for innovation studies to keep their positions in the competitive market conditions. The companies aged between 3 and 10 years, are collaborating for 1 – 3 years. This shows that the competitive market conditions urge them for corporation.

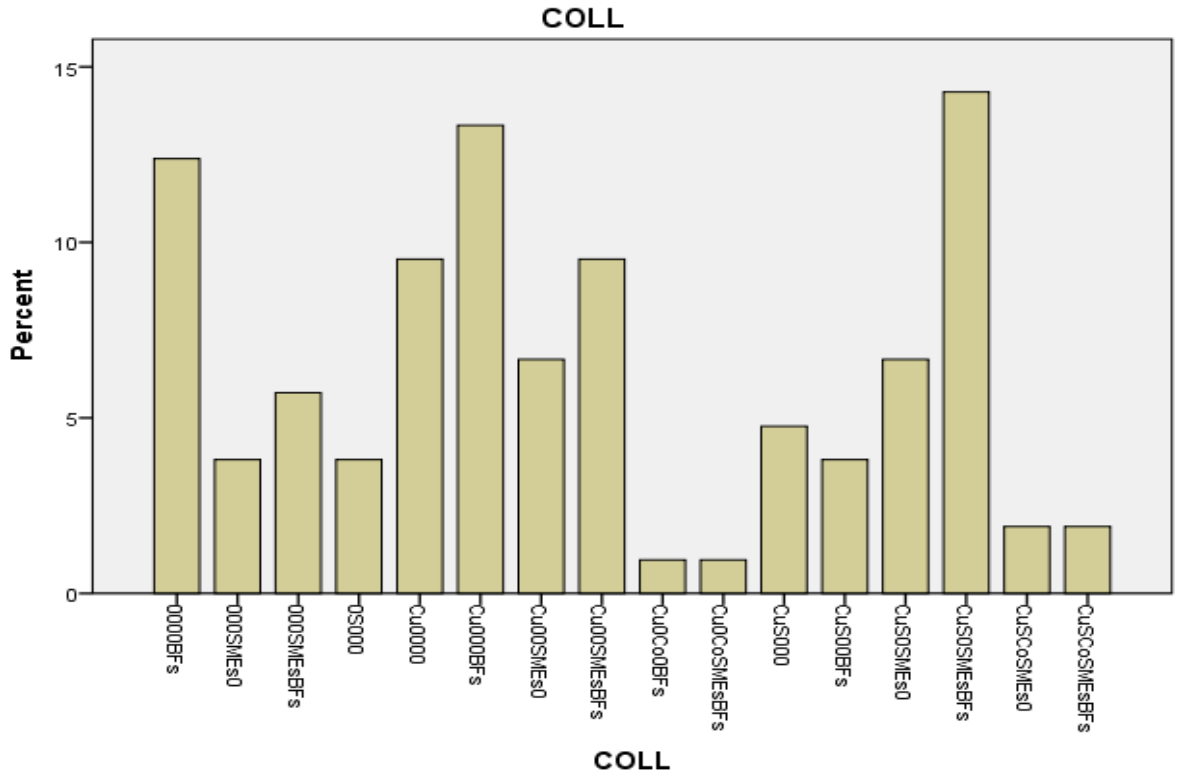


Figure 5.12. Frequency chart for collaboration and the size of the firm

When the objectives of informants are studied in detail, on Figure 5.12 above, the 14.3% of the firms are collaborating with their customers and suppliers at the same time, never indifferent of size of the firm, is it a big firm or SME. 13.3% of firms are collaborating only with the big firm customers. 12.4% of 105 SMEs collaborate with only big firms, customer, supplier or competitor. 9.5% of the firms are collaborating with the customers only; the size of the firm is not a factor for collaboration. Another %9.5 of SMEs collaborates with the customers even if they are big firm or SME. 6.7% of the firms are collaborating only with the SME customers. Another 6.7% of SMEs are collaborating with the SME customers and SME suppliers at the same time. The percentage of SMEs that collaborate with both SMEs and big firms is 5.7%. There is another group with 4.8% that collaborates with the customers and suppliers at the same time. The next group covers the 3.8% of participants collaborating with the suppliers only. Another group has the same

percentage that collaborates with their big firm customers and big firm suppliers at the same time. Those try to strengthen their cooperation with the big firms. 1.9% of the firms collaborate with the customer, supplier and competitor SMEs. Only 1.9% of the informants are in collaboration with customers, suppliers and competitors indifferent of the size. 1% of the firms are collaborating with the big firm customers and big competitors. The last 1% group collaborates with the customers and competitors at the same time either they are big firms or SMEs.

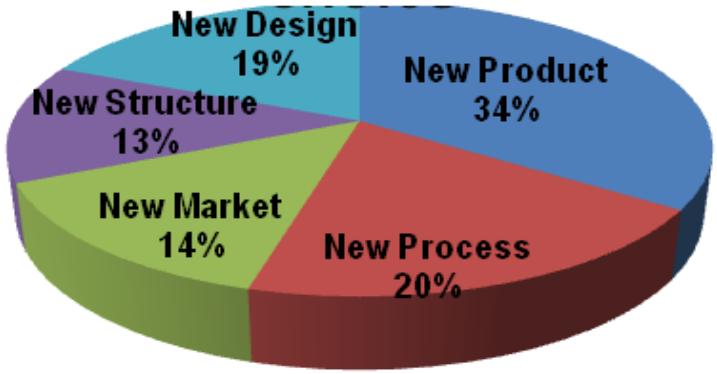


Figure 5.13. The choice of collaboration for innovation

When the choices of SMEs for innovation based collaboration is examined, the results are as follows. The number of responses is greater than 105, since this question gives the choice to select more than 1 reason for innovation based collaboration. Most of the SMEs are trying to develop a new product through innovation investments; total number is 61. Secondly 35 firms are trying to have a new process at the end of the innovation tasks. There are 33 firms trying to find new design. The number of firms trying to reach new markets is 25. The number of SMEs targeting the structural change is 23. 19 of the firms have specified different goals. Just three of the firms aim all of the goals that are mentioned here. The percentage distribution of the choices is shown in Figure 5.13 above. According to these numbers, the main reason to collaborate for innovation is new products, followed by new processes, and followed by new designs.

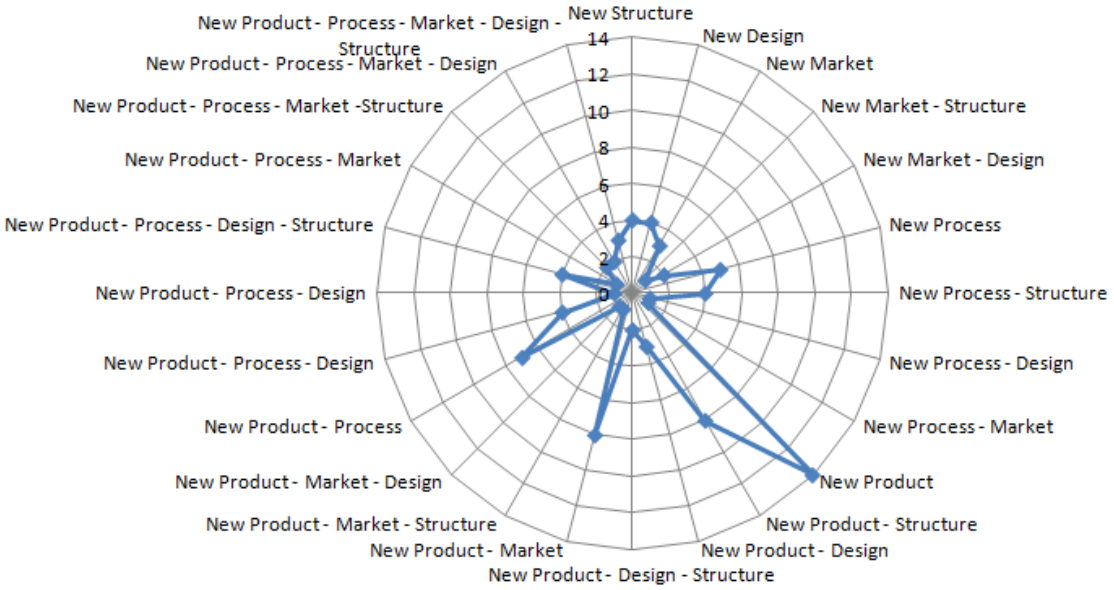


Figure 5.14. The choice of collaboration for innovation – Frequency distribution

The frequency distribution of the choices is shown in Figure 5.14 above. According to these numbers, the main reason to collaborate for innovation is only new products, new products and new structures, new products and new markets, new product and new processes, and only new processes, respectively.

5.2.4.1 Industry analysis

The 3rd question is about the main industry of the firm, and the 4th question is about the field of the collaborating company. The answers of these two questions are analyzed based on frequencies shown in Table 5.2 and Figure 5.15. To describe the variables, frequencies provide graphical representations and statistics, as a useful method. The distinct values can be categorized according to their frequencies. If a variable has more than one distinct value, the frequency report can be suppressed. The charts may be labeled with frequencies or percentages.

Table 5.2. Frequency and percentage of company field

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agriculture- Food	6	2.6	2.6	2.6
	Automation	4	1.8	1.8	4.4
	Automative	5	2.2	2.2	6.6
	Clothing	1	.4	.4	7.0
	Company Field	1	.4	.4	7.5
	Construction	4	1.8	1.8	9.3
	Defence	1	.4	.4	9.7
	Design	1	.4	.4	10.1
	E Learning - Other Education	3	1.3	1.3	11.5
	e-commerce	4	1.8	1.8	13.2
	Electrics - Electronics	7	3.1	3.1	16.3
	Energy – Environment	8	3.5	3.5	19.8
	Engineering - Consultancy	4	1.8	1.8	21.6
	Financial – Accounting	7	3.1	3.1	24.7
	Health	2	.9	.9	25.6
	IT	35	15.4	15.4	41.0
	Logistics	2	.9	.9	41.9
	Machine	4	1.8	1.8	43.6
	Mining	5	2.2	2.2	45.8
	Production	8	3.5	3.5	49.3
	R&D	7	3.1	3.1	52.4
	Service	6	2.6	2.6	55.1
	Software	92	40.5	40.5	95.6
	Space and Defence	3	1.3	1.3	96.9
	Technology	2	.9	.9	97.8
	Telecommunication	5	2.2	2.2	100.0
	Total	227	100.0	100.0	

Industry distribution is grouped in 26 fields. These groups are shown in table above. As it is shown in below bar-chart, the majority of the collaborating firms are working on software technologies and in the IT fields, having a share of 40.5% and 14.5% respectively. Production

and Energy-Environment industries are following them with 3.5%. The next areas are R&D, Electrics-Electronics and Finance-Accounting with 3.1% share.

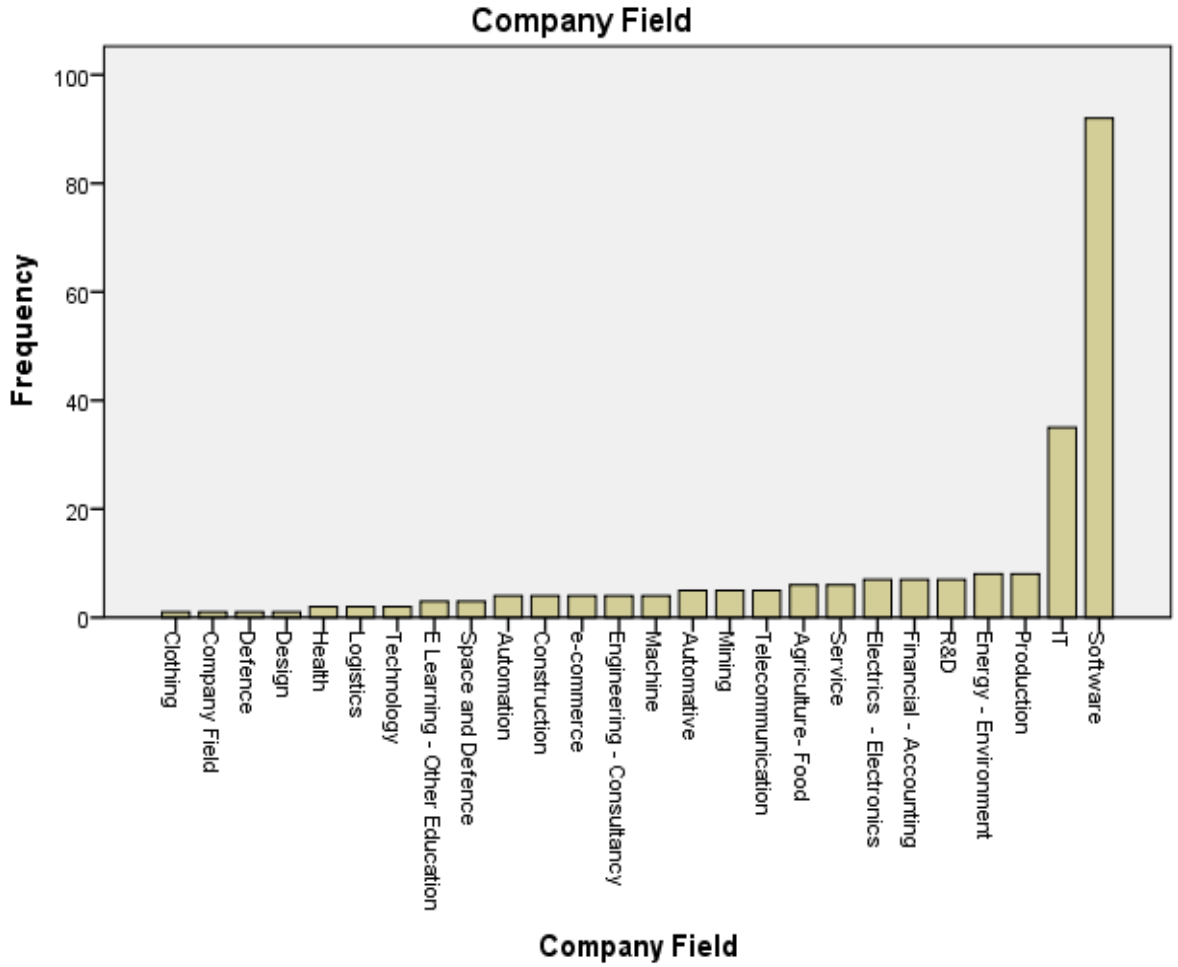


Figure 5.15. Bar chart of company field frequencies

According to the answers of 105 participant companies, the most popular industries for collaboration are Production, IT, Software, Finance-Accounting, Health, Automotive, Electrics-Electronics, and Construction given in a descending order. Responses are shown in questionnaire for 33 main industries as frequencies and the percentages are shown below in Table 5.3 and graphed in Figure 5.16.

Table 5.3. Frequency and Percentage of Collaborated Industry

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agriculture- Food	3	1.3	1.3	1.3
	Audit	1	.4	.4	1.8
	Automative	11	4.8	4.8	6.6
	Chemsitry	1	.4	.4	7.0
	CNC Controls	1	.4	.4	7.5
	Collaborated Industry	1	.4	.4	7.9
	Construction	9	4.0	4.0	11.9
	Defence	3	1.3	1.3	13.2
	E Learning - Other Education	6	2.6	2.6	15.9
	Electrics - Electronics	9	4.0	4.0	19.8
	Energy - Environment	7	3.1	3.1	22.9
	Engineering - Consultancy	4	1.8	1.8	24.7
	Financial - Accounting	21	9.3	9.3	33.9
	Furniture	1	.4	.4	34.4
	Game	1	.4	.4	34.8
	Hardware	1	.4	.4	35.2
	Health	15	6.6	6.6	41.9
	Industrial Design	1	.4	.4	42.3
	IT	22	9.7	9.7	52.0
	Logistics	7	3.1	3.1	55.1
	Machine	4	1.8	1.8	56.8
	Mining	7	3.1	3.1	59.9
	News	1	.4	.4	60.4
	Pharmaceutic - Chemistry	2	.9	.9	61.2
	Production	40	17.6	17.6	78.9
	R&D	1	.4	.4	79.3
	Service	8	3.5	3.5	82.8
	Software	21	9.3	9.3	92.1
	Telecommunication	5	2.2	2.2	94.3
	Textile-Leather	3	1.3	1.3	95.6
	Tourism	2	.9	.9	96.5
	Transportation	4	1.8	1.8	98.2
	White goods	4	1.8	1.8	100.0
	Total	227	100.0	100.0	

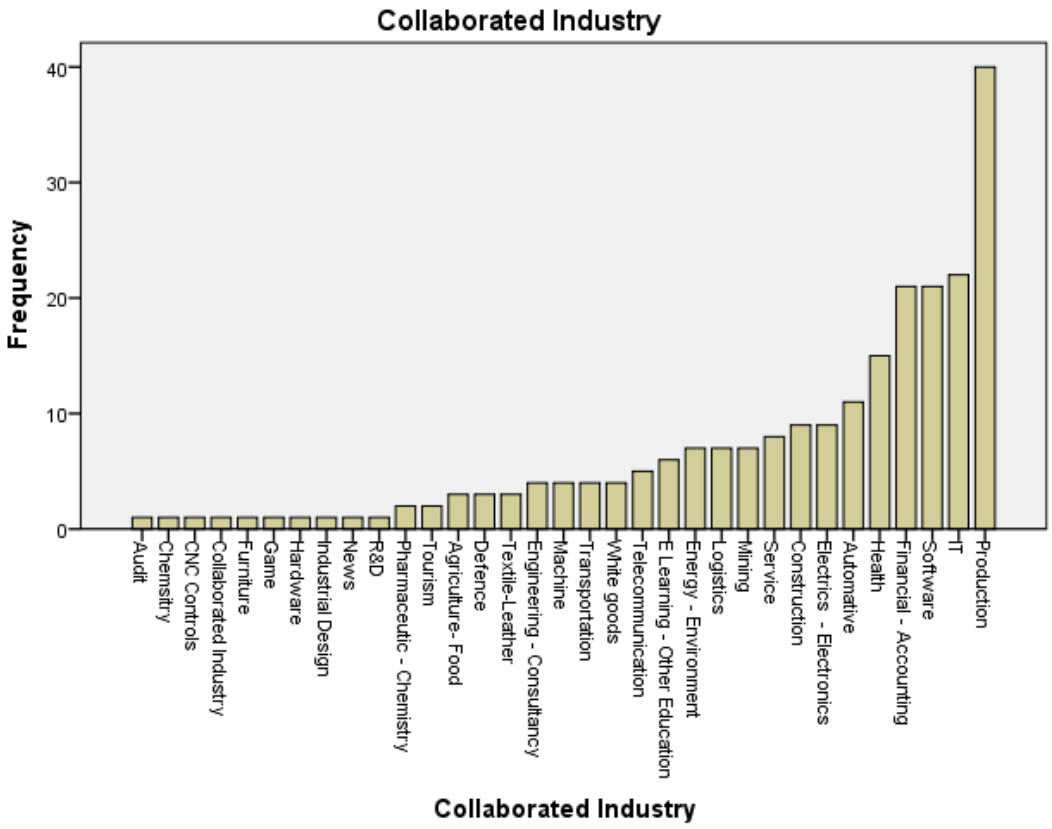


Figure 5.16. Collaborated industry frequencies

Industries for the 105 participants and their collaborators made 227 relations. Crosstabs are applied on these 227 using the SPSS software. The associations are measured in Crosstabs with two-way tables (IBM, 2014). For determining what test or measure will be used, the structure of the table and the ordered categories can be useful. The measures of association and the Crosstabs statistics are calculated only for two-way tables. When a column, a row and a layer factor (control variable) is specified, the Crosstab procedure creates one panel for associated statistics and measures for every single value of the control variable (layer factor), or a combination of values for two or more control variables.

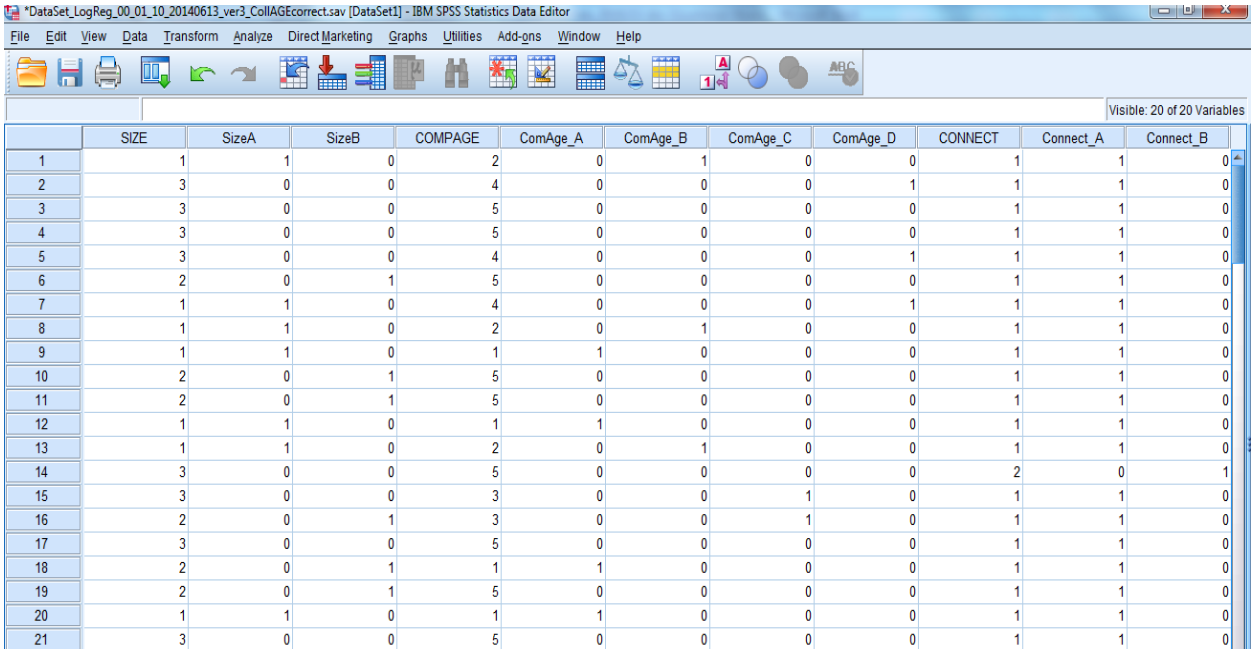
The pivot table is created as a result of Crosstab analysis where the companies working in the Software and IT fields are seen in match with frequencies, 92 and 35 respectively. (Detailed tables are given in Appendix II). Most of the collaboration matches are seen in Production (49), IT (22), Software (21), Financial-Accounting (21), Health (15) and Automotive (11) industries.

5.3 Application of Multinomial Logistic Regression

5.3.1 Reconstruction of categorical data

The levels are coded as 0 and 1, and a new variable is added, if the categorical variable has only two levels. If the categorical variable has k>2 levels, it is necessary to add k-1 additional variables (Evans & Olson, 2007).

Logistic Regression Method can be used for categorical data easily. Because of this feature, the answers of the questionnaire are rearranged to construct the model by using the multinomial logistic regression in IBM SPSS Statistics 21 (Figure 5.17).



	SIZE	SizeA	SizeB	COMPAGE	ComAge_A	ComAge_B	ComAge_C	ComAge_D	CONNECT	Connect_A	Connect_B
1	1	1	0	2	0	1	0	0	1	1	0
2	3	0	0	4	0	0	0	1	1	1	0
3	3	0	0	5	0	0	0	0	1	1	0
4	3	0	0	5	0	0	0	0	1	1	0
5	3	0	0	4	0	0	0	1	1	1	0
6	2	0	1	5	0	0	0	0	1	1	0
7	1	1	0	4	0	0	0	1	1	1	0
8	1	1	0	2	0	1	0	0	1	1	0
9	1	1	0	1	1	0	0	0	1	1	0
10	2	0	1	5	0	0	0	0	1	1	0
11	2	0	1	5	0	0	0	0	1	1	0
12	1	1	0	1	1	0	0	0	1	1	0
13	1	1	0	2	0	1	0	0	1	1	0
14	3	0	0	5	0	0	0	0	2	0	1
15	3	0	0	3	0	0	1	0	1	1	0
16	2	0	1	3	0	0	1	0	1	1	0
17	3	0	0	5	0	0	0	0	1	1	0
18	2	0	1	1	1	0	0	0	1	1	0
19	2	0	1	5	0	0	0	0	1	1	0
20	1	1	0	1	1	0	0	0	1	1	0
21	3	0	0	5	0	0	0	0	1	1	0

Figure 5.17. SPSS view of survey data

Since the collected data to build the model is categorical, the dummy columns are added to make the B coefficient meaningful when the categorical data is increased 1 unit (UCLA, 2014).

Number of Category = k

Number of dummy column = k-1

The codes that are seen in Figure 5.18 and Figure 5.19 for the questions having three categories are:

1: 1-0

2: 0-1

3: 0-0

	A	B	C
1	SIZE	Size A	Size B
2	1	1	0
3	3	0	0
4	3	0	0
5	3	0	0
6	3	0	0
7	2	0	1
8	1	1	0
9	1	1	0
10	1	1	0
11	2	0	1

Figure 5.18. Coding for size factor

BX	BY	BZ
COMM_TE	ComTech_	ComTech_
1	1	0
3	0	0
1	1	0
1	1	0
1	1	0
2	0	1
1	1	0
1	1	0
1	1	0
1	1	0
1	1	0
1	1	0
1	1	0
1	1	0
1	1	0
3	0	0
2	0	1

Figure 5.19. Coding for communication technology factor

The codes that are seen in Figure 5.20 for the questions having five categories are:

1: 1-0-0-0

2: 0-1-0-0

3: 0-0-1-0

4: 0-0-0-1

D	E	F	G	H	
COMPA	ComAg	ComAg	ComAg	ComAg	C
2	0	1	0	0	
4	0	0	0	1	
5	0	0	0	0	
5	0	0	0	0	
4	0	0	0	1	
5	0	0	0	0	
4	0	0	0	1	
2	0	1	0	0	
1	1	0	0	0	
5	0	0	0	0	
5	0	0	0	0	
1	1	0	0	0	
2	0	1	0	0	
5	0	0	0	0	
3	0	0	1	0	
3	0	0	1	0	
5	0	0	0	0	

Figure 5.20. Coding for firm age factor

5.3.2 Application of MLR in SPSS

The first model includes technology related criteria and the age of the firm as factors and firm size as the dependent variable (Figure 5.20). Since dependent variable is categorical, first of the categories is selected as reference in SPSS. In the example below, the selected factors are for Size 1 (micro) taken as reference for the dependent variable. Table 5.4 shows that attributes of firm size – firm age based on technology related criteria model. The other attributes are selected as factors of the model, whereas collaborator was a field dependent variable. “Size 1” field is observed 43 times and its marginal percentage according to the other attributes is 41% in this model (Table 5.4). Also there is no missing data in this dataset, which has 105 valid data.

Table 5.4. Case processing summary

		N	Marginal Percentage
SIZE	1	43	41,0%
	2	47	44,8%
	3	15	14,3%
ComAge_A	0	96	91,4%
	1	9	8,6%
ComAge_B	0	87	82,9%
	1	18	17,1%
ComAge_C	0	86	81,9%
	1	19	18,1%
ComAge_D	0	83	79,0%
	1	22	21,0%
Connect _A	0	13	12,4%
	1	92	87,6%
Connect _B	0	93	88,6%
	1	12	11,4%
ChngMng_A	0	46	43,8%
	1	59	56,2%
ChngMng_B	0	73	69,5%
	1	32	30,5%
ComTech_A	0	28	26,7%
	1	77	73,3%
ComTech_B	0	80	76,2%
	1	25	23,8%
MIS_A	0	55	52,4%
	1	50	47,6%
MIS_B	0	56	53,3%
	1	49	46,7%
Valid		105	100,0%
Missing		0	
Total		105	

LogReg_ Technology Related Criteria_1

Dependent : Firm Size (first=1)

Factors: Firm Age_A

Firm Age_B

Firm Age_C

Firm Age_D

Connectivity_A

Connectivity_B

Change Management_A

Change Management_B

Communication Technology_A

Communication Technology_B

Management Information Systems_A

Management Information Systems_B

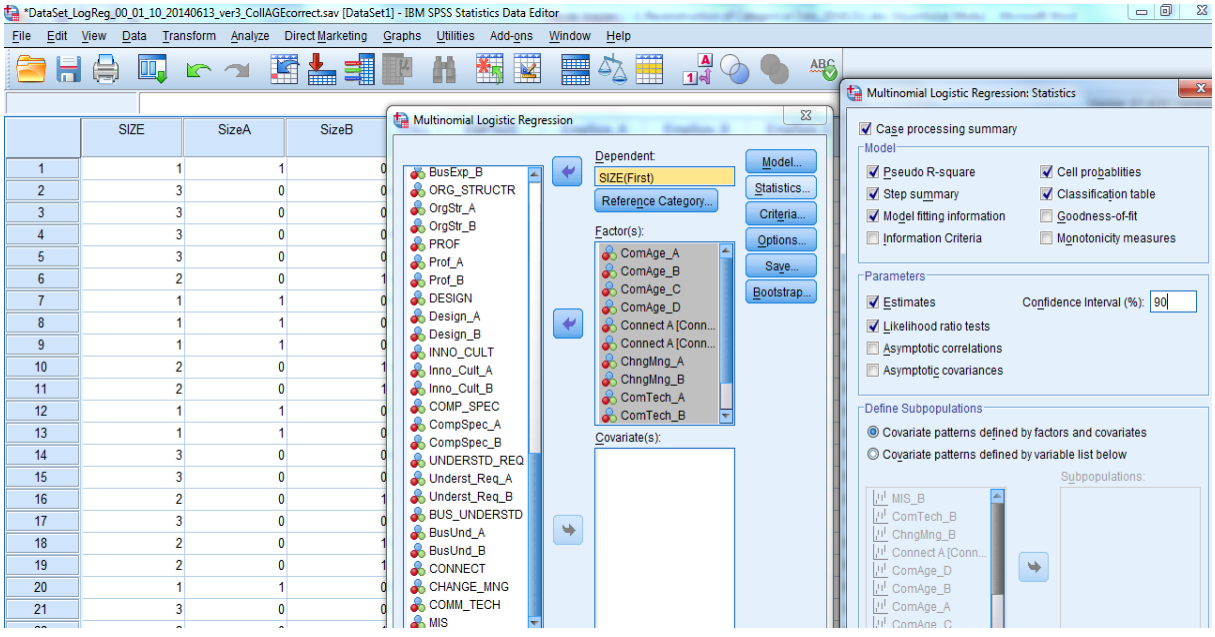


Figure 5.21. SPSS view of multinomial logistic regression analysis tool

The null and alternative hypotheses are as follows:

H_o: There is no relationship between dependent variable firm size and factors technology related criteria and age of the firm.

H_1: There is a relationship between dependent variable firm size and factors technology related criteria and age of the firm.

The confidence level for this multinomial logistic regression analysis is chosen as 0.90 (Figure 5.21). If the significance value is found as less than or equal to 0.10 (p-value ≤ α), the decision is to reject the null hypothesis. Then it is concluded that the model is significant and at least one of the model coefficients is statistically significantly different from zero.

Table 5.5. Model fitting information

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	d_f	Sig.
Intercept Only	146.768			
Final	99.225	47.544	24	.003

Significance value in Table 5.5 is the probability of receiving an extreme MLR test under the null hypothesis; which is that all of the model coefficients are not equal to zero (UCLA, 2014).

Significance values in Table 5.6 indicate that all of the model coefficients are not equal to zero. The Wald Test for predictors implies that, the square of estimate of predictor must be divided to the square of its standard error. **B coefficients** are the model estimates for the multinomial logistic regression coefficients. One **standard error is** obtained for each individual logistic regression coefficient. **Wald** is the Wald chi-square test, testing if the estimate is zero, as the null hypothesis. Degrees of freedom for each individual is equal to 1.

90% confidence interval for Exp (B) is the confidence interval for a single multinomial odds ratio; given all other predictors are in the model for outcome m relative to the reference category. Advantage of confidence interval (CI) provides a range for the "true" odds ratio in the given range, which is illustrative.

Table 5.6. Parameter Estimates Table – Firm Size = 2

SIZE[a]	B	Std. Error	Wald	D_f	Sig.	Exp(B)	90% Confidence Interval for Exp(B)	
							Lower Bound	Upper Bound
2 Intercept	11.969	793.441	.000	1	.988			
[ComAge_A=0]	1.809	1.016	3.168	1	.075	6.102	1.147	32.467
[ComAge_A=1]	0[b]			0				
[ComAge_B=0]	2.016	.784	6.606	1	.010	7.509	2.066	27.285
[ComAge_B=1]	0[b]			0				
[ComAge_C=0]	1.202	.750	2.567	1	.109	3.327	.968	11.433
[ComAge_C=1]	0[b]			0				
[ComAge_D=0]	-.438	.755	.336	1	.562	.645	.186	2.235
[ComAge_D=1]	0[b]			0				
[Connect_A =0]	-30.229	.834	1313.278	1	.000	7.444E-14	1.888E-14	2.935E-13
[Connect_A=1]	0[b]			0				
[Connect_B=0]	-29.814	0.000		1		1.127E-13	1.127E-13	1.127E-13
[Connect_B=1]	0[b]			0				
[ChngMng_A=0]	-1.183	.837	1.998	1	.158	.306	.077	1.214
[ChngMng_A=1]	0[b]			0				
[ChngMng_B=0]	-.072	.893	.006	1	.936	.931	.214	4.041
[ChngMng_B=1]	0[b]			0				
[ComTech_A=0]	-2.219	2.099	1.118	1	.290	.109	.003	3.432
[ComTech_A=1]	0[b]			0				
[ComTech_B=0]	-.712	2.105	.114	1	.735	.491	.015	15.648
[ComTech_B=1]	0[b]			0				
[MIS_A=0]	16.150	793.437	.000	1	.984	########	0.000	.[c]
[MIS_A=1]	0[b]			0				
[MIS_B=0]	15.268	793.437	.000	1	.985	########	0.000	.[c]
[MIS_B=1]	0[b]			0				

When only logistic regression coefficients for the significant variables are used in the logistic regression model, the equations for Technology Related Criteria based on company size are seen above in Table 5.7. The reference category is size 1 (micro company) and the comparative variable is size 2 (small company) in the first equation of logistic regression models.

Logistic regression models for size = 1 (log(Odds Ratio)):

$$\log\left(\frac{p_{size\,2}/q_{size\,2}}{p_{size\,1}/q_{size\,1}}\right) = 11.969 + 1.809\,\text{ComAge_A} + 2.106\,\text{ComAge_B}$$
$$+1.202\,\text{ComAge_C} - 0.438\,\text{ComAge_D} - 30.229\,\text{Connect_A} - 29.814\,\text{Connect_B}$$

Intercept - This is the multinomial log-odds-ratio estimate for size 2 (small) relative to size 1 (micro) when the predictor variables in the model are evaluated at zero. For all variables evaluated at zero value, the log-odds-ratio for preference of size 2 (small) to size 1 (micro) is 11.969.

ComAge_A (younger than 1 year old) If a subject changes the category from ComAge_E (older than 10 years old) to ComAge_A, the multinomial log-odds of preferring size 2 (small) to size 1 (micro) would be expected to **increase** by 1.809 units while holding all other variables in the model constant.

ComAge_B (between 1 to 3 years old) : If a subject changes the category from ComAge_E (older than 10 years old) to ComAge_B (between 1 to 3 years old), the multinomial log-odds-ratio of preferring size 2 (small) to size 1 (micro) would be expected to **increase** by 2.106 units while holding all other variables in the model constant.

ComAge_C (between 3 to 5 years old): If a subject changes the category from ComAge_E (older than 10 years old) to ComAge_C (between 3 to 5 years old), the multinomial log-odds-ratio of preferring size 2 (small) to size 1 (micro) would be expected to **increase** by 1.202 unit swhile holding all other variables in the model constant.

ComAge_D (between 5 to 10 years old): If a subject changes the category from ComAge_E (older than 10 years old) to ComAge_D (between 5 to 10 years old), the multinomial log-odds-ratio of preferring size 2 (small) to size 1 (micro) would be expected to **decrease** by 0.438 units while holding all other variables in the model constant.

Connect_A (all communication ways must be used): If a subject changes the category from Connect_C (connectivity is not important for collaborative innovation) to Connect_A (all communication ways must be used), the multinomial log-odds-ratio of preferring size 2 (small) to size 1 (micro) would be expected to **decrease** by 30.229 unit while holding all other variables in the model constant.

Connect_B (only one possible communication way is enough): If a subject changes the category from Connect_C (connectivity is not important for collaborative innovation) to Connect_B (only one possible communication way is enough), the multinomial log-odds-ratio of preferring size 2 (small) to size 1 (micro) would be expected to **decrease** by 29.814 unit while holding all other variables in the model constant.

Table 5.7. Parameter Estimates Table – Firm Size = 3

3	Intercept	-21.402	1491.159	.000	1	.989			
	[ComAge_A=0]	15.597	1030.426	.000	1	.988	########	0.000	.[c]
	[ComAge_A=1]	0[b]			0				
	[ComAge_B=0]	16.523	729.538	.001	1	.982	########	0.000	.[c]
	[ComAge_B=1]	0[b]			0				
	[ComAge_C=0]	2.185	1.062	4.234	1	.040	8.889	1.550	50.968
	[ComAge_C=1]	0[b]			0				
	[ComAge_D=0]	.923	.961	.921	1	.337	2.516	.518	12.231
	[ComAge_D=1]	0[b]			0				
	[Connect_A=0]	-29.164	1.092	713.796	1	.000	2.160E-13	3.586E-14	1.301E-12
	[Connect_A=1]	0[b]			0				
	[Connect_B=0]	-28.710	0.000		1	.000	3.400E-13	3.400E-13	3.400E-13
	[Connect_B=1]	0[b]			0				
	[ChngMng_A=0]	-.969	1.103	.771	1	.380	.379	.062	2.330
	[ChngMng_A=1]	0[b]			0				
	[ChngMng_B=0]	-1.119	1.155	.938	1	.333	.327	.049	2.183

The referent is the size 1 (micro company) and the comparative variable is size 3 (medium company) in the second equation of this logistic regression model (Table 5.7).

$$\log\left(\frac{p_{size3}/q_{size3}}{p_{size1}/q_{size1}}\right) = -21.402 + 15.597\,\text{ComAge_A} + 16.523\,\text{ComAge_B} + 2.185\,\text{ComAge_C} + 0.923\,\text{ComAge_D} - 29.164\,\text{ConnectA} - 28.710\,\text{ConnectA_A}$$

Intercept - This is the multinomial log-odd-ratio estimate for size 3 (medium) relative to size 1 (micro) when the predictor variables in the model are evaluated at zero. For all variables evaluated at zero value. The log-odds-ratio for preferring size 3 (medium) to size 1 (micro) is – 20.402.

ComAge_A (younger than 1 year old) If a subject changes the category from ComAge_E (older than 10 years old) to ComAge_A, the multinomial log-odds-ratio of preferring size 3 (medium) to size 1 (micro) would be expected to **increase** by 15.597 unit while holding all other variables in the model constant.

ComAge_B (between 1 to 3 years old): If a subject changes the category from ComAge_E (older than 10 years old) to ComAge_B (between 1 to 3 years old), the multinomial log-odds-ratio of preferring size 3 (medium) to size 1 (micro) would be expected to **increase** by 16.523 unit while holding all other variables in the model constant.

ComAge_C (between 3 to 5 years old): If a subject changes the category from ComAge_E (older than 10 years old) to ComAge_C (between 3 to 5 years old), the multinomial log-odds-ratio of preferring size 3 (medium) to size 1 (micro) would be expected to **increase** by 2.185 unit while holding all other variables in the model constant.

ComAge_D (between 5 to 10 years old): If a subject changes the category from ComAge_E (older than 10 years old) to ComAge_D (between 5 to 10 years old), the multinomial log-odds-ratio of preferring size 3 (medium) to size 1 (micro) would be expected to **decrease** by 0.923 unit while holding all other variables in the model constant.

Connect_A (all communication ways must be used): If a subject changes the category from Connect_C (connectivity is not important for collaborative innovation) to Connect_A (all communication ways must be used), the multinomial log-odds-ratio of preferring size 3 (medium)

to size 1 (micro) would be expected to **decrease** by 29.164 unit while holding all other variables in the model constant.

Connect_B (only one possible communication way is enough): If a subject changes the category from Connect_C (connectivity is not important for collaborative innovation) to Connect_B (only one possible communication way is enough), the multinomial log-odds-ratio of preferring size 3 (medium) to size 1 (micro) would be expected to **decrease** by 28.710 units while holding all other variables in the model constant.

5.3.3 Cross-relations tables

5.3.3.1 Model fitting information

The first analysis is statistically significant as seen in Table 5.8. When the observed and predicted frequency table is examined some cross-relations can be produced as a basis of association rules (Figure 5.22). Also these cross – relations have been constituted for only significant models of training data analysis. These relations guide to SMEs to reach rules for successful collaboration for innovation.

Table 5.8. Model fitting Information - Firm Size – Firm Age – Technology Related Criteria

	Model Fitting Criteria	Likelihood Ratio Tests		
Model	-2 Log Likelihood	Chi-Square	D_f	Sig.
Intercept Only	146.768			
Final	99.225	47.544	24	.003

5.3.3.2 Achievements cross-relations tables

Figure 5.22 shows too many relations using the below mentioned models. In order to reduce the number of rules the analysis is performed on a combination of 3 factors: one demographic and two criteria attributes. Furthermore focused rules will be demonstrated.

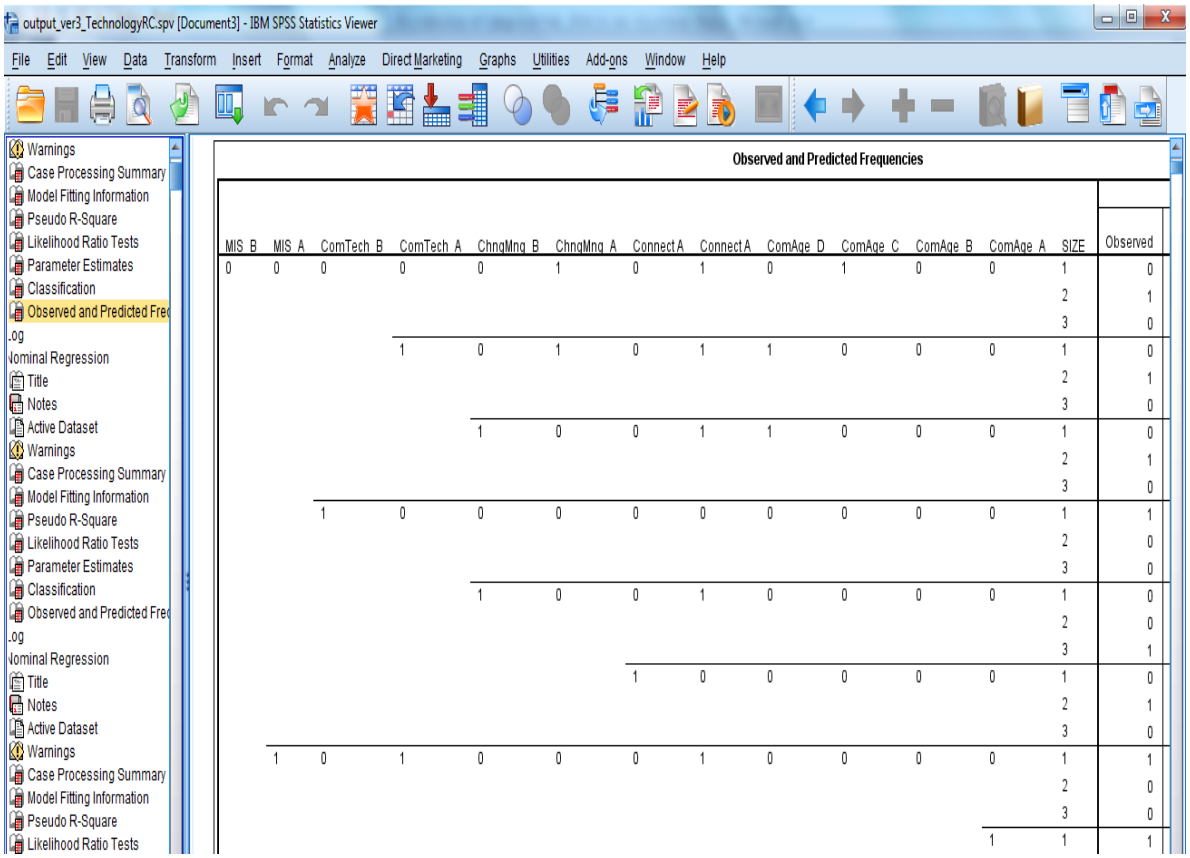


Figure 5.22. SPSS view of the observed and predicted frequency table - Firm Size – Firm Age – Technology Related Criteria

One of the important cross – relations is between firm age and technology related criteria which is size dependent as observed in Table 5.9. This cross – relation is from predicted and observed frequency table. This mentioned model makes sense statistically significant as a result of the logistic regression analysis.

Table 5.9. Cross – relations table: Firm Size – Firm Age – Technology Related Criteria

Ref: Size 1									
Technology Related Criteria		**Connect_ All ways (A)**	**Connect_ Possible ways (B)**	**Change Mngmnt_ All (A)**	**Change Mngmnt_ Indıvıdual (B)**	**CommTech_ All tech (A)**	**CommTech_ Existing (B)**	**MIS_All (A)**	**MIS_ At least one (B)**
Firm Size	**Firm Age**								
MICRO (1)	**< 1 YEAR OLD (A)**	■				■		■	
	1-3 YEARS OLD (B)								
	3-5 YEARS OLD ©	■							■
	5-10 YEARS OLD (D)	■					■		■
SMALL (2)	**< 1 YEAR OLD (A)**								
	1-3 YEARS OLD (B)								
	3-5 YEARS OLD ©	■		■					
	5-10 YEARS OLD (D)	■		■		■			
		■			■	■			
		■				■			■
MEDIUM (3)	**< 1 YEAR OLD (A)**								
	1-3 YEARS OLD (B)								
	3-5 YEARS OLD ©								
	5-10 YEARS OLD (D)	■		■					■

Micro SMEs:

✓ *Preferences for the micro size firms who are collaborating with younger than 1 year old firms emphasize usage of all connecting ways, all communication technologies concurrently and having the MIS application in all of the firms.*

✓ *Preferences for the micro size firms who are collaborating with older than 3 years and younger than 5 years old firms emphasize usage of all connecting ways and the application of MIS in at least one of the firms.*

✓ *Preferences for the micro size firms who are collaborating with older than 5 years and younger than 10 years old firms emphasize usage of all connecting ways and existing communication technologies concurrently having the MIS application at least in one of the firms.*

Small SMEs:

✓ *Preferences for the small size firms who are collaborating with older than 3 years and younger than 5 years old firms emphasize usage of all connecting ways and applying the management changes together with their collaborators.*

✓ *Preferences for the small size firms who are collaborating with older than 5 years and younger than 10 years old firms emphasize usage of all connecting ways and all communication technologies at the same time applying the management changes together with their collaborators.*

✓ *Preferences for the small size firms who are collaborating with older than 5 years and younger than 10 years old firms emphasize usage of all connecting ways and all communication technologies s at the same time applying the management changes independently.*

✓ *Preferences for the small size firms who are collaborating with older than 5 years and younger than 10 years old firms emphasize usage of all connecting ways and all communication technologies at the same time and having the MIS application at least one of the firms.*

Medium SMEs:

✓ *Preferences for the medium size firms who are collaborating with older than 5 years and younger than 10 years old firms emphasize usage of all connecting ways and applying the*

management changes independently at the same time having the MIS application in at least one of the firms.

5.4 Association Rules Achieved

Rules are extracted based on the significance of attribute in cross relations; where inattentive rules are eliminated and significances of the models are tested.

- Since the focus is not populated in young micro firms the association rules cannot be deducted.
- Innovation related criteria in this study have no significance based on firm size and collaborator types of these firms. In other words, respondent firms care the technological features but ignore the innovative attributes.

FINANCE RELATED RULES

93 associations are detected for the finance related criteria which are consistent with the constructed model.

Firm Size – Collaboration Duration – Financial Criteria

RULE 1:

IF (Firm Size= “Micro” AND Collaboration Duration = “0-3 years”)

THEN (Innovation Operation Expenditure= “Proportionally Shared”)

RULE 2:

IF (Firm Size= “Small” AND Collaboration Duration =”Aged”)

THEN (Innovation Operation Expenditure= “Balanced”)

RULE 3:

IF (Firm Size= “Micro” AND Collaboration Duration =”1-3 years”)

THEN (Price=”Important” AND Exportation Facilities= “Equal Level”)

RULE 4:

IF (Firm Size= “Micro” AND Collaboration Duration =”0-3 years”)

THEN (Price=”Important AND Exportation Facilities= “Only One Firm”)

RULE 5:

IF (Firm Size= “Micro” AND Collaboration Duration =”0-3 years”)

THEN (Price=”Motivation” AND Exportation Facilities= “Equal Level”)

RULE 6:

IF (Firm Size= “Micro” AND Collaboration Duration =”1-5 years”)

THEN (Price=”Important” AND Exportation Facilities= “Only One Firm”)

RULE 7:

IF (Firm Size= “Small” AND Collaboration Duration =”3-5 years”)

THEN (Price=”Important” AND Exportation Facilities= “Only One Firm”)

RULE 8:

IF (Firm Size= “Micro” AND Collaboration Duration =”Aged”)

THEN (Price=” Motivation” AND Exportation Facilities= “Only One Firm”)

RULE 9:

IF (Firm Size= “Small” AND Collaboration Duration =”Aged”)

THEN (Capital=” More Than Average” AND Exportation Facilities= “Only One Firm”)

RULE 10:

IF (Firm Size= “Medium” AND Collaboration Duration =”3-5 years”)

THEN (Capital=” More Than Average” AND Price=” Motivation”)

RULE11:

IF (Firm Size= “Small” AND Collaboration Duration =”1-3 years”)

THEN (Innovation Operation Expenditure= “Proportionally Shared” AND Exportation Facilities= “Only One Firm”)

RULE 12:

IF (Firm Size= “Small” AND Collaboration Duration = “0-3 years”)

THEN (Innovation Operation Expenditure= “Balanced” AND Price= “Important”)

RULE 13:

IF (Firm Size= “Small” AND Collaboration Duration =”1-3 years”)

THEN (Innovation Operation Expenditure= “Balanced” AND Price= “Motivation”)

RULE 14:

IF (Firm Size= “Medium” AND Collaboration Duration =”Aged”)

THEN (Innovation Operation Expenditure= “Balanced” AND Price= “Motivation”)

Firm Size – Firm Age – Financial Criteria

RULE 1:

IF (Firm Size= “Micro” AND Firm Age =”0-3 years”)

THEN (Price= “Important” AND Innovation Operation Expenditure = “Proportionally Shared”)

RULE 2:

IF (Firm Size= “Micro” AND Firm Age =”0-3 years old”)

THEN (Price= “Motivation” AND Innovation Operation Expenditure = “Proportionally Shared”)

RULE 3:

IF (Firm Size= “Micro” AND Firm Age = “Aged”)

THEN (Price= “Motivation” AND Innovation Operation Expenditure = “Proportionally Shared”)

Firm Age – Collaboration Duration – Financial Criteria

RULE 1:

IF (Firm Age=”Aged” AND Collaboration Duration =”Aged”)

THEN (Price= “Motivation” AND Innovation Operation Expenditure = “Balanced”)

RULE 2:

IF (Firm Age=”Aged” AND Collaboration Duration =”0-3 years”)

THEN (Price=” Motivation” AND Exportation Facilities= “Only One Firm”)

RULE 3:

IF (Firm Age= “3-5 Years” AND Collaboration Duration =”3-5 Years”)

THEN (Price= “Important” AND Exportation Facilities = “Equal Level”)

RULE 4:

IF (Firm Age= “3-5 Years” AND Collaboration Duration =”0-3 years”)

THEN (Price= “Important”)

RULE 5:

IF (Firm Age=”Aged” AND Collaboration Duration =”0-3 years”)

THEN (Innovation Operation Expenditure = “Proportionally Shared” AND Exportation Facilities = “Equal Level”)

Collaboration – Firm Size – Financial Criteria

RULE 1:

IF (Collaboration= “Collaborating with Customers, Suppliers, Large Firms and SMEs” AND Firm Size= “Small”)

THEN (Innovation Operation Expenditure = “Proportionally Shared” AND Price= “Motivation”)

RULE 2:

IF (Collaboration= “Collaborating with Customers, Large Firms and SMEs” AND Firm Size= “Small”)

THEN (Innovation Operation Expenditure = “Balanced” AND Price= “Motivation”)

RULE 3:

IF (Collaboration= “Collaborating with Customers, Large Firms and SMEs” AND Firm Size= “Small”)

THEN (Innovation Operation Expenditure = “Proportionally Shared” AND Exportation Facilities= “Only One Firm”)

RULE 4:

IF (Collaboration= “Collaborating with Customers, Suppliers, Large Firms and SMEs” AND Firm Size= “Small”)

THEN (Price=” Important” AND Exportation Facilities= “Only One Firm”)

IF (Collaboration= “Collaborating with Customers, Suppliers, and Large Firms” AND Firm Size= “Small”)

THEN (Price=" Important" AND Exportation Facilities= "Equal Level")

RULE 5:

IF (Collaboration= "Collaborating with Customers, and SMEs" AND Firm Size= "Micro")

THEN (Innovation Operation Expenditure = "Proportionally Shared")

RULE 6:

IF (Collaboration= "Collaborating with Customers, Large Firms and SMEs" AND Firm Size= "Small")

THEN (Innovation Operation Expenditure = "Balanced")

RULE 7:

IF (Collaboration= "Collaborating with Customers, and SMEs" AND Firm Size= "Micro")

THEN (Price= "Important")

RULE 8:

IF (Collaboration= "Collaborating with Customers, Suppliers, Large Firms and SMEs" AND Firm Size= "Small")

THEN (Price= "Motivation")

Collaboration – Firm Age – Financial Criteria

RULE 1:

IF (Collaboration= "Collaborating with Customers, Suppliers, and SMEs" AND Firm Age= "3-5 Years Old")

THEN (Capital = "Average" AND Price= "Motivation")

RULE 2:

IF (Collaboration= “Collaborating with Customers, Large Firms and SMEs” AND Firm Age = “1-3 Years Old”)

THEN (Innovation Operation Expenditure = “Proportionally Shared” AND Exportation Facilities= “Only One Firm”)

RULE 3:

IF (Collaboration= “Collaborating with Customers, Suppliers, Large Firms and SMEs” AND Firm Age = “3-5 Years Old”)

THEN (Exportation Facilities= “Only One Firm” AND Price=” Motivation”)

RULE 4:

IF (Collaboration= “Collaborating with Customers, Suppliers, Large Firms and SMEs” AND Firm Age = “Aged”)

THEN (Exportation Facilities= “Only One Firm” AND Price=” Important”)

RULE 5:

IF (Collaboration= “Collaborating with Customers, Large Firms and SMEs” AND Firm Age = “1-3 Years Old”)

THEN (Exportation Facilities= “Only One Firm” AND Price=” Motivation”)

RULE 6:

IF (Collaboration= “Collaborating with Customers, and SMEs” AND Firm Age = “1-3 Years Old”)

THEN (Innovation Operation Expenditure = “Proportionally Shared” AND Price=” Motivation”)

RULE 7:

IF (Collaboration= “Collaborating with Customers, Suppliers, Large Firms and SMEs” AND Firm Age = “1-3 Years Old”)

THEN (Innovation Operation Expenditure = “Proportionally Shared” AND Price=” Motivation”)

RULE 8:

IF (Collaboration= “Collaborating with Customers, Large Firms and SMEs” AND Firm Age = “Aged”)

THEN (Innovation Operation Expenditure = “Balanced” AND Price=” Motivation”)

RULE 9:

IF (Collaboration= “Collaborating with Customers, and Large Firms” AND Firm Age = “3-5 Years Old”)

THEN (Innovation Operation Expenditure = “Balanced” AND Price=” Motivation”)

RULE 10:

IF (Collaboration= “Collaborating with Customers,” AND Firm Age = “Aged”)

THEN (Price=” Important”)

RULE 11:

IF (Collaboration= “Collaborating with Customers, Suppliers, Large Firms and SMEs” AND Firm Age = “1-3 Years Old”)

THEN (Price=” Motivation”)

Collaboration – Collaboration Duration – Financial Criteria

RULE 1:

IF (Collaboration= “Collaborating with Large Firms” AND Collaboration Duration = “3-5 Years”)

THEN (Capital = “More Than Average” AND Price=” Motivation”)

RULE 2:

IF (Collaboration= “Collaborating with Customers, Suppliers, Large Firms and SMEs” AND Collaboration Duration = “0-3 years old”)

THEN (Price = “Motivation” AND Innovation Operation Expenditure = “Proportionally Shared”)

RULE 3:

IF (Collaboration= “Collaborating with Customers, Large Firms and SMEs” AND Collaboration Duration = “1-3 Years”)

THEN (Price = “Motivation” AND Innovation Operation Expenditure = “Balanced”)

RULE 4:

IF (Collaboration= “Collaborating with Customers, and Suppliers” AND Collaboration Duration = “Aged”)

THEN (Price = “Motivation” AND Innovation Operation Expenditure = “Balanced”)

RULE 5:

IF (Collaboration= “Collaborating with Customers, Large Firms and SMEs” AND Collaboration Duration = “1-3 Years”)

THEN (Innovation Operation Expenditure = “Proportionally Shared” AND Exportation Facilities= “Only One Firm”)

RULE 6:

IF (Collaboration= “Collaborating with Customers, Suppliers, and Large Firms” AND Collaboration Duration = “1-3 Years”)

THEN (Exportation Facilities= “Equal Level” AND Price = “Important”)

RULE 7:

IF (Collaboration= "Collaborating with Customers, Suppliers, and Large Firms" AND Collaboration Duration = "Aged")

THEN (Exportation Facilities= "Only One Firm" AND Price = "Important")

Firm Size – Innovation – Financial Criteria

RULE 1:

IF (Firm Size = "Micro" AND Innovation = "Collaboration for Innovation")

THEN (Price = "Important" AND Innovation Operation Expenditure = "Proportionally Shared")

BUT

RULE 2:

IF (Firm Size = "Small" AND Innovation = "Collaboration for Innovation")

THEN (Price = "Motivation" AND Innovation Operation Expenditure = "Balanced")

BUT

RULE 3:

IF (Firm Size = "Small" AND Innovation = "Collaboration for Innovation")

THEN (Price = "Motivation" AND Innovation Operation Expenditure = "Proportionally Shared")

IF (Firm Size = "Small" AND Innovation = "Collaboration for Innovation")

THEN (Price = "Important" AND Exportation Facilities = "Have No Affect")

RULE 4:

IF (Firm Size = "Small" AND Innovation = "Collaboration for Innovation")

THEN (Capital = "Average" AND Exportation Facilities = "Only One Firm")

RULE 5:

IF (Firm Size = "Small" AND Innovation = "Collaboration for Innovation")

THEN (Capital = “More Than Average” AND Exportation Facilities = “Only One Firm”)

Innovation –Firm Age –Financial Criteria

RULE 1:

IF (Firm Age = “1-3 years old” AND Innovation = “Collaboration for Other Reasons”)

THEN (Price = “Important” AND Innovation Operation Expenditure = “Balanced”)

RULE 2:

IF (Firm Age = “1-3 years old” AND Innovation = “Collaboration for Innovation”)

THEN (Price = “Important” AND Innovation Operation Expenditure = “Balanced”)

RULE 3:

IF (Firm Age = “3-5 years old” AND INN = “Collaboration for Innovation”)

THEN (Price = “Motivation” AND Exportation Facilities = “Only One Firm”)

Firm Age – Firm Size –Financial Criteria

RULE 1:

IF (Firm Age = “0-3 years old” AND Firm Size = “Micro”)

THEN (Innovation operation expenditure = “Balanced” AND Price = “Motivation”)

RULE 2:

IF (Firm Age = “0-3 years old” AND Firm Size = “Micro”)

THEN (Innovation operation expenditure = “Balanced” AND Price = “Important”)

RULE 3:

IF (Firm Age = “0-3 years old” AND Firm Size = “Micro”)

THEN (Innovation operation expenditure = “Proportionally Shared” AND Price = “Important”)

BUT

RULE 4:

IF (Firm Age = “1-3 Years Old” “Young” AND Firm Size = “Small”)

THEN (Innovation operation expenditure = “Proportionally Shared” AND Price =“Motivation”)

BUT

RULE 5:

IF (Firm Age = “3-10 Years Old” AND Firm Size = “Small”)

THEN (Innovation operation expenditure = “Balanced” AND Price =“Motivation”)

RULE 6:

IF (Firm Age = “Aged” AND Firm Size = “Micro”)

THEN (Innovation operation expenditure = “Balanced” AND Price =“Motivation”)

RULE 7:

IF (Firm Age = “0-3 years old” AND Firm Size = “Micro”)

THEN (Exportation Facilities = “Only One Firm” AND Price =“Important”)

RULE 8:

IF (Firm Age = “0-3 years old” AND Firm Size = “Small”)

THEN (Exportation Facilities = “Only One Firm” AND Price = “Motivation”)

RULE 9:

IF (Firm Age = “Aged” AND Firm Size = “Small”)

THEN (Exportation Facilities = “Only One Firm” AND Price =“Important”)

RULE 10:

IF (Firm Age = “1-3 Years Old” AND Firm Size = “Small”)

THEN (Exportation Facilities = “Only One Firm” AND Price = “Motivation”)

RULE 11:

IF (Firm Age = “3-5 Years Old” AND Firm Size = “Small”)

THEN (Exportation Facilities = “Equal Level” AND Price = “Important”)

RULE 12:

IF (Firm Age = “Aged” AND Firm Size = “Micro”)

THEN (Exportation Facilities = “Equal Level” AND Price = “Motivation”)

RULE 13:

IF (Firm Age = “1-3 Years Old” AND Firm Size = “Micro”)

THEN (Exportation Facilities = “Only One Firm” AND Price = “Motivation”)

RULE 14:

IF (Firm Age = “3-5 Years Old” AND Firm Size = “Medium”)

THEN (Exportation Facilities = “Only One Firm” AND Price = “Motivation”)

BUT

RULE 15:

IF (Firm Age = “0-3 years old” AND Firm Size = “Micro”)

THEN (Capital = “More Than Average” AND Innovation operation expenditure = “Balanced”)

RULE 16:

IF (Firm Age = “3-5 Years Old” AND Firm Size = “Small”)

THEN (Capital = “Average” AND Innovation operation expenditure = “Balanced”)

RULE 17:

IF (Firm Age = “Aged” AND Firm Size = “Small”)

THEN (Capital = “Average” AND Exportation Facilities = “Only One Firm”)

RULE 18:

IF (Firm Age = “Aged” AND Firm Size = “Small”)

THEN (Capital = “More Than Average” AND Exportation Facilities = “Only One Firm”)

RULE 19:

IF (Firm Age = “Aged” AND Firm Size = “Small”)

THEN (Capital = “More Than Average” AND Exportation Facilities = “Equal Level”)

RULE 20:

IF (Firm Age = “Aged” AND Firm Size = “Small”)

THEN (Capital = “More Than Average” AND Exportation Facilities = “Only One Firm”)

RULE 21:

IF (Firm Age = “0-3 years old”)

THEN (Exportation Facilities = “Only One Firm” AND Price = “Motivation”)

RULE 22:

IF (Firm Age = “1-3 Years Old” AND Firm Size = “Small”)

THEN (Innovation operation expenditure = “Proportionally Shared” AND Exportation Facilities = “Only One Firm”)

RULE 23:

IF (Firm Age = “1-3 Years Old” AND Firm Size = “Small”)

THEN (Capital = “Average” AND Price = “Motivation”)

Firm Age – Employee Size – Financial Criteria

RULE 1:

IF (Firm Age = “3-5 Years Old” AND Employee Size = “<49 workers”)

THEN (Price = “Motivation” AND Exportation Facilities = “Only One Firm”)

RULE 2:

IF (Firm Age = “3-5 Years Old” AND Employee Size = “<49 workers”)

THEN (Price = “Important” AND Exportation Facilities = “Equal Level”)

RULE 3:

IF (Firm Age = “3-5 Years Old” AND Employee Size = 50-99 workers”)

THEN (Price = “Motivation” AND Exportation Facilities = “Only One Firm”)

RULE 4:

IF (Firm Age = “Aged” AND Employee Size = <49 workers”)

THEN (Price = “Motivation” AND Exportation Facilities = “Equal Level”)

RULE 5:

IF (Firm Age = “Aged” AND Employee Size = 100-149 workers”)

THEN (Capital = “More Than Average” AND Price = “Motivation”)

RULE 6:

IF (Firm Age = “Aged” AND Employee Size = <49 workers”)

THEN (Capital = “More Than Average” AND Exportation Facilities = “Only One Firm”)

RULE 7:

IF (Firm Age = “1-3 Years Old” AND Employee Size = <49 workers”)

THEN (Innovation operation expenditure = “Balanced” AND Exportation Facilities = “Only One Firm”)

RULE 8:

IF (Firm Age = “1-3 Years Old” AND Employee Size = <49 workers”)

THEN (Innovation operation expenditure = “Proportionally Shared” AND Exportation Facilities = “Only One Firm”)

RULE 9:

IF (Firm Age = “Aged” AND Employee Size = <49 workers”)

THEN (Innovation operation expenditure = “Proportionally Shared” AND Exportation Facilities = “Equal Level”)

RULE 10:

IF (Firm Age = “0-3 years old” AND Employee Size = <49 workers”)

THEN (Innovation operation expenditure = “Proportionally Shared” AND Price = “Important”)

RULE 11:

IF (Firm Age = “1-3 Years Old” AND Employee Size = <49 workers”)

THEN (Innovation operation expenditure = “Proportionally Shared” AND Price = “Motivation”)

RULE 12:

IF (Firm Age = “Aged” AND Employee Size = <49 workers”)

THEN (Innovation operation expenditure = “Balanced” AND Price = “Motivation”)

RULE 13:

IF (Firm Age = “Aged” AND Employee Size = 100-149 workers”)

THEN (Innovation operation expenditure = “Balanced” AND Price = “Motivation”)

ALSO

RULE 14:

IF (Firm Age = “Aged” AND Employee Size = <49 workers”)

THEN (Innovation operation expenditure = “Balanced”)

RULE 15:

IF (Firm Age = “1-3 Years Old” AND Employee Size = <49 workers”)

THEN (Innovation operation expenditure = “Proportionally Shared”)

MANAGEMENT RELATED CRITERIA RULES

5 associations are interpreted about the management related criteria which consisting to the constructed model.

Firm Age – Employee Size – Managerial Criteria

RULE 1:

IF (Firm Age = "Aged" AND Employee Size = "<49 Workers")

THEN (Leadership = "Same Level" AND Business Experience = "Same Level" AND Profession = "Important")

Firm Age – Firm Size – Managerial Criteria

RULE 1:

IF (Firm Age = "Aged" AND Firm Size = "Small")

THEN (Leadership = "Same Level" AND Business Experience = "Same Level" AND Profession = "Important")

RULE 2:

IF (Firm Age = "Aged" AND Firm Size = "Micro")

THEN (Leadership = "Same Level" AND Business Experience = "Same Level" AND Profession = "Important")

Collaboration Duration – Firm Size – Managerial Criteria

RULE 1:

IF (Collaboration Duration = "Aged" AND Firm Size = "Micro")

THEN (Leadership = "Same Level" AND Business Experience = "Same Level" AND Profession = "Important")

Firm Age – Employee Size – Managerial Criteria

RULE 1:

IF (Firm Size = "Micro" AND Employee Size = "<49 Workers")

THEN (Leadership = “Same Level” AND Business Experience = “Same Level” AND Profession = “Important”)

TECHNOLOGY RELATED CRITERIA RULES

42 associations are interpreted about the technology related criteria which consisting to the constructed model.

Firm Age – Employee Size–Technological Criteria

RULE 1:

IF (Firm Age = “1-3 Years Old” AND Employee Size = “<49 workers”)

THEN (Change Management = “Individual”)

RULE 2:

IF (Firm Age = “Aged” AND Employee Size = “>49 workers”)

THEN (Change Management = “All”)

RULE 3:

IF (Firm Age = “0-3 years old” AND Employee Size = “<49 workers”)

THEN (Change Management = “Individual” AND Communication Technologies = “All”)

RULE 4:

IF (Firm Age = “1-3 Years Old” AND Employee Size = “<49 workers”)

THEN (Change Management = “Individual” AND Communication Technologies = “Existing”)

RULE 5:

IF (Firm Age = “3-5 Years Old” AND Employee Size = “<49 workers”)

THEN (Communication Technologies = “All” AND Management Information Systems = “Same Level”)

RULE 6:

IF (Firm Age = "3-5 Years Old" AND Employee Size = "<49 workers")

THEN (Connectivity = "All Ways" AND Change Management = "All")

RULE 7:

IF (Firm Age = ">3 Years Old" AND Employee Size = "<49 workers")

THEN (Connectivity = "All Ways" AND Management Information Systems = "At Least One")

RULE 8:

IF (Firm Age = "Aged" AND Employee Size = "<49 workers")

THEN (Change Management = "All" AND Communication Technologies = "Existing")

RULE 9:

IF (Firm Age = "Aged" AND Employee Size = "<49 workers")

THEN (Communication Technologies = "Existing" AND Management Information Systems = "Same Level")

RULE 10:

IF (Firm Age = "3-5 Years Old" AND Employee Size = "50-99 workers")

THEN (Communication Technologies = "Existing" AND Management Information Systems = "At Least One")

RULE 11:

IF (Firm Age = "Aged" AND Employee Size = "100-149 workers")

THEN (Communication Technologies = "Existing" AND Change Management = "All")

Firm Size – Firm Age –Technological Criteria

RULE 1:

IF (Firm Size= "Micro" AND Firm Age ="3-5 years old")

THEN (Connectivity = “All Ways” AND Management Information Systems = “At Least One”)

RULE 2:

IF (Firm Size= “Small” AND Firm Age =”3-5 years old”)

THEN (Connectivity = “All Ways” AND Change Management = “All”)

Collaboration Duration – Firm Age –Technological Criteria

RULE 1:

IF (Collaboration Duration =” 0-3 years old” AND Firm Age = “3-5 Years Old”)

THEN (Connectivity = “All Ways” AND Management Information Systems = “At Least One”)

RULE 2:

IF (Collaboration Duration =” 1-3 Years” AND Firm Age = “3-5 Years Old”)

THEN (Connectivity = “All Ways” AND Management Information Systems = “At Least One”)

RULE 3:

IF (Collaboration Duration =” 1-3 Years” AND Firm Age = “3-5 Years Old”)

THEN (Connectivity = “All Ways” AND Change Management = “All”)

MIDDLE AGED COLLABORATORS

RULE 4:

IF (Collaboration Duration =” 3-5 Years” AND Firm Age = “3-5 Years Old”)

THEN (Connectivity = “All Ways” AND Change Management = “All”)

Collaboration Duration – Firm Size –Technological Criteria

RULE 1:

IF (Collaboration Duration = “0-3 years” AND Firm Size = “Micro”)

THEN (Connectivity = “all ways” AND Management Information Systems = “At Least One”)

RULE 2:

IF (Collaboration Duration = “1-3 years” AND Firm Size = “Micro”)

THEN (Connectivity = “All Ways” AND Management Information Systems = “At Least One”)

RULE 3:

IF (Collaboration Duration = “1-3 years” AND Firm Size = “Small”)

THEN (Connectivity = “All Ways” AND Change Management = “All”)

RULE 4:

IF (Collaboration Duration = “3-5 years” AND Firm Size = “Small”)

THEN (Connectivity = “All Ways” AND Change Management = “All”)

RULE 5:

IF (Collaboration Duration = “3-5 years” AND Firm Size = “Small”)

THEN (Connectivity = “all ways” AND Change Management = “Individual”)

RULE 6:

IF (Collaboration Duration = “Aged” AND Firm Size = “Small”)

THEN (Connectivity = “All Ways” AND Change Management = “Individual”)

Firm Size – Firm Size –Technological Criteria

RULE 1:

IF (Firm Size = “Micro” AND Employee Size = “< 49 workers”)

THEN (Connectivity = “All Ways” AND Management Information Systems = “At Least One”)

RULE 2:

IF (Firm Size = “Small” AND Employee Size = “< 49 workers”)

THEN (Connectivity = “All Ways” AND Change Management = “All”)

Collaboration Duration – Employee Size –Technological Criteria

RULE 1:

IF (Collaboration Duration = “1-3 years” AND Employee Size = “< 49 workers”)

THEN (Connectivity = “All Ways” AND Management Information Systems = “At Least One”)

RULE 2:

IF (Collaboration Duration = “3-5 years” AND Employee Size = “< 49 workers”)

THEN (Connectivity = “All Ways” AND Change Management = “All”)

Collaboration – Collaboration Duration –Technological Criteria

RULE 1:

IF (Collaboration= “Collaboration with Customers” AND Collaboration Duration = “0-3 years”)

THEN (Connectivity = “All Ways” AND Management Information Systems = “At Least One”)

RULE 2:

IF (Collaboration= “Collaboration with Customers and Large Firms” AND Collaboration Duration = “1-3 Years”)

THEN (Connectivity = “All Ways” AND Change Management = “All”)

Collaboration – Firm Size –Technological Criteria

RULE 1:

IF (Collaboration= “Collaboration with Customers” AND Firm Size = “Micro”)

THEN (Connectivity = “All Ways” AND Management Information Systems = “At Least One”)

RULE 2:

IF (Collaboration= “Collaboration with Customers” AND Firm Size = “Micro”)

THEN (Connectivity = “All Ways” AND Change Management = “All”)

Communication Technology –Technological Criteria

RULE 1:

IF (Firm Age = “Aged” AND Employee Size = “<49 Workers”)

THEN (Communication Technology= “Existing”)

RULE 2:

IF (Firm Age = “Aged” AND Firm Size = “Micro”)

THEN (Communication Technology= “Existing”)

RULE 3:

IF (Firm Age = “Aged” AND Innovation = “Collaboration for Innovation”)

THEN (Communication Technology= “Existing”)

RULE 4:

IF (Firm Size = “Micro” Old” AND Innovation = “Collaboration for Innovation”)

THEN (Communication Technology= “Existing”)

RULE 5:

IF (Firm Size = “Micro” AND Collaboration Duration = “3-5 Years”)

THEN (Communication Technology= “Existing”)

RULE 6:

IF (Firm Size = “Micro” AND Collaboration Duration = “Aged”)

THEN (Communication Technology= “Existing”)

RULE 7:

IF (Employee Size = "<49 Workers" AND Innovation = "Collaboration for Innovation")

THEN (Communication Technology= "Existing")

RULE 8:

IF (Firm Size = "Micro" AND Employee Size = "<49 Workers")

THEN (Communication Technology= "Existing")

RULE 9:

IF (Employee Size = "<49 Workers" AND Collaboration Duration = "Aged")

THEN (Communication Technology= "Existing")

RULE 10:

IF (Innovation = "Collaboration for Innovation" AND Collaboration Duration = "Aged")

THEN (Communication Technology= "Existing")

RULE 11:

IF (Collaboration Duration = "3-5 Years" AND Collaboration = "Collaboration with Large Firms")

THEN (Communication Technology= "Existing")

5.5 Model Testing

The SPSS Modeler of IBM which was produced by ISL Company of UK was originally named as 

. It was acquired by IBM. The IBM SPSS Modeler supplies the user a great ability to operate and process the data with its comprehensive use of visual techniques. IBM's SPSS Modeler, a set of data mining facilities, which makes easy and fast decision making processes by offering the ability to develop predictive models using professional expertise and apply them to the business operations. IBM SPSS Modeler supplies broad opportunities of modeling methods, which can be taken from machine learning, artificial intelligence, and statistics. The available modeling techniques of IBM SPSS Modeler give the ability to derive

different information from the same data for built up new predictive models. Each technique can fit to a particular problem with acceptable strength (IBM, 2011).

5.5.1 Reading data files into Clementine

The data is arranged in .xls format for Clementine 12.0 version. Two different MS Excel files are developed as Train and Test. The data taken from the IBM SPSS 21 is used directly. Multinomial Logistic Regression model is built up by employing Clementine 12.0 using 105 Train data.

Add - Source : Var. File (train.xls)

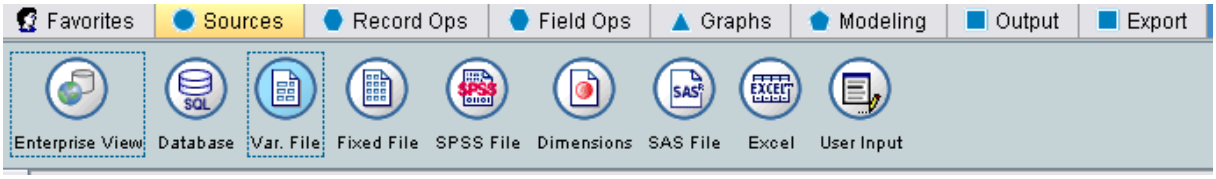


Figure 5.23. Variable file reads data form delimited column text files

The Source node of Clementine 12.0 can read data from any external source. Initial step is to transfer the data by using a Variable Node (Figure 5.23). A dialog box is opened to browse on the directory of the loaded data (Figure 5.24). Then the data file is opened.

From the “Sources” tab by clicking on “Var. File”, the “Train data.xls” file is opened.

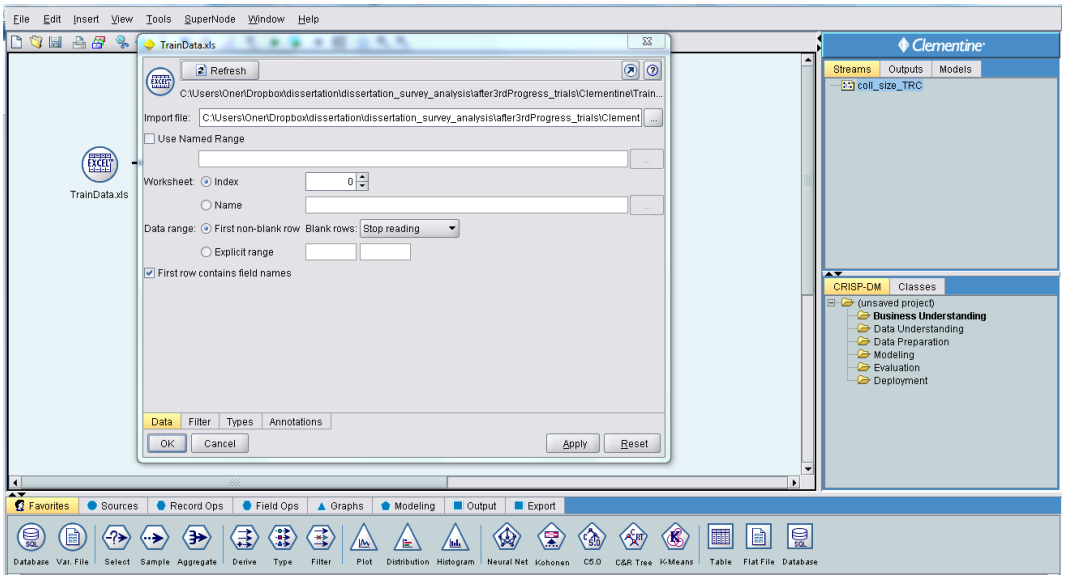


Figure 5.24. Selection of train data set

Add - Field Ops: Type

Field Ops. Nodes carry out operations on data, like creating new fields, filtering, and stating the type of the data (measurement level) for predetermined fields. By using Fields Opt. the “Type” node is added.

The type node that identifies the data field properties, such as the type of the data in the field, and in the modeling, the mission of each data field whether it is a target or an input. This node also helps the user to know the data field properties. When the “Read Values” is chosen, the actual values can be seen for each field which is selected from the Values column.

The same multinomial logistic regression models constructed in SPSS 21 have been built with Clementine 12.0 using the training data.

The identical values can read when selected as “SET”, in the Clementine 12.0 (Figure 5.25). The collaboration field is set as Output, and all other fields will be set as Input.

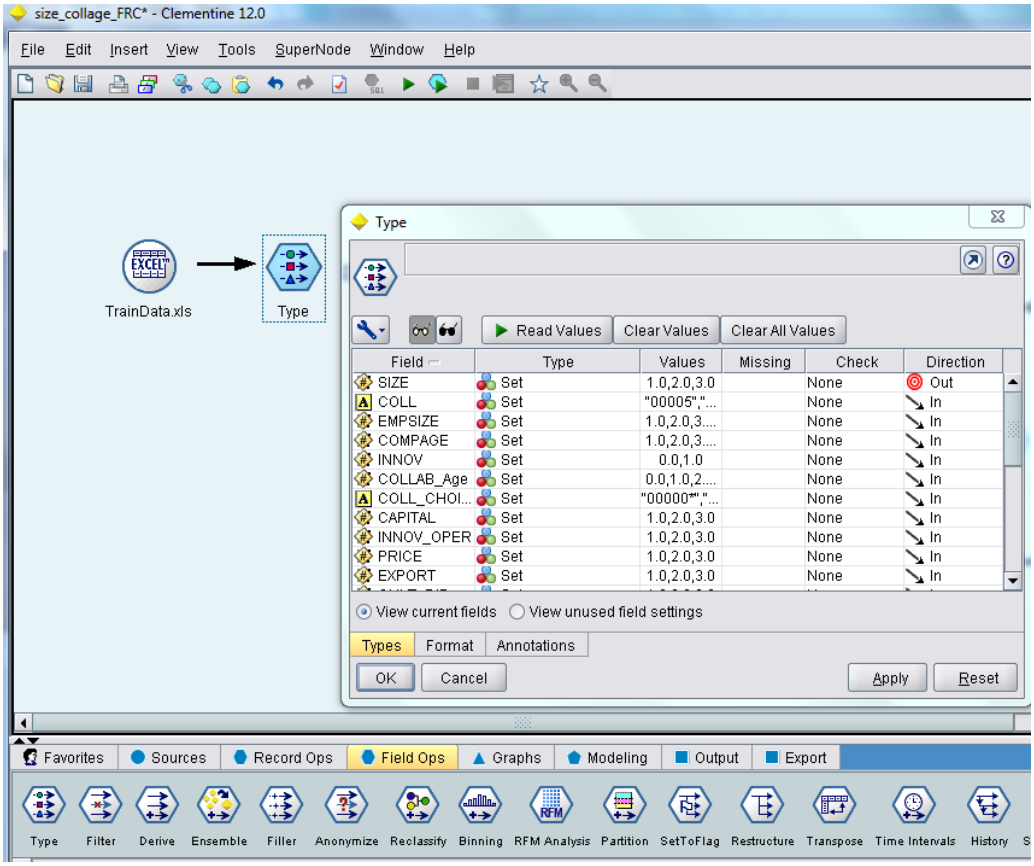


Figure 5.25. A view of building stream and setting the target and input fields with the type node.

Add – Field Ops: Filter

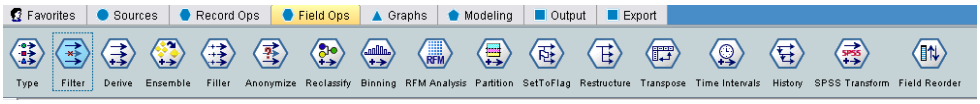


Figure 5.26. Filter allows fields to be renamed and removed

To drop the fields which are brought by Clementine 12.0, the Filter tab can be used (Figure 5.26). Collaboration – Firm Size for Technology Criteria model that was built in SPSS by multinomial logistic regression is used as an example (Figure 5.27). To filter a field, click on the field's arrow, and the X mark will be seen to show that field is filtered out.

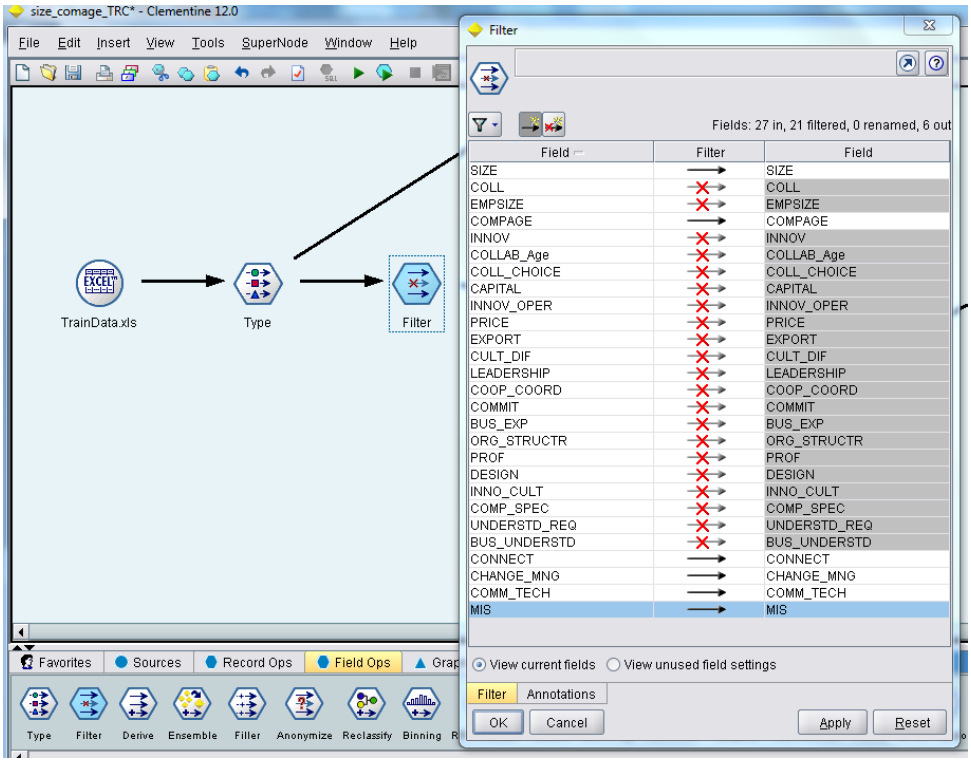


Figure 5.27. Filter fields for Firm Size – Firm Age based on Technology Related Criteria model.

Add – Modeling : Logistics

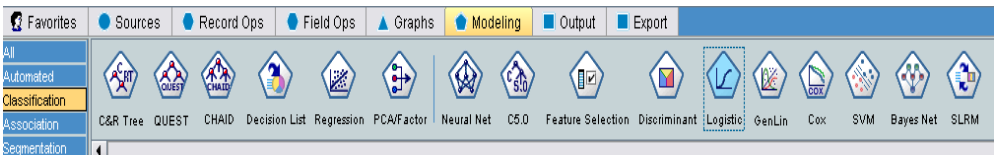


Figure 5.28. Logistics constructs a predictive logistic regression model

In the Logistics node of SPSS Clementine 12.0, The Model tab is clicked to select the Enter method. To include constant in equation, select the Multinomial Logistic Regression and Main Effects (Figure 5.28 and 5.29).

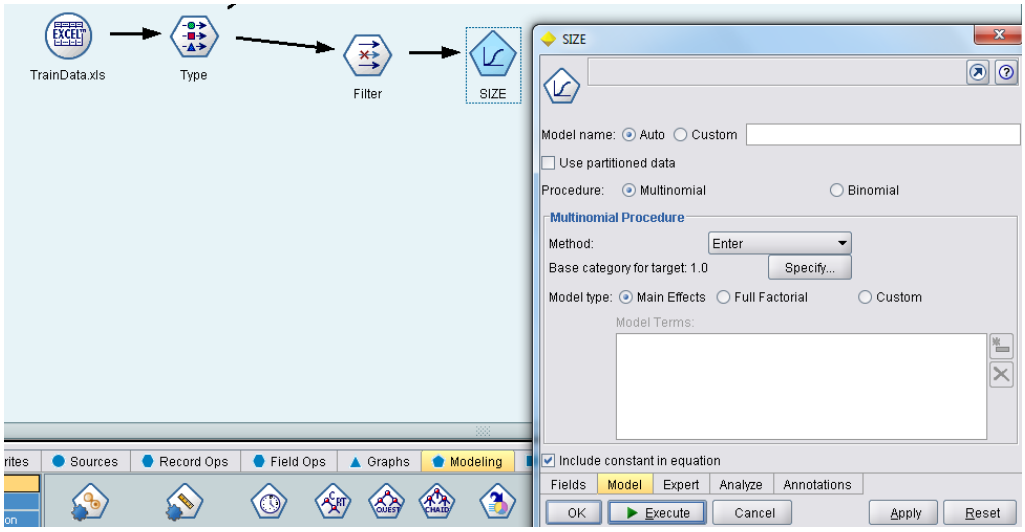


Figure 5.29. Choosing model options in MLR

On the Expert tab, click on the Expert mode, then select Output, and, select Classification Table on the Advanced Output dialog box (Figure 5.30). As the Multinomial Logistic regression modeling is executed (Figure 5.31); the collaboration model has been attained quickly (Figure 5.32).

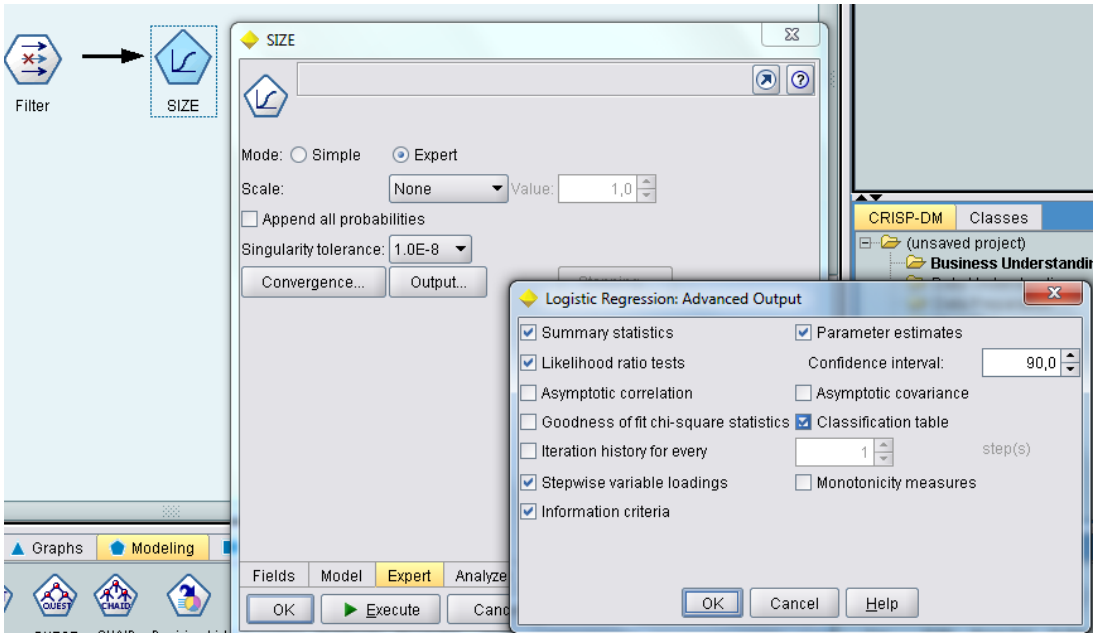


Figure 5.30. Choosing output options in MLR

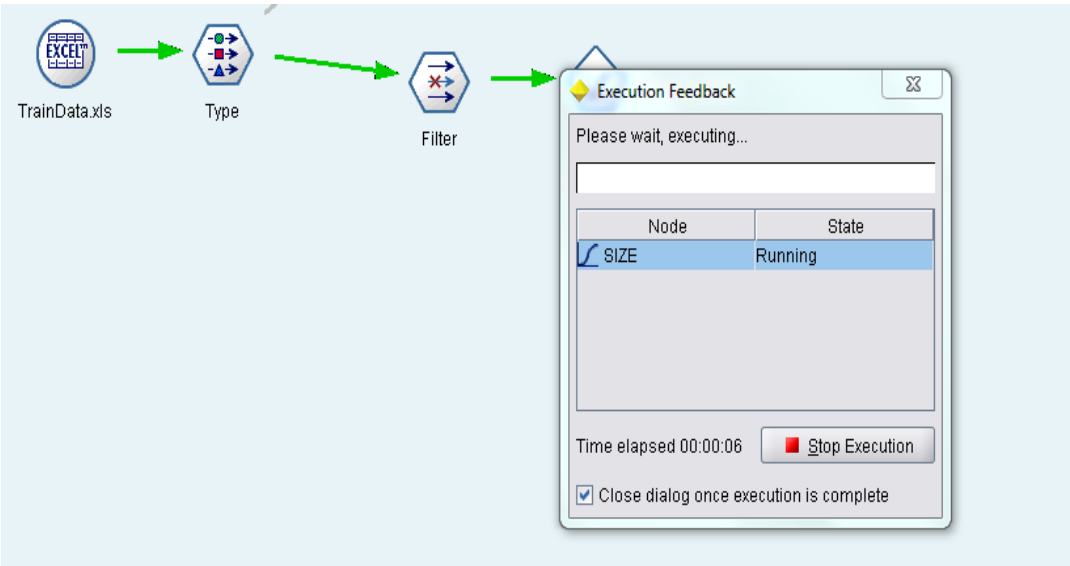


Figure 5.31. Executing MLR modeling



Figure 5.32. MLR model for Firm Size – Firm Age for Technology Related Criteria

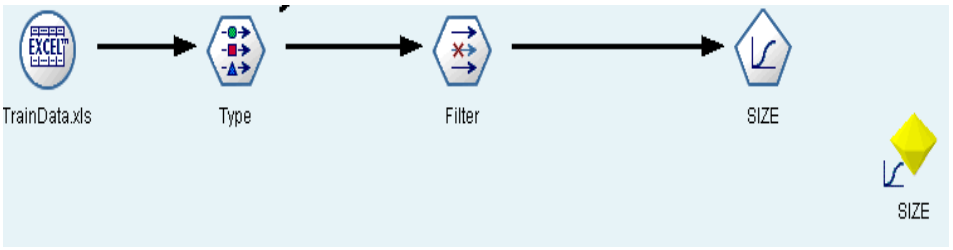


Figure 5.33. Screenshot of structure of the model

The model fitting and missing variable information will be seen when the Firm Size model (Figure 5.34) is examined (Figure 5.35). It is seen that the significance of Firm Size – Firm Age – Technology Related Criteria Model (Table 5.10), that was built by SPSS 21 is equal with the significance of the same model built by Clementine 12.0 using the same data.

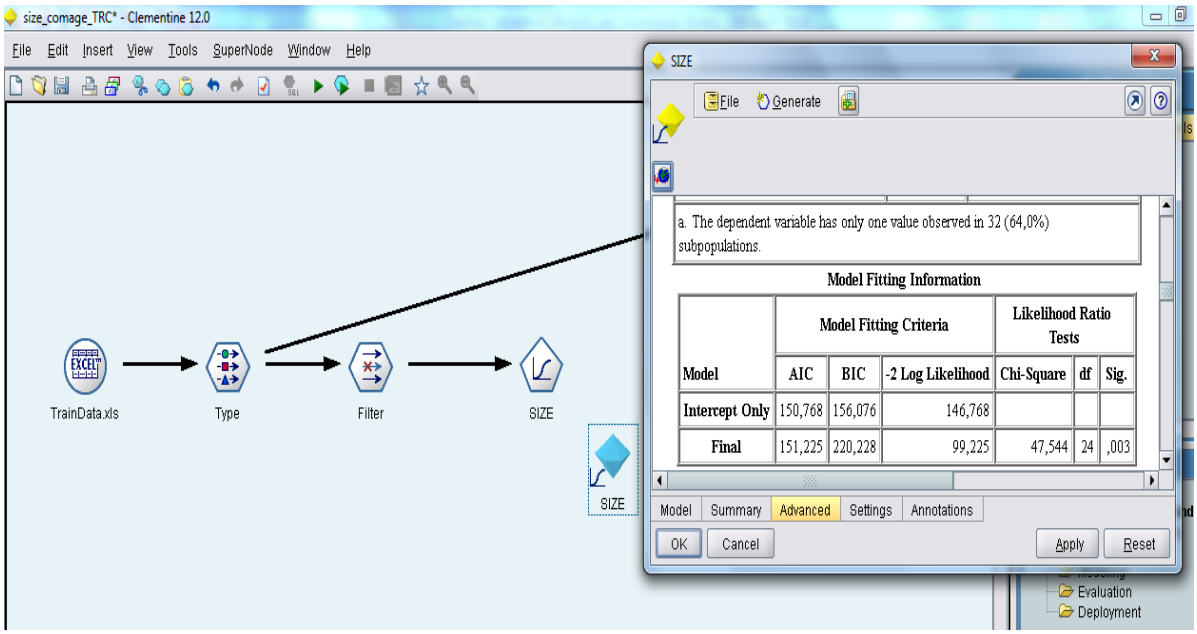


Figure 5.34. Model fitting information table from Clementine 12.0

Table 5.10. Model fitting information – SPSS 21

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	Df	Sig.
Intercept Only	146.768			
Final	99.225	47.544	24	.003

Clicking the Model tab displays the used equations to appoint records to each category of the output field (Figure 5.35).

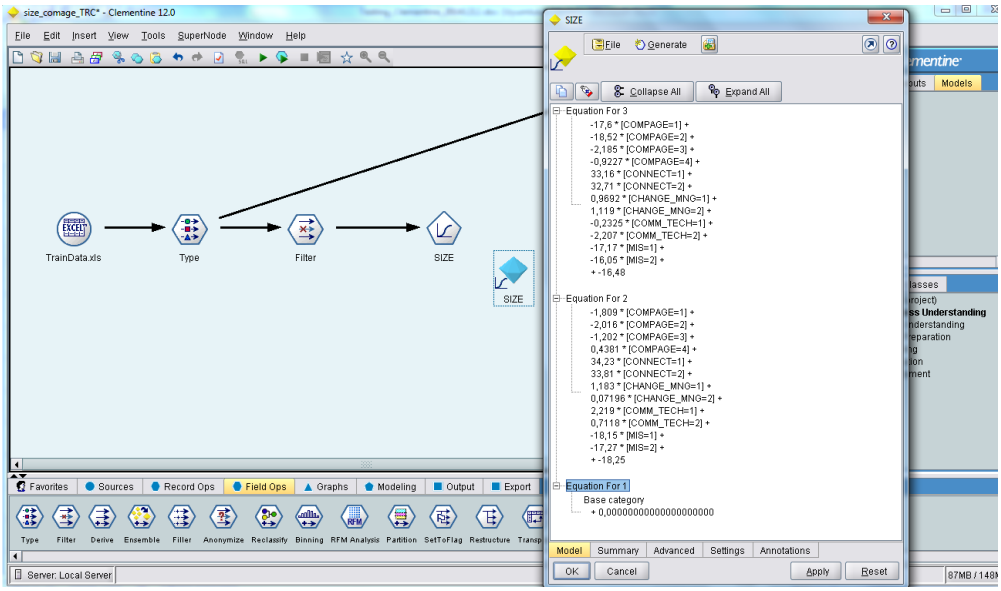


Figure 5.35. Model summary showing output and input fields

The significance of both SPSS and Clementine 12.0 software models have the same values. These models have been validated.

5.5.2 Creating test data

One or more datasets are used to perform data mining. One is used to train the model, the training data; the other is used to test the model created with the training data, the test data. These two datasets are necessary for data modeling: to train the model, and to test the model. To train the model, one sample of records is used. Another sample of records is used to test the model created by using the training data (Nettleton, 2014).

The data is randomly splitted into two, training and test data. The training data part is generally has the larger proportion than the test part. Usually 2/3of the data is used for training and the rest is for testing (Javaheri et al., 2014).

14 of the training data are selected randomly for test. The proportions are 75% is for training the model, and 25% is to test it. 105 of total 122 records are used for training the model. 14 (13%) randomly selected records are added to 17 records separately obtained, total 31 records are used to test the model. By clicking the “Sample” node, “13%” is selected with “Random Selection”

(Figure 5.36). Sampling data can be selected from the training data in different ways with the "Sample". By clicking "Excel" node launches MS Excel on the train data. The 14 records which are selected randomly from the training data is exported to MS Excel (Figure 5.37), added to the test data, then the test data, involving 31 records, is obtained.

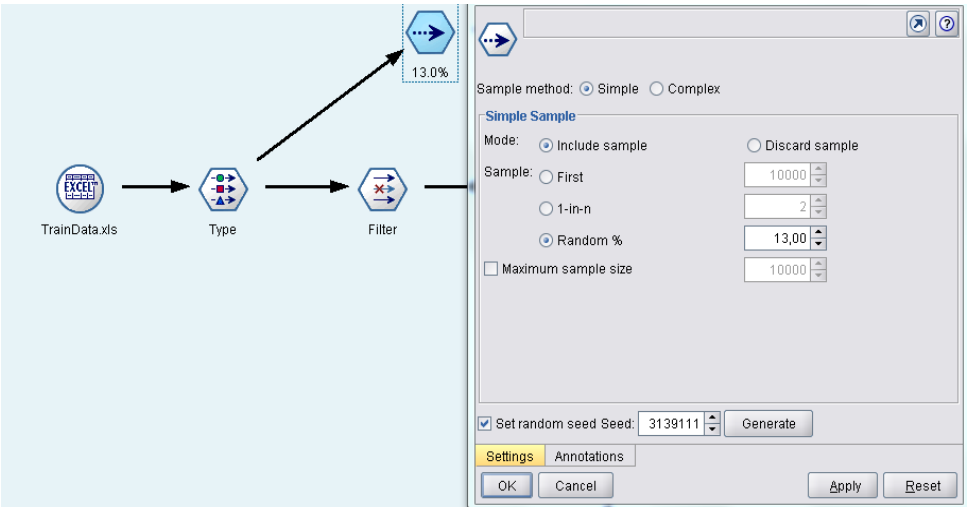


Figure 5.36. Sample node: obtains different methods for sampling data

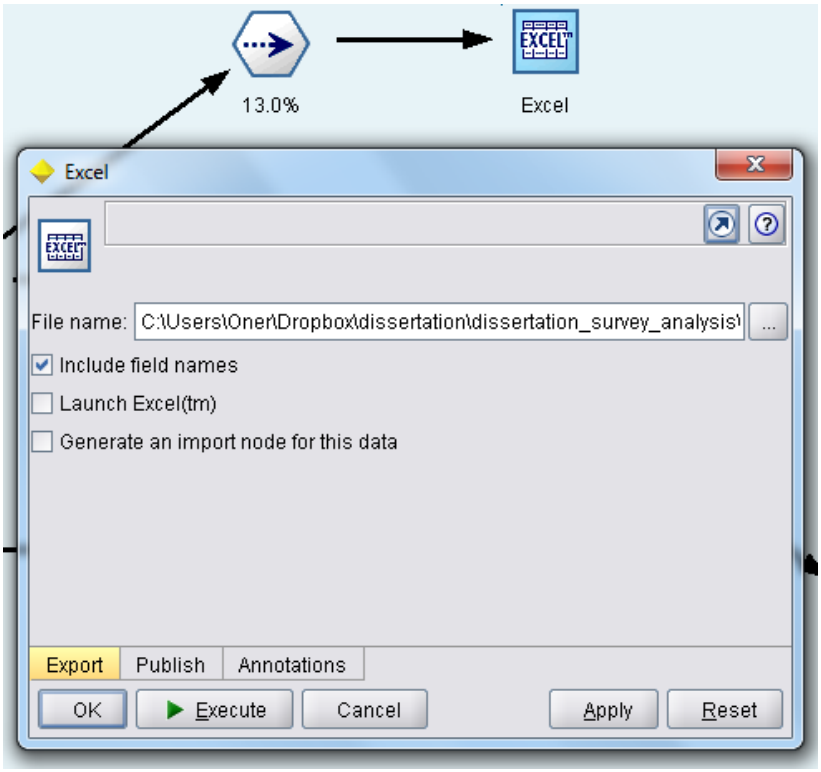


Figure 5.37. Open Excel node

5.5.3 Verification of models with test data

A new Var. file is added (Figure 5.38). The form of the model is obtained by adding the Type node and Filer node (Figure 5.39, 5.40).

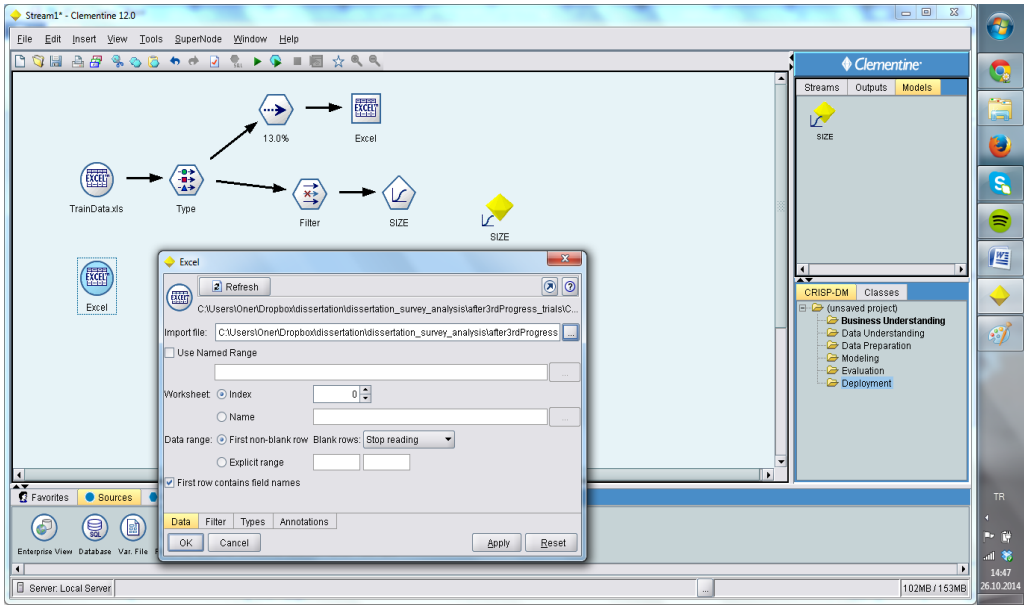


Figure 5.38. Open a variable file for test data

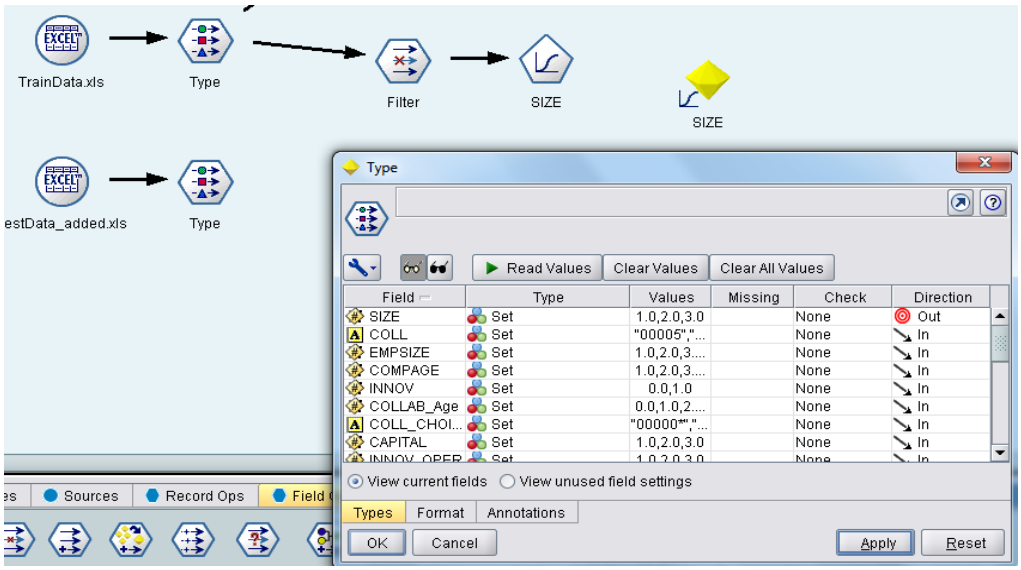


Figure 5.39. Add a type node

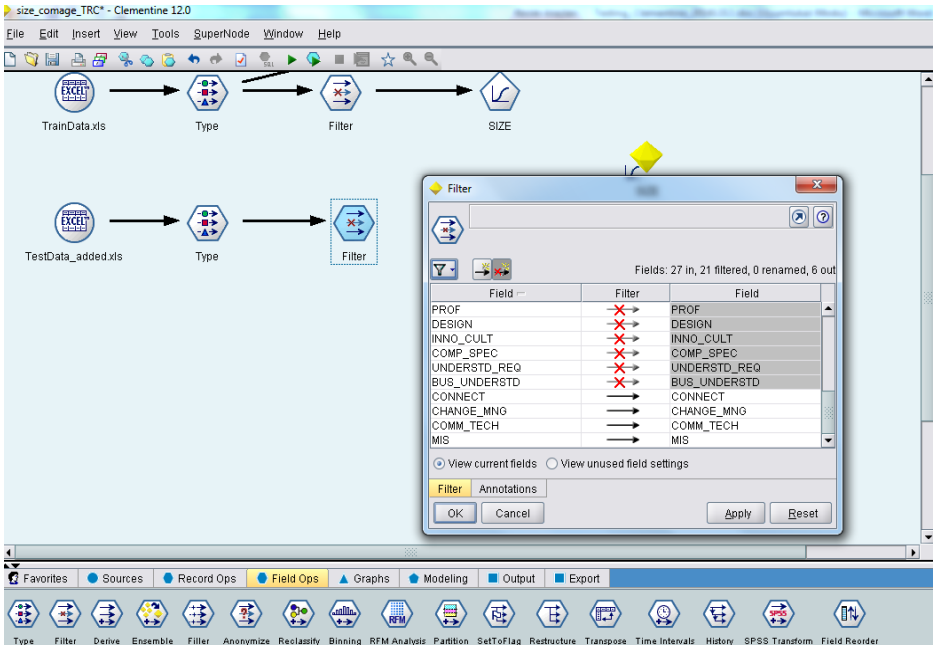


Figure 5.40. Add a filter node for testing data

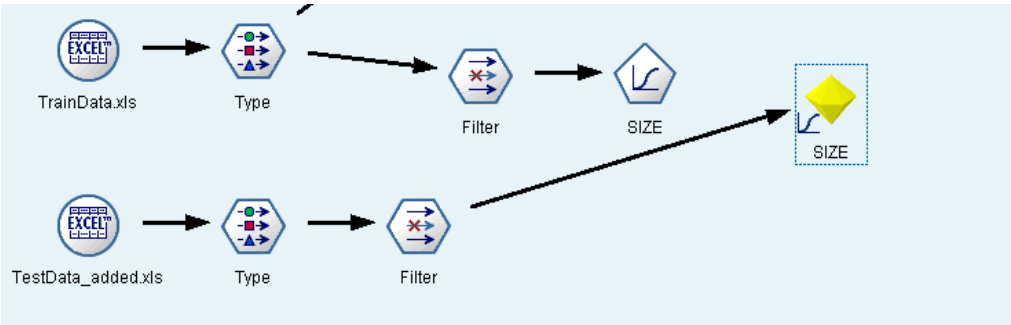


Figure 5.41. Connect test data to the MLR model

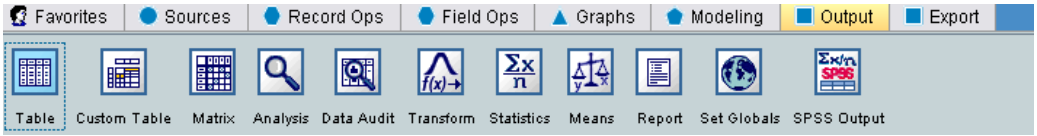


Figure 5.42. Add a table node

The MLR model that was obtained using training data has been verified by employing the test data (Figure 5.41). To display the data in tabular form, Table is selected from Output node (Figure 5.42). To see the result of test that is performed by using test data the output of the SIZE is added to the Table (Figure 5.43).

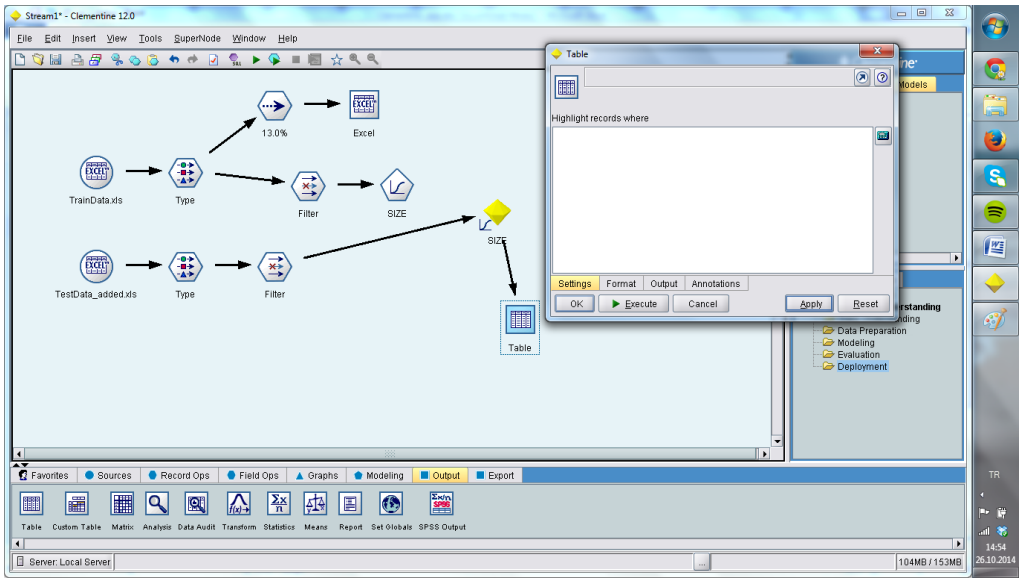


Figure 5.43. Connect MLR model to the table node

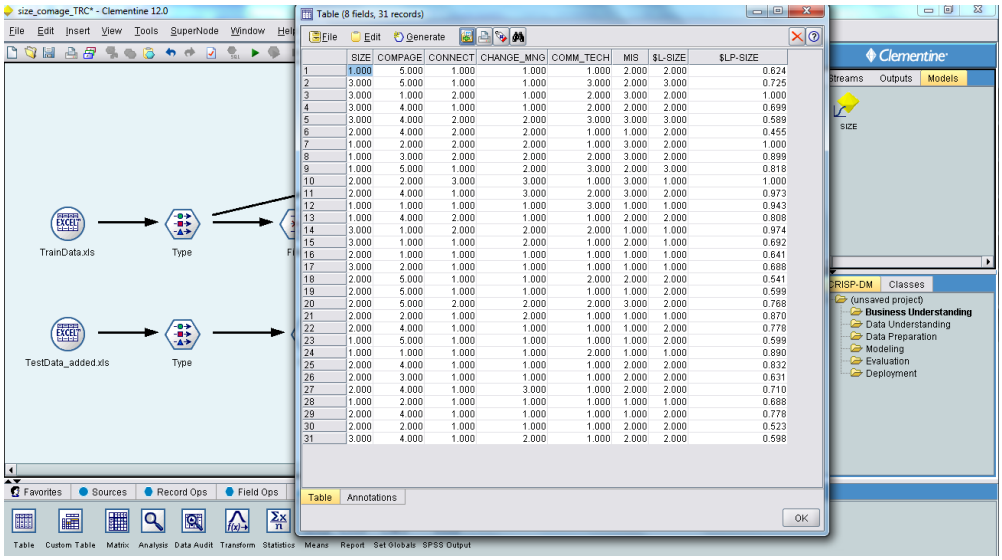


Figure 5.44. View of result table

When the logistic model is executed, the result table is obtained (Figure 5.44). The new two fields added are the prediction of the model and the associated probability. The names of these two new fields are created from the name of the predicting output. For predicting category the prefix is *$L, and $LP* for associated probability.

If the name of the output is *collaboration*; the names of the new fields will be *$L-Collaboration* and *$LP- Collaboration.* The probability of predicted category can be read from the last column of the table.

5.5.4 Results

7 models were selected randomly from the multinomial logistic regression models which were developed by using training data in SPSS. These 7 models were conducted – tested in the Clementine 12.0 software of IBM. It is observed that the significances of these models equal to the same values of the models developed by using Clementine 12.0. Models developed by using training data in Clementine 12.0 were verified with test data. For testing the resulting associated probability of prediction, 0.50 (50%) is determined as a threshold value. It is observed that the $LP is greater than 0.50 for the test data when the threshold value is 50% (Table 5.11). It is concluded that models, which have been developed according to the answers of the demographic questions, are suitable to use.

Table 5.11. Ratio of threshold value for test data

	Model			**Significance**	**Number of data $LP > 0.50**	**Ratio of $LP > 0.50**
No	**Dependent variable**	**Independent variable**				
1	Firm Size	Firm Age	Financial RC	0.007	26	0.84
2	Collaboration for Innovation	Collaboration Age	Financial RC	0.000	31	1.00
3	Firm Size	Firm Age	Technology RC	0.003	30	0.97
4	Collaboration for Innovation	Firm Size	Technology RC	0.019	31	1.00
5	Collaboration	Firm Size	Technology RC	0.059	16	0.52
6	Collaboration Age	Firm Size	Management RC	0.000	25	0.81
7	Firm Age	Collaboration for Innovation	Management RC	0.030	24	0.77

5.6 Cross Validation of Rules

5.6.1 Application in RapidMiner 5.3

General aim of data mining is to discover useful forms in data that can be used for predictions (Yuan et al., 2011). For a successful application of machine learning techniques, together with the data reduction and pre-processing steps, some other steps like domain and data understanding are crucial (Groth and Muntermann, 2014).

Learning-to-rank, is a progressing research subject in information retrieval natural language processing and data mining, which is the machine learning based ranking (G. Huang et al. 2015).  , introduced and improved by RapidMiner Inc, is an open source data mining platform. RapidMiner supplies software to be used, solutions for the problems, and necessary services in the areas of advanced analytics, including predictive analytics, data mining, and text mining. The data can be analyzed intrinsically and cleverly – including databases and text – on a great measure. After the data is imported, the data may actually be visualized and, if required, selected subsets or converted the data. Here, the basic visualization, followed by selecting data by subsets will be covered. An overview for the basic data scaling and converting applications will be provided and introduced data sampling and missing value handling tools. Later, some of the improved utilities of RapidMiner such as process design and optimization will be explained (Kotu and Deshpande, 2014).

5.6.1.1 Data preparation in RapidMiner

In this study, the rules are defined distinctly for each dataset. The responses taken from LimeSurvey into Microsoft Excel 2003 are imported into the Repository of RapidMiner 5.3.

To do this;

Import: Data > Read Excel

operator is used. Data is loaded from Microsoft Excel spreadsheets by using this operator, which can read the data from Excel 95, 97, 2000, XP, and 2003, after the user introduced the version of spreadsheets in the workbook should be used as data table.

Retrieve is added to Process from the Repository Access in the Design tab of the RapidMiner 5.3.000. This operator can be used to access the repositories (Figure 5.45). The data must be in binomial format for modeling with association rules mining. But, because of the data taken from LimeSurvey, it is in numerical form.

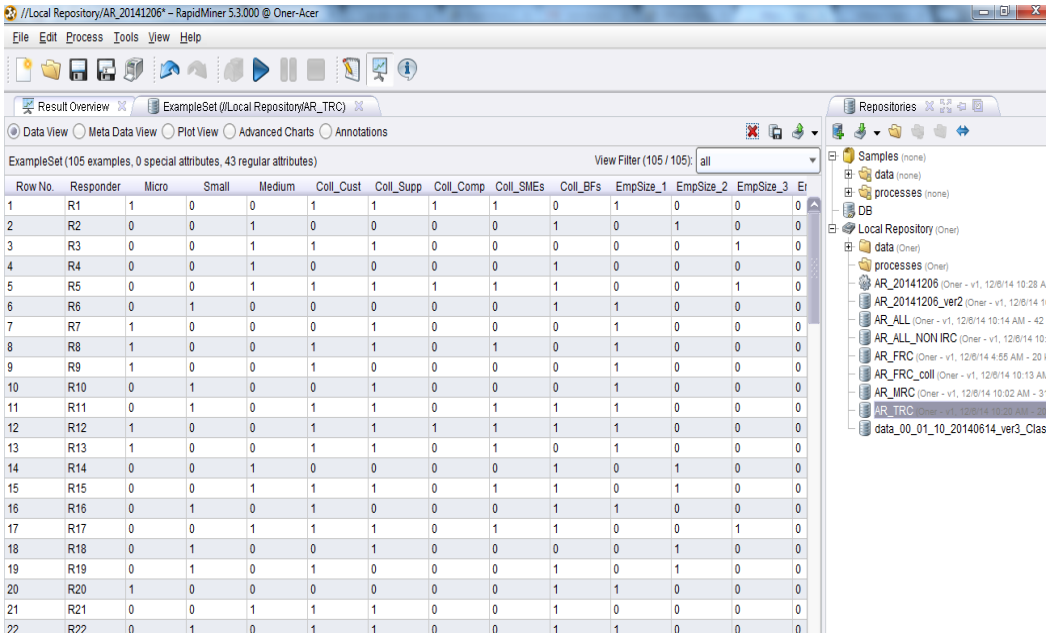


Figure 5.45. View of training data in RapidMiner 5.3

Data Transformation: Type Conversation > Numerical to Binomial

operator is added (Figure 5.46). The numerical data is converted into the binomial with the help of this operator. The attributes converted to binomial form limited with having only two choices; true or false. The value of an attribute is false when it is between specified minimal and maximal values; otherwise it is true.

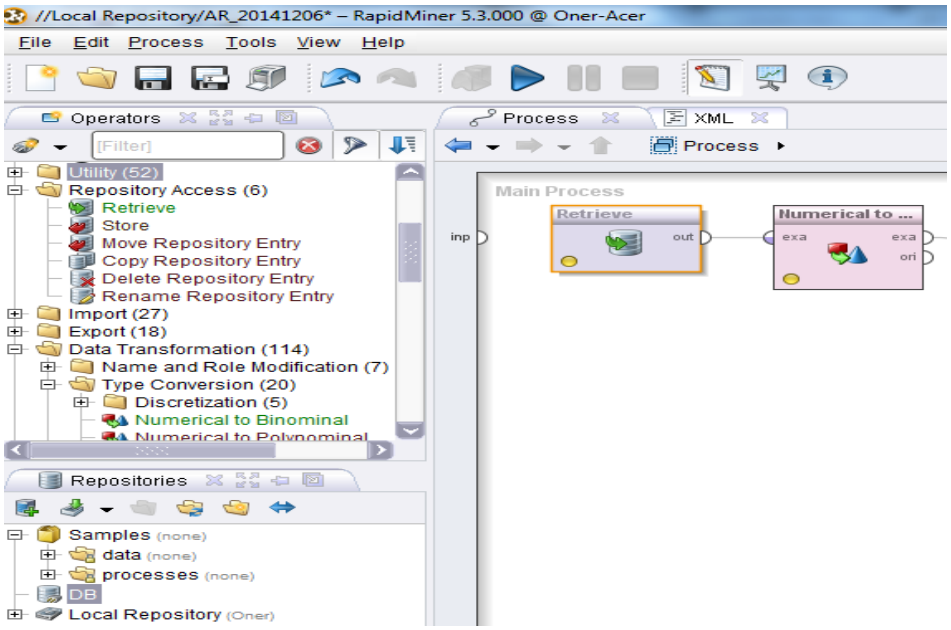


Figure 5.46. View of Main Process screen in RapidMiner

5.6.1.2 Modeling for rule generation

Relationships between unrelated apparent data are explored by using association rules which are if/then expressions. Association rules are formed by using the *support* and *confidence* criteria to define the most important relationships and by analyzing data for frequent if/then structures. Support shows the frequency of the items appears in the database. Confidence points out the number of the true if/then statements. The frequent if/then patterns are mined by employing the operators Frequent Pattern (FP)-Growth operator. The Association Rules are generated with the help of The Create Association Rules operator which uses these frequent itemsets (RapidMiner, 2008). Generating meaningful association rules from the data set is constituted two basic steps (Kotu and Deshpande, 2014).

In an Association Analysis having n items, the possible numbers of itemsets, excluding the null item sets, are 2n-1. The number of itemsets will increase exponentially when the numbers of items are increase.

To obtain these itemsets in the Design tab of the RapidMiner:

Modeling: Association and Item Set Mining > FP-Growth

Operator is added. All frequent itemsets can be calculated efficiently from the given ExampleSet using the FP-tree data. An item set tree helps to exhibit the methods to easily find frequent itemsets. Frequent itemsets are often seen together in the data as groups. All attributes of the **input** ExampleSet have to be binominal (RapidMiner, 2008).

The set of items is generally characterized as set of attributes. Most of these attributes are in binominal form. Finding the set of items seen together at lowest limit of the ratio of transactions is the frequent-itemsets problem. This lowest limit is expressed by the 'minimum support' criteria. The support of an itemset is the ratio of number of times that itemset appears in the ExampleSet to the total number of examples.

In this model, the operator finds at least the specified number of itemsets having the highest support without searching the ‘min support’. This working procedure can be found if the minimum number of itemsets parameter is defined as true. The number of itemsets is found then in the minimum number of itemsets determined in the minimum number of itemsets. In this case the min support parameter is ignored. At each iteration, the support threshold is decreased by 20% (Kotu and Deshpande, 2014).

Min Number of Item Sets: The value of minimum number of item sets that can be generated.

Max number of Retries: Number of retries allowed reaching minimum item sets.

In this study, all values of each parameter are set as default in FP-Growth operator in RapidMiner.

A set of generated itemsets is the result of the FP-Growth operator; it can be seen in the results page. The reporting of results can be done filtering on the basis of the number of items and sorting according to the support threshold. Figure 5.47 below shows the output of frequent item sets operator where all possible item sets with support higher than the threshold can be seen.

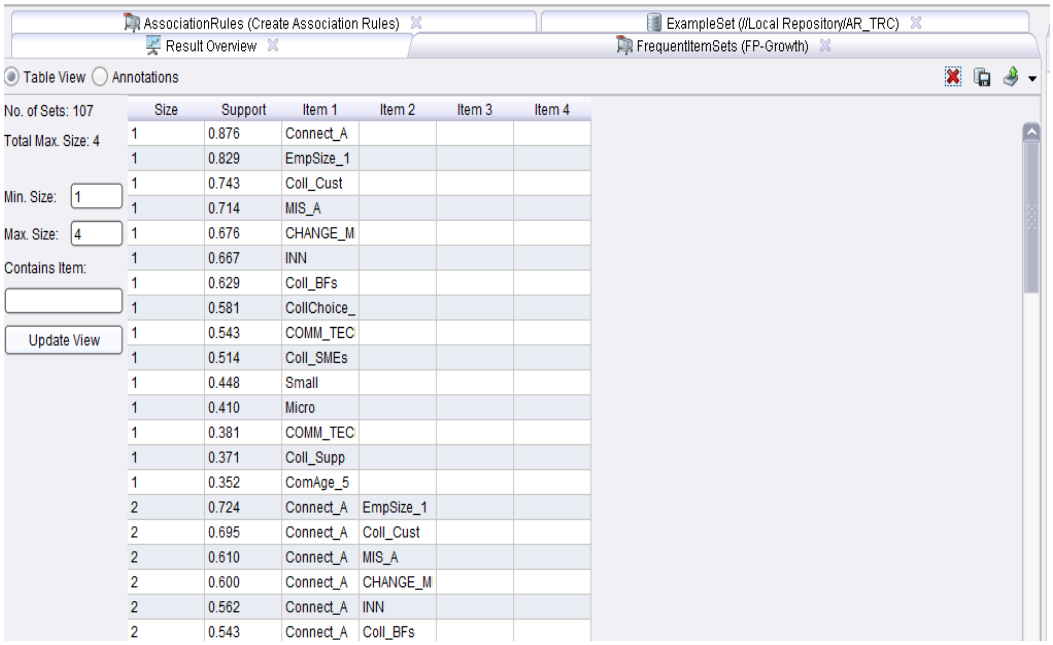


Figure 5.47. Frequent item set output for Technology Related Criteria

Extracting rules from frequent item sets:

It is possible to find 3n – 2n + 1 + 1 rules, if the dataset has n items. In this step all the rules with a confidence higher than a minimum confidence threshold are extracted (Kotu and Deshpande, 2014). The exploration of frequent itemsets often appears as discovering 'association rules'; where, discovering 'association rules' is a more complex characterization of data,, that depends basically on the discovery of frequent itemsets. Association rules are generated from the frequent itemsets. The FP-Growth operator discovers the frequent itemsets and operators like the Create Association Rules operator calculates the association rules by using these frequent itemsets (RapidMiner, 2008).

Modeling: Association and Item Set Mining > Create Association Rule

A set of association rules is produced by using the given set of frequent itemsets by this operator. **Input** port waits for the frequent itemsets. These frequent itemsets can be generated by using The FP-Growth and similar operators. **Output** is derived from **item sets** *(Frequent Item Sets)*. The input of the operator, the itemsets, is passed through this port without any change to the output. This obtains the chance to reuse the same itemsets in further operators or to view the itemsets in the Results Workspace. The generated association rules are forwarded via **rules** *(Association Rules)* output port.

Some criteria are in the **Parameters.** The criterion which is used for the selection of rules is expressed by the **Criterion** parameter. **Confidence** is defined as a parameter for this study. Confidence is an estimate of Pr(Y | X), the probability of observing Y given X. In this study, minimum confidence value is 0.90 as the Confidence interval for the SPSS and Clementine applications. Gain Theta and Laplace values are used as default values.

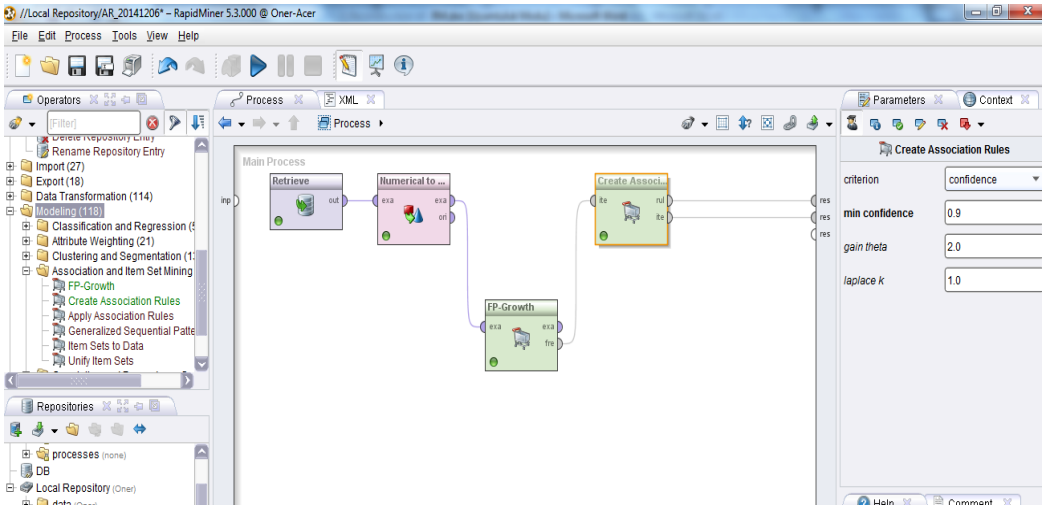
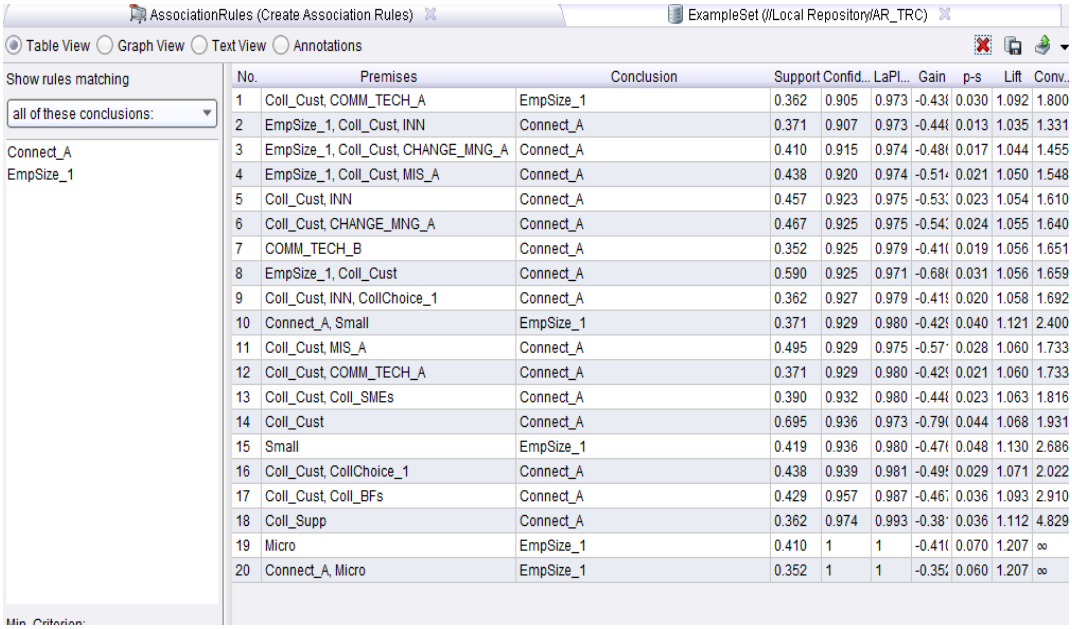


Figure 5.48. Design perspective from RapidMiner

In the Figure 5.48, above, the structure of the model and selected parameter values is seen in the design perspective. In the Figure 5.49, below, the rules and the confidence coefficients are tabled after the model is run. The listed association rules are in a table with columns including the premise and conclusion of the rule, together with the confidence of the rule.



No.	Premises	Conclusion	Support	Confid...	LaPl...	Gain	p-s	Lift	Conv...
1	Coll_Cust, COMM_TECH_A	EmpSize_1	0.362	0.905	0.973	-0.43(	0.030	1.092	1.800
2	EmpSize_1, Coll_Cust, INN	Connect_A	0.371	0.907	0.973	-0.44(	0.013	1.035	1.331
3	EmpSize_1, Coll_Cust, CHANGE_MNG_A	Connect_A	0.410	0.915	0.974	-0.48(	0.017	1.044	1.455
4	EmpSize_1, Coll_Cust, MIS_A	Connect_A	0.438	0.920	0.974	-0.51(	0.021	1.050	1.548
5	Coll_Cust, INN	Connect_A	0.457	0.923	0.975	-0.53(	0.023	1.054	1.610
6	Coll_Cust, CHANGE_MNG_A	Connect_A	0.467	0.925	0.975	-0.54(	0.024	1.055	1.640
7	COMM_TECH_B	Connect_A	0.352	0.925	0.979	-0.41(	0.019	1.056	1.651
8	EmpSize_1, Coll_Cust	Connect_A	0.590	0.925	0.971	-0.68(	0.031	1.056	1.659
9	Coll_Cust, INN, CollChoice_1	Connect_A	0.362	0.927	0.979	-0.41(	0.020	1.058	1.692
10	Connect_A, Small	EmpSize_1	0.371	0.929	0.980	-0.42(	0.040	1.121	2.400
11	Coll_Cust, MIS_A	Connect_A	0.495	0.929	0.975	-0.57(	0.028	1.060	1.733
12	Coll_Cust, COMM_TECH_A	Connect_A	0.371	0.929	0.980	-0.42(	0.021	1.060	1.733
13	Coll_Cust, Coll_SMEs	Connect_A	0.390	0.932	0.980	-0.44(	0.023	1.063	1.816
14	Coll_Cust	Connect_A	0.695	0.936	0.973	-0.79(	0.044	1.068	1.931
15	Small	EmpSize_1	0.419	0.936	0.980	-0.47(	0.048	1.130	2.686
16	Coll_Cust, CollChoice_1	Connect_A	0.438	0.939	0.981	-0.49(	0.029	1.071	2.022
17	Coll_Cust, Coll_BFs	Connect_A	0.429	0.957	0.987	-0.46(	0.036	1.093	2.910
18	Coll_Supp	Connect_A	0.362	0.974	0.993	-0.38(	0.036	1.112	4.829
19	Micro	EmpSize_1	0.410	1	1	-0.41(	0.070	1.207	∞
20	Connect_A, Micro	EmpSize_1	0.352	1	1	-0.35(	0.060	1.207	∞

Figure 5.49. Association rules output table view –Technological Related Criteria

Understanding the relationship between items is the main aim of the association analysis. A visual representation of these relationships between all the items through a rule will be useful to understand the analysis, because of the same items playing the role of premise and conclusion. Figure 5.50 shows the rules in text format and Figure 5.51 shows the rules by interconnected graph format through the results window, for selected items which is Connectivity=All ways.

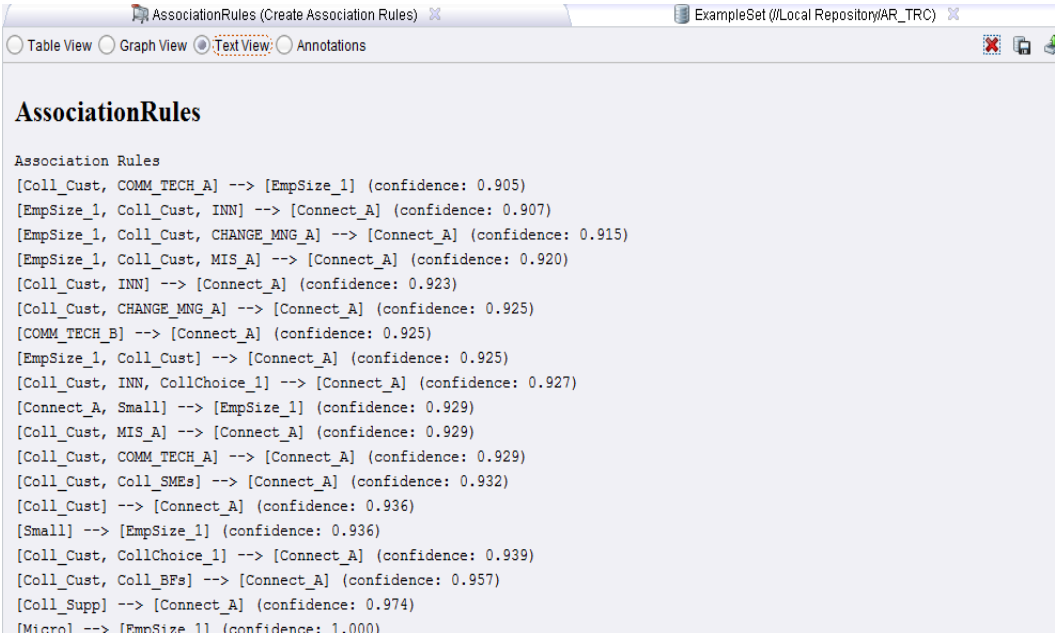


Figure 5.50. Association rules output text view – Technological Related Criteria

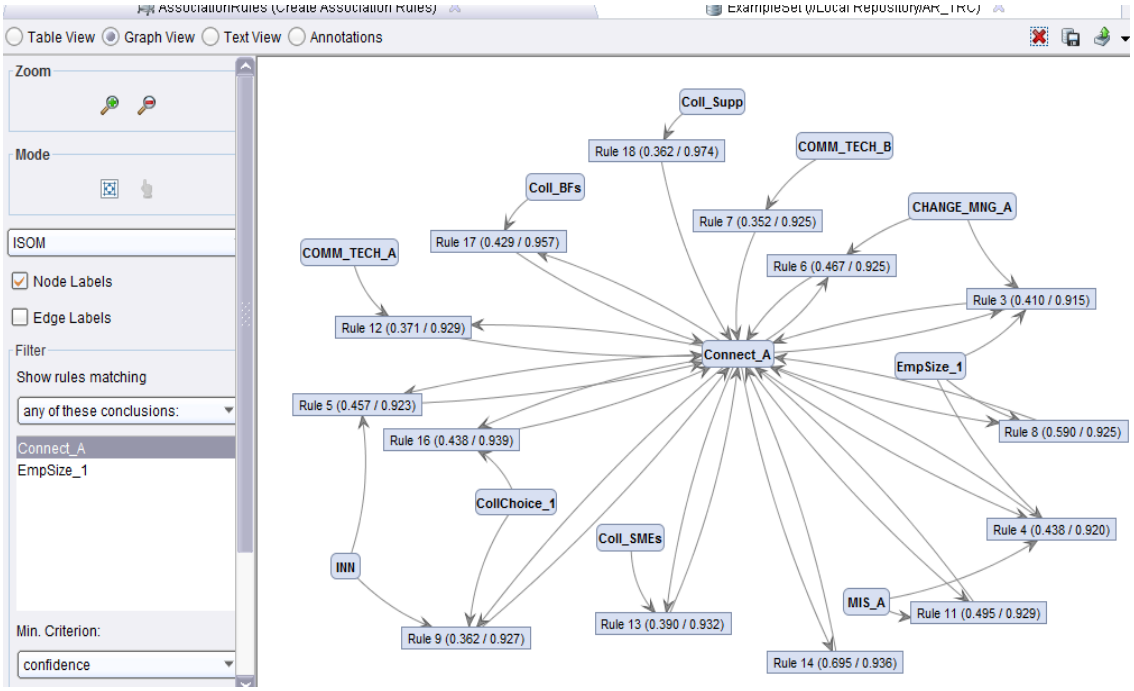


Figure 5.51. Association rules graph view – Technological Criteria: Connectivity = All ways

5.6.2 Association Rules achieved from RapidMiner

Criteria are ranked and selected by using ANP. Associations of criteria are modeled in SPSS and tested in Clementine. The statistical results are cross validated with machine learning based analysis in Rapid Miner. The rules explored by both statistical and machine learning methods are selected. .

13 appropriate rules of 45 Association Rules are achieved in this study. 1 of these is Management Related, 2 of these are Finance related, and 10 of them are Technology Related criteria. The rules and their support and confidence values are seen below.

FINANCE RELATED CRITERIA

Rule 1 (Support = 0.352, Confidence = 0.902).

IF (Collaboration= “Collaborated with SMEs” AND Employee Size = “<49 Workers”)

THEN (Exportation Facilities = “Equal Level”)

Rule 2 (Support = 0.305, Confidence = 0.914).

IF (Collaboration= “Collaborated with customers”)

THEN (Exportation Facilities = “Equal Level” AND Innovation Operation Expenditure= “Balanced”)

MANAGEMENT RELATED CRITERIA

Rule 1 (Support = 0.410, Confidence = 0.915).

IF (Collaboration = “Collaborated with customers” AND Employee Size = “<49 Workers”)

THEN (Professionalism = “Important”)

TECHNOLOGY RELATED CRITERIA

Rule 1 (Support = 0.410, Confidence = 0.915).

IF (Collaboration= “Collaborated with customers” AND Employee Size = “<49 Workers”)

THEN (Change Management = “All” AND Connectivity = “All Ways”)

Rule 2 (Support = 0.438, Confidence = 0.920).

IF (Collaboration= “Collaborated with customers” AND Employee Size = “<49 Workers”)

THEN (Management Information Systems = “Same Level” AND Connectivity = “All Ways”)

Rule 3 (Support = 0.333, Confidence = 0.921).

IF (Collaboration= “Collaborated with customers” AND Employee Size = “<49 Workers”)

THEN (Communication Technologies = “Existing” AND Connectivity = “All Ways”)

Rule 4 (Support = 0.333, Confidence = 0.921).

IF (Collaboration= “Collaborated with customers” AND Innovation = “Collaboration for Innovation”)

THEN (Management Information Systems = “Same Level” AND Connectivity = “All Ways”)

Rule 5 (Support = 0.467, Confidence = 0.925).

IF (Collaboration= “Collaborated with customers”)

THEN (Change Management = “All” AND Connectivity = “All Ways”)

Rule 6 (Support = 0.495, Confidence = 0.929).

IF (Collaboration= “Collaborated with customers”)

THEN (Management Information Systems = “Same Level” AND Connectivity = “All Ways”)

Rule 7 (Support = 0.371, Confidence = 0.929).

IF (Collaboration= “Collaborated with customers”)

THEN (Communication Technologies = “Existing” AND Connectivity = “All Ways”)

Rule 8 (Support = 0.333, Confidence = 0.946).

IF (Collaboration= “Collaborated with customers which are Large Firms” AND Employee Size = “<49 Workers”)

THEN (Connectivity = “All Ways”)

Rule 9 (Support = 0.352, Confidence = 1).

IF (Firm Size= “Micro” AND Employee Size = “<49 Workers”)

THEN (Connectivity = “All Ways”)

Rule 10 (Support = 0.362, Confidence = 0.905).

IF (Collaboration= “Collaborated with customers” AND Employee Size = “<49 Workers”)

5.7 Discussion

It is observed that there is confusion between technology and innovation. Innovation related criteria in this study have no significance based on firm size and collaborator types of these firms. In other words, respondent firms care the technological features but ignore the innovative attributes.

Small and medium aged companies collaborate only for innovation without any supplementary objective. Since the focus is not populated in young micro firms the association rules cannot be deducted.

In the finance group, it is concluded that, there are associations between the 'customers', 'SMEs', and 'large firms' on the collaboration subjects.

When the collaboration is established as an SME-SME relation indifferent of type and duration the majority of the responders see potential price as a motivator. However, micro SMEs see price important in some combination with other financial criteria. Furthermore, when the age of company is not too high and equal to the collaboration duration, then price becomes important for equal size of exportation. As a matter of fact, exportation facility choices also vary by the age of the company, that is, young SMEs prefer proportionally shared exportation instead of equally shared.

On the other hand, when aged companies collaborate with SME customers price becomes important.

Small SMEs with very short period of collaboration see the new product price as a motivator and find the industrial average capital enough for a collaborator. *Medium* sized SMEs with *long term collaboration* see "the new product price" also as a "motivator", but they prefer collaborators with "bigger capital than industrial average".

Aged SMEs would normally have growing capital therefore; they would not like to work with firms financially weaker. Small SMEs would not like to be overlooked as well; they just want financial status similar to theirs. It can be summarized that the choices are in accordance with the financial size. Through these two rules one success statement can be achieved saying "SMEs do not want to play the power game, that is, why they prefer collaborators with similar financial size for collaboration".

For a second financial criteria considering the innovation operation expenditures, micro SMEs with shortest experience in collaboration prefer proportional investment shares, whereas small SMEs with longer collaboration would ask for equal share.

Majority of the technology firms responding the survey do not see the need to improve the existing communication technologies for innovative collaboration. Probably the

reason of this choice is the advanced technologies used in Techno-parks. Yet, all kind of connectivity is a necessity for small and micro firms collaborating with the customers.

Change management is expected to be applied by all collaborators by micro size and aged companies. Most of the other size and age of companies agree with this choice.

It is interesting that Micro SMEs and/or SMEs who are young in collaboration would like to have MIS to be installed by at least one company, whereas all the rest emphasize to have MIS at the same level.

Professionalism, leadership and business experience are the only managerial criteria emphasized. According to the aged SMEs, all the long duration collaborators should have professionalism; moreover, the leadership and business experience are to be at equal levels for each collaborator.

The above achievements of SPSS and Clementine applications are also fully validated when association rule extracted by the Rapid Miner.

6 CONCLUSION

SMEs need to construct successful alliances in order to have sustainable business in a competitive environment. Recent experiences with randomly chosen collaborators have shown failures that caused the fear of new collaborative work. Experiences in different countries show a variety of causes and results in different types of alliances. Pre-analysis of the path for successful alliances will lead improvements in innovative power.

This study attempts to perform the analysis of SME alliances in order to depict the criteria causing failures and supporting the success in innovation. These criteria will allow realizing the main objective of the dissertation, which is to construct the association rules leading innovative success.

The innovation criteria related to collaboration for SMEs are examined in 70 scientific research papers. The clusters and attributes are identified as a result of these studies. A total of 103 criteria are defined in clusters. According to their frequencies, the most popular are the competitive advantage, relationships, managerial skills, technological and operational criteria respectively.

The criteria are evaluated by Analytic Network Process method to prioritize and eliminate the selected criteria. After all the iterations are done, the weights of attributes are calculated. Only 25 of the all attributes detected have weights more than 10%, so these attributes are used as a threshold for ranking the criteria in this study. The cultural differences and the capital impact criteria take precedence among all of the 103 criteria.

The questionnaire is prepared according to these attributes. The data are collected from the SMEs in the technoparks as the application area since they have the potential for successful collaborative innovation.

The methods of 112 papers written on ‘Strategic alliances in SMEs for innovation’ are studied. These techniques are classified into 12 main groups. The biggest part of the pie is covered by the experimental design methods, with 35.28%; followed by regression methods with 25.20% and, basic statistical methods with 16.13%. It is observed that the mostly used methods are the statistical methods. Also, it is observed that Multinomial Logistic Regression is not used to derive the association rules for the collaborative innovation.

The Multinomial Logistic Regression Analysis Technique is used to construct the model for association rules. The Logistic Regression Analysis is observed as a technique that is used for categorical data and its results are reasonable.

The questionnaire of survey is composed of discrete questions composed of 9 demographic information and 29 criteria. Those criteria are extracted through the literature survey and a ranking performed by applying ANP. The questionnaire is responded by a total of 122 technology SMEs established in Turkish Technoparks. The data from 105 technology SMEs are used in the analysis phases and the data from 17 technology SMEs in the test phase in this study. The cross relations are extracted and Multinomial Logistic Regression Analysis is used for evaluating the relational analysis. A total of 140 rules are created, of which 93 are based on financial criteria, 5 are based on managerial criteria and 42 are based on technological criteria.

The rules are first achieved by applying statistical techniques in SPSS using the significance analysis with different confidence intervals. These achievements are cross-validated by analyzing the data in RapidMiner using pattern recognition for creating association rules.

The results show that the young micro companies cannot be included in analysis because of not having common choices. It is observed that the fear of being crashed by the collaboration increases as the firm size decreases. Another important result is that innovation eagerness grows with age.

Furthermore, innovation related criteria in this study have no significance based on firm size and collaborator types. It is assumed that the technology firms are not differentiating technology and innovation. In the technology group, it has been seen that the ‘micro’, ‘aged’, ‘and collaborated with large firms’ groups prefer the ‘existing communication technologies’. In the finance group, it is concluded that, there are associations between the ‘customers’, ‘SMEs’, and ‘large firms’ on the collaboration subjects. Besides, for the managerial criteria there is a minor impact of relation type (customer, supplier) or company size (SMEs, LFs) of collaborators.

It is emphasized that powerful communication technologies is important to achieve collaborative innovation. The underlying reason is the desire for information sharing independent of geographical location. Moreover, information and communication technologies should be included in new organizational structure to improve innovation capacities for SMEs alliances.

Analysis shows that innovative solutions are with strong leadership and improved business experiences and professionalism. The main purpose is to increase the competitiveness.

This study involves structuring strategic decisions based on association rules extracted through local analysis. Logical analysis and rule mining are used to facilitate defining association rules.

Extracted association rules will be used to support strategic choice of the collaborators. The implication of the study is generic enough to help any SME or research organization or large business to reduce risks in future alliances, if the survey is extended.

RECOMMENDATIONS AND FUTURE WORKS

This study can be easily repeated in larger group of respondents. It is recommended to implement it online for a global work. Respondents from different cultures will certainly add value to the association rules.

The results of this study will certainly be more specific by clustering association rules which will combine two data mining techniques.

The rules of alliances which are extracted by the survey run in Turkish technoparks, may be compared with the analysis of technoparks in the other countries.

Results obtained by this study can be reworked with different intelligent techniques to create dynamic adoptive rules.

A project with a hybrid team of computer scientists and industrial engineers can allow developing an expert system for strategical decision support using the association rules that are extracted in this study.

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APPENDICES

APPENDIX I: Innovation Alliances in SMEs in literature.

APPENDIX II: The collaborative innovation questionnaire.

APPENDIX I: Innovation Alliances in SMEs in literature.

REFERENCE	COLLABORATION CASE	OBJECTIVES	MEASURABLE ALLIANCES CRITERIA
Stadtler, H. (2005). Supply chain management and advanced planning—basics, overview and challenges. *European journal of operational research*, *163*(3), 575-588.	Advance Planning System	To extract two conceptual frameworks: The house of SCM and the supply chain planning matrix.	Competitiveness Leadership Coordination Information and communication technology
Bougrain, F., & Haudeville, B. (2002). Innovation, collaboration and SMEs internal research capacities. *Research Policy*, *31*(5), 735-747.	313 case studies about different sectors from 1980 to 1987 in Orléans, French.	To examine how SMEs' own research capacities help to take an advantage external scientific and technical knowledge and to reach networks of innovators. To find a comparison of the ways in which success differ from failures about case studies.	R&D intensity; The number of executives employed by the firm; The number of SMEs, The existence of a design office.
Woodland, R. H., & Hutton, M. S. (2012). Evaluating Organizational Collaborations Suggested Entry Points and Strategies. *American Journal of Evaluation*, *33*(3), 366-383.	Different fields of USA (education ,health, etc..)	To present the Collaboration Evaluation and Improvement Framework (CEIF) as an extension of earlier work in collaboration theory development, like the social network analysis (SNA).	Preexisting channels of communication.
McLarty, Roy, Pichanic, Mikulas, & Srpova, Jitka. (2012). Factors Influencing the Performance of Small to Medium-Sized Enterprises: An Empirical Study in the Czech Republic. International Journal of Management, 29(3), 36-47.	Pilot: Axis LTD Main: 50 Czech SMEs by sector: rubber and plastics/ machinery/ steel and steel product/ mechanical engineering	Performance measurements of SMEs in the Czech Republic. To examine development with using a set of tangible and intangible factors to the future success SMEs in the Czech Republic.	Processes and innovations Quality and Corporate Social Responsibility Supply Chain Management and Logistics Human Resoruces Management Information Systems
Shengnan, F., Wen, Z., Zongtian, L., Yan, Z., Ying, Z., & Xiaolong, L. (2011, October). The effects of innovation alliance on network structure and association rules. In *Internet of Things (iThings/CPSCom), 2011 International Conference on and 4th International Conference on Cyber, Physical and Social Computing* (pp. 479-482). IEEE.	156 firms in China	To analyse the relationship between network structure and the innovative capacity of the network among Chinese enterprises.	Network density Betweenness Centrality Centralization Closeness Centrality

Liu, Y., & Song, D. J. (2009). Conceptualizing service innovation and service innovation model constructing. In *Service Systems and Service Management, 2009. ICSSSM'09. 6th International Conference on* (pp. 381-386). IEEE.	Service Industry in China	To construct a five dimensional model of service innovation.	Customer guided innovation Flexible Process
Swarnkar, R., Choudhary, A. K., Harding, J. A., Das, B. P., & Young, R. I. (2012). A framework for collaboration moderator services to support knowledge based collaboration. *Journal of Intelligent Manufacturing*, *23*(5), 2003-2023.	NA	To present the system architecture and specifications of the Collaboration Moderator Services (CMS) within the context of the SYNERGY system, whose purpose is to offer interoperable service utilities to help enterprises plan, setup and run complex knowledge collaborations.	Manipulating process Publishing Analysing Monitoring Receiving data for mining
Arku, G. (2002). Collaboration in industry: Empirical findings among small electronics manufacturing firms in the Greater Toronto Area. *GeoJournal*, *57*(4), 325-336.	191 Small electronics firms in Great Toronto Area	To examine the incidence of inter-firm relations, the motivations and forms of collaboration, and the influence of public policies on inter-firm relationships.	Access to technological know-how Share high costs Access specialized skills Share risk Penetrate new geographical market Penetrate new product market
Huggins, R. (2010). Network resources and knowledge alliances: Sociological perspectives on inter-firm networks as innovation facilitators. *International Journal of Sociology and Social Policy*, *30*(9/10), 515-531.	NA	To examine the role of network resources in governing and managing knowledge alliances. To analyse of the types of network resources.	the source of the capital the objects of the capital the impact of the capital
Pullen, A., de Weerd-Nederhof, P. C., Groen, A. J., & Fisscher, O. A. (2012). SME network characteristics vs. product innovativeness: How to achieve high innovation performance. Creativity and Innovation Management, 21(2), 130-146.	60 Dutch SMEs medical device companies with an NPD department.	To find the answer of " what extent are network characteristics, product innovativeness and innovation performance related?"	**Product Innovativeness** **Network characteristics** **(**complementarity,trust)

Cecia, F., & Iubatti, D. (2012). Personal relationships and innovation diffusion in SME networks: A content analysis approach. *Research Policy*, *41*(3), 565-579.	Manufacturing SMEs in Switzerland.	To investigate "how do different types of relationships existing in a network of SMEs favour the development of economic activities?" Content analysis is a "research technique for the objective, systematic, and quantitative description of the manifest content of a communication"	Strategic actvities Innovative activities Operational activities Communication based activities
Davenport, S. (2005). Exploring the role of proximity in SME knowledge-acquisition. *Research Policy*, *34*(5), 683-701.	Manufacturing and service SMEs in New Zealand	To explore the knowledge-acquisition processes and critical interfaces of innovative SMEs and outline factors that contributed to an observed lack of geographic proximity-based knowledge search activity.	R&D Design Unconstrained creativity Breadth of specialist skills Unique combinations of technology Fast and efficient flexible manufacturing High quality product and packaging Deep understanding of 'doing business' Supplier/contractor Trust, honesty, loyalty, social capital in relationships Customer/distributor Trust, honesty, loyalty, social capital in relationships Deep understanding of 'doing business'
Wang, C. H., Chin, Y. C., & Tzeng, G. H. (2010). Mining the R&D innovation performance processes for high-tech firms based on rough set theory. *Technovation*, *30*(7), 447-458.	High - technology firms in local market.	To find a taxonomy of induction-related activities using a rough set theory approach or rule-based decision-making technique to infer R&D innovation decision rules and models linking R&D innovation to sales growth.	Total assets R&D expenditures ratio Proportion of R&D researchers The proportion of exports Located in a science park (R&D capability) Return on Investment (ROI)
Kajikawa, Y., Mori, J., & Sakata, I. (2012). Identifying and bridging networks in regional clusters. *Technological Forecasting and Social Change*, *79*(2), 252-262.	Hamammutsu Region, analysis of 1049 nodes and 4080 links	1. to evaluate the structure of a regional cluster; 2. Analyze the network structure through surveys, computational analysis and field study; 3.to develop a tool promoting networking among firms;	purchasing rate selling rate

Capó-Vicedo, J., Expósito-Langa, M., & Molina-Morales, F. X. (2008). Improving SME competitiveness reinforcing interorganisational networks in industrial clusters. *International Entrepreneurship and Management Journal*,*4*(2), 147-169.	The Valencia textile cluster for microclusters in Spain	To underline a few aspects to understand the economic position and dynamics of the Valencia Textile Cluster with respect to growth, labour cost or economic structures.	types of relationship Relationships between training organisation Cooperation between associated firms and client firms. Joint activities
Eraydin, A., & Armatli-Köroğlu, B. (2005). Innovation, networking and the new industrial clusters: the characteristics of networks and local innovation capabilities in the Turkish industrial clusters. *Entrepreneurship & Regional Development*, *17*(4), 237-266.	The three regional clusters established in Denizli, Bursa and Ankara SMEs.	1.The importance of R&D and different types of innovations in peripheral industrial clusters. 2. The importance of different types of linkages at different geographical levels. 3. The link between innovativeness of SMEs and their networking at different geographical levels.	The share of R&D personnel in total employees The share of R&D expenditure in total The share patentees in the total firms The share of firms that introduced new products or modified products Average number of new products The share of firms that introduced process or improved existing ones Average number of new process The share of firms either introduced a product or a process innovation
Padmore, T., & Gibson, H. (1998). Modelling systems of innovation: II. A framework for industrial cluster analysis in regions. *Research policy*, *26*(6), 625-641.	A cluster study in Western Canada.	To stimulate critical discussion among corporate and government policy makers. To form a holistic view of the strengths and weaknesses of the subject cluster from the perspective of six determinants. Presenting a model for describing and assessing the strengths and weaknesses of industrial clusters from a regional perspective.	Resources, Infrastructure Supplier and related industries, Firm structures, strategies and rivalry Local markets, Access to external markets
Youli, X., & Huiwei, L. (2011). Research on Evaluation of Enterprises' Technology Innovation Performance from the Perspective of Industrial Cluster Networks. *Energy Procedia*, *5*, 1279-1283.	Technological innovation	To propose a system includes industrial cluster structural features, cluster network relation level, technical innovation capability and technology innovation of industrial cluster.	Network centrality, Network scale strength of relations and quality of relations Capability of technology innovation Technological Innovation results (transformation)

Carbonaraa, N., Giannoccaro, I., & Pontrandolfo, P. (2002). Supply chains within industrial districts: A theoretical framework. *International Journal of Production Economics*, *76*(2), 159-176.	The leather sofa district localise in the area of Bari and Matera (Southern Italy)	To propose a theoretical framework is proposed to characterize the IDs as a kind of production systemsunder a managerial perspective.	Frequency of communication, Resource sharing, Information sharing about processes and products, Co-design practices (design and relation style) Exclusivity degree of the relationship, Inter-changeability of firms within the network, Technology and knowledge dependence.
Yamawaki, H. (2002). The evolution and structure of industrial clusters in Japan. *Small Business Economics*, *18*(1-3), 121-140.	To examine the industrial clusters for 14 Japan districts	Overview of two aspects of the evolution and structure of clusters in Japan: what gives rise to clusters, what benefits are acquired by small firms from participating in clusters.	Experience Technological change Demand condition Competition On the job training Inter-firm cooperation in skill formation Joint R&D Technology alliance Joint production Competitive advatage (production and marketing contract) Informal information exchange Capital share Joint venture
Enno Masurel Kees van Montfo$rt Ramon Lentink "SME Innovation and the Crucial Role of the Entrepreneur" Faculty of Economics and Business Admlnlstratlon, 2003.	638 companies were selected from the Dutch MarktSelect	To examine the perceptions of entrepreneurs and other concemed individuals which factors do they consider critical for success in the innovation process?	unique product advantages, HRM, Marketing activities, product definition(relevance), market, product - company fit, pre-development, technological activities, competition, enterprenuer, (leadership) project app., (Realistic goals) innovation culture, finance means.
Kadocsa, G. (2006). Research of competitiveness factors of SME. *Acta Polytechnica Hungarica*, *3*(4), 71-84.	Competitiveness of SME in Hungary	Application of Certain Management and Organisation Methods Competitiveness, especiallay for Family Business in Hungary	Planning, Marketing, Quality assurance, Organisational methods, Controlling Outsourcing

Nauwelaers, C., & Wintjes, R. J. M. (2000). SME policy and the regional dimension of innovation: towards a new paradigm for innovation policy?. MERIT, Maastricht Economic Research Institute on Innovation and Technology.	40 innovation policy in 11 Europen regions	To expose a new innovation policy paradigm and propose shift it to rationale. Broad orientations for policy, addressing SMEs in regional context. To show up failures and barriers to innovation and boundaries to learning in SMEs and regions with rules of regional policy for SMEs.	Financial / Technology./ HR/ Market access(Openness and learning attitude)/ Strategy & Organization
Pullen, A., Weerd-Nederhof, P., Groen, A., & Fisscher, O. (2008). Configurations of external SME characteristics to explain differences in innovation performance. 16th Annual High Technology Small Firms Conference, HTSF 2008.	Medical devices sector in Netherlands	To identify and analyse of the organisation of New Product Development in networks for high innovation performance from view of SMEs. To identify combinations of external firms characteristics with hypothesis.	stakeholder positions Structural holes position Strenght of ties Resource exchange bonds
Robson, P. J., & Bennett, R. J. (2000). SME growth: the relationship with business advice and external collaboration. *Small Business Economics*, *15*(3), 193-208.	Large scale survey of 2424 SMEs in Britian	To establish the relationship of business advice and external collaboration with SME growth. To show up the result of relationships between 3 measurement of SMEs performance: (1) Rates of employement growth, (2) rates of turnover growth, (3) changes in profitability per employee of firms	Age Export attribute Skill level of firm High tehnology Innovation Number of serious competitors Manufacturing/service Number of competitors Business friends Business link Customers Suppliers Consultants Chamber of Commerce Trade/Professional association
Poggel, C., Schönwetter, G. (2010). Analyzing Differences in the Logistics Competence Between SMEs and Large Copmanies – An Emprical Study. Proceedings of the 2nd ICLT.	7 SMEs and 10 large companies in logistics in Austria	To describe a research project undertaken to analyze the logistics competence of SMEs compared to larger companies To identifying specific weaknesses and best practices. Null Hypothesis: There is no difference between SMEs and large companies. RQ 1: What is the current state of logistics competence in small and large companies? RQ 2: Is there a difference in process-orientated logistics understanding	Structure of firm - HRM - R&D - Procurement inbound/outbound logistics - operations - marketing/sales - service

		between small and large companies? RQ 3: Who's responsible (management level) for logistics management in SMEs and large companies? RQ 4: What are the enablers and barriers (e.g. IT) creating differences between small and large companies?	
Casals, F. E. (2011, February). The SME co-operation framework: A multi-method secondary research approach to SME collaboration. In *Proceeding of 2010 International Conference on E-business* (pp. 118-124).	Collaboration of SMEs with other SMEs and research organizations.	To analyse the field of SME collaboration To understand how small businesses cooperate To define internal-external factors and barriers to collaboration for improve SME performance and reduce risk of alliance failure.	**Strategic factors** **Management factors** **Social Factors** **Internal reasons for SME collaboration** **External reasons for SME collaboration** **Internal problems and barriers** **External problems and barriers**
Andrea Rangone "A Resource-Based Approach to Strategy Analysis in Small-Medium Sized Enterprises" Small Business Economics 12: 233–248, 1999. 1999 Kluwer Academic Publishers. Printed in the Netherlands.	14 Manufacturing SMEs	Definition of the basic capabilities and key performances. To define strategic goal and key performance, identify resources of key performance, scoring strategic values of resources and consistency, and define strategy approach.	Capabilities in Innovation - Production - Market Mngmt Suitable skills Infrastructure Flexibility Quality Knowledge Loyalty
Jitesh Thakkar, Arun Kanda and S.G. Deshmukh "A conceptual role interaction model for supply chain magement in SMEs" Journal of Small Business and Enterprise Development, Vol. 15 Iss: 1 pp. 74 - 95, 2008	A case of XYZ tin-container manufacturing SME.	To propose supply chain contribution model for a single manufacturing SME. To define priorities among the criteria for SCM within SMEs. To state differences and complexities of SCM for SMEs and compare with the large organisations. Suggestions for combinations of SMEs.	Competitive priorities/ SCM view/ Complexity of SC objectives/ Key strategies/ Kind of integration/ Key sourcing related activities/ Inventory mngmnt/ Time frame and relationships/ SC flows/ Product offerings/ Managing supply/ Managing demand/ Use of third-party logistics (3PL) and fourth party logistics (4PL)/ Demand and forecast planning/ External - Internal control structure/ Coordination mechanisms/ Use of IT and information/ Transactional processes/ Purchasing/ Customer relation/

Jimmy Hill "A multidimensional study of key determinants of effective SME marketing activity: Part 2" International Journal of Entrepreneurial Behaviour & Research, Vol. 7 Iss: 6 pp. 211 - 235, 2001	Marketing SMEs	To find key elements of SMEs marketing. To build a holistic model with these key determinants for marketing competencies of SMEs.	sales orientation and sales competencies Networking experience knowledge
Rosalind Chew and Soon-Beng Chew "A study of SMEs in Singapore" People and Places in the Global Economy, Vol. 2 Iss: 4 pp. 332 - 347, 2008	SMEs in manufacturiing in Singapore from 1990 to 2005	To analyse the performance of SMEs in manufacturing with compare the economic indicators and relationships with government policies.	employment rate, productivity, fixed assets, export value, government fundings for training, prefer multi national companies
Bashar S. Gammoh and Kevin E. Voss "Alliance competence: The moderating role of valence of alliance experience" European Journal of Marketing, Vol. 47 Iss: 5 (Date online 11/6/2012)	Research on brands in 44 industries based on "The BrandWeek Directory" of brands provided by VNU Business Publications.	To investigates alliance formation competence and attitudes toward brand alliances. To test the hypothesis about the relationship between alliance experience and alliance competence moderated by the relative quality of the experience as valence of alliance experience.	organizational compatibility with the potential partner firm resource complementarily, goal interdependence with the potential partner firm, direct prior experience has an influence on firms' long-term alliance intentions.
McAdam, R., McConvery, T., & Armstrong, G. (2004). Barriers to innovation within small firms in a peripheral location. *International Journal of Entrepreneurial Behaviour & Research, 10*(3), 206-221.	A multiple case study methodology involving 41 SMEs in Northern Ireland.	To explore key weaknesses and strengths in relations to successful innovation implementation in SMEs of SC within an EU peripheral region.	Innovation capability - culture suitable skills, organisational structure, owner-manager leadership issues, empowerment use of employees' ideas creativity
Wolff, F., Schmitt, K., & Hochfeld, C. (2007). Competitiveness, innovation and sustainability–clarifying the concepts and their interrelations. *Institute for Applied Ecology, Berlin*.	Review	The purpose of this paper is to present and explain the core concepts at the heart of the debate: competitiveness, innovation and sustainability.	Financial Physical Human capital R&D expenditure Stock to turnover rates Employeed encompass profitability Market share Expert performance Firm growth Productivity performance Patents Competitiveness Sustainability Innovation

Albaladejo, M. (2001). *Determinants and policies to foster the competitiveness of SME clusters: Evidence from Latin America*. Queen Elizabeth House.	Italian model in 5 clusters of Latin America	To state key determinants of competitiveness in SME clusters for country- , firm- , cluster-level factors of the "collective efficiency" approach. To determine the level of similarity of Italian model for determinants.	External economies Joint action Trust Connectivity Skills (management, technology-related) Technological effort and learning Working conditions Physical infrastructure and machinery
Kienzle, R., & Shadur, M. (1997). Developments in business networks in East Asia. *Management Decision*, *35*(1), 23-32.	170 networks involving 739 SMEs in over 30 industry for South East Asia (Japanese Business Networking, Korean Business Networking, Chinese Family Business Networking)	To examine Japanese, Korean and Chinese business networking approaches in relation to small and medium sized enterprises. To suggest some implications for managers and Western policy makers.	Dominance fuctional control rivaly (SME-LC)
Parry, S., Kupiec-Teahan, B., & Rowley, J. (2011). Exploring marketing and relationships in software SMEs: A mixed methods approach. *Management Research Review*, *35*(1), 52-68.	16 Software SMEs in B2B sector in North Wales	To understand key determinants of customer value in software SMES through the customer needs. To explain the relation between customer and marketing in software SMEs using a mixed methods approach.	Software quality Professionalism Understanding of requirement Software functionality Expertise of employees Service Trustworthiness of the supplier Price Relationship style Communication Bilingual capability Supplier office location.
Lee, K. S., Lim, G. H., & Tan, J. (2000). Feasibility of strategic alliance as an entry strategy into markets dominated by major competitors. *Journal of Small Business and Enterprise Development*, *7*(1), 43-57.	Small provision shop owners in Singapore and grocery market against alliance among dealers of industrial products in Malaysia.	To show strategic alliances to be an effective entry-cum-deterrence strategy for SMEs. To find successful usage conditions of strategic alliances by SMEs.	Competitor's behaviour Resources (balance of resources) Synergy Complement Risk taking Joint operations
Marri, H. B., Grieve, R. J., Gunasekaran, A., & Kobu, B. (2002). Government-industry-university collaboration on the successful implementation of CIM in SMEs: an empirical analysis. *Logistics Information Management*, *15*(2), 105-114.	Computer Integrated Manufacturing (CIM) in 24 SMEs in Great Britain.	Brief background of university-industry-government collaboration applications of CIM in SMEs. To from a model this triangular co-operation for British SMEs.	Technical backing/ Special Loans / Liberalization of economy / Logistics Collaboration (Complementarity)/ Provide funds / Short term employee training / Arrange seminars Age of companies / Revenue / Employee numbers / R&D (%)

Baregheh, A., Rowley, J., Sambrook, S., & Davies, D. (2012). Innovation in food sector SMEs. *Journal of Small Business and Enterprise Development*,*19*(2), 300-321.	221 Food sector SMEs in UK.	To present a profile of innovation in food sector SMEs in the UK, To explore the degree and types of innovation. To support activities for development of characteristics of an innovation orientation.	Encouraging new ideas Innovative skills of employees Effective change - flexibility Organizational culture Gathering information (customer / consumer / competitor) - information capacity size / product group / Year of establishment / location
Butler, C. J. (2010). Internal and lateral communication in strategic alliance decision making. *Management Decision*, *48*(5), 698-712.	150 defence manufacturing SMEs in Yorkshire, UK.	To investigate relationship between internal and lateral communication for UK and non-UK managers in defence manufacturing firms and decision-making alliances based on control.	Control of decision making Lack communication Cultural differences Organizational culture strengthening the relationship Trust Joint ventures
Fink, D., & Disterer, G. (2006). International case studies: to what extent is ICT infused into the operations of SMEs?. *Journal of Enterprise Information Management*, *19*(6), 608-624.	ICT usage of SMEs in Australia and Germany	To seek macro (industry, country) and micro (functions, enterprise) level phenomena within the ICT (information communication tech.) usege of SMEs overcome previous research limitations.	Strategy, IS/IT competence Environment Structure, Organisational structure, power relationships, Synergy, leverage Staff, style, skills, user attitudes
Ojeda-Gomez, J., Simpson, M., Koh, S. L., & Padmore, J. (2007). Achieving competitive advantage in the Mexican footwear industry. *Benchmarking: An International Journal*, *14*(3), 289-305.	2 small and 5 medium company of footwear industry in Mexico	To provide a systemic view of competitive advantage in small- and medium-sized enterprises (SMEs) in Mexico.	the entrepreneur, the firm's resources and capabilities, the supporting institutions.
Chong, C. W., Chong, S. C., & Gan, G. C. (2011). Inter-organizational knowledge transfer needs among small and medium enterprises. *Library Review*, *60*(1), 37-52.	70 Malaysian SMEs	To explore inter-organizational knowledge transfer needs and practices SMEs.	number of employees years of operation industry type type of ownership Commitment Culture Loss of power Emphasis on individual IT Lack of time

Moreira, A. C. (2009). Knowledge capability flows in buyer-supplier relationships: Challenges for small domestic suppliers in international contexts.Journal of Small Business and Enterprise Development, 16(1), 93-114. MU (University of Mumbia).	New Process Development in Electronics, footwear and automobile SMEs in Portuguese	To present the main findings that involve knowledge transfer-oriented and interaction-oriented capabilities as reported throughout absorptive, transmissive and interaction oriented capacities. To understand how suppliers have managed to accumulate knowledge in their relationship with large multinational clients. To explore situations that are not clear and may have different outcomes.	Organisational characteristics Cumulativeness of knowledge transferred (quality, cost, NPD) Motivated staff to respond to new challenges posed by client Ability to internalise new knowledge from consecutive projects Strategic similarities between partners Institutional co-operative environment
Desouza, K. C., & Awazu, Y. (2006). Knowledge management at SMEs: five peculiarities. *Journal of knowledge management*, *10*(1), 32-43.	25 SMEs by sector: Coffee shops and local cafe, Dry-cleaning and laundry shops, Technology companies, Security consultants, Management consultants, Restaurants	To discuss five key peculiarities that differentiate knowledge management practices at SMEs versus largers.	Usage of technology, Usage of knowledge, Qualification of individuals Motivation of individuals, Equality of resources
Lu, H., Feng, S., Trienekens, J. H., & Omta, S. W. F. (2012). Network strength, transaction-specific investments, inter-personal trust, and relationship satisfaction in Chinese agri-food SMEs. *China Agricultural Economic Review*,*4*(3), 363-378.	80 Agri-food SMEs in China	To seek how buyer-seller relationships contribute to SMEs' relationship satisfaction in Chinese context from SMEs involved in agri-food processing and exporting in China.	Relationship satisfaction Network strength - number of companies in relation Inter-personal trust sales amount Uncertainty Business experience
Mu, J., Peng, G., & Tan, Y. (2007). New product development in Chinese SMEs: key success factors from a managerial perspective. *International Journal of Emerging Markets*, *2*(2), 123-143.	113 Chinese SMEs	To connect the gap by examining the key success factors of NPD in Chinese SMEs by mean value of each criterion for each stage.	Technological criteria Marketing criteria Commercial criteria Managerial criteria

Olsen, J. R., Harmsen, H., & Friis, A. (2008). Product development alliances: factors influencing formation and success. *British Food Journal*, *110*(4/5), 430-443.	19 Dannish food industry (large and SMEs)	To develop a framework for factors influencing the formation and success of product development alliances in the food industry.	Flexibility Technology complementarity Inimitability Meeting new and complex market demands Gaining a competitor Increased product quality Strong social position Innovation strategy Culture Market development perspective Communication Commitment Trust Partners, complementarity of resources Previous experience Joint teams
Nunes, P. M., Serrasqueiro, Z., Mendes, L., & Sequeira, T. N. (2010). Relationship between growth and R&D intensity in low-tech and high-tech Portuguese service SMEs. *Journal of Service Management*, *21*(3), 291-320.	High - tech and low-tech service SMEs in Portuguese.	The purpose of this paper is to determine if the relationship between growth and research and development (R&D) intensity is of a different nature in the context of low- and high-tech Portuguese service small to medium-sized enterprises (SMEs).	Growth (business experience) Age R&D intensity Size Cash flows Debt
Bo, Z., & Qiuyan, T. (2012). Research of SMEs' technology innovation model from multiple perspectives. *Chinese Management Studies*, *6*(1), 124-136.	Chinese SMEs	To study technology innovation models from multiple perspectives such as growth stage of SMEs, the environmental features in the enterprises' locations, competitive characteristics of the industries and the enterprises' innovation ability.	Technology, Market size, Personnel, Organizational structure, The strategic innovation Business experience - growth Environment
Hughes, A., & Wood, E. (2000). *Rethinking innovation comparisons between manufacturing and services: the experience of the CBR SME surveys in the UK* (105-124). Springer US.	SMEs in UK	The purpose is to compare the innovation activities in manufacturing and service industries.	Economic factors Firm level factor Customer responsiveness Technological opportunities

Cooke, P., & Wills, D. (1999). Small firms, social capital and the enhancement of business performance through innovation programmes. *Small Business Economics*, *13*(3), 219-234.	Most of IT and electronic SMEs in Denmark(54), Ireland(56) and Wales(43) (U.K.) which have R&D departments.	To identify the effect of social capital in the form of SME inter-firm networks for innovation. To determine advantages of globally/domestically and formal /informal collaboration. To search government programmes to improve collaboration amongst SMEs.	Business growth R&D Innovation Skills Finance Markets Service access
Berry, A. (1997). *SME competitiveness: the power of networking and subcontracting*. Inter-American Development Bank.	Latin American SMEs	To suggest ways (i.e. identify best practices) to increase the contribution of interfirm cooperation to the efficiency of industrial sectors.	Joint action Network support programmes Large - small linkages Training Information systems Culture Finance
Bharati, P., & Chaudhury, A. (2009). SMEs and competitiveness: the role of information systems. *International Journal of E-Business Research*.	SMEs	To review of the current state of research on information systems and SMEs.	Financial performance New product development ICT E-business performance Competitiveness
Lajara, B. M., & Lillo, F. G. (2004). SMEs and supplier alliances use: an empirical analysis. *Supply Chain Management: An International Journal*, *9*(1), 71-85.	Spanish industries based on the Alicante province	To analyses how small Spanish manufacturing firms develop supplier partnership with the aim of improving their competitivness. To find out the creation of alliances, whereas the interest focuses on the examination of the benefits derived from such partnerships, as well as soome of the features that define them.	Degree of Co-operation Communication joint tasks Trust.
Jaouen, A., & Gundolf, K. (2009). Strategic alliances between microfirms: Specific patterns in the French context. *International Journal of Entrepreneurial Behaviour & Research*, *15*(1), 48-70.	40 of microfirms in South of France sectoring by trade, hanscraft, services, light industry.	To obtain a typology and governence modes of strategic alliances between microfirms.	Trust

Singh, R. K., Garg, S. K., & Deshmukh, S. G. (2008). Strategy development by SMEs for competitiveness: a review. *Benchmarking: An International Journal*,*15*(5), 525-547.	SMEs	To consider the major areas of strategy development by SMEs for improving competitiveness of SMEs in globalised market from review the literature on this subject. To identify gaps for strategy development by SMEs for competitiveness.	Knowledge Product design and development (R&D) capability Training infrastructure and networking Concept of strategy development Competitive priorities Leadership/top management support Organization culture Total quality management Development of alliances Vendor development Supply chain management Clean production/TPM Innovation/knowledge management Research and development Technology management IT applications Performance and competitiveness Benchmarking of processes and performance
Thakkar, J., Kanda, A., & Deshmukh, S. G. (2009). Supply chain performance measurement framework for small and medium scale enterprises.*Benchmarking: An International Journal*, *16*(5), 702-723.	SMEs	To propose an integrated supply chain performance measurement framework for the case of SMEs using set of qualitative and quantitative insights gained during the case study research.	uncertainty innovation evolution. Strategy Leadership Capability Culture SCM
Maguire, S., Koh, S. C. L., & Magrys, A. (2007). The adoption of e-business and knowledge management in SMEs. *Benchmarking: An International Journal*,14(1), 37-58.	140 SMEs in south of UK.	To define the traditional forms of ICT in SMEs and small firms to gain competitiviness. To seek which SMEs are able to take advantage of any of the recent tools/techniques/ methods that have been adopted by large organisations.	Tacit knowledge managment Cultural knowledge managemen Support knowledge managment
Felzensztein, C., & Gimmon, E. (2007). The influence of culture and size upon inter-firm marketing cooperation: a case study of the salmon farming industry.*Marketing Intelligence & Planning*, *25*(4), 377-393.	Salmon farms in Scotland and Chile.	To explore affect of national or sub-national culture and company size on inter-firm cooperation in marketing among cluster-based firms.	Informal relationships Competition stronger than co-operation Joint market activities

Bjerregaard, T. (2009). Universities-industry collaboration strategies: a micro-level perspective. *European Journal of Innovation Management*, *12*(2), 161-176.	9 Public university deparments and 19 SMEs (biotech., ICT, energy, nanotech., science) in Denmark.	To explore collaboration for University - Industry (UI) relationship form 3 phases of collaboration and to make nwe R&D alliances between university and SMEs.	reasons for collaboration expectations knowledge exchange technical and cultural impediments learning and relation building
Sinha, P., Akoorie, M. E., Ding, Q., & Wu, Q. (2011). What motivates manufacturing SMEs to outsource offshore in China?: comparing the perspectives of SME manufacturers and their suppliers. *Strategic Outsourcing: An International Journal*, *4*(1), 67-88.	Offshore outsorucing SMEs in China.	To seek why SMEs choose to offshore outsource their manufacturing operations by using Transaction cost approach, The core comptences approach, Network, alliances and internationalization approach. To find how their suppliers (the contractors) view the relationship.	Outsourcing experience - outsourcing içinde Types of outsourcing - outsorucing içinde Firm size

APPENDIX II: The collaborative innovation questionnaire.

Aşağıdaki soru formu, "Yenilikçi KOBİ'ler İçin İşbirliği Kuralları"nı konu alan bir tez çalışmasına veri sağlamak amacıyla hazırlanmıştır. Çalışmanın güvenilirliği ve sonuca ulaşabilmesi açısından **tüm soruları eksiksiz** olarak cevaplandırmanızı önemle rica ederiz.

Çalışmaya gösterdiğiniz ilgi, ayırdığınız zaman ve değerli katkılarınız için teşekkür ederiz.

Doç. Dr.	**Doç. Dr.**	
Bahar SENNAROĞLU	**Gülgün KAYAKUTLU**	**İrem Düzdar**
Endüstri Mühendisliği Bölümü	**Endüstri Mühendisliği Bölümü**	**Endüstri Mühendisliği Doktora Programı**
Mühendislik Fakültesi	**İşletme Fakültesi**	**Fen Bilimleri Enstitüsü**
Marmara Üniversitesi	**İstanbul Teknik Üniversitesi**	**Marmara Üniversitesi**

1. Firmanız hangi ölçekteki KOBİ sınıfına girmektedir?

   - Mikro (1 – 9 çalışan)
   - Küçük (10 – 49 çalışan)
   - Orta (50 – 250 çalışan)

2. Firmanız aşağıdakilerden hangisi ile işbirliği içindedir?
   (Birden fazla yanıt verebilirsiniz)

   - ☐ Müşteri
   - ☐ Tedarikçi
   - ☐ Rakip Firma
   - ☐ KOBİ
   - ☐ Büyük Firmalar

3. Şirketiniz hangi sektördedir?

   ……..

   ……..

   ……..

   ……..

4. Şirketiniz hangi sektörlerde işbirliği içinde çalışıyor?

   ……..

   ……..

   ……..

5. Şirketinizdeki çalışan sayısı ne kadardır?

   □ 0-49

   □ 50-99

   □ 100-149

   □ 150-199

   □ >200

6. Firmanızın kuruluş yılı hangi zaman aralığında yer alır?

   □ 1 yıldan yeni

   □ 1-3 yıl

   □ 3-5 yıl

   □ 5-10 yıl

   □ 10 yıldan fazla

7. Yenilikçiilik için işbirliği yaptığınız firma var mı?

   □ Evet

   □ Hayır

   Cevabınız evet ise:

8. Yenilikçilik açısından işbirliği yaptığınız firmalarla kaç yıldır çalışıyorsunuz?

   □ < 1 yıl

   □ 1-3 yıl

   □ 3-5 yıl

   □ 5 yıl <

   □ 0

   Cevabınız Hayır ise “0” ı işaretleyiniz.

9. İşbirliğinde bulunduğunuz firmalarla yenilikçilik açısından başarılı olan sonuçları seçiniz:

- Yeni ürün
- Yeni süreç
- Yeni Pazar
- Yeni yapılanma
- Yeni tasarım
- Hiçbiri

10. Yenilikçilik (inovasyon) amacı ile işbirliği yaptığınız firmaların sermayesi aşağıdakilerden hangisi olmalıdır?
    - Sektör ortalamalarından yüksek olmalıdır.
    - En az sektör ortalaması (%5) olması zorunludur.
    - Sermayesi önemli değildir.

11. İşbirliğindeki şirketler arasında
    - Hiç kültürel farklılık olmamalıdır.
    - Kültürel farklılıklar çok değilse tolere edilebilir.
    - Kültürel farklılık önemsizdir.
12. İşbirliklerinde yapılan yenilikçilik operasyon harcamaları
    - Mutlaka dengeli paylaşılmalıdır.
    - Payı fazla olan fazla harcamalıdır.
    - Harcamaların büyüklüğü işbirliğini etkilemez.
13. İşbirliğinde yenilikçiliğin başarılı olması için
    - Her iki şirketin de liderlik özelliği taşıması zorunludur.
    - İşbirliğindeki şirketlerin en az bir tanesinin liderlik özelliği taşıması şarttır.
    - Liderlik özellikleri yenilikçilik için önemli değildir.
14. İşbirliğindeki şirketlerin yenilikçilik açısından sorunları çözmek için bağlanabilirlik (connectivity) nasıl olmalıdır:
    - Tüm olası iletişim yolların kolayca kullanılması gerekir.
    - Mümkün olan tek iletişim yolu yeterlidir.
    - Yenilikçilik için bağlanabilirlik önemsizdir.
15. Yenilikçilik amacı ile işbirliğinde
    - Şirketlerin hepsi tasarım becerileri taşımalıdır.
    - Şirketlerden en az birinin tasarım becerileri olması yeterlidir.
    - Tasarım becerileri önemsizdir.
16. Yenilikçiliğin başarılı olması için
    - İşbirliğindeki tüm şirketlerde yenilikçilik kültürü gelişmiş olmalıdır.
    - İşbirliğindeki şirketlerden en az bir tanesinde yenilikçilik kültürü gelişmiş olmalıdır.
    - İşbirliğindeki hiçbir firmada yenilikçilik kültürü olmasa da olur.
17. Yenilikçilik potansiyelini geliştirmek için
    - Tüm iletişim teknolojilerinin etkin kullanımı zorunludur.
    - İşbirliğine başlamadan önce şirketlerde var olan iletişim teknolojileri yeterlidir.
    - İletişim teknolojileri gelişimde rol oynamaz.

18. İşbirliğinde geliştirilen ürünün pazarda alabileceği fiyat
    - Yenilikçiliği besleyen en önemli etkenlerdendir.
    - Yenilikçiliği sadece motive eder.
    - Yenilikçiliği hiç etkilemez.
19. İşbirliğinde yenilikçilik yaratabilmek için
    - Rekabetçi uzmanlık için şirketlerin bir araya gelmesi bir yoldan kısa sürede pozitif etki sağlar.
    - Rekabetçi uzmanlık için şirketlerin bir araya gelmesi bir-üç yılda pozitif etki sağlar.
    - Rekabetçi uzmanlık için şirketlerin bir araya gelmesi üç yıldan uzun sürede pozitif etki sağlar.
20. Yenilikçiliğin başarılı olması için işbirliği konusunda pazar gereksinimlerini
    - İşbirliğindeki tüm şirketlerin çok iyi anlıyor olması zorunludur.
    - İşbirliğindeki birden fazla şirketin anlıyor olması gerekir.
    - İşbirliğindeki bir tek şirketin anlıyor olması yeterlidir.
21. Yenilikçi işbirliğinde başarılı olmak için yönetim bilişim sistemleri
    - Tüm şirketler tarafından etkin kullanılmalıdır.
    - İşbirliğindeki şirketlerden en az birisi (karar veren ortak) tarafından etkin kullanılması yeterlidir.
    - Gerekli değildir.
22. İşbirliklerinde yenilikçilik kültürünün yayılması ve başarılı olması için
    - İşbirliğinde olan şirketlerin hepsinde koordinasyon ve beraberlik özellikleri olmalıdır.
    - İşbirliğinde olan şirketlerin en az birisinde (işbirliğini başlatan ortağın) koordinasyon ve beraberlik özelliği olmalıdır.
    - Koordinasyon ve beraberlik özelliği olmaması tolere edilebilir.
23. İşbirliğinde yenilikçiliğin başarılı olması için
    - İhracatın arttırılmasına yönelik faaliyetler işbirliği içindeki tüm şirketler tarafından gerçekleştirilmelidir.
    - İhracatın arttırılmasına yönelik faaliyetler işbirliği içindeki şirketlerden en az biri tarafından gerçekleştirilmelidir.
    - İhracatın arttırılmasına yönelik faaliyetler etkili değildir.

24. Şirketler arasındaki işbirliğine karşı sorumluluk/sadakat duygusu
    - Yenilikçiliği besleyen en önemli etkenlerdendir.
    - Yenilikçiliği sadece motive eder.
    - Yenilikçiliği hiç etkilemez.
25. Yenilikçi işbirliğinin başarılı bir şekilde gerçekleşebilmesi için
    - İşbirliğindeki tüm firmaların sektör tecrübesi olması zorunludur.
    - İşbirliğindeki şirketler arasında sektör tecrübesi bulunmayan şirketlerin olabilir.
    - Şirketlerin sektör tecrübeleri önemli değildir.
26. Yenilikçilik amacı ile kurulan işbirliğinin yürütülebilmesi için
    - İşbirliği için seçilen tüm şirketlerin problem çözümünde sektör/iş anlayışına sahip olmaları önemlidir.
    - İşbirliği için seçilen şirketlerden en az birinin sektör/iş anlayışına sahip olması yeterlidir.
    - İşbirliği için seçilen şirketlerin sektör/iş anlayışı katkı sağlamaz (çok yeni girişimci şirket de olabilir.)
27. İşbirliklerinin etkili bir şekilde gerçekleşmesi için şirketlerin organizasyonel yapıları
    - Yenilikçiliğin başarısında en önemli etkenlerdendir.
    - Yenilikçiliği sadece motive eder.
    - Yenilikçilik için önem taşımaz.
28. İşbirlikçi yenilikçiliğin başarılı olabilmesi için
    - İşbirliğindeki şirketlerin tümünde değişim yönetiminin ortak gerçekleşmesi önemlidir.
    - İşbirliğindeki şirketlerin kendi başlarına gerçekleştirmesi önemlidir.
    - Değişim yönetimi yenilikçilik için önemli değildir.
29. İşbirliklerinde profesyonellik anlayışı
    - Yenilikçiliği besleyen en önemli etkenlerdendir.
    - Yenilikçiliği sadece motive eder.
    - Yenilikçiliği hiç etkilemez.

CURRICULLUM VITAE

1. Name, Surname : İrem Düzdar

2. Date of Birth : 07.06.1982

3. Title : Instructor

4. Education :

Degree	**Branch**	**University**	**Year**
Under graduate	Chemistry	Çukurova University	2004
MSc.	Industrial Engineering	İstanbul Commerce University	2006
PhD. (Continue)	Industrial Engineering	Marmara University	2009 – ...

5. Academical Titles:

Date of Assistant Professorship:

Date of Associate Professorship:

Date of Professorship :

6. Advised Graduate and Post graduate thesis

7. Publications:

7.1 The articles published on the international refereed journals:

7.2. The papers presented at international academical symposiums and printed in their proceedings:

- Irem Düzdar, Gülgün Kayakutlu "Quality Cost Balance" The 7th Asia Pacific Industrial Engineering and Management Science Conference, APIEMS 2006
- Irem Düzdar, Gülgün Kayakutlu, Sami Ercan "Building A General Goal Programming Model for Balancing Quality Costs" International Conference on Service Industry: Challenges & Opportunities, Waljat Colleges of Applied Sciences Birla Institute of Technology International Centre Muscat Sultanate of Oman, 2006
- Irem Düzdar, Gülgün Kayakutlu, Sami Ercan "ANP Supported Model for Balancing the Project Quality" — 22nd European Conferences on Operation Research, EURO XXII, Prague, 2007
- Irem Düzdar, Gülgün Kayakutlu "Evaluation of Customer Impact on Innovation Strategies" International Federation of Operational Research Societies Conference 13-18 July 2008, IFORS 2008, Sandstone, South Africa
- Irem Düzdar, Özay Özaydın "Analysis of Potential Gain From Using Hybrid Vehicles In Public Transportation" International Conferences on Prospects for Research in Transport and Logistics on a Regional – Global Perspective, 12 – 14 February, RTraL, Istanbul, Turkey, 2009
- Irem Düzdar, Gülgün Kayakutlu "Access of Green Supply Chain Management for SMEs" 24th European Conferences on Operation Research (EURO XXIV), Lisbon, Portugal, 2010
- Irem Düzdar, Serol Bulkan "Trajectory Tracking Performance Comparison Of Genetic Algorithm And Ant Colony Optimization For PID Controller Tuning On Water Level Process" 12th International Symposium On Econometrics Statistics And Operations Research, Denizli, Turkey, 26-29 May 2011.
- Ayça Altay, Didem Cinar, Gülgün Kayakutlu, Irem Duzdar **"SME Clustering Based on Innovation Needs"** 10th International FLINS Conference on Uncertainty Modeling in Knowledge Enginering and Decision Making, İstanbul, Turkey, 26-29 August 2012.

7.3. The international books or the section of the international books written:

7.4. The articles published on the refereed national journals:

- Sami Ercan, Burçin Can Metin, Irem Düzdar "Industrial Engineering: An Up-to-Date Look" — ITICU, Istanbul Commerce University Publications, 2005

7.5 The papers presented at national academical symposiums and printed in their proceedings:

- İrem Düzdar, Göksu Kaya, Sami Ercan "The Goal Programming Model to Balance the Quality Costs" 7th National Manufacturing Researches Symposium, Ankara, Turkey, 2007
- Irem Düzdar, Tolga Ezen, Göksu Kaya, Sami Ercan " Innovation and the Meeting of TRIZ with KFG two of the Quality Improvement Techniques" , YAEM 2008, 30th June – 2nd July, İstanbul, Turkey, 2008
- İrem Düzdar, Hakan Tozan "The Estimation of Medical Wastes of İstanbul by Fuzzy Regression and GSCM Approach Proposals" YAEM 2010, 30th June – 2nd July, Sabancı University, İstanbul, Turkey, 2010

7.6 Other Publications:

- **Books**

Translated Books

8. Projects

- European Union Sixth Framework Project "Thrace Turkey Innovation Strategies" MIRIAD (Managing and Infusing Research Investment And Development) : 029490-MIRIAD, FP6-2004-KNOW-REGIONS , 2006 - 2008

9. Administrative Jobs

- İstanbul Arel University Faculty of Engineering and Architecture Member of Graduation and Adaptation Committee (2011 - 2013)
- İstanbul Arel University Department of Industrial Engineering Member of the Summer Practise Commission (2010 - …..)

- İstanbul Arel University Department of Industrial Engineering Erasmus Coordinator (2010 - ...)
- İstanbul Arel University Faculty of Engineering and Architecture Erasmus Coordinator (2010 - 2011)
- İstanbul Arel University Faculty of Engineering and Architecture Academical Coordinator (2010 - 2011)
- İstanbul Arel University Bologna Coordination Commission Member (2010 - 2011)

10. Membership to Academical Organizations

11. Prizes

12. Courses Given

Academic Year	Semester	Name of the Course	Hours /Week		No. of Students
			Theo.	Lab.	
2009-2010	Fall	INDUSTRIAL CHEMISTRY	2	0	40
	Spring	INTRODUCTION TO INDUSTRIAL ENGINEERING	2	0	40
2010-2011	Fall	INDUSTRIAL CHEMISTRY	2	0	30
		FUNDAMENTALS OF ENGINEERING AND ORIENTATION	2	0	30
	Spring	INTRODUCTION TO INDUSTRIAL ENGINEERING	2	0	30
		STATISTICS FOR ENGINEERS	3	0	19
2011-2012	Fall	INDUSTRIAL CHEMISTRY	2	0	38
		FUNDAMENTALS OF ENGINEERING AND ORIENTATION	2	0	40
		PROJECT MANAGEMENT	2	2	18
	Spring	PROBABILITY AND STATISTICS	2	2	46
		INTRODUCTION TO INDUSTRIAL ENGINEERING	2	0	40
		GENERAL CHEMISTRY LAB.	0	4	11

2012-2013	Fall	INDUSTRIAL CHEMISTRY	2	0	38
		PROJECT MANAGEMENT	2	2	18
2012-2013	Spring	PROBABILITY AND STATISTICS	2	2	46
		PLANT LAYOUT AND FACILITIES PLANNING	1	2	35
2013-2014	Fall	INDUSTRIAL CHEMISTRY	2	0	38
		PROJECT MANAGEMENT	2	2	18
		ENGINEERING ORIENTATION	3	0	45
		SUPPLY CHAIN MANAGEMENT	3	0	20
2013-2014	Spring	STATISTICS FOR ENGINEERS	3	0	65
		PLANT LAYOUT AND FACILITIES PLANNING	1	2	30

International Course facilities:

- **The 5 hours' lecture is given about the** "Regional Innovation and Analytical Hierarchy Process for Multi Criteria Decision Making" **to the 20 students of Faculty of Engineering at the Rome tor Vergata University between 18th and 20th April in the Teaching Mobility of LLP/Erasmus Program .**
- **The 5 hours' lecture is given about the** "Analytical Hierarchy Process for Multi Criteria Decision Making on Regional Innovation" **to the 50 students of Faculty of Engineering at the Deusto University, Bilbao, Spain between 23th and 26th September in the Teaching Mobility of LLP/Erasmus Program .**

13. Other Job Experiences

i. İstanbul Commerce University, the European Union the 6th Frame Program MIRIAD (Managing and Infusing Research Investment and Development) Project: 029490-MIRIAD, FP6-2004-KNOW-REGIONS – Researcher, May 2006 – September 2007.

ii. Haliç University, Faculty of Engineering, Department of Industrial Engineering - Research Assistant, October 2007 – August 2009.