RELIABILITY ANALYSIS OF A COMPLEX SYSTEM UNDER UNCERTAINTY AND FAILURE EVENT DEPENDENCY

(KARMAŞIK BİR SİSTEMİN BELİRSİZLİK VE HATALARIN BAĞIMLILIĞI ALTINDA GÜVENİLİRLİK ANALİZİ)

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LIST OF SYMBOLS

APJ	: Absolute Probability Judgment
ARPA	: Advanced Research Projects Agency
ASEP	: Accident Sequence Evaluation Program
ATHEANA	: A Technique for Human Event ANAlysis
BORA	: Barrier and Operational Risk Analysis
BS	: British Standard
CESA	: Commission Error Search and Assessment
CHEP	: Conditional Human Error Probability
CMs	: Cognitive Maps
COG	: Center Of Gravity
CREAM	: Cognitive Reliability and Error Analysis Method
EOC	: Error Of Commission
EOO	: Error Of Omission
EPRI-HRA	: Electric Power Research Institute Human Reliability Analysis
FCMs	: Fuzzy Cognitive Maps
FIS	: Fuzzy Inference System
FST	: Fuzzy Set Theory
HEART	: Human Error Assessment and Reduction Technique
HRA	: Human Reliability Analysis
IJS-HRA	: Institute Jozef Stefan HRA
INEEL	: Idaho National Engineering and Environmental Laboratory
ISO	: International Standards Organization
JHEDI	: Justification of Human Error Data Information
LCC	: Life Cycle Cost
LCP	: Life Cycle Profit
MCDM	: Multiple Criteria Decision Making
MDTA	: MisDiagnosis Tree Analysis
MLE	: Maximum Likelihood Estimation
OCHRA	: Observational Clinical Human Reliability Assessment
OSCEs	: Objective Structured Clinical Examinations
PC	: Paired Comparison
PIFs	: Performance Influencing Factors
PRA	: Probabilistic Risk Analysis
RA	: Reliability Analysis
RAMS	: Reliability, Availability, Maintainability and Safety
RBFCM	: Rule Based Fuzzy Cognitive Map
SLIM-MAUD	: Success Likelihood Index Method using Multi-Attribute Utility Decomposition
SPAR-H	: Standardized Plant Research Institute HRA
TFN	: Triangular Fuzzy Number
THERP	: Technique for Human Error Rate Prediction
WASH	: The US Reactor Safety Study

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ABSTRACT

Reliability is the fundamental element of safety operation of all systems. The aim of reliability analysis is to quantify the failure probability and its protective barriers. These barriers are intended to protect the system from failures.

Along with the emerging world economy, the growing complexity of systems and the advantage of increasing computational power, system reliability concept expanded to involve service availability, organizational and human reliability, uncertainty of complex systems, network system reliability.

Human performance plays a significant role in developing and operating complex systems. Hence it is obvious that human errors have serious effects on complex systems' performance. All engineering systems are created by human endeavor, so it is actually suitable to claim that most of the system failures are due to human causes as ignorance, negligence or ineptitude. Human Reliability Analysis (HRA) techniques are used in different fields such as manufacturing, transportation, military or medicine. Human Reliability (HR) is a highly important notion as human errors may cause serious adverse consequences.

Healthcare services sector is one of the major fields that require human reliability assessment as most of the applications involve human handling, decisions and processing. This study aims to draw a complete representation of doctors' behavior leading to clinical error by acquiring a complete causal relation model between all possible performance-influencing factors (PIFs) in healthcare operations which have been determined and analyzed for various healthcare operations.

A major problem of HR studies is the lack of numerical measures of the likelihood of an erroneous event and its consequences. In these conditions, many methods have been developed to provide a quantitative risk assessment for HR concept. On the other hand, the nature of human error differs from the nature of component failure with the uncertainties involved.

It is requisite to develop a clear understanding of human performance or behavior and their dependence on dynamic context and socio-technical environment. Human behavior can be affected by many different factors; furthermore these factors can be the connection between different stages of human behavior. Therefore a good mapping of PIFs is one of the essential concerns of understanding human behavior.

In this context, Fuzzy Cognitive Maps (FCM) have been used to procure an explicit understanding of human behavior and all of the reasons relying under that behavior. In this respect, four doctors working in different high-risk healthcare fields evaluated all PIFs. The causal relationships are obtained and evaluated through a sensitivity analysis using different $\alpha - cuts$. In real-life decisions, decision-makers / experts may have different confidence levels on their judgments. Sensitivity analysis procures decision-makers, a perspective that explains how the fuzziness in judgment may affect the solution robustness.

Keywords: Human Reliability Assessment (HRA); Healthcare; Fuzzy Cognitive Maps (FCMs); Fuzzy Inference Systems; Fuzzy Rule-Based Systems.

RÉSUMÉ

La fiabilité est l'élément fondamental du fonctionnement sécuritaire de tous les systèmes. L'objectif de l'analyse de fiabilité est la quantification de la probabilité de défaillance ainsi que la quantification de ses barrières de protection. Ces barrières sont destinées à protéger le système contre les pannes.

Parallèlement à l'économie mondiale émergente, à la complexité croissante des systèmes et à l'avantage de la puissance informatique, le concept de fiabilité d'un système a été étendu pour inclure la disponibilité des services, la fiabilité organisationnelle et humaine, l'incertitude des systèmes complexes, la fiabilité des réseaux.

La performance humaine joue un rôle important dans le développement et le fonctionnement des systèmes complexes. Il est donc évident que les erreurs humaines ont des effets graves sur la performance des systèmes complexes. Considérant que tous les systèmes techniques sont créés par des activités humaines, il faut admettre que la plupart des défaillances du système sont dues à des défauts humains telles que l'ignorance, la négligence ou l'ineptie. Les techniques d'analyse de fiabilité humaine (HRA) sont utilisées dans différents domaines tels que la fabrication, la transportation, l'armée ou la médecine. La fiabilité humaine (HR) est une notion extrêmement importante puisque les erreurs humaines peuvent avoir des conséquences graves.

Le secteur des services de soins de santé est l'un des principaux domaines dans lesquels une évaluation de la fiabilité humaine est nécessaire car la plupart des applications impliquent une manipulation, une décision et un traitement humain. Ce travail vise à établir une représentation complète du comportement des médecins aboutissant à une erreur clinique, en établissant un modèle complet de relation de cause à effet entre tous les facteurs d'influence sur la performance (FIP-PIF en

anglais) possibles déterminés et analysés pour diverses opérations de soins de santé.

Un des principaux problèmes des travaux sur les ressources humaines est l'absence de mesures quantitatives d'un événement erroné et de ses conséquences. Dans ce contexte, de nombreuses méthodes ont été développées pour fournir une évaluation quantitative des risques dans le concept de fiabilité humaine.

D'autre part la nature de l'erreur humaine diffère de la nature de la défaillance d'un composant, dû aux incertitudes impliquées. Il est nécessaire de développer une compréhension claire de la performance ou du comportement humains et de sa dépendance au contexte dynamique et à l'environnement socio-technique. Le comportement humain peut être affecté par de nombreux facteurs différents. En outre, ces facteurs peuvent être le lien entre différentes étapes du comportement humain. Par conséquent, une bonne cartographie des FIP est l'une des préoccupations essentielles de la compréhension du comportement humain.

Dans ce contexte, les cartes cognitives floues (FCM) ont été utilisées pour permettre une compréhension explicite du comportement humain et de toutes les raisons invoquées sous son comportement. A cet égard, quatre médecins travaillant dans différents domaines de la santé présentant des risques élevés ont évalué tous les FIP. Les relations de causalité sont obtenues et évaluées par une analyse de sensibilité utilisant différentes coupes α. Dans la vie réelle, les décideurs peuvent avoir des niveaux de confiance différents quant aux jugements des experts. L'analyse de sensibilité fournit aux décideurs une perspective qui explique comment la logique flou peut affecter la robustesse de la solution.

ÖZET

Güvenilirlik, tüm sistemlerin emniyetli çalışmasının temel unsurudur. Güvenilirlik analizinin amacı, başarısızlık olasılığının ölçülmesi ve aynı zamanda koruyucu bariyerinin nicelleştirilmesidir. Bu engeller, sistemi arızalardan korumak için tasarlanmıştır.

Gelişmekte olan dünya ekonomisi, sistemlerin artan karmaşıklığı ve artan veri isleme yetisi ile birlikte, sistem güvenilirliği konsepti, hizmet kullanılabilirliğini, organizasyonel ve insan güvenilirliğini, karmaşık sistemlerin belirsizliğini, ağ sistemi güvenilirliğini de içerecek şekilde genişlemiştir.

İnsan performansı, karmaşık sistemlerin geliştirilmesi ve işleyişinde önemli bir rol oynar, bu açıdan insan hatalarının karmaşık sistem performansı üzerinde ciddi etkileri olduğu açıktır. Tüm mühendislik sistemleri, insan gayretiyle yaratılmış olduğundan, sistem başarısızlıklarının önemli bir kısmının, cehalet, ihmal veya beceriksizlik gibi insani nedenlere bağlı olduğunu iddia etmek yanlış olmayacaktır. İnsan Güvenilirlik Analizi (İHD) teknikleri imalat, ulaşım, askeri veya ilaç gibi farklı alanlarda kullanılmaktadır. İnsan Güvenilirliği (İG), insan hataları ciddi olumsuz sonuçlara neden olabileceğinden, son derece önemli bir kavramdır.

Sağlık hizmetleri sektörü, çoğu insan uygulamaları, kararları ve işlemleri içerdiği için insan güvenilirliği değerlendirmesi gerektiren temel alanlardan biridir. Bu çalışma, çeşitli sağlık hizmetleri operasyonları için belirlenen ve analiz edilen tüm olası performans etkileyen faktörler (PIF) arasında tam bir nedensel ilişki modeli oluşturarak klinik hataya yol açan davranışların detaylı bir temsilini çizmeyi amaçlamaktadır.

İG çalışmalarının en önemli sorunu, hatalı olay olasılığının ve sonuçlarının sayısal ölçümlerinin olmamasıdır. Bu bağlamda, İnsan Güvenilirliğinde nicel bir risk

değerlendirmesi sağlamak için birçok yöntem geliştirilmiştir. Ancak insan hatasının doğası, bileşen belirsizliğinin doğasından, içerdiği belirsizlikler açısından oldukça farklıdır.

İnsan performansı veya davranışları ve bunların dinamik dünyaya ve sosyo-teknik çevreye bağımlılıklarının net bir şekilde anlaşılması gereklidir. İnsan davranışları birçok farklı faktörden etkilenebilir. Ayrıca bu faktörler, insan davranışının farklı aşamaları arasındaki bağlantı olabilir. Bu nedenle, PIF'lerin iyi bir şekilde haritalanması, insan davranışının anlaşılmasında temel kaygılardan biridir.

Bu bağlamda, Bulanık Bilişsel Haritalar (FCM), insan davranışlarını ve ardındaki tüm nedenleri açık bir şekilde anlamak için kullanılmıştır. Bu bağlamda, sağlık hizmetlerinde farklı alanlarda, yüksek risklerle çalışan dört doktor tüm PİF'leri değerlendirmiştir. Nedensel ilişkiler farklı α kesileri kullanılarak bir duyarlılık analizi ile elde edilmiş ve değerlendirilmiştir. Gerçek hayattaki kararlarda, karar vericilerin uzman görüşlerine güven düzeyleri farklı olabilir. Bu çalışmada kullanılan duyarlılık analizi, karar vericilere, yargıdaki belirsizliğin çözümün sağlamlığını nasıl etkileyebileceğini açıklayan bir bakış açısı sağlar.

1 INTRODUCTION

The notion of Reliability originates from before the 1800's, differing from its current meaning, is related rather to the personal aspects of workers rather than technical systems. In the beginning of the 21st century, reliability was also attributed to the engineering processes, leading to the rise of reliability engineering as a scientific discipline. Reliability is fundamental for the safe operation of all kinds of technological systems. In its modern sense reliability covers dependability i.e. successful operation in the absence of failures and breakdowns (Zio, 2009). On the other hand, the dependability of complex systems relies on human operators to a large extent.

The definition of reliability given in standards like ISO 8402 and British Standard BS 4778 is: "The ability of an item to perform a required function, under given environmental and operational conditions and for a stated period of time". Here the word item is used to denote component, subsystem or system that is considered as an entity (Høyland, 2009).

In fact the term 'unreliable' is used to describe the undependable behavior of an individual or an item, whereas the cautionary term 'risky' is used to warn of possible exposure to an adverse consequence (Singpurwalla, 2006). The management of risk calls for the quantification of uncertain occurrence of adverse events and their consequences. If the outcomes of interest are adverse events as a component or system failure, then the risk analysis takes a more specialized name of 'reliability analysis'.

Standard definition of risk says that in order to answer the question "What is the risk?" it is necessary to answer three subsidiary questions: "What can go wrong?", "How likely is it?", "What are the consequences?" (Kaplan & Garrick, 1981). A good answer to the first question is a list of worst case scenarios. Then, the illustration of these scenarios by real cases will be a good answer to the second question when the list of consequences will be a good one for the third.

Risk characterization is mostly related to quantifying uncertainties. For engineered systems, answering “What can go wrong?” is the hardest phase of risk assessment. To characterize system risk one must develop a complete set of system crash scenarios with the plant model, the collection model, the system components model, the system operators model and the failure prevention actions must be implemented for all of these models. After identifying a set of scenarios, the practice has been to first develop conceptual models that describe the general behavior of the system then use mathematical models for the quantification process. The final step is the interpretation of the results of risk assessment from a risk manager point of view (Garrick, 2002).

The aim of the reliability analysis is the quantification of failure probability and also the quantification of its protective barriers. These barriers are intended to protect the system from failures. The fundamental challenge in a reliability analysis is the uncertainty of failure occurrences and the consequences of different sort of failures. To handle this issue we can:

- Identify the failure event sequences that lead to a credible worst-case accident scenarios. (design-based accidents)
- Predict the consequences of these failures
- Design safety barriers for preventing bad scenarios and their consequences and for reducing failures (Zio, 2009).

The availability or reliability of an engineering system has significant impacts on the operational cost and safety characteristics of a modern system over its life-cycle.

The emerging world economy, the growing complexity of the systems and the advantage of increasing computational power, system reliability concept expanded to involve service availability, organizational and human reliability, uncertainty of complex systems, network system reliability. The big deal is to compromise the demand to improve the performance of systems and the aim of cost minimization (Lewis, 1996).

Human performance plays a significant role in the development and operation of complex systems so it is obvious that human errors have serious effects on the complex system performance. HRA techniques are used in different fields such as manufacturing, transportation, military or medicine. Human Reliability (HR) is a highly important notion as human errors may cause serious adverse consequences.

All engineering systems are created by human endeavor so it is actually suitable to claim that most of the system failures are due to human causes such as ignorance, negligence or ineptitude (Lewis, 1996). On the other hand, in the operation phase, even though the system is automated, existing very complex human-machine interaction may also be the cause of accidents. Therefore, safety analysis has to focus not only on machine-centered analysis but also on human centered analyses (Vanderhaegen, 2001).

Human errors can be crucial,vital and catastrophic in many different areas such as nuclear industry, transportation, hazardous waste disposal, heavy industry and healthcare applications, whether established systems are automated or not.

In the next sub-section, reliability engineering and human reliability engineering related basic terms have been enlisted followed by the sub-section where the primary motivation of the study has been revealed. The major contribution has been put forth for consideration in the third subsection and the overall architecture has been given in the last sub-section.

1.1 Basic Terms

According to O'Connor and Kleyner, the usual engineering definition of reliability is (Connor, 2012):

The probability that an item will perform a required function without failure under stated conditions for a stated period of time.

Thus, the problems of reliability analysis (RA) require the assessment of uncertainty related with the undesired events such as system, component or human failures (Singpurwalla, 2006).

Human Reliability Analysis (HRA) consists of detailed analysis and inspection of human tasks and actions in a system in order to detect all aspects of human behavior, to identify existent human errors and their causes, to predict possible errors and to realize an impact analysis on system safety. The terminology used for the HRA is as follows:

- Human Error: The major factor of catastrophic and fatal events and accidents in diverse areas, where actions or tasks are not performed as designated.
- Failure: The inability of a system component such as a machine or a human being to perform its or his designated duty.
- Performance: Degree of accomplishment of a task considering predetermined standards of accuracy, completeness and speed.
- Performance Influencing Factors (PIFs): A list of diverse factors influencing the accomplishment of a task.

1.2 Motivation

As explained widely in the last section, reliability is the fundamental element of safety operation of all systems. Reliability engineering is a well-established, multi-disciplinary scientific principle involving a wide range of formal methods to manage the system sustainability/maintainability against failures. In fact, scientific discipline tries to answer questions such as "Why systems fail?"; "How to develop reliable systems?"; "How to measure and test reliability in design, operation and management?"; "How to keep systems reliable, by maintenance or system improvement?".

Failures can originate from different types of source such as:

- Component failures

- service failures
- mechanical failures
- control system failures
- changeover failures
- logistic failures
- instrument failures
- human errors

These are among the failures to affect the system performance and should be taken into account for system reliability calculations. Yet, each failure type can have a different occurrence rate function with different kind of distributions. Occasionally, for one or more of these failure types it may be difficult to estimate the occurrence rate of an event by using one simple probability. Besides, considering a simple two-component parallel system, the failure rate of the system lifetime may increase although the component lifetimes have decreasing failure rates according to Simpson's paradox. It is obvious that estimating complex system reliability requires a detailed analysis of each component of the system and their interdependencies. System reliability cannot be calculated by just a sum of component reliabilities.

In many past works, component (machine or human being) failures are assumed statistically independent. However, failure times are often not independent, for a number of reasons, the most important being environmental effects. Since the components of a system share the same environment, the environment has an impact on the failure of all components. This implies that failure times of components are not statistically independent and it is necessary to consider their interrelationships in assessing system reliability (Blischke, 2000).

Human performance plays a significant role in the development and operation of complex systems so it is obvious that human errors have serious effects on the complex system performance. HRA techniques are used in different fields such as manufacturing, transportation, military or medicine.

Conventionally, human errors are classified in three groups which are (Huang et al., 2001; Yuan, 1995; Onisawa et al., 1988):

- P1: Fail to detect correctly
- P2: Fail to respond in a timely manner
- P3: Fail to execute successfully

Moreover, the total human error probability is approximated as P1 + P2 + P3. Nevertheless there is interdependency between these types of error and estimating human error probability without considering these interdependencies can lead to worthless data use in reliability analysis.

The major problem of HR studies is the lack of numerical measures of the likelihood of erroneous event and its consequences. In these conditions, many methods have been developed to provide a quantitative risk assessment for the HR concept.

However the nature of human error differs from the nature of component failure with the uncertainties involved. There are three categories of uncertainties. A big part of the uncertainties comes from the variability of human performance. This performance not only differs from man to man but also for a single man from hour to hour. A second source of uncertainty is the variability of human performance due to interactions between him and the environment, the working conditions, other workers. The third source of uncertainty is his psychological background (Lewis, 1996).

On the other hand, risk management should take into account the vagueness and uncertainty inherent in risk and provide a good assessment based upon experts judgments as mentioned by Kahraman (2011).

It is requisite to develop a clear understanding of human performance or behavior and their dependence on dynamic context and socio-technical environment. Human behavior can be affected by many different factors; furthermore these factors can be the connection between different stages of human behavior. Therefore a good mapping of PIFs is one of the essential concerns of understanding the human behavior as discussed in the following sections.

1.3 Contribution

This study incorporates HRA in healthcare systems and goes a step further by making a detailed examination of human error nature and the dependency between human errors. In other words, this study procures a general standpoint covering the determination of human errors and their causes, the detection of all relations in between as well as interdependencies.

Recent studies focus generally on analyzing some major factors leading to human error in healthcare operations or on special cases producing defects due to human errors. However a general study searching out all PIFs for whole situations and analyzing them for different healthcare operations in order to acquire finally a complete relation model between all possible causes and consequences does not exist. This study fulfills these deficiencies in the literature.

In this context, the second section consists of a detailed reliability engineering literature survey, an elaborate classification of HRA techniques in order to draw a picture of what has been done in various research areas and a complete list of PIFs created as a result of a wide literature review and expert consultation. The methodology used to evaluate these factors and its contributions are given in section three. The fourth section involves the complete relation model between all possible causes and consequences. A sensitivity analysis conducted for different $\alpha - cuts$ is given in section five.

1.4 Thesis Structure

The overall architecture of the study is represented as follows in Figure 1.1.

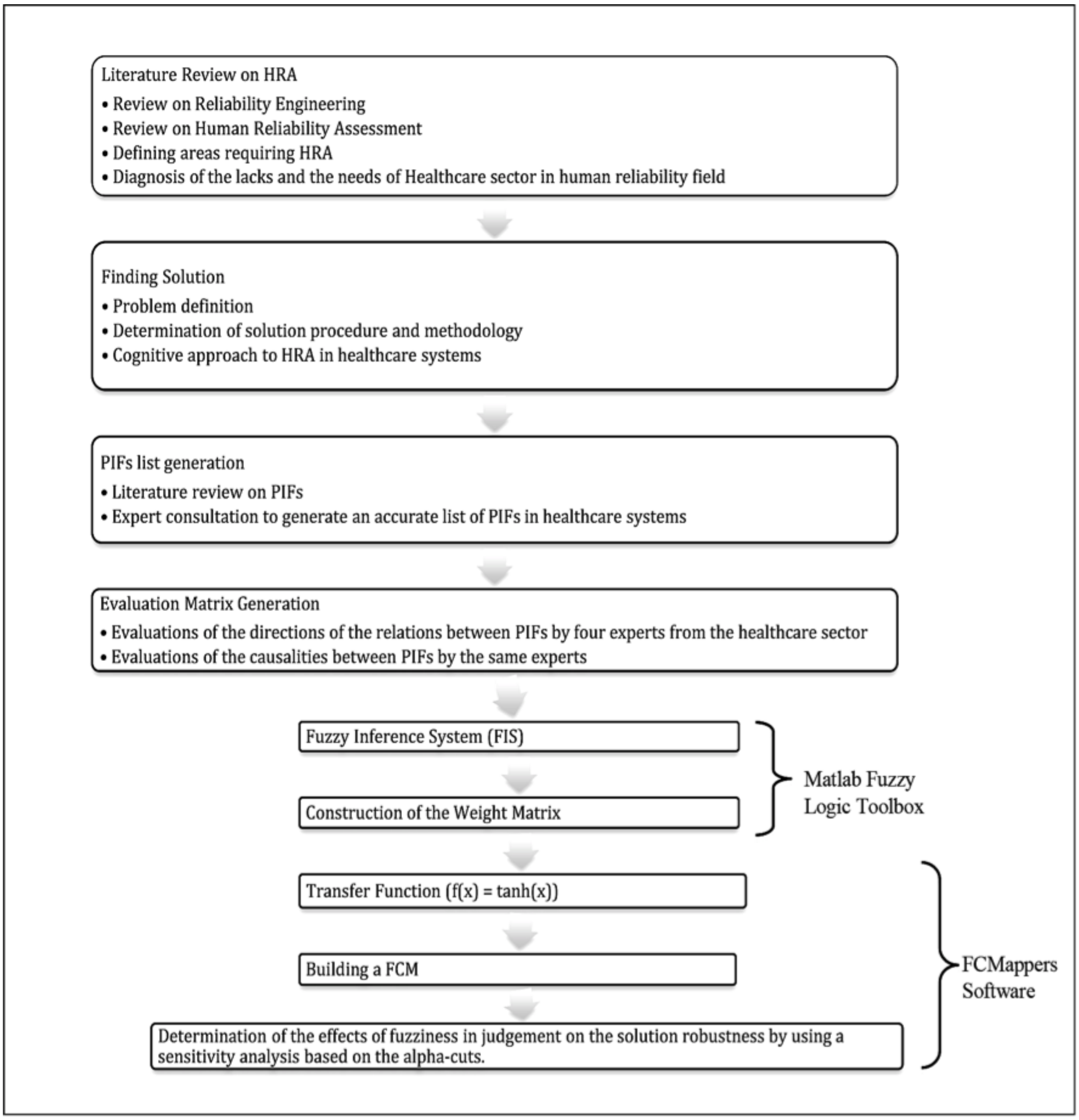

Figure 1.1: Architecture of the Study

2 LITERATURE SURVEY

2.1 The Progress of Reliability Engineering

As explained before the notion of Reliability has been around since before the 1800s, referred to a person not a technical system. After the 1800s, the reliability concept has grown in both qualitative and quantitative dimensions. Since 1950s, reliability engineering has been established as a scientific discipline when social and technological developments in reliability topic have provided the formation of a quantitative reliability treatment framework. The mass production in 1900s of rifle, car and vacuum tube productions became a driving force of the reliability engineering. The relations between component faults and system failures have been investigated and necessary measures to obtain more reliable components have been detected. All these military-funded projects accelerated the development of reliability discipline along two dashes; the sophistication of the techniques such as redundancy modeling, Bayesian statistics and Markov chains and the shift of focus from component reliability to the system reliability (Zio, 2009).

In 1960s, by the growing aerospace technology and nuclear energy use, a new, more rational approach has appeared which focuses on the principle of looking quantitatively at the reliability of the accident-preventing and consequence-limiting protection systems. It is based on probability for the treatment of the uncertainty associated with the occurrence and evolution of accident scenarios without looking to the dimension of the accidents. In 1963, the first journal on the subject named IEEE-Transactions on reliability came out and many papers on the subject were edited (Høyland, 2009).

The findings motivated the first complete probabilistic risk assessment and fault tree analysis of a nuclear power plant installation which was the new interest in the 1970s (Zio, 2009; Garrick, 2002; Jovanovic, 2003). In the United States, a large research commission was organized by Norman Rasmussen to analyze the problem and to form finally the so-called Rasmussen Report, WASH-1400 (Høyland, 2009).

During the 1980s, producers were induced to use quantified measures of reliability for assigning competitive warranty periods to the products due to the rise of consumerism and competitiveness (Singpurwalla, 2006). These years witnessed also to the emergence of network reliability concept. This was motivated by the early Advanced Research Projects Agency (ARPA) network, the forerunner of today's Internet and World Wide Web (Barlow, 1998). A new derivative 'Transport network reliability' has been a popular subject of the 2000s. It relies on the urban road networks and the probability that a network will deliver a required standard of performance (Murray, 2007).

All of these discoveries and their demonstrations revealed the probabilistic approach to risk analysis (PRA) which is an effective way of analyzing system safety. This new approach that takes the form of probabilistic reliability analysis in the context of engineering applications focus not only on worst-case scenarios but on all feasible scenarios and their consequences, with the probability of occurrence of such scenarios becoming an additional key aspect to be quantified in order to rationally and quantitatively handle uncertainty. In fact the conversational use of reliability and risk includes an expression of uncertainty. On the other hand, the quantification of uncertainty is also the quantification of reliability and risk (Zio, 2009; Singpurwalla, 2006).

The emerging world economy, the growing complexity of the systems and the advantage of the increasing computational power, system reliability concept expanded to involve service availability, organizational and human reliability, uncertainty of complex systems, network system reliability. The big deal is to compromise the demand to improve the performance of systems and the aim of cost minimization (Lewis, 1996).

Gnedenko (1999) present a brief introduction of statistical reliability analysis method in their book (Gnedenko, 1999). The main goal of the book is statistical analysis of system reliability. Aven and Jensen affirmed in 1998 that 1% of all mathematical publications are connected to the keyword reliability, based on databases of Zentralblatt/Mathematical Abstracts and Mathematical Reviews (Aven, 1999).

Although this rate has decreased by half today due to new search areas, this gives an impression of the importance of this field. The existing literature on reliability covers complex system and maintenance models (Zio, 2009; Marseguerra & Zio, 2000a,b), multi-objective maintenance problems (Zille et al., 2007), human reliability analysis models such as THERP, CREAM, ATHEANA (Konstandinidou et al., 2006), complex system analysis and uncertainty (Cai, 1996b,a; Utkin & Coolen, 2007; Gudder, 2000; Zadeh, 1968) and many different system reliability engineering applications. The aim of the book of Aven and Jensen is to give a comprehensive presentation of some of the classical areas of reliability, based on a more advanced probabilistic framework. This framework provides a formulation of general failure models and allows the analyst to establish formulas for computing various performance measures.

As mentioned previously, reliability has a potentially wide range of application areas. The list below gives a clear categorization of main reliability applications and research areas:

- Risk analysis: An important number of the risk analysis relies on reliability techniques as failure analysis, fault tree analysis.

- Environmental Protection: Considering the pollution caused by the current manufacturing systems, the safety design of antipollution systems and waste disposal systems. However the improvement of existing systems to create more environmentally friendly systems require a wide use of reliability techniques.

- Maintenance Optimization: Maintainability is, according to the British Standards BS 4778, the ability of an item, under stated conditions of use, to be retained in, or restored to, a state in which it can perform its required functions, when maintenance is performed under stated conditions and using prescribed procedures and resources. Hence, maintenance actions are interventions to prevent system failures and to restore the system function in case of a failure. There is a very strong connection between maintenance and reliability because the optimization of maintenance actions is possible only by considering reliability analysis of the system. Thus, many industries have implemented Reliability Centered Maintenance (RCM) methodology that aims to improve the cost-effectiveness and the maintenance control. Reliability is also indispensable constituent of Life Cycle Cost (LCC), Life Cycle profit (LCP) and Logistic support.

• Quality: Reliability may be considered as a quality characteristic perhaps even one of the most important. The compulsory application of the ISO 9000 series of standards promotes the reliability management and assurance.

Garrick (2002) carried out a review work on the use of risk assessment to evaluate waste disposal facilities in USA. It is a wide study involving the review of the risk assessment practices and standards for two different types of waste which are radioactive waste and solid waste. According to this review study, while risk assessment is a requirement and in the main stream of the safety management of radioactive disposal facilities, it is really just beginning to make its move into the world of solid waste management.

In the field of operational risk assessment there have been some important researches. Barrier and Operational Risk Analysis (BORA) is one of these researches carried out in the period 2003 through 2006. The aim of the researchers was to enable both industry and authorities to improve safety through the knowledge about overall performance of barriers and improvement potentials, the identification of the need to reinforce the total set of barriers during operational activities. Erik Vinnem et al. (2007); Sklet et al. (2006) handle in their study the generalized methodology of BORA based on the use of event trees, fault trees, influence diagrams, risk influencing factors. They affirm that the application of the methodology to real world process will improve complex system safety. The study of Øien introduces a methodology for the quantification of the impact of organizational factors on risk. The framework developed by Øien (2001) provides a risk control covering the most important parameters in the technical risk model in terms of potential change in risk and aids in a frequent control of the risk.

The paper of Clemen and Winkler handles the problem of using multiple experts in risk analysis. Expert judgments provide useful information for managing risk. The main focus of the study is the combination of experts' probability distributions in risk analysis, comparing a group of combination methods and attempting to determine the important issues to be used in the designing of a combination process (Clemen & Winkler, 1999).

In the system reliability analysis, the key issue is to determine the failure occurrence rate and the distribution that represent the failure rates. Many methods have been developed recently to overcome this complex problem. Song and Kang propose a matrix-based system reliability method to compute the probabilities of general system events efficiently by simple matrix operations. It is affirmed in the paper that the method is applicable to any type of system events including series, parallel, cut-set and link-set systems. The method can estimate various importance measures without additional probability computations (Song & Kang, 2009).

In his paper, Yeh presents a simple formula for evaluating the rate of occurrence of failures assuming that a system process is either a continuous-time Markov chain or a higher dimensional Markov process after introducing some supplementary variables. Yeh claims that the method is easier to adopt than Monte-Carlo simulation method (Yeh, 1995). Several generalization of two-parameter Weibull model have been proposed to model data sets that exhibit complex non-monotone shapes of hazard rate function. Gupta et al. propose the Weibull extension model. They make a complete Bayesian analysis using Markov Chain Monte-Carlo simulation. The model does not fit to higher order observations because generally, a single mathematical formulation cannot draw the picture of the actual shape of the bathtub curve (Gupta et al., 2008).

Tan develops the maximum likelihood estimation (MLE) problem to handle interval data for the Weibull distribution. The new approach combines the Weibull-to-exponential transformation technique and the equivalent failure and lifetime technique o estimate exponential failure rates from uncertain data. This method is more efficient and effective than conventional MLE methods because it allows the analyzers to involve interval data (Tan, 2009).

Traditional fault tree analysis is widely used in reliability assessment of complex and critical engineering systems. As some important features of complex systems as component dependencies cannot be analyzed through traditional FT analysis, dynamic methods have been proposed by many authors. The dynamic fault tree approach of Rao et al. defines additional gates called dynamic gates to model these complex system features. Generally Markov models are used in solving dynamic gates but to overcome some difficulties deriving from Markov models, Monte-Carlo simulation-based approach is used to solve dynamic gates in this work. Because Markov models are applicable for only exponential failure and repair distributions and state space become to large for calculations (Rao et al., 2009).

Marseguearra et al. discusses the use of genetic algorithms within the area of reliability, availability, maintainability and safety (RAMS) optimization. The paper affirms that the design and maintenance optimization problem must be developed as a multiple criteria decision making (MCDM) problem where RAM and cost are conflicting attributes (Marseguerra & Zio, 2000b). Marseguerra and Zio combine genetic algorithms and Monte-Carlo simulation to optimize the logistic management of a plant. The flexibility of Monte-Carlo methods allows the analyzers to include several practical aspects such as stand-by operation modes, deteriorating repairs, aging, sequences of periodic maintenances, and different kinds of repair interventions. Genetic algorithm is used to optimize the maintenance periods (Marseguerra & Zio, 2000a).

Sikos and Klemeš used RAMS software to model a waste management system in Hungary. Their main goal is to provide quantitative forecasts for various performance measures of waste management systems. The use of RAMS software can decrease or even avoid failure affecting the availability and the reliability of a complex system (Sikos & Klemeš, 2009).

2.2 Human Reliability Analysis

During this research a lack of HRA Techniques classification has revealed itself by the ineptitude of placement of the technique used in the study to evaluate HR in healthcare operations. This section is composed of a com- prehensive literature survey of HRA techniques followed by a classification of these techniques. Mainly, HRA techniques are roughly classified in two groups; Probabilistic Risk Assessment based techniques that seek to quantify human error probabilities in terms of success-failure and Qualitative Assessment based techniques that models human performance as a set of control modes (strategic, tactical, opportunistic, scrambled) (Tuddenham, 1962).

Human reliability assessment is a crucial field in the probabilistic safety assessment of any technological system because human performance plays a significant role in the development and operation of these systems. The study of Mosneron-Dupin et al. reveals that HRA methods do not cover decision-based unrequired actions which contribute to risk significantly. They propose a human-centered model which highlights the active role of the operators and the importance of their culture, attitudes and goals (Mosneron-Dupin et al., 1997).

The Idaho National Engineering and Environmental Laboratory (INEEL) has developed and applied structured methods of human error analysis to identify potential human errors, assess their effects on system performance and develop strategies to prevent the errors or minimize their consequences. NASA used the results in the airplane maintenance and air traffic management programs (Nelson et al., 1998).

To handle the vagueness of real life data Huang et al. try to integrate fuzzy concepts to event tree analysis in human reliability assessment. A systematic fuzzy event tree analysis algorithm is developed to evaluate the risk of a large-scale system as nuclear power plants (Huang et al., 2001). According to Gregoriades the use of Bayesian Belief Network in a human error analysis enables the analyst to rapidly pinpoint poorly performing systems. The model quantifies error influences arising from user knowledge, ability, and task environment (Gregoriades et al., 2003). According to Mosleh and Chang the model-based approach that provides explicit cognitive causal links between operator behaviors and directly or indirectly measurable causal factors is in the core of the advanced methods as conventional HRA methods have major limitations (Mosleh & Chang, 2004).

Kostandinidou et al. uses a fuzzy classification system to calculate the probability of human error according to CREAM methodology, the most known and used method for HRA. This study is the successful translation of CREAM into a fuzzy logic model (Konstandinidou et al., 2006). To improve HRA, another study proposes simulator studies which can produce important basic information for HRA method development and data for informing use of existing HRA methods (Bye et al., 2006). Boring introduces the application of dynamic event tree analysis in HRA. The author affirms that the key to dynamic HRA is not in the development of specific methods but in the utilization of cognitive modeling and simulation to produce a framework of data that may be used in qualifying the likelihood of human error (Boring, 2007).

The assessment of dependence among human errors is another important issue of HRA. Zio et al. introduces a systematic framework for the elicitation of expert knowledge on the factors influencing the dependence between two successive tasks

(Zio, 2009).

All engineering systems are created by human endeavor so it is actually suitable to claim that most of the system failures are due to human causes as ignorance, negligence or ineptitude (Lewis, 1996). On the other hand, in the operation phase, even though the system is automated, existing very complex human-machine interaction may also be the cause of accidents. Therefore, safety analysis has to focus not only on machine centered analysis but also on human centered analyses (Vanderhaegen, 2001).

Human action is a specific action required by human operator and if he cannot perform this action or cannot perform it in time and correctly, then the human action becomes the human failure event or shortly the human error (Čepin, 2008b). The nature of human error differs from the nature of component failure with the uncertainties involved. There are three categories of uncertainties. A big part of the uncertainties comes from the variability of human performance. This performance not only differs from man to man but also for a single man from hour to hour. A second source of uncertainty is the variability of human performance due to interactions between him and the environment, the working conditions, other workers and his psychological background. Even if one can construct limited models to point out some human errors, the model parameters yet numerical probabilities are usually very approximate and their area of usage is very slight (Lewis, 1996). Thereby, the good collection, interpretation and application of human failure data is an essential must of Human Reliability Analysis (HRA) (Čepin, 2008b).

One of the human failure events is the error of omission (EOO) which arises from human inaction about a task or a problem to be solved. Another human failure event is the error of commission (EOC) that results from the performance of an action (Reer, 2008). It is noticeable that most of human error studies focus on the EOC both for the lack of coverage of EOCs in the accident sequence models and for the relative easiness of modeling such error type. However regardless to the type of error, in the phase of error quantification, there is a strong need to model specific decision errors and also the correlation between environmental conditions and tendencies of human behavior.

The HRA is a systematic framework, which evaluates the process of human performance and associated impacts on structures, systems and components in a complex system. A diversity of HRA methods exist in the literature for different scopes and different approaches. Limitations in the analysis of human actions in reliability analysis were identified years ago and the fundamental limitations are as follows (Konstandinidou et al., 2006):

- Insufficient data
- Methodological limitations related to subjectivity of analysts and expert judgment
- Uncertainty concerning the actual behavior of people during accident conditions

An important feature of human reliability is the dependency between human actions (Čepin, 2008a). Here human actions imply tasks performed by operator during the operation process. There is also another subject of dependency to inspect which is the dependency between human attitudes that can lead to failures when they perform a single task. These attitudes can be classified as follows (Huang et al., 2001):

- Fail to detect correctly
- Fail to respond correctly
- Fail to execute successfully

In fact, there are many ways to categorize human error, as exogenous versus endogenous (Meister, 1993), situation assessment versus response planning (errors in problem detection, in problem diagnosis, in action planning) (Roth et al., 1994).

HRA techniques can be roughly classified in two groups; Probabilistic Risk Assessment based techniques and Cognitive Theory of Control based techniques. Probabilistic Risk Assessment uses failure or error probabilities as data when Cognitive Theory of Control tries to model human performance as a set of control modes (strategic, tactical, opportunistic, scrambled).

Huang et al. constructed an easy method to evaluate human errors and integrate them into event tree analysis by using fuzzy concepts. In their study linguistic values are used to assess human failure events and are transformed to fuzzy error possibilities. Then by converting the possibilities into the fuzzy error rate and by integrating them into the event tree analysis, they analyzed and interpreted the results (Huang et al., 2001). The method is based to expert judgment and does not consider at all the dependency between human failure events and the interaction between the environment and human error. On the other hand it is important to notice that the analyst is not required to understand the fuzzy partition of the occurrence of a human error-dominated event and the overall Fuzzy Logic model. Here a recent study of Zio et al. can be more efficient to model human error dependency (Zio, 2009). It is obvious that when there is dependency between two tasks the probability of the operators' failure in the latter task is higher if the preceding task has been failed. They introduce hereby the conditional human error probability (CHEP).

Dependencies have been considered to a certain extent by many methods as Technique for Human Error Rate Prediction (THERP)(Swain & Guttmann, 1983; Kirwan, 1988, 1996; Zio, 2009), Cognitive Reliability and Error Analysis Method (CREAM) (Hollnagel, 1998; Kim, 2001; Kim et al., 2006; Marseguerra et al., 2006; Konstandinidou et al., 2006), A Technique for Human Error Analysis (ATHEANA) (Commission., 1998; Kirwan, 1996), Accident Sequence Evaluation Program (ASEP) (Swain, 1987), Electric Power Research Institute Human Reliability Analysis (EPRI HRA) (Grobbelaar et al., 2005), Standardized Plant Research Institute HRA (SPAR-H) (Gertman et al., 2005) , Institute Jozef Stefan (IJS-HRA) (Čepin, 2008b) and other techniques mentioned below. These methods try to calculate the probability of erroneous human actions (Konstandinidou et al., 2006).

Human reliability assessment is a crucial field in the probabilistic safety assessment of any technological system because human performance plays a significant role in the development and operation of these systems. The study of Mosneron-Dupin et al. reveals that HRA methods do not cover decision-based unrequired actions which contribute to risk significantly. They propose a human-centered model which highlights the active role of the operators and the importance of their culture, attitudes and goals (Mosneron-Dupin et al., 1997).

The Idaho National Engineering and Environmental Laboratory (INEEL) has developed and applied structured methods of human error analysis to identify potential human errors, assess their effects on system performance and develop strategies to prevent the errors or minimize their consequences. NASA used the results in the airplane maintenance and air traffic management programs (Nelson et al., 1998).

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Kostandinidou et al. uses a fuzzy classification system to calculate the probability of human error according to CREAM methodology, the most known and used method for HRA. This study is a successful translation of CREAM into a fuzzy logic model (Konstandinidou et al., 2006). In this context it is necessary to note that cognitive or human performance modeling is a field focused on developing simulations that mimic human decision making and behavior (Boring et al., 2010). In this approach main issue is the data accuracy and accessibility because cognitive modeling requires both qualitative and quantitative data.

To improve HR, another study proposes simulator studies which can produce important basic information for HRA method development and data for informing use of existing HRA methods (Bye et al., 2006). Boring introduces the application of dynamic event tree analysis in HRA. The author affirms that the key to dynamic HRA is not in the development of specific methods but in the utilization of cognitive modeling and simulation to produce a framework of data that may be used in qualifying the likelihood of human error (Boring, 2007).

The assessment of dependence among human errors is another important issue of HRA. Zio et al. introduces a systematic framework for the elicitation of expert knowledge on the factors influencing the dependence between two successive tasks (Zio, 2009).

It is important to point out that each HRA technique has another spectrum of applications. In other words, different HRA methods may have different areas, tasks, scenarios or even different types of analyses (Boring et al., 2010). There are many comparative studies on HRA methods that reveal weak and strong parts of HRA methods. Swain compared 14 HRA methods for their effectiveness according to three main criteria which are usefulness, acceptability and practicality (Swain, 1990). In his study, Kirwan provided a list of eight criteria, comprehensiveness, accuracy, consistency, theoretical validity, usefulness, resource use, auditability, and acceptability, to assess the most appropriate HRA to use in a special condition (Kirwan, 1992). There is also a subjective benchmark of 14 HRA methods in terms of 21 factors concerning HRA applications for aerospace performed by NASA (Chandler et al., 2006). The study is meaningful only for NASA HRA applications. A validation study of three techniques of HRA consisting of three parts made by Kirwan et al. determined the predictive accuracy and the precision of the methods, Human Error Assessment and Reduction Technique HEART (Williams, 2015, 1988, 1992), Justification of Human Error Data Information JEDHI (Kirwan, 1990, 1994) and THERP. It also helped to prove the consistency of usage of these techniques and revealed the necessary improvements (Kirwan, 1996; Kirwan et al., 1997).

Later, Kirwan conducted a more extensive comparative validation study on nine HRA methods according to five major criteria. These methods are: THERP, the most famous technique having a large nuclear power station database and considering dependence between errors; ASEP (Swain, 1987), a quicker but more conservative version of THERP; Success Likelihood Index Method using Multi-Attribute Utility Decomposition SLIM-MAUD (Embrey et al., 1984), an approach that uses expert judges who derive an index of the relative likelihood of errors; Absolute Probability Judgment APJ (Seaver & Stillwell, 1983), the usage of experts to directly estimate probabilities with knowledge and experience of the task and associated likely errors; Paired Comparisons PC (Hunns, 1982), the approach that uses experts to create a relative scale of error probabilities through psychometric technique of paired comparisons; HEART, a technique comprising a substantial section of the Ergonomics literature; Human Cognitive Reliability HCR (Hannaman et al., 1984), the method used for assessing failure to respond in time in emergency decision-making situations in nuclear power plants; Human Reliability Management System HRMS (Kirwan, 1989, 1990), a technique having a set of operationally-based error data and a set of performance shaping factors as time pressure; JHEDI, a technique starting from a set of basic error descriptors and error data, using a set of performance shaping factors questions to determine the error probabilities (Kirwan et al., 1997).

In 2008, Reer reviewed the advances in HRA of errors of commission comprising both error identification (Part 1) (Reer, 2008) and quantification (Part 2) (Reer & Dang, 2007). The review refers to methods addressing the problem of error identification as ATHEANA, method developed by US Nuclear Regulatory Commission based on a multidisciplinary framework that considers both the human centered factors and the conditions of the plant that create operational causes for human-system interactions; Misdiagnosis Tree Analysis MDTA (Kim et al., 2008, 2006), method whose innovative steps are the assessment of the potential for diagnosis failures and the identification of human failure events that might be induced due to diagnosis failures; and Commission Error Search and Assessment CESA, method developed in 2002 with the aim of providing a tool for error of commission identification in probabilistic safety assessment practice (Dang et al., 2002; Reer et al., 2004; Reer, 2008).

A recent study of Boring et al. represents the results of several relevant benchmarking studies of probabilistic HRA techniques and the lessons learned from these studies (Boring et al., 2010). This study put emphasis on demonstrating the reliability and validity of HRA methods.

An elaborate classification is given in Table 2.1 and Table 2.2.

Table 2.1: Detailed Classification of Probabilistic Risk Assessment based HRA Techniques

Probabilistic Risk Assessment Based Techniques				
Technique	**Full Name**	**Origins**	**Description**	**Usage Domain**
PC	Paired Comparisons	Hunns (1982)	An approximate model for THERP. Simple comparative expert judgments on human errors. Differs from APJ with simple judgments rather than absolute judgments.	Transportation, Nuclear Industry
THERP	Technique for Human Error Rate Prediction	Swain & Guttman (1983)	HRA with task analysis, task decomposition into elements, assignment of nominal HEPs (human error probabilities) to each element, modeling HRA event tree, quantification of total task HEP.	NP&R industries. Applicable for any other sector as Healthcare, Engineering etc.
APJ	Absolute Probability Judgment	Seaver&Stillwell (1983)	It assumes that people can remember and estimate the likelihood of an error. It requires judgments on the chances of a human error.	,Nuclear Industry, Offshore Industry
SLIM-MAUD	Success Likelihood Index Methodology, Multi Attribute Utility Decomposition	Embrey et al. (1984)	An expert judgment methodology. SLIM is a set of procedures for making expert judgment to find out Human Error Probability (HEP) estimates and MAUD is a computer based multi-attribute utility decomposition version of SLIM.	Nuclear Industry, Chemical Industry, Healthcare, Engineering, Transportation
HCR	Human Cognitive Reliability	Hannaman et al. (1984)	The success or the failure of an operator in a time-critical task depends on the cognitive process used to make the critical decision. Performance Shaping Factors (Operator Experience, Stress Level, Quality of Operator/Plant Interface)	Nuclear Industry
HEART	Human Error Assessment	Williams (1986)	In perfect conditions, level of reliability is a nominal likelihood within probabilistic limits. In normal conditions, human reliability may degrade as a function of Error Producing Conditions (EPCs). 9 generic task types and 38 EPCs.	In any domain (nuclear, chemical, aviation, medical)
ASEP	Accident Sequence Evaluation Programme	Swain (1987)	Abbreviated and slightly modified version of THERP, pre-accident and post-accident tasks, screening HRAs, nominal HRAs.	,Nuclear Industry
EPRI HRA	Electric Power Research Institute Human Reliability Analysis	Swain (1987)	Identification and definition of post-fire human failure events. Qualitative and quantitative analysis. Performance-shaping factors (PSFs).	,Electric Industry, Nuclear Industry
HRMS	Human Reliability Management System	Kirwan&James (1989)	A human error identification (HEI) module that is used by assessor on a previously and computerized task analysis. Realization of a task analysis, an error analysis and performance shaping factor-based quantification.	Nuclear Chemical Plant (design stage)
JEDHI	Justified Human Error Data Information	Kirwan&James (1989)	A simplified version of HRMS. Realization of a task analysis, an error analysis and performance shaping factor-based quantification.	,UK Nuclear Chemical Industry
IJS HRA	Institute Josef Stefan Human Reliability Analysis	Čepin (2008a)	,Evaluation of the HEPs of human actions.	,Nuclear Industry
DEPEND HRA	A method for consideration of DEPENDency in Human Reliability Analysis	Čepin (2008b)	,Dependencies between human actions.	,Nuclear Industry
CHEP	Conditional Human Error Probability	Zio et al. (2009b)	Extension of THERP formulation with a fuzzy expert system to procure a more lucid expert elicitation and a new dependence assessment method.	Nuclear Industry. Applicable for any other sector.

Table 2.2: Detailed Classification of Qualitative Assessment based HRA Techniques

Qualitative Assessment Based Methods				
Technique	**Full Name**	**Origins**	**Description**	**Usage Domain**
CREAM	Cognitive Reliablity and Error Analysis Method	Hollnagel (1994, 1998)	Fundamental distinction between competence (person's skills and knowledge) and control (running from a position of non-control to a position of control). Separation of genotypes (causes) and Phenotypes (manifestations).	Nuclear Industry, Rail Crash Scenario, ,Healthcare, Engineering, Transportation, Business
SPAR-H	Simplified Plant Analysis Risk Human Reliability Assessment	Gertman et al. (2005)	Decomposition of probability into diagnosis failures and action failures. Association of human failure events (HFEs) by using performance-shaping factors (PSFs). Use of pre-defined base-case HEPs and 8 PSFs together.	Nuclear Industry
ATHEANA	A Technique for Human Error ANAlysis	?	Method for obtaining qualitative and quantitative HRA results. Human errors occur as a result of 'Error-Forcing Contexts' (EFCs). Use of knowledge, experience in engineering, (Probabilistic Risk Asses.) PRA, human factors and psychology to find such EFCs.	Nuclear Industry
CESA	Commission Errors Search and Assessment	Strater (2000)	Based on importance screening. Scenarios are prioritized based on the contribution to the core damage frequency. Trade-off between scenarios with high safety impact against the completeness of the search.	Nuclear Industry
MERMOS	Méthode d'Evaluation de la Réalisation Des Missions Opérateur pour la Sûreté	Bot et al. (1998)	The method takes into account human factors aspects and determines missions to accomplish to recover the accident.	Nuclear Industry
FETA	Fuzzy Event Tree Analysis	Huang et al. (2001)	To assess the reliability of a large-scale system o systematic FETA is proposed.	Nuclear Industry
MDTA	Misdiagnosis Tree Analysis	Kim et al. (2006))	Assessment of the potential for diagnosis failures and identification of human failures caused by diagnosis failures.	Nuclear Industry
CREAM with Fuzzy Logic	Cognitive Reliability and Error Analysis Method	Konstandinidou et al. (2006)	Application of CREAM based fuzzy modeling. Gives the output human error probabilities with exact numbers instead of intervals.	Nuclear Industry, Transportation. Applicable for any other sector.

2.3 Different HRA Studies in Healthcare

Healthcare services sector is one of the major fields that requires human reliability assessment as most of the healthcare applications involve human handling, decisions and processing. On the other hand human errors in healthcare services lead to serious injuries or worse to death. Therefore patient safety issues have become a new research area that emphasizes the reporting, analysis, and prevention of medical error that often leads to adverse healthcare events.

Medical error in healthcare is one of the major HR issues as the results can be fatal. It is highly difficult to define what medical (clinical) error is. It is a very delicate matter and requires a considerably wide and complex research. In sixteenth century medical books were written attacking the false beliefs and practices of other doctors (Richman et al., 2009). It is obvious that the problem is not new coined but it is still crucial. (Richman et al., 2009) affirm that there is no simple answer to the question 'What is clinical error?' and that one cannot necessarily blame clinical staff in any cases unless he has a concrete example such as a doctor not wearing their glasses or removing the wrong leg.

On the other hand, it must be considered that according to World Health Organization (WHO), healthcare errors impact is calculated as one in every 10 patients since 1990s and that it is admitted as an endemic concern. It is recorded that in 2000s deaths caused by medical error was roughly triple of deaths caused by aids, equal to deaths caused by car accidents or by breast cancer (Institute of Medicine, 2000).

Until 1990s, the frequency of these events was not known, as there was not a systematic reporting system. However according to World Health Organization (WHO, 2008; 2013), healthcare errors impact is calculated as one in every 10 patients since that time and is admitted as an endemic concern. In other words, according to WHOs (2008) estimations tens of millions of patients worldwide suffer disabling injuries or death every year due to unsafe medical practices and care. Today, the WHO patient safety curriculum includes 11 topics among which two are:

- 'What is human factors engineering, and why is it important to patient safety?'

• 'Understanding systems and the impact of complexity on patient care' and 'Understanding and learning from errors' (Walton et al., 2010; Carayon et al., 2014).

Sujan et al. (2018) emphasize the poor levels of reliability in healthcare processes, the performance variability and the absence of regulatory frameworks where HRA has the potential of being a real opportunity to contribute to making healthcare safer.

Furthermore, a detailed research analysis performed on Scopus and Web of Science shows that medicine, health professions and healthcare services form one of the most studied fields which implies their significance. Figure 2.1 and figure 2.2 indicate the distribution of HR studies conducted in different fields between 1980 and 2017 compiled using data from Scopus and Web of Science.

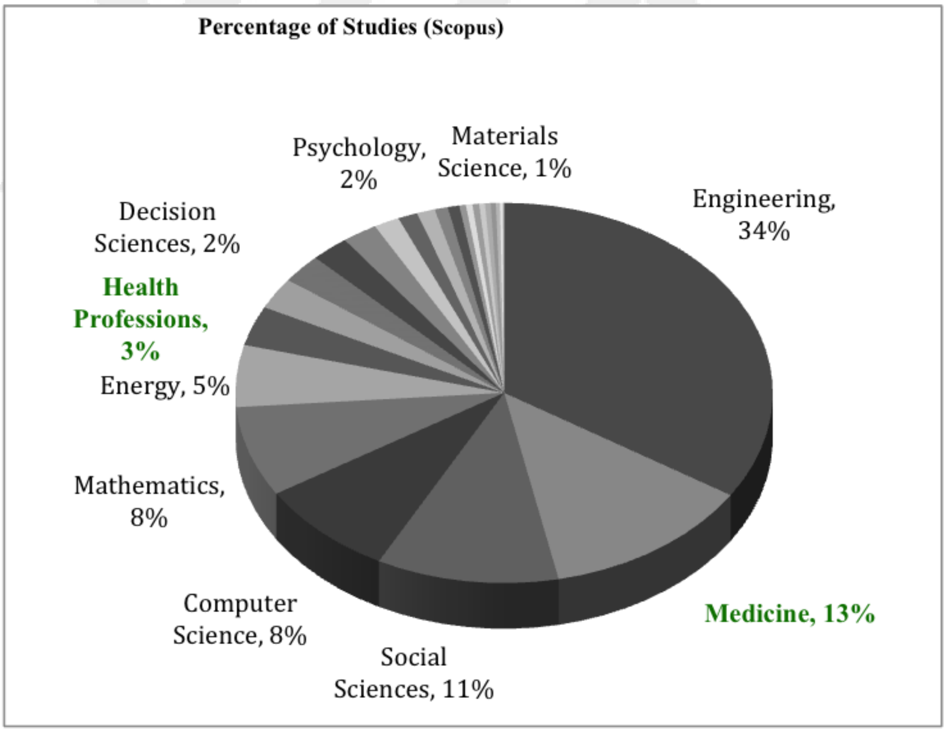

Figure 2.1: Distribution of HR Studies in Different Fields (Scopus)

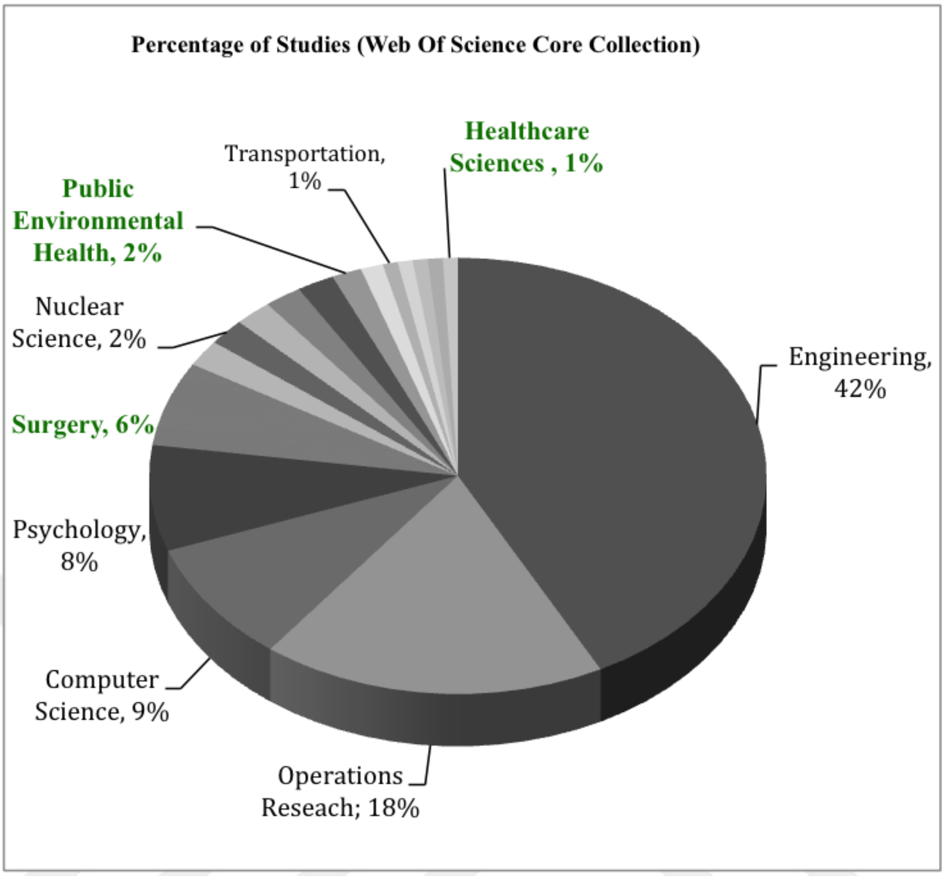

Figure 2.2: Distribution of HR Studies in Different Fields (Web of Science)

Concerning their delicacy, healthcare operations are highly stress-strain process affecting human reliability and some of the important studies conducted in this field are given in Table 2.3.

Table 2.3: HRA Studies in Healthcare

Studies	Description
Reason (1993)	Accident causation model. Analysis of adverse clinical events considering human factors.
Taylor-Adams et al. (1999)	Classification of failures in two main groups: Latent and Active Failures.
Taylor-Adams et al. (2004)	Review of popular HRA techniques used in different fields in order to determine their feasibility for use in healthcare.
O'Rourke (2006)	Risk issues in pediatric cases, risk prevention methods. Significant Event Auditing (SEA) method.
Duff et al. (2005)	Monitoring medical errors in a hospital to show the importance of information management.
Trucco & Cavallin (2006)	Clinical Risk and Error Analysis (CREA), quantitative risk analysis of error modes and critical organizational factors affecting patient safety.
Karnon et al. (2007)	Prospective Hazard and Improvement Analysis (PHIA): a novel quantitative modeling method to predict preventable adverse drug events.
Flin (2007)	Different dimensions of safety climate: Management/Supervision, Safety system, Risk, Work pressure, Competence.
Stock et al. (2007)	Integration of Critical Success Factors (CSFs) to reduce medical errors in hospitals.
Johnstone (2007)	Many preventable human errors are linked to cognitive errors (making the wrong diagnosis, choosing the wrong medication etc.)
van der Geer et al. (2009)	Productivity Measurement and Enhancement System (ProMES) to develop performance indicators.
Buckle et al. (2010)	System Mapping Workshops in understanding medication errors. A method to better design requirements.
Taib et al. (2011)	Comparison of 26 medical error taxonomies using human error perspective. Occurrence of medical errors depends on factors: workers, machines, environment
Zheng et al. (2011)	Classification of surgeons in two groups: Experts and Novices. Novices performed the task faster, with less frustration and more physical demands.
Bohacik & Davis (2013)	Fuzzy Rule-Based System applied to risk estimation of cardiovascular decision support to create an application of knowledge discovery.
Bethune & Francis (2015)	Description of human factors affecting surgical patients and of how well-trained surgeons make mistakes.
Shams Ghareneh et al. (2015)	Identification of human errors in the field of dentist equipment treatment and hand washing in infection control by using SHERPA method.
van Rutte et al. (2017)	OCHRA (Observational clinical human reliability analysis) developed to detect surgical errors is used in identifying the hazard zones of the sleeve gastrectomy.
Faiella et al. (2018)	HFMEA (Healthcare Failure Mode and Effect Analysis) combining two risk analysis methods as SHERPA and STAMP-STPA to maximize the benefits of risk analysis.
Liu et al. (2018)	LGDA (Large Group Dependence Analysis) approach to evaluate dependence among human errors within HRA.

2.4 Performance Influencing Factors

Importance of human factors and human psychology in anesthesia management has been emphasized since 1980s. The study of Cooper et al. (1984) on 130 anesthetists' reports reveals that 96 percent of substantive negative outcomes among all critical incidents are caused by human errors . Which means that human error is the dominant issue of critical and fatal anesthesia incidents. Leape (1994) claimed that it is requisite to consider human psychology and human factors in understanding the nature, mechanisms and causes of error.

Taylor-Adams et al. (1999) itemized some root causes of medical errors as:

- Use of locums
- Communication problems
- Supervision problems
- Excessive workload
- Educational and training deficiencies

Their study is illustrated with a real case analysis on partum hemorrhage of 1200 ml. By analyzing that case they revealed that latent failures lying dormant under active failures. They combined each active failure with latent failure(s) which is/are the essential cause of the errors.

They combined each active failure with latent failure(s) which is/are the essential cause of the errors. According to the interviews with six people involved in the case including two junior doctors, midwifes and obstetric staff, latent failures are mentioned below (Taylor-Adams et al., 1999). These latent failures have been reconsidered and reevaluated by two experts, one doctor and one sociologist assisting this study:

- ***Inadequate communication:*** The protocol states that it is necessary that seniors help juniors but does not enforce formal communication structures. That creates misunderstandings or misinformation.

- ***Task workload:*** The lack of a detailed task analysis hence the ignorance of the specific time frame in which tasks should and could be completed may lead to overloading of the personnel.

- ***Environment/Task:*** The design of the environment is not specialized to the task. Tasks conducted on an obstetric ward are time wise and the lack of a clock leads to mistiming.

- ***Training/skills:*** The lack of awareness of the personal may be the indicator of the training and experience deficiencies. This will lead to risk recognition failure.

- ***Knowledge and skills/supervision:*** Lack of supervision leads to wrong assignments of the personal to the tasks. Assigning a worker with limited experience to risky tasks requiring knowledge and skill may lead to important issues.

- ***Maintenance management:*** The lack of procedures to check and record the equipment functionality and the lack of maintenance contracts with third parties to ensure rectifying the faults may lead to serious issues as a vital equipment out of order unexpectedly.

- ***Inadequate leadership skills:*** The lack of assertiveness by the junior doctor or his ignorance about the hospital policies will complicate the procedures and disable the immediate response to urgent situations.

- ***Safety culture/supervision:*** The reluctance of the personal must be supervised and task assignment must be comprised with respect to these supervisions. The root causes of this behavior may be poor moral, poor desire etc. These aspects may have more profound invisible motives.

- ***Training:*** All new staff must be trained with emphasis on assertiveness and adequate communication with supervisors. If they detect an error of their supervisor, they should be able to utter accurately.

- ***Procedures:*** The procedures must be designed clearly and well-ordered compromising time and risk constraints. Otherwise delays, incorrect sequencing of events would be unavoidable.

- ***Team functioning:*** There should be a solid team structure and support in order to handle new situations. Lack of team structure and support will most probably lead to failure in unprecedented incidents.

Kennedy and Mortimer classified error-causing factors as casual factors, timing factors and mitigating factors. Casual factors are determined as active, latent failures, planning, design, policy, communication, training, equipment/resources deficiencies, policy violations, unawareness, team and social factors, working conditions (Kennedy & Mortimer, 2007).

A taxonomy study, which integrates human factors, safety management systems and wider organizational issues, offers an interesting classification of performance shaping factors. Bellamy et al. reviewed eight chemical facility accidents between 1974 and 1998: Flixborough, Grangemouth, Allied Colloids, Hickson and Welch, Associated Octel, Texaco in UK, Cindu in Netherlands and Longford in Australia. These accidents have been chosen due to detailed accident investigations performed for each of them and procuring appropriate data for taxonomy. Each performance-shaping factor is associated to a number of accidents according to their contribution or non-contribution to the accident occurrence. For example social norms and pressures factor has contributed in five accidents when man-machine interface factor has contributed to four accidents etc. (Bellamy et al., 2008). That kind of taxonomy may be relevant to human reliability assessment in a special field but it requires detailed incident and accident data.

Champion et al. regrouped surgical errors under three major titles: Perception errors, Cognition errors and Technical errors (Champion et al., 2008). Their aim is to explore the concept of surgical error and to minimize these errors by using objective assessment. Tuddenham revealed the importance of perception errors by his affirmation (Tuddenham, 1962): 'One cannot interpret a shadow he has not perceived and failure of perception must, therefore, account for a substantial fraction of all of our diagnostic errors.' Cognition errors in medical practice have been researched and studied in depth by Satish and Streufert and also in the studies OSCEs (Objective Structured Clinical Examinations), OCHRA (Observational Clinical Human Reliability Assessment) and by using cognitive factors from aviation (Satish, 2002; Tang et al., 2006; Stripe et al., 2006).

It is underlined that well-defined problems in surgery are rare and that more common are ill-defined ones containing unclear information (Schön, 2017).

Recent studies focus generally on analyzing some major factors leading to human error in healthcare operations. Researchers work on special cases in healthcare system producing defects due to human errors.

A general study searching out all performance influencing factors in healthcare operations and analyzing them for different healthcare operations in order to acquire finally a complete relation model between all possible causes and consequences, does not exist. This study tries to procure a general standpoint covering the determination of human errors and their causes, the formation of all possible causes list, the detection of all relations between errors and causes as well as interdependencies and finally the creation of a final model representing these relations and interdependencies in different healthcare operations.

Based on a wide literature review and expert consultation, taking Kim & Jung (2003)'s study as a starting point, a comprehensive list of PIFs has been created. Faced with the various nomenclature and categorization of factors, it was preferred to adapt the categorization of Kim & Jung (2003), since it was the clearest and easiest to understand list.

Actually, PIFs named inadequate communication in Taylor-Adams et al. (1999)'s study, communication in Kennedy & Mortimer (2007)'s study or communications and coordination in groups and teams structures in Bellamy et al. (2008)'s study all describe the same criteria also called team communication related factors in this study after Kim & Jung (2003)'s study.

On the other hand, PIF with the name of human anatomical capacities including body measurements, vision capacity and disabilities in Bellamy et al. (2008)'s study also called human physical states in this study, has been removed from PIFs list by experts as a medical practitioner with disabilities is oriented to risk-free medicine and does not perform surgery. The complete list of PIFs, including their detailed explanation, is represented in Table 2.4:

Table 2.4: The Full-set PIF (Performance Influencing Factors) Taxonomy *Kim & Jung (2003)*

Group	Subgroup	Description	Code
HUMAN	Human Cognitive States *(Vincent et al., 1998 ; Taylor-Adams et al. 1999 ; Flin, 2007 ; Zheng et al., 2011)*	Includes sub-criteria as attention, intelligence, skill, knowledge, experience and training of the operator. These are operator's mental abilities exploited in reasoning, evaluation, problem-solving and decision-making processes.	C1
	Human Temporal Cognitive States	Includes sub-criteria as memory of recent actions, operator diagnosis, perceived importance and consequences, operator expectations, confidence in diagnosis, memory of previous actions and accident history. This performance criterion grows out of short term experience gaining.	C2
	Physical States	Includes sub-criteria as gender, motor skills, physical disabilities, and fatigue. These are permanent or long-term physical states of the operator. Our experts have removed this criterion from the criteria list because it does not affect directly medical operations. According to the experts, the sub criteria here are inconvenient in different ways. For example, gender is not distinctive in medical operation performance. On the other hand physical disabilities are deterministic in specialization in order to eliminate all incompetence and disabilities. A medical practitioner who has permanent hand tremor cannot be a surgeon or a radiologist. But there are some medicine domains that don't require hand perfection as dermatology.	-
	Psychological States *(Vincent et al., 1998)*	This criterion includes sub-criteria as emotion/feeling, confusion/perplexity, and fear of failure, stress and task burden. It has to be noted that this criterion refers to negative aspects of these psychological states.	C3
	Personal Characteristics *(Taylor-Adams et al. 1999; Flin, 2007; Kennedy & Mortimer, 2007)*	This criterion includes sub-criteria as attitude, morale/motivation, risk taking, leadership abilities, sense of responsibility and personality. Briefly personality refers to individual differences among people in behavior patterns, cognition and emotion. These sub criteria are some positive aspects of whole personality that are necessary in working environment.	C4
	Social Characteristics *(Vincent et al., 1998)*	This criterion includes sub-criteria as social status, role/responsibility norms, attitudes based on family and other outside persons. It refers to social character structure of the people according to their way of life. These sub criteria are positive aspects of social character.	C5
TASK	Task Procedures *(Vincent et al., 1998; Kennedy & Mortimer, 2007)*	This criterion includes sub-criteria as availability, format, quality, number of steps and logic structure that are used to qualify task-performing process.	C6

Table 2.4: (Continued)

Group	Subgroup	Description	Code
	Task Attribute/Requirement *(Vincent et al., 1998)*	This criterion includes sub-criteria as number of required information, task difficulty, frequency and familiarity of task, interruptions, discrepancy between training and reality, narrowness, task criticality, degree of manual operation and speed.	C8
OPERATION ROOM & PATIENT	Operation Room Man Machine Interface Indicators/Controllers *(Taylor-Adams et al. 1999; Flin, 2007)*	This criterion includes sub-criteria as availability, reliability, discrimination/distinguishability of signals, labeling, location, instruments, indicators and signals functioning properly.	C9
	Op. Room Man Machine Interface Panel/Screen Layout *(Vincent et al., 1998)*	This criterion includes sub-criteria as reachability, visibility, coding/labeling, compatibility, state of arrangement and simplicity of operation room panels.	C10
	Op. Room Machine Support Systems	This criterion includes sub-criteria as availability/adequacy of all equipment, tools and supplies, usability of required function.	C11
	Op. Room System States *(Vincent et al., 1998; Taylor-Adams et al. 1999; Flin, 2007; Kennedy & Mortimer, 2007)*	This criterion includes sub-criteria as simplicity, organization of components, reliability, redundancy, level of automation, all components functioning properly, configuration of system and availability of vital sources.	C12
	Op. Room Phenomenological Physical Characteristics *(Vincent et al., 1998)*	This criterion includes sub-criteria as rate of change of critical parameters, required medication level vs. current status of medication level, number of dynamic changing variables, highly unstable plant situations.	C13
	Op. Room Phenomenological Operational Characteristics *(Vincent et al., 1998)*	This criterion includes sub-criteria as suddenness, overlap with previous tasks, time pressure, absence of preceding information on scenario, absence or inadequacy of EOP response phase.	C14

Table 2.4: (Continued)

Group	Subgroup	Description	Code
ENVIRONMENT	Physical Constraints *(Taylor-Adams et al. 1999)*	This criterion includes sub-criteria as inadequate temperature/humidity/pressure/illumination, noise, vibration, air pressure, inadequate air quality, movement constriction, narrow workspace or obstacles, inaccessibility of components, architectural incompetence, disorder, inadequate hygiene.	C15
	Timing Aspects	This criterion includes sub-criteria as time of day, time on duty, time into scenario, circadian rhythm effects. These sub-criteria refer to negative aspects of time on human psychology and physiology.	C16
	Team Related Factors *(Vincent et al., 1998; Taylor-Adams et al. 1999; Kennedy & Mortimer, 2007)*	This criterion includes sub-criteria as clearness and adequacy in job description and in responsibilities, adequacy of distributed workload, team cohesiveness/collaboration, ability/leadership/ authority of team leader, and commitment to leadership.	C17
	Team Communication Related Factors *(Vincent et al., 1998; Taylor-Adams et al. 1999; Kennedy & Mortimer, 2007)*	This criterion includes sub-criteria as structure and standardization of instruction/information delivery, standard communication structure/network, media of information delivery (Phone, fax, paper, software…), communication protocols (information delivery, infra-team, inter-team, written/oral, protocol between receiver and sender).	C18
	Team Training *(Taylor-Adams et al. 1999; Kennedy & Mortimer, 2007)*	This criterion includes sub-criteria as simulation training, fidelity of simulation scenario, frequency of trainings, training of all team members.	C19
	Management and Policy *(Vincent et al., 1998; Taylor-Adams et al. 1999; Flin, 2007; Kennedy & Mortimer, 2007)*	This criterion includes sub-criteria as hospital policy, work organization, schedule, shift organization, maintenance, working methods, human resource developing, level of supervision, supporting team, adequate investments, adequate instructions and adequate safety measures.	C20
	Safety Culture *(Vincent et al., 1998; Taylor-Adams et al. 1999; Flin, 2007)*	This criterion includes sub-criteria as routine violations, safety/economy tradeoff in favor of economy, and communication deficiency.	C21

3 METHODOLOGY

In the presence of divers performance influencing factors in healthcare operations, it is obvious that the decision process is highly complex and vague. To establish the relationships between these factors and to be able to interpret the effects of these relationships, Fuzzy Cognitive Maps (FCMs) is an effective tool. The concepts here are the actual conditions of different PIFs in healthcare operations. To be able to map inputs to outputs, we use an algorithm called fuzzy inference using Fuzzy Set Theory (FST) as in (C. Kutlu et al., 2014).

3.1 Fuzzy Inference System and Rule Based Reasoning

A FIS is a knowledge-based system consisting of knowledge-base which are facts about the world. Reasoning about these facts by using rules and determining inconsistencies are implemented by the inference engine.

A FIS four steps are as stated below, translating inputs into truth values, computing output truth values and aggregating truth values of all experts, transfering truth values into output.

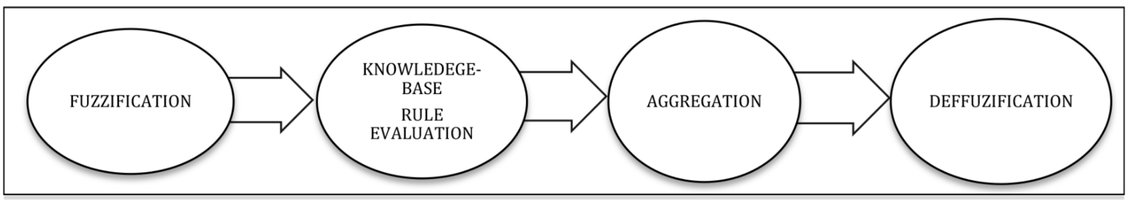

Figure 3.1: FIS Structure

3.2 Cognitive Maps and Fuzzy Cognitive Maps

Muzzi and Ortolani (2002) pointed out that a neoclassic decision maker would have an unlimited capacity of cognitive adjustments to new situations.Codara (1998), mentioned in his study that cognitive maps could be used for various purposes:

- Reconstructing of the anchor points behind the behavior of decision makers and understanding their motives in making such decisions (explanatory function),
- Predicting future decisions (prediction function),
- Assisting decision makers to reflect upon their decision to ensure their completeness (reflective function),
- Constructing an accurate description of complex situations (strategic function) (Bertolini & Bevilacqua, 2010).

One of the main features of this study is to understand the behavior of human as an agent of a complex system under different circumstances, to reveal the reasons for his decisions and his actions, to predict his future decisions and actions, to take preventive measures by eliminating or altering some causes. FCM is the most effective way to procure an explicit understanding of human behavior and all of the reasons relying under his behavior.

The term cognitive maps also called 'Internal Spatial Representations' designate stored memories of experienced environments. First identification of the term cognitive was made in 1948 in Tolman's study on rats but in a metaphoric sense. Today, the term is used widely in many human sciences and it implies deliberate and motivated encoding of environmental information (G Golledge, 1999; Hollnagel, 1998). To understand human performance, one must comprehend human cognition. That's why today cognitive engineering and cognitive tools constitute a vast research field. Cognitive Maps (CMs) were introduced in 1976 by Axelrod to study social scientific knowledge in decision-making process in international politics (Kosko, 1986; Bertolini, 2007).

CMs consist of points, lines, areas and surfaces learned, experienced and recorded in quantitative and qualitative forms (G Golledge, 1999). In CMs, nodes represent variable concepts where edges represent casual connections between them. The edges are positive or negative according to the direction of the causality. In other words a positive edge from a node to another means that an increase in the first one causes an increase in the second one. However a negative edge from a node to another indicates that an increase in the first one causes a decrease in the second one (Kosko, 1986).

Causality is different from logical implication. In logical implication, “A implies B” is always replaceable with “non-B implies non-A”. Yet in causality, “A causes B” is not always replaceable with “non-B causes non-A” (Kosko, 1986). For example, lack of illumination causes human error but not committing error does not cause good illumination.

A cognitive map is an effective way to display causalities between variable concepts however it is limited and cannot represent complex causalities in real world. Real world causalities are gradational and vague in other words fuzzy. That’s why the use of Fuzzy Cognitive Maps (FCMs) is a better and more effective way to represent such relationships.

As FCMs are the symbolic representation of complex systems and illustrate different aspects in the behavior of the system, human experience and knowledge of the operation of the system are essential. FCMs are constructed using human experts who know well the system and his behavior under different circumstances (Groumpos, 2010).

3.3 Methodology of FCM

FCMs consist of fuzzy causal graphs made up of nodes representing causal concepts occurring to some degree and edges that combine nodes representing fuzzy rules between concepts (Kosko, 1986).

Concepts variables: $C = C_1, C_2, ..., C_n$. Causal links: Arcs $(C_i, C_j), C_i$ causes concept C_j.

Causalities between concepts are not formed by the usual binary logic, but have

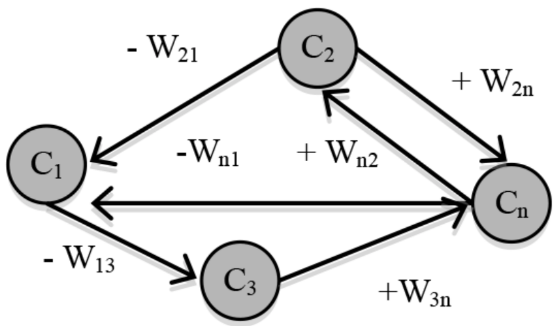

Figure 3.2: Example of causal graph

degrees, so their weights can be expressed in the interval $[-1, 1]$ or by linguistic terms, such as "negatively strong", "zero", "positively very weak" etc. The causality between concepts C_i and C_j is positive ($w_{ij} > 0$) when an increase in the concept C_i leads to an increase in the concept C_j or vice versa, when a decrease leads to a decrease. When there is no causality between concepts; $w_{ij} = 0$. The direction of causality indicates whether concept C_i causes concept C_j , or vice versa. The value given to the weight w_{ij} represents the strength of the influence between C_i and C_j. Hence, as shown in the example, an increase in the concept C_2 causes a decrease in the concept C_1 to a degree w_{21}. The values of concepts are calculated at each time step according to the general formulation (Stylios et al., 2008):

$$A_i^{(k+1)} = f\left(A_i^{(k)} + \sum_{\substack{i=1 \\ i \neq j}}^{N} A_j^{(k)} W_{ij}\right) \tag{3.1}$$

where

$A_i^{(k)}$ is the value of concept Ci at iteration step k, $A_j^{(k+1)}$ is the value of the concept C_j at iteration $k+1$, w_{ji} is the weight of the connection from C_j to C_i and f is a threshold function.

4 HRA IN HEALTHCARE USING RULE BASED FCM

4.1 Scope of the Rule Based FCM application

In order to detect all causal relations and to show their degree, four experts (medical doctors) of different high-risk fields in healthcare sector have evaluated the causality among PIFs using linguistic notions. The determination of causal relations between PIFs and their effects on HR procures crucial information used in healthcare system design, vital clinical judgements and hospital policy and procedures determination.

Next step is to construct weight matrix of FCM. The aggregated weights of interconnections have been obtained with help of fuzzy inference rule based method using MATLAB (Fuzzy Logic Tolbox).

In the final step of this application process, the weights of PIFs that affect HR have been calculated for different $\alpha - cut$ values, using FCMapper Software (http://www.fcmappers.net). This has allowed us to perform a sensitivity analysis in order to observe the modification of HR with the changes on the confidence level of experts' judgements. In other words, this sensitivity analysis shows how the degree of fuzziness could affect the results and the solution robustness of Rule Based FCM.

4.2 First Step: Expert Evaluation

Since this study tries to draw a real picture of HR issues and to evaluate all PIFs in healthcare operations, four medical doctors, each experienced in his field, have been designated as follows:

- Expert 1- Cardiac surgeon

- Expert 2- Surgical intern
- Expert 3- Specialist in internal medicine
- Expert 4- Radiology specialist

Each expert has been interviewed in depth in two different sessions. In the first session, they have determined the sign of causalities among PIFs as in Tables 4.1-4.4. Subsequently, they have expressed the degree of those causal relations using a linguistic variable as in Table 4.5-4.8. The first session has lasted more than two hours. The second session will be mentioned lately in the second-step. The causal relations are represented by the variable influence taking values in the universe $U = [-1; 1]$. The term set $T(influence)$ consists of nine variables (C. Kutlu et al., 2014):

$$T(influence) = \begin{Bmatrix} \text{negatively very high (nvh)} \\ \text{negatively high (nh)} \\ \text{negatively medium (nm)} \\ \text{negatively small (ns)} \\ \text{zero (z)} \\ \text{positively small (ps)} \\ \text{positively medium (pm)} \\ \text{positively high (ph)} \\ \text{positively very high (pvh)} \end{Bmatrix}$$

$$T(influence) = \begin{Bmatrix} \text{negatively very strong (nvs)} \\ \text{negatively strong (ns)} \\ \text{negatively medium (nm)} \\ \text{negatively weak (nw)} \\ \text{zero (z)} \\ \text{positively weak (pw)} \\ \text{positively medium (pm)} \\ \text{positively strong (ps)} \\ \text{positively very strong (pvs)} \end{Bmatrix}$$

Table 4.1: Sign of each causal relationship among PIFs assigned by the first expert-Cardiac Surgeon

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1		+	-	+	+	+	+							-		-	+	+				+
C2	+		-	+	-	+	+						-	-			+			+	-	+
C3	-			-	-	-	-	+					+	+		+	-					+
C4	+	+	-		+	+		-						-		-	+					+
C5	+	+				+										-	+			+		
C6				+	+		+	-	+	+	+	+	-	-	-	-	+	+		+	-	+
C7			-			+		-	+	+		+	-			-				+		+
C8			+	-	-	-	-					-	+	+		+	-		+	-	+	-
C9			-	+	+	+	+	-				+	-	-		-						+
C10			-	+	+	+	+	-				+	-	-		-						+
C11			-			+	+	-				+	-	-		-	+	+		+	-	+
C12			-			+	+	-	+	+	+		-	-		-	+	+		+	-	+
C13	-	-	+			-	-	+	-	-	-	-		+		+	-		+	-	+	-
C14	-		+	-		-	-	+	-	-		+				+	-			+	+	-
C15	-	-	+	-		-		+				-	+	+		+					+	-
C16	-	-	+	-		-	-	+					+	+							+	-
C17						+	-					+	-			-				+	-	+
C18			-	+		+	+	-				+	-	-		-	+				-	+
C19	+		-	+		+	+	-				+	-	-							-	+
C20					+	+						+	-	-	-	-	+	+	+		-	+
C21	-	-		-	-	-		+				+										-
HR																						

Table 4.2: Sign of each causal relationship among PIFs assigned by the second expert-Surgical Intern

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1		+	+		+												+	+				+
C2	+		+		+												+	+				+
C3				-	+												-	-				-
C4			-		+												+	+				+
C5			-	+													+	+				+
C6			-	+				-	+	+	+	+	+	-	-	-	+	+				+
C7						+		-	+	+	+	+	+	-	-	-						+
C8		+	+	-									+	-		+	-		+	-	+	
C9			-	-		+		-				+	+	+		-			-	+		+
C10			-	-		+		-				+	+	+		-			-	+		
C11			-	+		+		-				+	-	+		-	+	+		+	-	+
C12			-	+		+		-	+	+	+		-	-	-	-	+	+		+	-	
C13			+	-				+						+		+	-			-	+	-
C14			+	-				+					+			+	-			-	+	-
C15			+	-		-	-	+	-							+					+	
C16			-	-	-	-		+									-			-	+	-
C17			-	+	+	+							-	-		-				+		
C18			+	-		-							+	+		+						-
C19	+	+	-	+		+	+	-					-			-	+				-	+
C20			-	+	+	+		-	+	+	+	+	-	-	-	-	+	+			-	+
C21								+									-	-				-
HR																						

Table 4.3: Sign of each causal relationship among PIFs assigned by the second expert-Specialist in internal medicine

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1		+	-	+	+	+	+		+	+	+	+	-	-	-	-	+	+		+	-	+
C2	+		-	+	+	+	+	-	+	+	+	+	-	-	-	-	+	+	+	+	-	+
C3					-	-	+		-	-			+	+	+	+	-	-		-	+	-
C4	+	+	-		+	+	+	-	+	+	+	+	-	-		-	+	+	-	+	-	+
C5	+	+	-	+		+		-	+	+	+	+	-				+	+		+	-	+
C6								-	+	+	+	+	-	-	-	-	+	+	+	+	-	+
C7	+	+	-	+		+		-	+	+	+	+	-	-		-	+	+			-	+
C8			+		-	-	-				-	-	+	+	+	+	-	-	+	-	+	-
C9	+	+	-			+	+	-			+	+	-	-				+	-		-	+
C10	+	+	-			+	+	-			+	+	-	-				+	-		-	+
C11			-			+		-	+	+		+	-	-		-		+		+	-	+
C12			-			+	+	-	+	+	+		-	-			+				-	+
C13	-	-	+	-	-	-	-	+	-	-	-	-		+		+	-	-	+	-	+	-
C14						-		+	-	-	-	-	+			+	-	-	+	-	+	-
C15	-	-				-	-	+	-	-	-	-	+	+		+			-	-	+	-
C16				-	-	-		+	-	-		-	+	+	+		-	-	-	-	+	-
C17			-	+	+	+	+	-								-					-	+
C18			-	+	+	+	+	-					-							+	-	+
C19	+	+	-	+		+	+	-	+	+			-	-						+	-	+
C20					+	+	+	-	+	+	+	+	-		-	-	+	+	+		-	+
C21	-		+	-	-	-	-	+	-	-	-	-	+	+		+	-	-		-		-

Table 4.4: Sign of each causal relationship among PIFs assigned by the second expert-Radiology specialist

	C1	C2	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	HR
C1		+	-	+	+	+	+	-	+	+	+	+	-	-	-		+	+	-	+	-	+
C2			+		+	+	+	-	+	+	+	+	-	-	-		+	+	-	+	-	+
C4	-	-		-	-	-	-	+	-	-	-	-	+	+	+	+	-	-	+	-	+	+
C5			-		+	+		+			+		-	+		-	+		+	+	-	+
C6	+	+	-	+		+	+	-	+	+	+	+	-	+	-	-	+	+	+	+	-	+
C7	+	+	-	+	+			-					-	-		-	+		-	+	-	+
C8	+	+	-	+	+	+		-	+	+		+	-	-		-	+	+	-	+	-	+
C9		+	+		-	-	-		-	-	-	-	+	+		+	-	-	+	-	+	-
C10	+	+	-	+	+	+	+	-		+		+	-	-		-		+	-	+		+
C11	+	+	-	+	+	+	+	-				+	-	-		-		+	-	+		+
C12	+	+	-	+	+	+	+	-	+	+		+	-	-		-	+	+	-	+	-	+
C13	+	+	-	+	+	+	+	-	+	+			-	-		-	+	+	-	+	-	+
C14	-	-	+	-	-	-		+			-	-		+		+	-	-	+	-	+	-
C15	-	-	+	-	-	-	-	+					+			+	-	-	+	-	+	-
C16	-	-	+		-	-		+	-	-			+	+		+	-	-		-	+	-
C17	-	-	+	-	-	-															+	-
C18	+	+	-	+	+	+	+	-			+	+	-	-		-		+	-	+	-	+
C19	+	+	-	+	+	+	+	-				+	-	-		-	+		-	+	-	+
C20	+	+	-	+	+	+	+	-	+	+		+	-	-			+	+		+	-	+
C21	+	+	+	+	+	+		-	+	+	+	+	-	-	-	-	+	+	+		-	+
C22	-	-	+	-	-	-		+				-	+	+		+	-			-		-

Table 4.5: Linguistic variables of causal relationships among PIFs assigned by the first expert-Cardiac Surgeon

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1		pvs	ns	pm	ps	pvs	pm							nvs		ns	ps	pm				ps
C2	pvs		ns	ps	pw	ps	ps						nm	ns			ps			ps	nm	ps
C3	nm			ns	ns	ns	nm	pvs					pm	ps		ps	nm					ps
C4	pm	ps	ns		pvs	ps		nm						ns		nw	ps					pm
C5	ps	pm				pw										nvs	pvs			ps		
C6				pvs	pm		pvs	nvs	pvs	pvs	pvs	pvs	nm	nvs	nm	nvs	pvs	pvs		pvs	nvs	pvs
C7			nm			ps		nvs	pvs	pvs		pm	nvs			nm				pm		pm
C8			pvs	nm	nm	nm	nm					nvs	pvs	pvs		pvs	nvs		pm	nvs	pvs	nm
C9			nvs	pvs	pvs	pvs	pvs	nvs				pvs	nm	nvs		nw						pvs
C10			nvs	pvs	pvs	pvs	pvs	nvs				pvs	nm	nvs		nw						pvs
C11			nm			pvs	ps	ns				ps	ns	ns		ns	ps	ps		ps	ns	ps
C12			ns			ps	pvs	ns	ps	ps	pvs		ns	nm		ns	ps	ps		ps	ns	ps
C13	ns	ns	pvs			nm	ns	ps	ns	ns	ns	ns		ps		ps	ns		ps	ns	ps	ns
C14	ns		ps	ns		ns	ns	ps	nw	nw		ps				ps	nvs			ps	ps	ns
C15	ns	nm	pm	nm		nm		pm				nm	pm	pm		pvs					pm	nm
C16	nm	nm	pm	nm		nm	nm	pm					pm	ps							pm	nm
C17						ps	ps					ps	ns			ns				ps	ns	ps
C18			nm	pm		ps	ps	ns				ps	ns	ns		ns	ps				ns	ps
C19	ps		ns	ps		ps	ps	ns				ps	ns	ns							ns	ps
C20					ps	ps						pvs	ns	ns	ns	ns	pvs	ps	ps		ns	ps
C21	nw	nw		ns	nm	nm		ps				pm										nvs

Table 4.6: Linguistic variables of causal relationships among PIFs assigned by the first expert-Surgical Intern

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1		pvs	nvs		pvs												ps	pw				pvs
C2	pvs		nvs		pw												ps	pw				pvs
C3				nvs	nw												ns	ns				ns
C4			nvs		ps												pvs	pvs				pvs
C5			nvs	pvs													ps	ps				ps
C6			nw	pw				ns	ps	ps	ps	ps	ns	ns	nvs	ns	ps	ps				pvs
C7						ps		ns	pvs	pvs	ps	pvs	ns	ns		ns						ps
C8		pw	ps	nw									ps	nw		pvs	nw		ps	ns	ps	
C9			ns	ps		ps		ns				ps	ns	ns		ns			nm	pm		ps
C10			ns	ps		ps		ns				ps	ns	ns		ns			nm	pm		ps
C11			ns	ps		ps		ns				ps	ns	ns		ns	ps	ps		ps	ns	ps
C12			ns	ps		ps		ns	ps	ps	ps		ns	ns		ns	ps	pw		pw	pw	
C13			ps	ns				ps						ps		pvs	nw			nvs	pvs	nvs
C14			ps	ns				pvs					pvs			pvs	nvs			ns	ps	nvs
C15			pm	nm		ns	ns	pvs	ns							pw					pw	
C16			ps	nm	nvs	ns		pm									ns				pvs	ns
C17			ns	ps	ps	ps							nw	ns		ns				ps		
C18			ns	pw		ps							nvs	nvs		ns						ns
C19	pvs	pvs	nvs	pvs		ps	pvs	ns					ns				ps				ns	pvs
C20			ns	ps	pvs	ps		nw	ps	ps	ps	ps	ns	ns	nvs	ns	ps	ps			nvs	pvs
C21								pm									ns	ns				nvs

Table 4.7: Linguistic variables of causal relationships among PIFs assigned by the first expert-Specialist in internal medicine

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1		ps	nm	ps	ps	pvs	pm		ps	ps	ps	pm	ns	ns	nm	nm	ps	ps		ps	nm	ps
C2	ps		ns	ps	pw	ps	ps	ns	pm	pm	ps	pm	ns	nm	nm		ps	ps	ps	ps	nm	ps
C3					nm	ns	nm		nm	nm			pm	pm	pm	pm	nm	nm		ns	pm	ns
C4	pvs	ps	nm		ps	ps		ns			ps		ns	ns		ns	ps	ps	nm	ps	nm	ps
C5	ps	ps	ns	ps		pm		ns	pm	pm	ps	pm	nm				ps	ps		ps	nm	ps
C6								nm	ps	ps	ps	pm	nm	ns	ns	nm	pm	ps	ps	ps	ns	ps
C7	pm	pm	ns	ps		ps		nvs	ps	ps	ps	ps	ns	ns		nm	ps	ps			nm	ps
C8			pm		nm	ns	nm				nm	nm	pm	ps		ps	nm	ns	ps	ns	ps	ns
C9	ps	pm	ns			ps	ps	ns				ps	nm	ns				pm	nm			pm
C10	ps	pm	ns			ps	ps	ns				ps	nm	ns				pm	nm			pm
C11			nm			ps		ns	pm	pm		ps	ns	ns		nm		pm		pm	ns	ps
C12			ns			ps	pw	ns	ps	ps	pm		nm	nm			ps				ns	ps
C13	nw	nm	ps	nm	nm	ns	nm	ps	nw	nw	nm	nm		ps		ps	ns	ns	ps	ns	ps	ns
C14						nm		pm	ns	ns		nw	pm			pm	ns	ns	pw	ns	ps	ns
C15	nw	nw				ns	nm	ps	ns	ns		nm	pm	pw		pvs				nvs	ps	ns
C16				nw	nm	nm		pw					pw	pm			ns				ps	ns
C17			ns	ps	pm	ps	ps	ns								nm					nvs	pvs
C18			ns	ps	pw	ps	pm	ns					nm							ps	ns	ps
C19	ps	pm	ns	ps		ps	pm	nm	ps	ps			ns	ns						ps	ns	ps
C20					pm	ps		nm	ps	ps	ps	ps	ns		ns	nw	pm	pm	pw		ns	ps
C21	nw		pm	nm	nm	ns		ps				ns	pm	ps			nm	nm		ns		ns

Table 4.8: Linguistic variables of causal relationships among PIFs assigned by the first expert-Radiology specialist

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1		pvs	nm	ps	ps	pvs	ps		ps	ps	pm	ps	nm	ns	ns		ps	pm		ps	ns	pvs
C2			nm		pw	pm	pm	nm	ps	ps	ps	pm	ns	ns	ns		pm	pm	pm	pm	ns	ps
C3	ns			ns	ns	ns	ns	ps	ns	ns			ps	ps	pm	ps	ns	ns		nm	ps	ns
C4			nm		ps	nm		nm			ps		ns	ns		ns	pvs		nm	ps	ns	pvs
C5	ps	ps	ns	ps		ps		nw	pw	pw	pw	pm	nm			ns	ps	ps		pm	ns	ps
C6			nm	ps	pm			ns					ns	ns		nm	ps		ps	ps	ns	ps
C7	pm	ps	ns	ps		ps		ns	ps	ps		ps	ns	ns		ns	pm	pm		pw	nm	ps
C8		ps	ps		ns	ns	ns				nm	ns	ps	ps		pvs	ns	ns	pm	ns	ps	ns
C9	pm	pm	nm	pm	pm	ps	ps	nm				ps	ns	ns		nm		ps	nm	pm		pm
C10	pm	pm	nm	pm	pm	ps	ps	nm				ps	ns	ns		nm		ps	nm	pm		pm
C11			ns	ps		ps	ps	ns	pm	pm		ps	ns	nvs		ns	ps	pm		ps	ns	pvs
C12			ns	pw		ps	ps	ns	ps	ps			nm	ns		ns	ps	pm		ps	ns	ps
C13	ns	ns	pvs	nm	nm	nm		pvs			ns	nm		ps		ps	ns	nm	pm	ns	pm	ns
C14	ns		pvs	nm		ns	ns	ps					ps			ps	nm	nm	pm	ns	ps	nvs
C15	ns	ns	ps			ns		ps	nm	nm			ps	ps		pvs				nm	pm	ns
C16	ns	ns	ps	ns	ns	nm															pw	nw
C17			ns	ps	ps	ps	ps	nm				ps	nm	ns		ns				pm	ns	ps
C18			ns	pm	pm	ps	pm	ns				ps	ns	ns		ns	ps			ps	ns	ps
C19	ps	ps	nm	ps		pm	pm	nm	pw	pw		pm	nm	nw			ps			ps	ns	ps
C20			ns	ps	ps	pvs		nm	ps	ps	ps	ps	ns	ns	ns	ns	ps	ps	pm		ns	pvs
C21	nw	nw	pvs	nvs	nm	ns		ps				nm	ps	ps			ns			ns		ns

Corresponding membership functions μ of these linguistic terms are given in Figure 4.1.

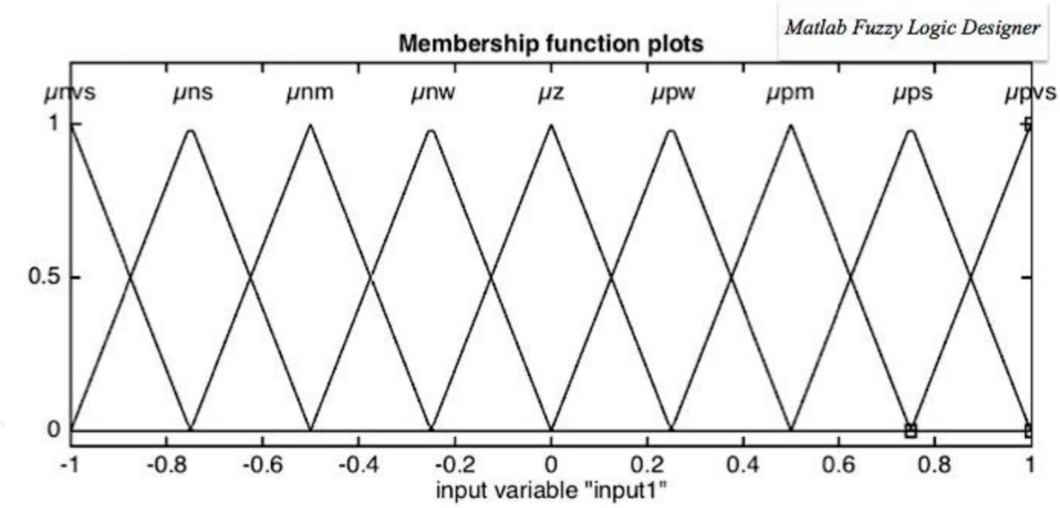

Figure 4.1: Membership functions corresponding to linguistic variables

4.3 Second Step: Knowledge-based fuzzy inference process

In this step, experts have described during a second session, each interconnection among concepts (PIFs) by an IF_THEN rule that infers the fuzzy linguistic variable determined recently to express the grade of causality between two concepts. To facilitate their evaluations, IF rule has been given to experts as **positive small** and they have been asked to determine $THEN$ rules. Here, the necessity of the use of causal relationships can be explained as the first step of establishing the relationship between the criteria. In this study a single input - single output Mamdani fuzzy model is used. The example below explains for an interconnection between two concepts of the study, IF_THEN rules determined by four experts:

Expert 1: IF a **positive small** change happens in the value of concept *"Hospital policy and management"* THEN **positive high** change in the value *"Reliability of human operator in a risky healthcare operation"* occurs.

Expert 2: IF a **positive small** change happens in the value of concept *"Hospital policy and management"* THEN **positive very high** change in the value *"Reliability of human operator in a risky healthcare operation"* occurs.

Expert 3: IF a **positive small** change happens in the value of concept *"Hospital policy and management"* THEN **positive high** change in the value *"Reliability of human operator in a risky healthcare operation"* occurs.

Expert 4: IF a **positive small** change happens in the value of concept *"Hospital policy and management"* THEN **positive high** change in the value *"Reliability of human operator in a risky healthcare operation"* occurs.

Infer: The influence from *"Hospital policy and management"* to *"Reliability of human operator in a risky healthcare operation"* is **positively very strong**.

4.4 Third Step: Aggregation of experts' evaluations

After revealing all of the rules for each interconnection among concepts, the outputs of each rule were combined into a single fuzzy set by the SUM method. Each fuzzy set belongs to an interconnection among two concepts. Deffuzification of these fuzzy sets with the Center of Gravity (COG) method procured numerical values corresponding to the weights (w_ij) of the cognitive map. This process is explained in Figure 5 based on the example mentioned above.

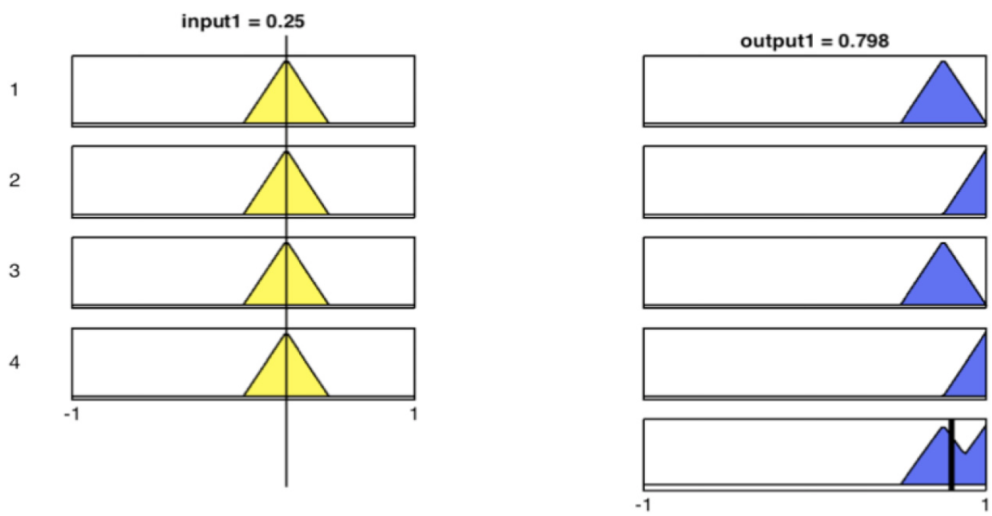

Figure 4.2: Aggregation of expert evaluations for the relationship between C20 and HR (MATLAB Fuzzy Logic Designer)

The aggregated matrix derived from rule-based evaluations is given in Table 4.9:

Table 4.9: Aggregated weights matrix derived from Fuzzy Rules

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1		0.796	-0.647	0.625	0.796	0.92	0.625		0.75	0.75	0.625	0.625	-0.625	-0.797	-0.625	-0.625	0.75	0.5		0.75	-0.625	0.796
C2	0.796		-0.671	0.75	0.25	0.625	0.625	-0.625	0.625	0.625	0.75	0.5	-0.697	-0.625	-0.625		0.625	0.5	0.626	0.625	0.626	0.796
C3	-0.625			-0.796	-0.5	-0.75	-0.625	0.796	-0.626	-0.625			0.626	0.625	0.5	0.625	-0.625	-0.625		-0.625	0.626	-0.75
C4	0.646	0.75	-0.671		0.796	0.124		-0.625			0.75		-0.75	-0.75		-0.5	0.796	0.796	-0.5	0.75	0.626	0.671
C5	0.75	0.625	-0.796	0.796		0.5		-0.5	0.375	0.375	0.5	0.5	-0.5			-0.796	0.796	0.75		0.625	-0.625	0.75
C6			-0.375	0.556	0.5			-0.671	0.796	0.796	0.796	0.671	-0.625	-0.796	-0.671	0.671	0.671	0.796	0.75	0.796	-0.796	0.796
C7	0.5	0.625	-0.625	0.75		0.75		-0.795	0.795	0.795	0.75	0.67	-0.796	-0.75		-0.625	0.625	0.625		0.375	-0.5	0.625
C8		0.5	0.671	-0.375	-0.625	-0.625	-0.625				-0.5	-0.671	0.671	0.337		0.795	-0.671	-0.75	0.625	-0.796	0.75	-0.625
C9	0.625	0.5	-0.671	0.671	0.646	0.796	0.796	-0.671				0.795	-0.625	-0.796		-0.5		0.625	-0.5	0.5		0.671
C10	0.625	0.5	-0.671	0.671	0.646	0.796	0.796	-0.671				0.795	-0.625	-0.796		-0.5		0.625	-0.5	0.5		0.671
C11			-0.625	0.75		0.796	0.75	-0.75	0.5	0.5		0.75	-0.76	-0.796		-0.625	0.75	0.625		0.625	-0.75	0.796
C12			-0.75	0.5		0.75	0.556	-0.75	0.75	0.75	0.671		-0.625	-0.625		-0.75	0.75	0.5		0.5	-0.25	0.75
C13	-0.5	-0.625	0.796	-0.625	-0.5	-0.625	-0.625	0.796	-0.5	-0.5	-0.625	-0.625		0.75		0.796	-0.5	-0.626	0.625	-0.796	0.671	-0.796
C14	-0.75		0.796	-0.625		-0.625	-0.75	0.671	-0.5	-0.5		-0.5	0.671			0.671	-0.671	-0.626	0.375	-0.75	0.75	-0.796
C15	-0.5	-0.5	0.5	-0.5		-0.625	-0.625	0.671	-0.626	-0.625		-0.5	0.625	0.5		0.484				-0.646	0.5	-0.625
C16	-0,625	-0.625	0.625	-0.5	-0.671	-0.625		0.375					0.375	0.625			-0.75				0.5	-0.5
C17			-0.75	0.75	0.625	0.75	0.75	-0.625				0.75	-0.5	-075		-0.625				0.625	-0.796	0.796
C18			-0.625	0.5	0.375	0.75	0.625	-0.75				0.75	-0.671	-0.796		-0.75	0.75			0.75	-0.75	0.796
C19	0.796	0.671	-0.671	0.796		0.625	0.671	-0.625	0.5	0.5		0.625	-0.625	-0.5			0.75			0.75	-0.75	0.796
C20			-0.75	0.75	0.671	0.796		-0.375	0.75	0.75	0.796	0.796	-0.75	-0.75	-0.796	-0.5	0.671	0.625	0.5		-0.796	0.796
C21	-0.25	-0.25	0.646	-0.671	-0.5	-0.625		0.625				-0.625	0.625	0.75			-0.625	-0.625		-0.75		-0.796

Table 4.10: Comparison Analysis for Two Aggregated Matrices

	C4-C6	C21-C12	C15-C16
E1	ps	pm	pvs
E2	-	-	pw
E3	ps	ns	pvs
E4	nm	nm	pvs

A comparison analysis between first-step outputs and second-step outputs may be useful to understand the coherence of experts in transforming causal relations to fuzzy rules. To procure this comparison analysis, the aggregated weights matrix derived from first-step evaluations is created as in 4.11.

The two aggregated weights matrices are nearly similar except except for several relationships as shown in the table 4.10 with relevant expert assessments. The differences between two matrices have occurred when experts have made very different incompatible assessments.

In such cases, the accuracy and delıcacy of rule-based fuzzy evaluations comes to the fore.

Table 4.11: Aggregated weights matrix derived from causal relations

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1		0,800	-0,643	0,635	0,770	0,944	0,608		0,750	0,750	0,621	0,621	-0,621	-0,775	-0,621	-0,621	0,750	0,500		0,750	-0,621	0,789
C2	0,800		-0,662	0,750	0,250	0,635	0,635	-0,621	0,621	0,621	0,750	0,500	-0,635	-0,635	-0,621		0,643	0,500	0,621	0,635	-0,608	0,770
C3	-0,621			-0,775	-0,521	-0,750	-0,608	0,789	-0,621	-0,621			0,608	0,635	0,500	0,635	-0,621	-0,635		-0,621	0,621	-0,124
C4	0,662	0,750	-0,643		0,770	0,193		-0,608			0,750		-0,750	-0,750		-0,528	0,789	0,789	-0,500	0,750	-0,621	0,683
C5	0,750	0,635	-0,775	0,775		0,500		-0,500	0,379	0,379	0,500	0,500	-0,500			-0,789	0,770	0,750		0,635	-0,621	0,750
C6			-0,379	0,555	0,500		0,944	-0,662	0,775	0,775	0,775	0,662	-0,621	-0,770	-0,662	-0,643	0,662	0,775	0,750	0,775	-0,775	0,789
C7	0,500	0,621	-0,621	0,750		0,750		-0,789	0,789	0,789	0,750	0,662	-0,770	-0,750		-0,621	0,621	0,621		0,379	-0,500	0,643
C8		0,500	0,662	-0,379	-0,608	-0,635	-0,608				-0,500	-0,662	0,662	0,353		0,800	-0,541	-0,750	0,621	-0,770	0,770	-0,635
C9	0,621	0,500	-0,662	0,662	0,662	0,770	0,775	-0,662				0,770	-0,621	-0,770		-0,500		0,621	-0,500	0,500		0,643
C10	0,621	0,500	-0,662	0,662	0,662	0,770	0,775	-0,662				0,770	-0,621	-0,770		-0,500		0,621	-0,500	0,500		0,643
C11			-0,621	0,750		0,770	0,750	-0,750	0,500	0,500		0,750	-0,750	-0,770		-0,643	0,750	0,621		0,643	-0,750	0,770
C12			-0,750	0,500		0,750	0,555	-0,750	0,750	0,750	0,662		-0,621	-0,621		-0,750	0,750	0,500		0,528	-0,333	0,750
C13	-0,528	-0,635	0,789	-0,608	-0,500	-0,608	-0,621	0,770	-0,500	-0,500	-0,635	-0,608		0,750		0,770	-0,541	-0,621	0,635	-0,770	0,662	-0,770
C14	-0,750		0,775	-0,635		-0,635	-0,750	0,662	-0,500	-0,500		0,250	0,662			0,662	-0,683	-0,621	0,379	-0,124	0,750	-0,789
C15	-0,528	-0,500	0,500	-0,500		-0,643	-0,621	0,662	-0,635	-0,621		-0,500	0,608	0,500		0,602				-0,662	0,500	-0,635
C16	-0,621	-0,621	0,635	-0,500	-0,662	-0,601	-0,500	0,392					0,379	0,621			-0,750				0,541	-0,521
C17			-0,750	0,750	0,635	0,750	0,750	-0,621				0,750	-0,500	-0,750		-0,643				0,635	-0,775	0,775
C18			-0,643	0,500	0,379	0,750	0,608	-0,750				0,750	-0,662	-0,775		-0,750	0,750			0,750	-0,750	0,124
C19	0,770	0,662	-0,662	0,770		0,643	0,643	-0,621	0,500	0,500		0,621	-0,643	-0,528		0,000	0,750			0,750	-0,750	0,770
C20			-0,750	0,750	0,662	0,770		-0,392	0,750	0,750	0,750	0,770	-0,750	-0,750	-0,770	-0,541	0,662	0,643	0,500		-0,770	0,789
C21	-0,250	-0,250	0,662	-0,662	-0,500	-0,635		0,643				-0,165	0,621	0,750		0,000	-0,635	-0,621		-0,750		-0,789

5 SENSITIVITY ANALYSIS AND ADVANTAGES OF PROPOSED METHOD

Decision makers may claim that a positive small change in concept C_i causes a positive high change in concept C_j but this is a highly subjective information and depends on the confidence level of the decision maker on expert (human) judgment (Promentilla et al., 2008). A sensitivity analysis characterized by the degree of fuzziness would be helpful to observe the solution robustness of RBFCM. Considering the interval of confidence level known as $\alpha - cut$, TFN can be characterized as in Figure 5.1 and Eq. 5.1.

$$\forall\alpha \in [0,1]; M_\alpha = [l^\alpha, u^\alpha] = [l + (m-l)\alpha, u - (u-m)\alpha] \tag{5.1}$$

where $M = (l, m, u)$ is a TFN where $l \leq m \leq u$

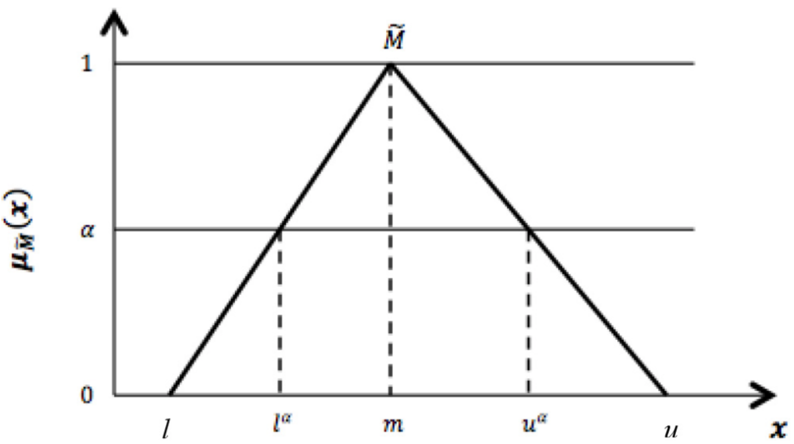

Figure 5.1: A Triangular Fuzzy Number M

The sensitivity analysis characterized by the degree of fuzziness was conducted for twenty one different $\alpha - cut$ values and twenty one weight matrices were obtained at the end of the aggregation process. These matrices are given in Appendix A.

5.1 Comparison Analysis of the Results for Different $\alpha - cuts$

Considering expert highlighting, it has been properly appropriate to analyze all of these data, beginning with twenty one different weights of one of the most significant relationship between concept C_{20} (Hospital Management and Policy) and HR computed for different $\alpha - cuts$.

Table 5.1: Weights of the relationship C_{20}-HR for different $\alpha - cut$

α-Cut	Weight	α-Cut	Weight	α-Cut	Weight	α-Cut	Weight
1.00	0.79846	0.70	0.79305	0.40	0.77913	0.10	0.76194
0.95	0.79789	0.65	0.79144	0.35	0.77644	0.05	0.76000
0.90	0.79733	0.60	0.78972	0.30	0.77350		
0.85	0.79658	0.55	0.78745	0.25	0.77047		
0.80	0.79550	0.50	0.79550	0.20	0.76777		
0.75	0.79445	0.45	0.78216	0.15	0.76457		

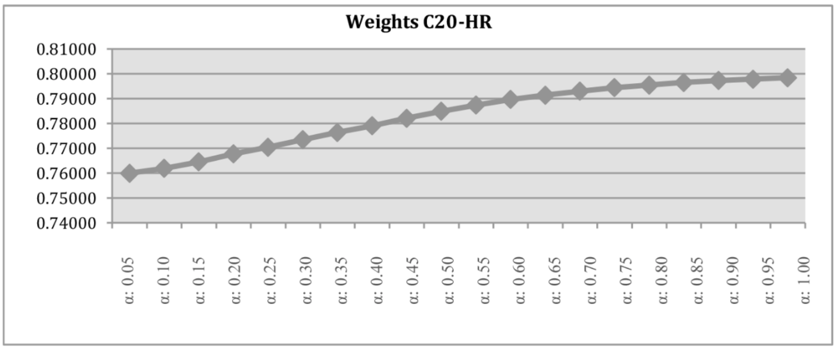

Figure 5.2: Variations of C_{20}-HR relationship weights for different $\alpha - cut$

According to Table 5.1 and Figure 5.2, it is obvious that the relationship weight between concepts C_{20} and HR decreases when the fuzziness increases and vice versa. However this situation was predicted by experts for related concepts. They claimed that there was a very strong relationship between hospital management-policy and human operator reliability and that the vagueness of linguistic variables used to evaluate causalities might have important effects on the causal relations.

Same weight values and same variations have been observed for the following relationships as in Appendix B:

- C_1-C_2: Human Cognitive States-Human Temporal Cognitive States
- C_1-C_5: Human Cognitive States - Social Characteristics
- C_1-HR: Human Cognitive States – Human Reliability
- C_2-C_1: Human Temporal Cognitive States - Human Cognitive States
- C_3-C_8: Psychological States - Task Attribute/Requirement
- C_4-C_{17}: Personal Characteristics - Team Related Factors
- C_4-C_{18}: Personal Characteristics - Team Communication Related Factors
- C_5-C_4: Social Characteristics - Personal Characteristics
- C_5-C_{17}: Social Characteristics - Team Related Factors
- C_6-C_9: Task Procedures - Operation Room Man Machine Interface Indicators/Controllers
- C_6-C_{10}: Task Procedures - Op. Room Man Machine Interface Panel/Screen Layout
- C_6-C_{11}: Task Procedures - Op. Room Machine Support Systems
- C_6-C_{18}: Task Procedures - Team Communication Related Factors
- C_6-C_{20}: Task Procedures - Management and Policy
- C_6-HR: Task Procedures – Human Reliability
- C_7-C_9: Task Type Characteristics - Operation Room Man Machine Interface Indicators/Controllers
- C_7-C_{10}: Task Type Characteristics - Op. Room Man Machine Interface Panel/Screen Layout
- C_8-C_{16}: Task Attribute/Requirement - Timing Aspects
- C_8-C_{21}: Task Attribute/Requirement - Safety Culture
- C_9-C_6: Operation Room Man Machine Interface Indicators/Controllers - Task Procedures

- C_9-C_7: Operation Room Man Machine Interface Indicators/Controllers - Task Type Characteristics

- C_9-C_{12}: Operation Room Man Machine Interface Indicators/Controllers - Op. Room System States

- C_{10}-C_6: Op. Room Man Machine Interface Panel/Screen Layout - Task Procedures

- C_{10}-C_7: Op. Room Man Machine Interface Panel/Screen Layout - Task Type Characteristics

- C_{10}-C_{12}: Op. Room Man Machine Interface Panel/Screen Layout - Op. Room System States

- C_{11}-C_6: Op. Room Machine Support Systems - Task Procedures

- C_{11}-HR: Op. Room Machine Support Systems - Human Reliability

- C_{13}-C_3: Op. Room Phenomenological Physical Characteristics - Psychological States

- C_{13}-C_8: Op. Room Phenomenological Physical Characteristics - Task Attribute/Requirement

- C_{13}-C_{16}: Op. Room Phenomenological Physical Characteristics - Timing Aspects

- C_{14}-C_3: Op. Room Phenomenological Operational Characteristics - Psychological States

- C_{17}-HR: Team Related Factors – Human Reliability

- C_{19}-C_1: Team Training - Psychological States

- C_{19}-C_4: Team Training - Personal Characteristics

- C_{19}-HR: Team Training - Human Reliability

- C_{20}-C_6: Management and Policy - Task Procedures

- C_{20}-C_{11}: Management and Policy - Op. Room Machine Support Systems

- C_{20}-C_{12}: Management and Policy - Op. Room System States

These relationships have been qualified as strong to very strong by experts as in the causal relationship (C_1-HR) Human Cognitive States including attention, intelligence, skill and knowledge and Human Reliability or in the causal relationship (C_{20}-C_6) Management and Policy inferring in this case hospital management policy and Task Procedures involving availability, format, quality and logic structure of task-performing process.

It has been observed that some relationships' weights between concepts (PIFs) varied slightly or didn't vary at all when the uncertainty namely the fuzziness of the evaluations increased as shown in Appendices B, C and D.

Figures 5.3 and 5.4 illustrate variations of the relationships: C_1-C_6; C_{10}-C_1; C_{20}-HR; C_7-C_{13}; C_{13}-C_7; C_{21}-C_5.

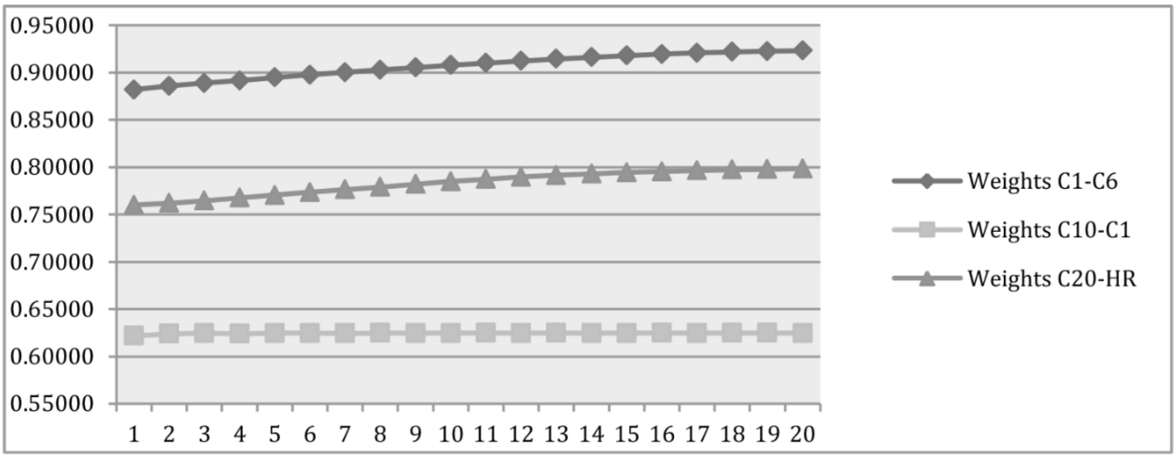

Figure 5.3: Some Variations of relationship weights for different $\alpha - cuts$ (a)

According to these charts the relationship weights among C_{13} (Operation Room Phenomenological Physical Characteristics) and C_7 (Task Type Characteristics) and among C_{10} (Operation Room Man Machine Interface Panel/Screen Layout)and C_1 (Human Cognitive States) did not vary.

All of the relationship weights that did not vary when the fuzziness increased are the ones that were evaluated unanimously by experts. The integration of fuzziness in the evaluation process did not affect the relationship C_{13}-C_7. The experts claim that the default relationship belonging to these concepts is interpreted as: "If the number of critical parameters and dynamic variables increases then monitoring, detection and diagnosis in emergency operations will be more difficult." Furthermore, considering

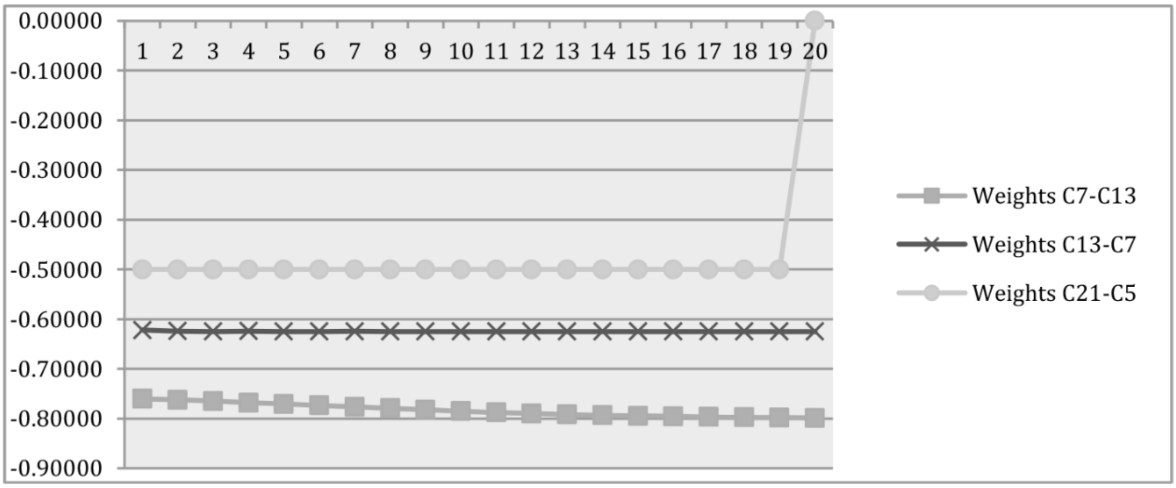

Figure 5.4: Some Variations of relationship weights for different $\alpha - cuts$ (b)

C_{10}-C_1 relationship is neither affected by the degree of fuzziness: "If the reachability, visibility and compatibility of panel/screen layout improve then the attention, reasoning, evaluation and problem-solving of the operator will improve."

However, the relationship weight between C_1 and C_6 (Task Procedures) increased and the relationship weight between C_7 and C_{13} decreased when the fuzziness of the evaluations increased. As indicated by experts when human cognitive states as intelligence, skill, experience level (C_1) of the human operator (the doctor) improves, the operation quality improves. Besides according to them, this relationship is considerably strong and the vagueness of linguistic variables may affect the causal relations. The sensitivity analysis indicated that the decrease of the fuzziness evoked the increase of the corresponding relationship weight.

Variation curves for different $\alpha - cuts$ of all positive and negative relationships' weights are given respectively in Figure 5.5 and Figure 5.6. The curves in Figure 5.7 show the relationships' weights that don't vary with the degree of fuzziness.

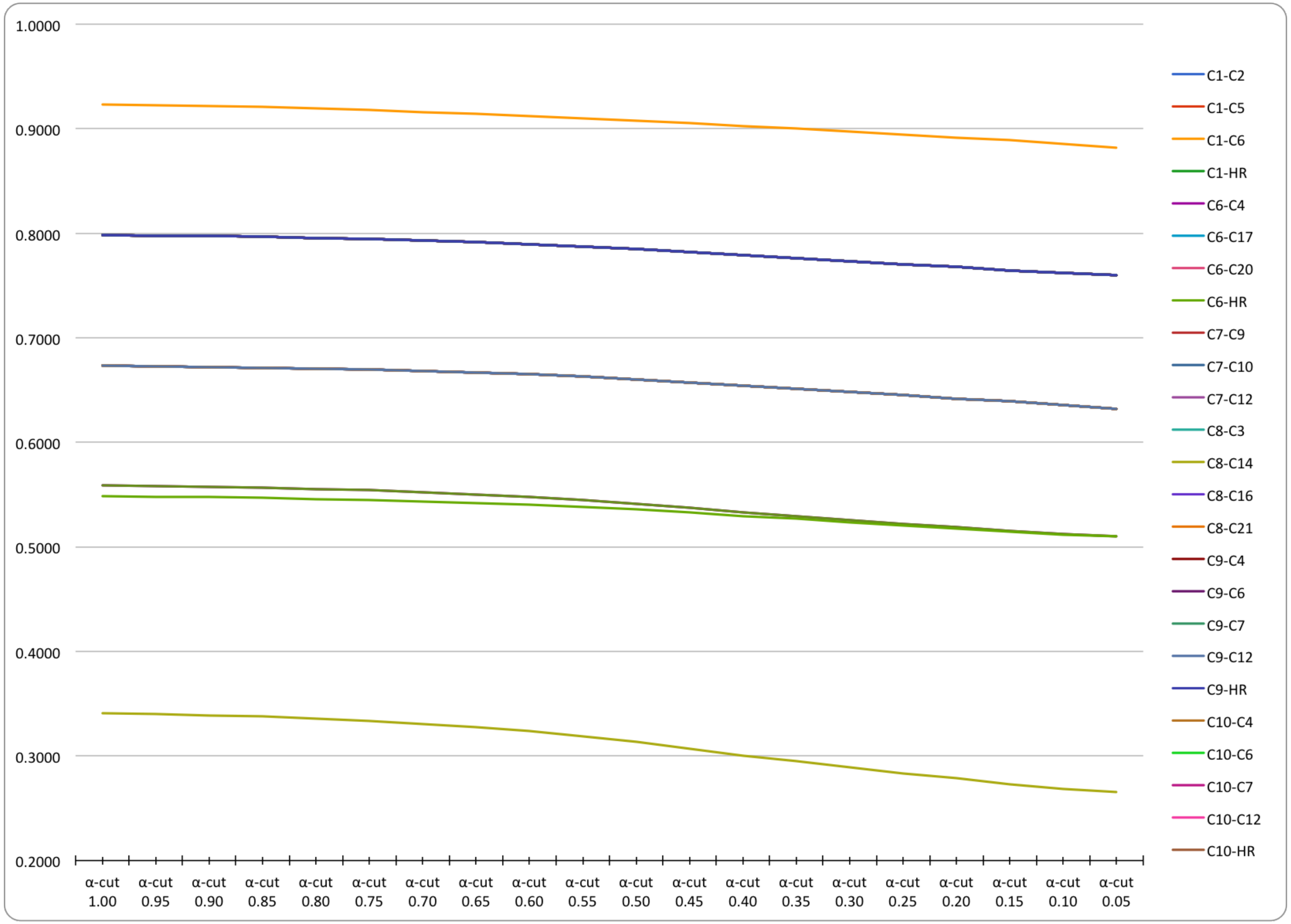

Figure 5.5: Complete Variations of positive relationship weights

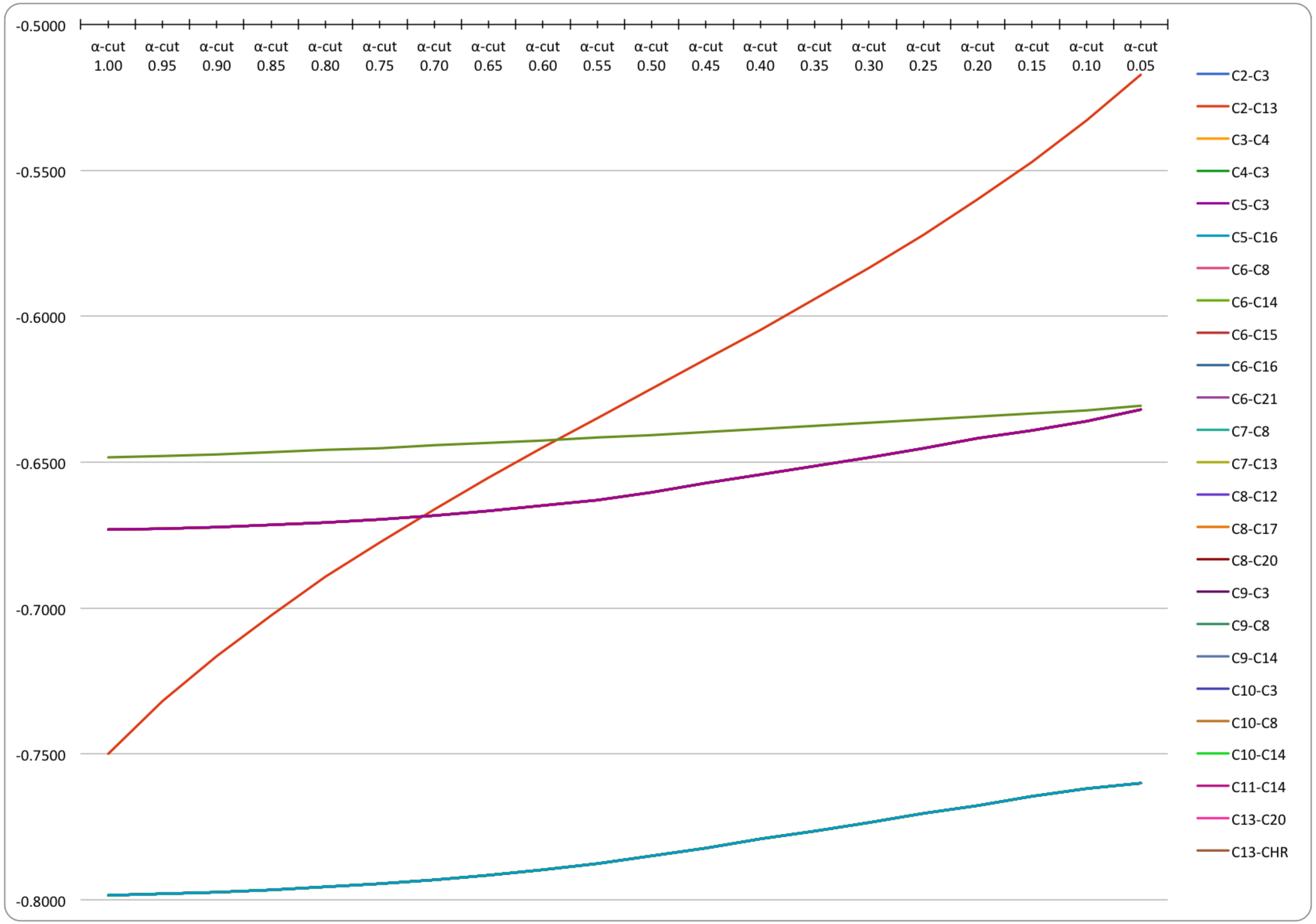

Figure 5.6: Complete Variations of negative relationship weights

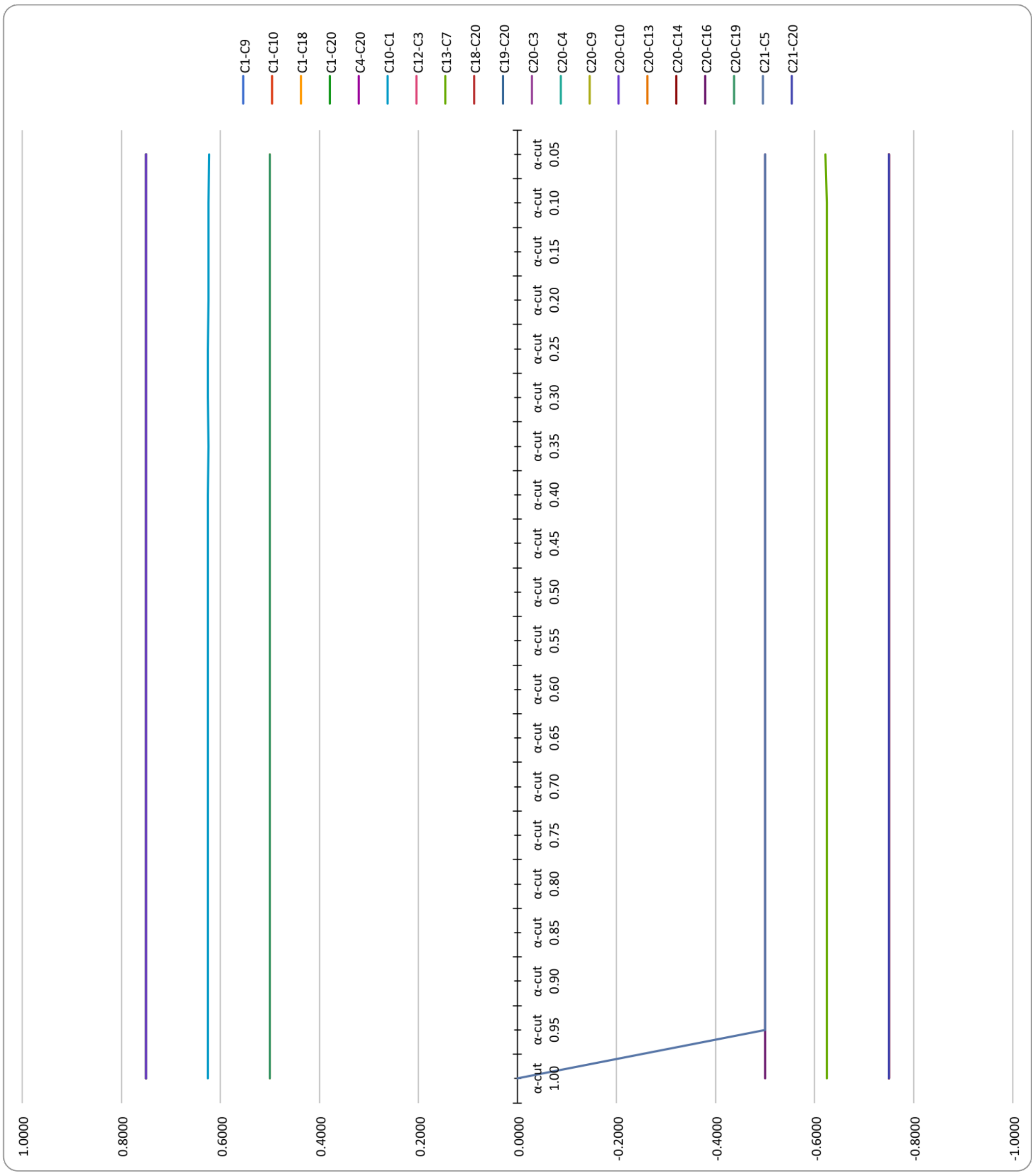

Figure 5.7: No varied relationship weights

In the process of determining causalities between concepts Indegree, outdegree and centrality values have been calculated for twenty-one weight matrices by FCMapper. These values are given in Appendix E. All the indegree, outdegree, centrality variations are shown respectively in Figures 5.8-5.10.

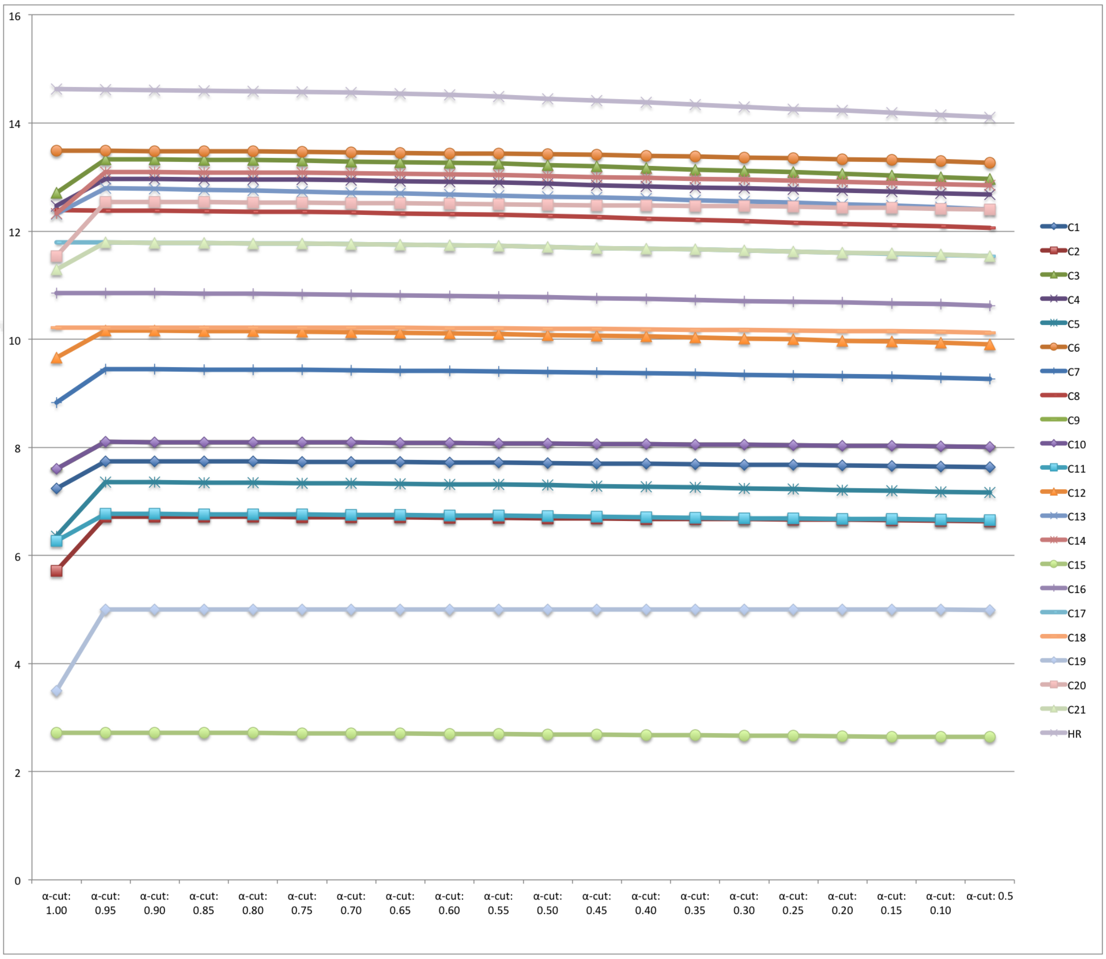

Figure 5.8: Variation of concepts' indegrees

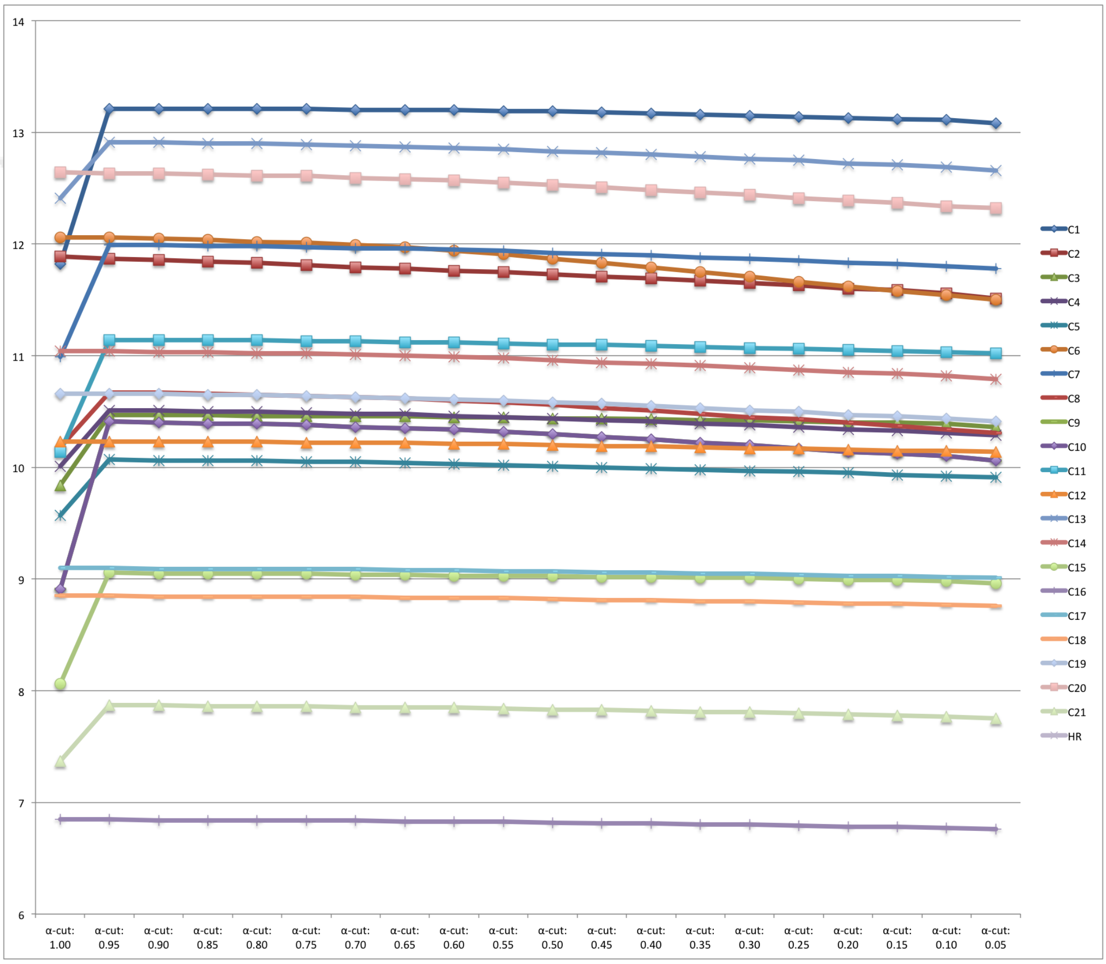

Figure 5.9: Variation of concepts' outdegrees

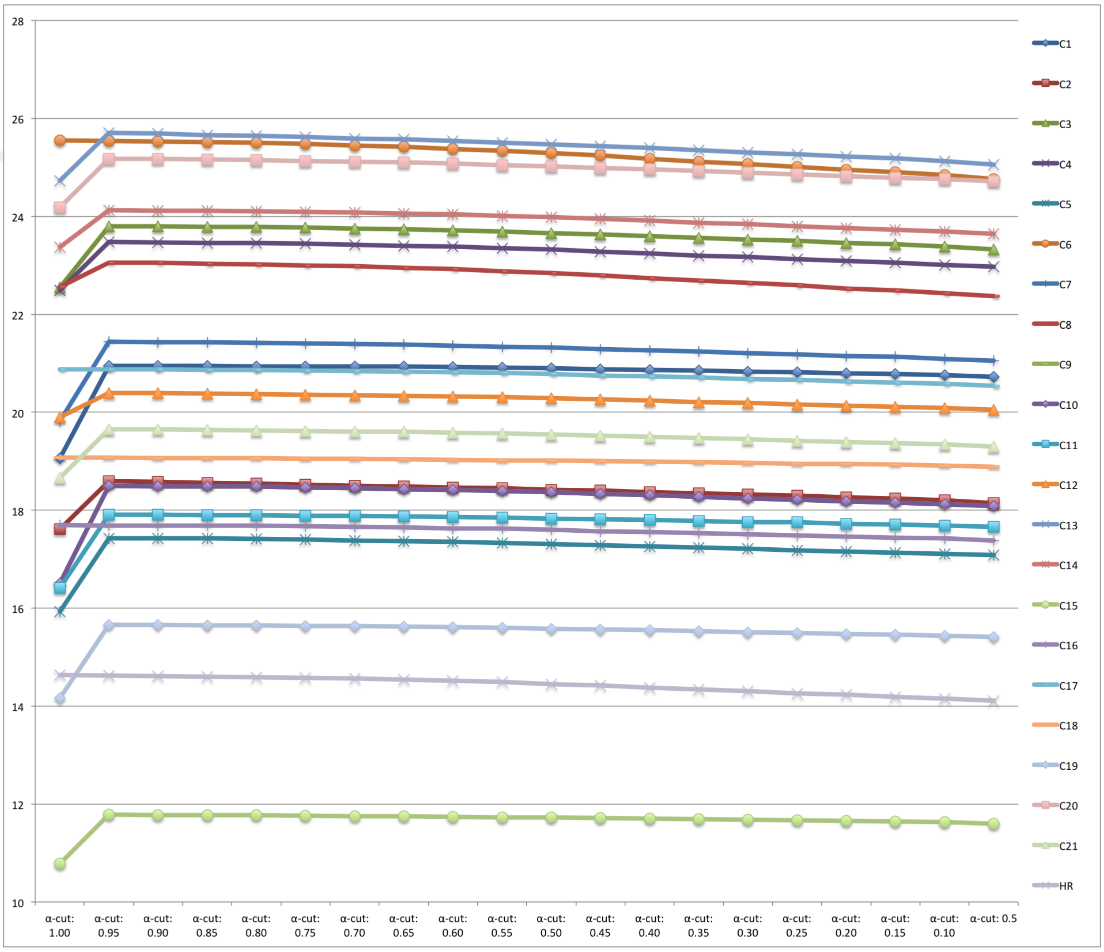

Figure 5.10: Variation of concepts' centralities

These charts show how the degree of fuzziness affects the rank order of overall intensity degrees of all concepts. For example in Figure 5.9, the rank of outdegrees of C_{10} and C_{12} alters. This alteration has been indicated in the Table 5.2. It occurs at $\alpha = 0.25$. This means that the sum of all outgoing influences of C_{12} (Operation Room Machine Support Systems) is more affected than the sum of all outgoing influences C_{10} (Operation Room Man Machine Interface Indicators/Controllers) by the fuzziness.

In other words, the sensitivity analysis shows that the availability and adequacy of all equipment's (C_{12}) outgoing influences decrease relatively lower than availability and reliability of operation room signals (C_{10}) outgoing influences. The experts predicted this result as: "Operation room equipment availability is less important than wrong signals. An experienced doctor can handle an emergency situation where equipment is unavailable but cannot easily predict and correct a wrong signal." They expressed that the vagueness could be more crucial for this type of criteria.

In Figure 5.8, the rank of indegrees of C_{12} and C_{18} (Team Communication Related Factors) behave differently towards fuzziness. The availability and adequacy of all equipment's (C_{12}) incoming influences' sum decreases by the increase of fuzziness when team communication related factors incoming influences' sum alters slightly as indicated in Table 5.2. In other words, the influences of other criteria on C_{18} are not affected by the fuzziness.

In Figure 5.10, it is observed that the centrality of C6 decreases relatively faster than the centrality of C_{20}. The centrality of the Task Procedures (C_6) is more affected by the fuzziness than the centrality of the Hospital Management and Policy (C_{20}). Their centralities are equal when the fuzziness reaches maximum.

Table 5.2: Intensity Degrees for different $\alpha - cuts$

	α-cut: 1.00	α-cut: 0.90	α-cut: 0.80	α-cut: 0.70	α-cut: 0.60										
	Outdegree	**Indegree**	**Centrality**	**Outdegree**	**Indegree**	**Centrality**	**Outdegree**	**Indegree**	**Centrality**	**Outdegree**	**Indegree**	**Centrality**	**Outdegree**	**Indegree**	**Centrality**
C1	11.82	7.24	19.06	13.21	7.74	20.95	13.21	7.74	20.94	13.20	7.73	20.93	13.20	7.72	20.92
C2	11.89	5.72	17.61	11.86	6.72	18.58	11.83	6.72	18.54	11.79	6.71	18.50	11.76	6.70	18.46
C3	9.84	12.71	22.55	10.47	13.33	23.80	10.46	13.32	23.78	10.46	13.29	23.75	10.45	13.26	23.71
C4	10.01	12.47	22.49	10.51	12.97	23.47	10.50	12.95	23.45	10.48	12.94	23.42	10.46	12.91	23.38
C5	9.57	6.36	15.93	10.06	7.36	17.42	10.06	7.35	17.41	10.05	7.34	17.38	10.03	7.32	17.35
C6	12.06	13.49	**25.55**	12.05	13.48	**25.53**	12.02	13.48	**25.50**	11.99	13.46	**25.45**	11.94	13.44	**25.38**
C7	10.99	8.83	19.82	11.99	9.45	21.43	11.98	9.44	21.42	11.96	9.43	21.39	11.95	9.42	21.36
C8	10.18	12.39	22.56	10.67	12.38	23.05	10.65	12.36	23.02	10.63	12.35	22.98	10.60	12.32	22.92
C9	8.91	7.60	16.51	10.40	8.09	18.49	10.39	8.09	18.48	10.36	8.09	18.45	10.34	8.08	18.41
C10	**8.91**	7.60	16.51	**10.40**	8.09	18.49	**10.39**	8.09	18.48	**10.36**	8.09	18.45	**10.34**	8.08	18.41
C11	10.14	6.27	16.41	11.14	6.77	17.91	11.14	6.76	17.90	11.13	6.75	17.88	11.12	6.74	17.86
C12	**10.23**	**9.66**	19.90	**10.23**	**10.16**	20.39	**10.23**	**10.15**	20.37	**10.22**	**10.13**	20.35	**10.21**	**10.11**	20.32
C13	12.41	12.32	24.73	12.91	12.78	25.69	12.90	12.75	25.64	12.88	12.71	25.59	12.86	12.68	25.54
C14	11.04	12.33	23.37	11.03	13.09	24.12	11.02	13.08	24.10	11.01	13.07	24.08	10.99	13.05	24.04
C15	8.06	2.72	10.78	9.05	2.72	11.77	9.05	2.72	11.77	9.04	2.71	11.75	9.03	2.70	11.74
C16	6.85	10.85	17.70	6.84	10.85	17.69	6.84	10.84	17.68	6.84	10.82	17.66	6.83	10.80	17.63
C17	9.10	11.79	20.88	9.09	11.78	20.88	9.09	11.77	20.86	9.09	11.76	20.84	9.08	11.74	20.82
C18	8.85	**10.22**	19.07	8.84	**10.22**	19.06	8.84	**10.22**	19.06	8.84	**10.21**	19.05	8.83	**10.20**	19.03
C19	10.66	3.50	14.16	10.66	5.00	15.66	10.65	5.00	15.65	10.63	5.00	15.63	10.61	5.00	15.61
C20	12.64	11.54	**24.18**	12.63	12.54	**25.17**	12.61	12.53	**25.15**	12.59	12.52	**25.12**	12.57	12.51	**25.08**
C21	7.37	11.29	18.66	7.87	11.78	19.65	7.86	11.77	19.63	7.85	11.76	19.61	7.85	11.74	19.58
HR	0.00	14.63	14.63	0.00	14.61	14.61	0.00	14.59	14.59	0.00	14.56	14.56	0.00	14.52	14.52

Table 5.2: Intensity Degrees for different $\alpha - cuts$

	α-cut: 0.50	**α-cut: 0.30**	**α-cut: 0.25**	**α-cut: 0.20**	**α-cut: 0.10**										
	Outdegree	**Indegree**	**Centrality**	**Outdegree**	**Indegree**	**Centrality**	**Outdegree**	**Indegree**	**Centrality**	**Outdegree**	**Indegree**	**Centrality**	**Outdegree**	**Indegree**	**Centrality**
C1	13.19	7.71	20.90	13.15	7.68	20.83	13.14	7.68	20.82	13.13	7.67	20.79	13.11	7.65	20.76
C2	11.73	6.69	18.42	11.65	6.67	18.32	11.63	6.66	18.30	11.60	6.66	18.26	11.56	6.64	18.20
C3	10.44	13.22	23.66	10.42	13.12	23.53	10.41	13.09	23.50	10.40	13.06	23.46	10.39	13.00	23.39
C4	10.44	12.88	23.32	10.38	12.79	23.17	10.36	12.77	23.13	10.34	12.75	23.09	10.31	12.70	23.01
C5	10.01	7.30	17.31	9.97	7.24	17.21	9.96	7.23	17.18	9.95	7.21	17.16	9.92	7.18	17.11
C6	11.87	13.42	**25.29**	11.71	13.36	**25.07**	11.66	13.35	**25.01**	11.62	13.33	**24.95**	11.54	13.30	**24.84**
C7	11.92	9.39	21.32	11.87	9.34	21.21	11.85	9.33	21.18	11.83	9.32	21.15	11.80	9.29	21.09
C8	10.56	12.28	22.84	10.45	12.19	22.64	10.43	12.16	22.59	10.40	12.13	22.53	10.34	12.09	22.43
C9	10.30	8.07	18.37	10.20	8.05	18.24	10.17	8.04	18.21	10.14	8.03	18.18	10.10	8.02	18.12
C10	**10.30**	8.07	18.37	**10.20**	8.05	18.24	**10.17**	8.04	18.21	**10.14**	8.03	18.18	**10.10**	8.02	18.12
C11	11.10	6.73	17.83	11.07	6.69	17.76	11.06	6.69	17.75	11.05	6.68	17.72	11.03	6.66	17.69
C12	**10.20**	**10.08**	20.29	**10.17**	**10.01**	20.19	**10.17**	**10.00**	20.16	**10.16**	**9.97**	20.13	**10.15**	**9.94**	20.09
C13	12.83	12.64	25.47	12.76	12.55	25.31	12.75	12.53	25.27	12.72	12.50	25.22	12.69	12.44	25.13
C14	10.96	13.02	23.98	10.89	12.95	23.84	10.87	12.93	23.80	10.85	12.91	23.76	10.82	12.87	23.69
C15	9.03	2.69	11.72	9.01	2.67	11.68	9.00	2.67	11.67	8.99	2.66	11.65	8.98	2.65	11.63
C16	6.82	10.78	17.60	6.80	10.71	17.51	6.79	10.70	17.49	6.78	10.68	17.46	6.77	10.65	17.42
C17	9.07	11.71	20.78	9.05	11.64	20.68	9.04	11.62	20.66	9.03	11.60	20.63	9.02	11.56	20.58
C18	8.82	**10.19**	19.01	8.80	**10.17**	18.97	8.79	**10.16**	18.95	8.78	**10.15**	18.94	8.77	**10.14**	18.91
C19	10.58	5.00	15.58	10.51	5.00	15.51	10.50	5.00	15.50	10.47	5.00	15.47	10.44	5.00	15.44
C20	12.53	12.49	**25.02**	12.44	12.46	**24.89**	12.41	12.45	**24.86**	12.39	12.43	**24.82**	12.34	12.41	**24.76**
C21	7.83	11.71	19.54	7.81	11.64	19.45	7.80	11.62	19.42	7.79	11.60	19.39	7.77	11.57	19.34
HR	0.00	14.45	14.45	0.00	14.30	14.30	0.00	14.26	14.26	0.00	14.23	14.23	0.00	14.15	14.15

6 CONCLUSION

In this dissertation, a human reliability assessment in healthcare operations has been conducted using Rule Based Fuzzy Cognitive Maps. In the literature, there is a lack of overall human reliability assessment on healthcare operations.

As mentioned in previous sections, HRA in Healthcare Systems requires general studies in different countries and cultures, in order to establish real causes leading to human errors. Expert systems procure free and easy-access training aid to increase the expertise of researchers and workers. On the other hand, they ensure the generation of a realistic portrait of the existing systems and the realization of rational decision process.

In this context, a complete list of PIFs is created and revised considering a wide literature review and by consulting experts. In order to establish any kind of relations, RBFCM Method is designated as the most efficient method which allowed us to integrate fuzzy causal relations as opposition, similarity, implication etc. What-if questions provided a more complete cognitive system.

The sensitivity analysis conducted with different -cuts represents the decision maker's confidence level. When $\alpha = 0$, the decision maker has no confidence at all to subjective evaluation of experts and considers a wider interval of numerical intensity from the scale.

It is obvious in this study that some relations as C_{20}-HR (Hospital Management and Policy - HR) and C_1-C_6 (Human Cognitive States - Task Procedures and Quality) are crucial causalities. The sensitivity analysis provides the decision maker the ability to adapt the cognitive map to different expert profiles and to observe freely diverse possibilities.

There is a list of some research gaps and contributions of the paper below to draw an overall picture of this research:

- Considering the need of an overall study to be able to design robust, error preventing healthcare systems and to designate accurate hospital policy, all PIFs have been determined through a wide literature survey and expert consulting. In other words, this study procures a general standpoint covering the determination of human errors and their causes, the formation of all possible causes list, the detection of all relations between errors and causes as well as interdependencies and finally the creation of a final model representing these relations and interdependencies in different healthcare operations.

- To draw a real picture of HR issues and to evaluate all the PIFs in healthcare operations, four medical doctors, each experienced in his field, are designated.

- The methodology used in this paper combines FCMs with Rule-based algorithm. In order to observe the solution robustness of RBFCM, a sensitivity analysis characterized by the degree of fuzziness was conducted and results were discussed.

- It has been observed that some relationships between concepts (PIFs) variated slightly or didn't vary at all when the uncertainty namely the fuzziness of the evaluations increased. According to this sensitivity analysis, some of the causalities are more influenced by the fuzziness. These are critically acclaimed causalities by the experts.

- The related FCM and a scenario analysis based on critical criteria will be provided in futur studies. It has also been envisaged for further research to integrate patients and hospital managers as experts to the existing model in order to have a wider insight. On the other hand, the method will be adapted to specific tasks or areas in healthcare to form a list consisting of crucial error causing criteria clusters for different areas.

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A FULL DATA FOR AGGREGATED WEIGHTS MATRIX WITH DIFFERENT $\alpha - CUTS$

Table A.1: Aggregated weights matrix for $\alpha - cut$ 1

$\alpha = 1$	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7985	0.0000	0.6247	0.7985	0.9231	0.6247	0.0000	0.7500	0.7500	0.6247	0.6247	-0.6247	0.0000	-0.6247	-0.6247	0.7500	0.5000	0.0000	0.7500	-0.6247	0.7985
C2	0.7985	0.0000	-0.6732	0.7500	0.0000	0.6247	0.6247	-0.6247	0.6247	0.6247	0.7500	0.0000	-0.7500	-0.6247	-0.6247	0.0000	0.6247	0.5000	0.6247	0.6247	-0.6247	0.7985
C3	-0.6247	0.0000	0.0000	-0.7985	-0.5000	-0.7500	0.0000	0.7985	-0.6247	-0.6247	0.0000	0.0000	0.6247	0.6247	0.0000	0.6247	-0.6247	-0.6247	0.0000	-0.6247	0.6247	-0.7500
C4	0.6483	0.7500	-0.6732	0.0000	0.7985	0.1240	0.0000	-0.6247	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7985	0.7985	0.0000	0.7500	-0.6247	0.6732
C5	0.7500	0.6247	-0.7985	0.7985	0.0000	0.5000	0.0000	-0.5000	0.3753	0.3753	0.5000	0.0000	0.0000	0.0000	0.0000	-0.7985	0.7985	0.7500	0.0000	0.6247	-0.6247	0.7500
C6	0.0000	0.0000	-0.3753	0.5591	0.0000	0.0000	0.0000	-0.6732	0.7985	0.7985	0.7985	0.6732	-0.6247	-0.7985	-0.6732	-0.6732	0.6732	0.7985	0.7500	0.7985	-0.7985	0.7985
C7	0.0000	0.6247	-0.6247	0.7500	0.0000	0.7500	0.0000	-0.7985	0.7985	0.7985	0.7500	0.6732	-0.7985	-0.7500	0.0000	-0.6247	0.6247	0.6247	0.0000	0.3753	0.0000	0.6247
C8	0.0000	0.5000	0.6732	-0.3753	-0.6247	-0.6247	-0.6247	0.0000	0.0000	0.0000	0.0000	-0.6732	0.6732	0.3410	0.0000	0.7985	-0.6732	-0.7500	0.6247	-0.7985	0.7985	-0.6247
C9	0.6247	0.0000	-0.6732	0.6732	0.6483	0.7985	0.7985	-0.6732	0.0000	0.0000	0.0000	0.7985	-0.6247	-0.7985	0.0000	-0.5000	0.0000	0.6247	0.0000	0.0000	0.0000	0.6732
C10	0.6247	0.0000	-0.6732	0.6732	0.6483	0.7985	0.7985	-0.6732	0.0000	0.0000	0.0000	0.7985	-0.6247	-0.7985	0.0000	-0.5000	0.0000	0.6247	0.0000	0.0000	0.0000	0.6732
C11	0.0000	0.0000	-0.6247	0.7500	0.0000	0.7985	0.7500	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.7500	-0.7985	0.0000	-0.6247	0.7500	0.6247	0.0000	0.6247	-0.7500	0.7985
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5591	-0.7500	0.7500	0.7500	0.6732	0.0000	-0.6247	-0.6247	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6247	0.7985	-0.6247	0.0000	-0.6247	-0.6247	0.7985	-0.5000	-0.5000	-0.6247	-0.6247	0.0000	0.7500	0.0000	0.7985	-0.5000	-0.6247	0.6247	-0.7985	0.6732	-0.7985
C14	-0.7500	0.0000	0.7985	-0.6247	0.0000	-0.6247	-0.7500	0.6732	-0.5000	-0.5000	0.0000	-0.5000	0.6732	0.0000	0.0000	0.6732	-0.6732	-0.6247	0.3753	-0.7500	0.7500	-0.7985
C15	-0.5000	-0.5000	0.5000	0.0000	0.0000	-0.6247	-0.6247	0.6732	-0.6247	-0.6247	0.0000	0.0000	0.6247	0.5000	0.0000	0.4865	0.0000	0.0000	0.0000	-0.6483	0.5000	-0.6247
C16	-0.6247	-0.6247	0.6247	-0.5000	-0.6732	-0.6247	0.0000	0.3753	0.0000	0.0000	0.0000	0.0000	0.3753	0.6247	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5485	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6247	0.7500	0.7500	-0.6247	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6247	0.0000	0.0000	0.0000	0.6247	-0.7985	0.7985
C18	0.0000	0.0000	-0.6247	0.5000	0.3753	0.7500	0.6247	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6732	-0.7985	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7985	0.6732	-0.6732	0.7985	0.0000	0.6247	0.6732	-0.6247	0.5000	0.5000	0.0000	0.6247	-0.6247	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7985
C20	0.0000	0.0000	-0.7500	0.7500	0.6732	0.7985	0.0000	-0.3753	0.7500	0.7500	0.7985	0.7985	-0.7500	-0.7500	-0.7985	-0.5000	0.6732	0.6247	0.5000	0.0000	-0.7985	0.7985
C21	0.0000	0.0000	0.6483	-0.6732	0.0000	-0.6247	0.0000	0.6247	0.0000	0.0000	0.0000	-0.6247	0.6247	0.7500	0.0000	0.0000	-0.6247	-0.6247	0.0000	-0.7500	0.0000	-0.7985

Table A.2: Aggregated weights matrix for $\alpha - cut$ .95

α = 0.95	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7979	-0.6307	0.6249	0.7979	0.9225	0.6249	0.0000	0.7500	0.7500	0.6249	0.6249	-0.6249	-0.7600	-0.6249	-0.6249	0.7500	0.5000	0.0000	0.7500	-0.6249	0.7979
C2	0.7979	0.0000	-0.6728	0.7500	0.0000	0.6249	0.6249	-0.6249	0.6249	0.6249	0.7500	0.0000	-0.7320	-0.6249	-0.6249	0.0000	0.6249	0.5000	0.6249	0.6249	-0.6249	0.7979
C3	-0.6249	0.0000	0.0000	-0.7979	-0.5000	-0.7500	-0.6220	0.7979	-0.6249	-0.6249	0.0000	0.0000	0.6249	0.6249	0.0000	0.6249	-0.6249	-0.6249	0.0000	-0.6249	0.6249	-0.7500
C4	0.6478	0.7500	-0.6728	0.0000	0.7979	0.1248	0.0000	-0.6249	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7979	0.7979	-0.5000	0.7500	-0.6249	0.6728
C5	0.7500	0.6249	-0.7979	0.7979	0.0000	0.5000	0.0000	-0.5000	0.3751	0.3751	0.5000	0.0000	-0.5000	0.0000	0.0000	-0.7979	0.7979	0.7500	0.0000	0.6249	-0.6249	0.7500
C6	0.0000	0.0000	-0.3751	0.5584	0.0000	0.0000	0.0000	-0.6728	0.7979	0.7979	0.7979	0.6728	-0.6249	-0.7979	-0.6728	-0.6728	0.6728	0.7979	0.7500	0.7979	-0.7979	0.7979
C7	0.5000	0.6249	-0.6249	0.7500	0.0000	0.7500	0.0000	-0.7979	0.7979	0.7979	0.7500	0.6728	-0.7979	-0.7500	0.0000	-0.6249	0.6249	0.6249	0.0000	0.3751	-0.5000	0.6249
C8	0.0000	0.5000	0.6728	-0.3751	-0.6249	-0.6249	-0.6249	0.0000	0.0000	0.0000	-0.5000	-0.6728	0.6728	0.3399	0.0000	0.7979	-0.6728	-0.7500	0.6249	-0.7979	0.7979	-0.6249
C9	0.6249	0.5000	-0.6728	0.6728	0.6478	0.7979	0.7979	-0.6728	0.0000	0.0000	0.0000	0.7979	-0.6249	-0.7979	0.0000	-0.5000	0.0000	0.6249	-0.5000	0.5000	0.0000	0.6728
C10	0.6249	0.5000	-0.6728	0.6728	0.6478	0.7979	0.7979	-0.6728	0.0000	0.0000	0.0000	0.7979	-0.6249	-0.7979	0.0000	-0.5000	0.0000	0.6249	-0.5000	0.5000	0.0000	0.6728
C11	0.0000	0.0000	-0.6249	0.7500	0.0000	0.7979	0.7500	-0.7500	0.5000	0.5000	0.0000	0.7500	-0.7500	-0.7979	0.0000	-0.6249	0.7500	0.6249	0.0000	0.6249	-0.7500	0.7979
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5584	-0.7500	0.7500	0.7500	0.6728	0.0000	-0.6249	-0.6249	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6249	0.7979	-0.6249	-0.5000	-0.6249	-0.6249	0.7979	-0.5000	-0.5000	-0.6249	-0.6249	0.0000	0.7500	0.0000	0.7979	-0.5000	-0.6249	0.6249	-0.7979	0.6728	-0.7979
C14	-0.7500	0.0000	0.7979	-0.6249	0.0000	-0.6249	-0.7500	0.6728	-0.5000	-0.5000	0.0000	-0.5000	0.6728	0.0000	0.0000	0.6728	-0.6728	-0.6249	0.3751	-0.7500	0.7500	-0.7979
C15	-0.5000	-0.5000	0.5000	-0.5000	0.0000	-0.6249	-0.6249	0.6728	-0.6249	-0.6249	0.0000	-0.5000	0.6249	0.5000	0.0000	0.4854	0.0000	0.0000	0.0000	-0.6478	0.5000	-0.6249
C16	-0.6249	-0.6249	0.6249	-0.5000	-0.6728	-0.6249	0.0000	0.3751	0.0000	0.0000	0.0000	0.0000	0.3751	0.6249	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5480	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6249	0.7500	0.7500	-0.6249	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6249	0.0000	0.0000	0.0000	0.6249	-0.7979	0.7979
C18	0.0000	0.0000	-0.6249	0.5000	0.3751	0.7500	0.6249	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6728	-0.7979	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7979	0.6728	-0.6728	0.7979	0.0000	0.6249	0.6728	-0.6249	0.5000	0.5000	0.0000	0.6249	-0.6249	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7979
C20	0.0000	0.0000	-0.7500	0.7500	0.6728	0.7979	0.0000	-0.3751	0.7500	0.7500	0.7979	0.7979	-0.7500	-0.7500	-0.7979	-0.5000	0.6728	0.6249	0.5000	0.0000	-0.7979	0.7979
C21	0.0000	0.0000	0.6478	-0.6728	-0.5000	-0.6249	0.0000	0.6249	0.0000	0.0000	0.0000	-0.6249	0.6249	0.7500	0.0000	0.0000	-0.6249	-0.6249	0.0000	-0.7500	0.0000	-0.7979

Table A.3: Aggregated weights matrix for $\alpha - cut$ .90

α = 0.90	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7973	-0.6322	0.6248	0.7973	0.9218	0.6248	0.0000	0.7500	0.7500	0.6248	0.6248	-0.6248	-0.7619	-0.6248	-0.6248	0.7500	0.5000	0.0000	0.7500	-0.6248	0.7973
C2	0.7973	0.0000	-0.6723	0.7500	0.0000	0.6248	0.6248	-0.6248	0.6248	0.6248	0.7500	0.0000	-0.7165	-0.6248	-0.6248	0.0000	0.6248	0.5000	0.6248	0.6248	-0.6248	0.7973
C3	-0.6248	0.0000	0.0000	-0.7973	-0.5000	-0.7500	-0.6240	0.7973	-0.6248	-0.6248	0.0000	0.0000	0.6248	0.6248	0.0000	0.6248	-0.6248	-0.6248	0.0000	-0.6248	0.6248	-0.7500
C4	0.6472	0.7500	-0.6723	0.0000	0.7973	0.1245	0.0000	-0.6248	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7973	0.7973	-0.5000	0.7500	-0.6248	0.6723
C5	0.7500	0.6248	-0.7973	0.7973	0.0000	0.5000	0.0000	-0.5000	0.3752	0.3752	0.5000	0.0000	-0.5000	0.0000	0.0000	-0.7973	0.7973	0.7500	0.0000	0.6248	-0.6248	0.7500
C6	0.0000	0.0000	-0.3752	0.5578	0.0000	0.0000	0.0000	-0.6723	0.7973	0.7973	0.7973	0.6723	-0.6248	-0.7973	-0.6723	-0.6723	0.6723	0.7973	0.7500	0.7973	-0.7973	0.7973
C7	0.5000	0.6248	-0.6248	0.7500	0.0000	0.7500	0.0000	-0.7973	0.7973	0.7973	0.7500	0.6723	-0.7973	-0.7500	0.0000	-0.6248	0.6248	0.6248	0.0000	0.3752	-0.5000	0.6248
C8	0.0000	0.5000	0.6723	-0.3752	-0.6248	-0.6248	-0.6248	0.0000	0.0000	0.0000	-0.5000	-0.6723	0.6723	0.3389	0.0000	0.7973	-0.6723	-0.7500	0.6248	-0.7973	0.7973	-0.6248
C9	0.6248	0.5000	-0.6723	0.6723	0.6472	0.7973	0.7973	-0.6723	0.0000	0.0000	0.0000	0.7973	-0.6248	-0.7973	0.0000	-0.5000	0.0000	0.6248	-0.5000	0.5000	0.0000	0.6723
C10	0.6248	0.5000	-0.6723	0.6723	0.6472	0.7973	0.7973	-0.6723	0.0000	0.0000	0.0000	0.7973	-0.6248	-0.7973	0.0000	-0.5000	0.0000	0.6248	-0.5000	0.5000	0.0000	0.6723
C11	0.0000	0.0000	-0.6248	0.7500	0.0000	0.7973	0.7500	-0.7500	0.5000	0.5000	0.0000	0.7500	-0.7500	-0.7973	0.0000	-0.6248	0.7500	0.6248	0.0000	0.6248	-0.7500	0.7973
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5578	-0.7500	0.7500	0.7500	0.6723	0.0000	-0.6248	-0.6248	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6248	0.7973	-0.6248	-0.5000	-0.6248	-0.6248	0.7973	-0.5000	-0.5000	-0.6248	-0.6248	0.0000	0.7500	0.0000	0.7973	-0.5000	-0.6248	0.6248	-0.7973	0.6723	-0.7973
C14	-0.7500	0.0000	0.7973	-0.6248	0.0000	-0.6248	-0.7500	0.6723	-0.5000	-0.5000	0.0000	-0.5000	0.6723	0.0000	0.0000	0.6723	-0.6723	-0.6248	0.3752	-0.7500	0.7500	-0.7973
C15	-0.5000	-0.5000	0.5000	-0.5000	0.0000	-0.6248	-0.6248	0.6723	-0.6248	-0.6248	0.0000	-0.5000	0.6248	0.5000	0.0000	0.4848	0.0000	0.0000	0.0000	-0.6472	0.5000	-0.6248
C16	-0.6248	-0.6248	0.6248	-0.5000	-0.6723	-0.6248	0.0000	0.3752	0.0000	0.0000	0.0000	0.0000	0.3752	0.6248	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5475	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6248	0.7500	0.7500	-0.6248	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6248	0.0000	0.0000	0.0000	0.6248	-0.7973	0.7973
C18	0.0000	0.0000	-0.6248	0.5000	0.3752	0.7500	0.6248	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6723	-0.7973	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7973	0.6723	-0.6723	0.7973	0.0000	0.6248	0.6723	-0.6248	0.5000	0.5000	0.0000	0.6248	-0.6248	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7973
C20	0.0000	0.0000	-0.7500	0.7500	0.6723	0.7973	0.0000	-0.3752	0.7500	0.7500	0.7973	0.7973	-0.7500	-0.7500	-0.7973	-0.5000	0.6723	0.6248	0.5000	0.0000	-0.7973	0.7973
C21	0.0000	0.0000	0.6472	-0.6723	-0.5000	-0.6248	0.0000	0.6248	0.0000	0.0000	0.0000	-0.6248	0.6248	0.7500	0.0000	0.0000	-0.6248	-0.6248	0.0000	-0.7500	0.0000	-0.7973

Table A.4: Aggregated weights matrix for $\alpha - cut$ .85

α = 0.85	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7966	-0.6333	0.6248	0.7966	0.9207	0.6248	0.0000	0.7500	0.7500	0.6248	0.6248	-0.6248	-0.7646	-0.6248	-0.6248	0.7500	0.5000	0.0000	0.7500	-0.6248	0.7966
C2	0.7966	0.0000	-0.6715	0.7500	0.0000	0.6248	0.6248	-0.6248	0.6248	0.6248	0.7500	0.0000	-0.7024	-0.6248	-0.6248	0.0000	0.6248	0.5000	0.6248	0.6248	-0.6248	0.7966
C3	-0.6248	0.0000	0.0000	-0.7966	-0.5000	-0.7500	-0.6246	0.7966	-0.6248	-0.6248	0.0000	0.0000	0.6248	0.6248	0.0000	0.6248	-0.6248	-0.6248	0.0000	-0.6248	0.6248	-0.7500
C4	0.6466	0.7500	-0.6715	0.0000	0.7966	0.1242	0.0000	-0.6248	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7966	0.7966	-0.5000	0.7500	-0.6248	0.6715
C5	0.7500	0.6248	-0.7966	0.7966	0.0000	0.5000	0.0000	-0.5000	0.3752	0.3752	0.5000	0.0000	-0.5000	0.0000	0.0000	-0.7966	0.7966	0.7500	0.0000	0.6248	-0.6248	0.7500
C6	0.0000	0.0000	-0.3752	0.5569	0.0000	0.0000	0.0000	-0.6715	0.7966	0.7966	0.7966	0.6715	-0.6248	-0.7966	-0.6715	-0.6715	0.6715	0.7966	0.7500	0.7966	-0.7966	0.7966
C7	0.5000	0.6248	-0.6248	0.7500	0.0000	0.7500	0.0000	-0.7966	0.7966	0.7966	0.7500	0.6715	-0.7966	-0.7500	0.0000	-0.6248	0.6248	0.6248	0.0000	0.3752	-0.5000	0.6248
C8	0.0000	0.5000	0.6715	-0.3752	-0.6248	-0.6248	-0.6248	0.0000	0.0000	0.0000	-0.5000	-0.6715	0.6715	0.3376	0.0000	0.7966	-0.6715	-0.7500	0.6248	-0.7966	0.7966	-0.6248
C9	0.6248	0.5000	-0.6715	0.6715	0.6466	0.7966	0.7966	-0.6715	0.0000	0.0000	0.0000	0.7966	-0.6248	-0.7966	0.0000	-0.5000	0.0000	0.6248	-0.5000	0.5000	0.0000	0.6715
C10	0.6248	0.5000	-0.6715	0.6715	0.6466	0.7966	0.7966	-0.6715	0.0000	0.0000	0.0000	0.7966	-0.6248	-0.7966	0.0000	-0.5000	0.0000	0.6248	-0.5000	0.5000	0.0000	0.6715
C11	0.0000	0.0000	-0.6248	0.7500	0.0000	0.7966	0.7500	-0.7500	0.5000	0.5000	0.0000	0.7500	-0.7500	-0.7966	0.0000	-0.6248	0.7500	0.6248	0.0000	0.6248	-0.7500	0.7966
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5569	-0.7500	0.7500	0.7500	0.6715	0.0000	-0.6248	-0.6248	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6248	0.7966	-0.6248	-0.5000	-0.6248	-0.6248	0.7966	-0.5000	-0.5000	-0.6248	-0.6248	0.0000	0.7500	0.0000	0.7966	-0.5000	-0.6248	0.6248	-0.7966	0.6715	-0.7966
C14	-0.7500	0.0000	0.7966	-0.6248	0.0000	-0.6248	-0.7500	0.6715	-0.5000	-0.5000	0.0000	-0.5000	0.6715	0.0000	0.0000	0.6715	-0.6715	-0.6248	0.3752	-0.7500	0.7500	-0.7966
C15	-0.5000	-0.5000	0.5000	-0.5000	0.0000	-0.6248	-0.6248	0.6715	-0.6248	-0.6248	0.0000	-0.5000	0.6248	0.5000	0.0000	0.4841	0.0000	0.0000	0.0000	-0.6466	0.5000	-0.6248
C16	-0.6248	-0.6248	0.6248	-0.5000	-0.6715	-0.6248	0.0000	0.3752	0.0000	0.0000	0.0000	0.0000	0.3752	0.6248	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5468	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6248	0.7500	0.7500	-0.6248	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6248	0.0000	0.0000	0.0000	0.6248	-0.7966	0.7966
C18	0.0000	0.0000	-0.6248	0.5000	0.3752	0.7500	0.6248	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6715	-0.7966	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7966	0.6715	-0.6715	0.7966	0.0000	0.6248	0.6715	-0.6248	0.5000	0.5000	0.0000	0.6248	-0.6248	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7966
C20	0.0000	0.0000	-0.7500	0.7500	0.6715	0.7966	0.0000	-0.3752	0.7500	0.7500	0.7966	0.7966	-0.7500	-0.7500	-0.7966	-0.5000	0.6715	0.6248	0.5000	0.0000	-0.7966	0.7966
C21	0.0000	0.0000	0.6466	-0.6715	-0.5000	-0.6248	0.0000	0.6248	0.0000	0.0000	0.0000	-0.6248	0.6248	0.7500	0.0000	0.0000	-0.6248	-0.6248	0.0000	-0.7500	0.0000	-0.7966

Table A.5: Aggregated weights matrix for $\alpha - cut$ .80

α = 0.80	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7955	-0.6343	0.6249	0.7955	0.9194	0.6249	0.0000	0.7500	0.7500	0.6249	0.6249	-0.6249	-0.7678	-0.6249	-0.6249	0.7500	0.5000	0.0000	0.7500	-0.6249	0.7955
C2	0.7955	0.0000	-0.6707	0.7500	0.0000	0.6249	0.6249	-0.6249	0.6249	0.6249	0.7500	0.0000	-0.6893	-0.6249	-0.6249	0.0000	0.6249	0.5000	0.6249	0.6249	-0.6249	0.7955
C3	-0.6249	0.0000	0.0000	-0.7955	-0.5000	-0.7500	-0.6240	0.7955	-0.6249	-0.6249	0.0000	0.0000	0.6249	0.6249	0.0000	0.6249	-0.6249	-0.6249	0.0000	-0.6249	0.6249	-0.7500
C4	0.6459	0.7500	-0.6707	0.0000	0.7955	0.1250	0.0000	-0.6249	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7955	0.7955	-0.5000	0.7500	-0.6249	0.6707
C5	0.7500	0.6249	-0.7955	0.7955	0.0000	0.5000	0.0000	-0.5000	0.3751	0.3751	0.5000	0.0000	-0.5000	0.0000	0.0000	-0.7955	0.7955	0.7500	0.0000	0.6249	-0.6249	0.7500
C6	0.0000	0.0000	-0.3751	0.5555	0.0000	0.0000	0.0000	-0.6707	0.7955	0.7955	0.7955	0.6707	-0.6249	-0.7955	-0.6707	-0.6707	0.6707	0.7955	0.7500	0.7955	-0.7955	0.7955
C7	0.5000	0.6249	-0.6249	0.7500	0.0000	0.7500	0.0000	-0.7955	0.7955	0.7955	0.7500	0.6707	-0.7955	-0.7500	0.0000	-0.6249	0.6249	0.6249	0.0000	0.3751	-0.5000	0.6249
C8	0.0000	0.5000	0.6707	-0.3751	-0.6249	-0.6249	-0.6249	0.0000	0.0000	0.0000	-0.5000	-0.6707	0.6707	0.3356	0.0000	0.7955	-0.6707	-0.7500	0.6249	-0.7955	0.7955	-0.6249
C9	0.6249	0.5000	-0.6707	0.6707	0.6459	0.7955	0.7955	-0.6707	0.0000	0.0000	0.0000	0.7955	-0.6249	-0.7955	0.0000	-0.5000	0.0000	0.6249	-0.5000	0.5000	0.0000	0.6707
C10	0.6249	0.5000	-0.6707	0.6707	0.6459	0.7955	0.7955	-0.6707	0.0000	0.0000	0.0000	0.7955	-0.6249	-0.7955	0.0000	-0.5000	0.0000	0.6249	-0.5000	0.5000	0.0000	0.6707
C11	0.0000	0.0000	-0.6249	0.7500	0.0000	0.7955	0.7500	-0.7500	0.5000	0.5000	0.0000	0.7500	-0.7500	-0.7955	0.0000	-0.6249	0.7500	0.6249	0.0000	0.6249	-0.7500	0.7955
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5555	-0.7500	0.7500	0.7500	0.6707	0.0000	-0.6249	-0.6249	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6249	0.7955	-0.6249	-0.5000	-0.6249	-0.6249	0.7955	-0.5000	-0.5000	-0.6249	-0.6249	0.0000	0.7500	0.0000	0.7955	-0.5000	-0.6249	0.6249	-0.7955	0.6707	-0.7955
C14	-0.7500	0.0000	0.7955	-0.6249	0.0000	-0.6249	-0.7500	0.6707	-0.5000	-0.5000	0.0000	-0.5000	0.6707	0.0000	0.0000	0.6707	-0.6707	-0.6249	0.3751	-0.7500	0.7500	-0.7955
C15	-0.5000	-0.5000	0.5000	-0.5000	0.0000	-0.6249	-0.6249	0.6707	-0.6249	-0.6249	0.0000	-0.5000	0.6249	0.5000	0.0000	0.4828	0.0000	0.0000	0.0000	-0.6459	0.5000	-0.6249
C16	-0.6249	-0.6249	0.6249	-0.5000	-0.6707	-0.6249	0.0000	0.3751	0.0000	0.0000	0.0000	0.0000	0.3751	0.6249	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5459	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6249	0.7500	0.7500	-0.6249	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6249	0.0000	0.0000	0.0000	0.6249	-0.7955	0.7955
C18	0.0000	0.0000	-0.6249	0.5000	0.3751	0.7500	0.6249	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6707	-0.7955	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7955	0.6707	-0.6707	0.7955	0.0000	0.6249	0.6707	-0.6249	0.5000	0.5000	0.0000	0.6249	-0.6249	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7955
C20	0.0000	0.0000	-0.7500	0.7500	0.6707	0.7955	0.0000	-0.3751	0.7500	0.7500	0.7955	0.7955	-0.7500	-0.7500	-0.7955	-0.5000	0.6707	0.6249	0.5000	0.0000	-0.7955	0.7955
C21	0.0000	0.0000	0.6459	-0.6707	-0.5000	-0.6249	0.0000	0.6249	0.0000	0.0000	0.0000	-0.6249	0.6249	0.7500	0.0000	0.0000	-0.6249	-0.6249	0.0000	-0.7500	0.0000	-0.7955

Table A.6: Aggregated weights matrix for $\alpha - cut$ .75

α = 0.75	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7945	-0.6355	0.6248	0.7945	0.9179	0.6248	0.0000	0.7500	0.7500	0.6248	0.6248	-0.6248	-0.7705	-0.6248	-0.6248	0.7500	0.5000	0.0000	0.7500	-0.6248	0.7945
C2	0.7945	0.0000	-0.6696	0.7500	0.0000	0.6248	0.6248	-0.6248	0.6248	0.6248	0.7500	0.0000	-0.6775	-0.6248	-0.6248	0.0000	0.6248	0.5000	0.6248	0.6248	-0.6248	0.7945
C3	-0.6248	0.0000	0.0000	-0.7945	-0.5000	-0.7500	-0.6248	0.7945	-0.6248	-0.6248	0.0000	0.0000	0.6248	0.6248	0.0000	0.6248	-0.6248	-0.6248	0.0000	-0.6248	0.6248	-0.7500
C4	0.6451	0.7500	-0.6696	0.0000	0.7945	0.1242	0.0000	-0.6248	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7945	0.7945	-0.5000	0.7500	-0.6248	0.6696
C5	0.7500	0.6248	-0.7945	0.7945	0.0000	0.5000	0.0000	-0.5000	0.3752	0.3752	0.5000	0.0000	-0.5000	0.0000	0.0000	-0.7945	0.7945	0.7500	0.0000	0.6248	-0.6248	0.7500
C6	0.0000	0.0000	-0.3752	0.5543	0.0000	0.0000	0.0000	-0.6696	0.7945	0.7945	0.7945	0.6696	-0.6248	-0.7945	-0.6696	-0.6696	0.6696	0.7945	0.7500	0.7945	-0.7945	0.7945
C7	0.5000	0.6248	-0.6248	0.7500	0.0000	0.7500	0.0000	-0.7945	0.7945	0.7945	0.7500	0.6696	-0.7945	-0.7500	0.0000	-0.6248	0.6248	0.6248	0.0000	0.3752	-0.5000	0.6248
C8	0.0000	0.5000	0.6696	-0.3752	-0.6248	-0.6248	-0.6248	0.0000	0.0000	0.0000	-0.5000	-0.6696	0.6696	0.3337	0.0000	0.7945	-0.6696	-0.7500	0.6248	-0.7945	0.7945	-0.6248
C9	0.6248	0.5000	-0.6696	0.6696	0.6451	0.7945	0.7945	-0.6696	0.0000	0.0000	0.0000	0.7945	-0.6248	-0.7945	0.0000	-0.5000	0.0000	0.6248	-0.5000	0.5000	0.0000	0.6696
C10	0.6248	0.5000	-0.6696	0.6696	0.6451	0.7945	0.7945	-0.6696	0.0000	0.0000	0.0000	0.7945	-0.6248	-0.7945	0.0000	-0.5000	0.0000	0.6248	-0.5000	0.5000	0.0000	0.6696
C11	0.0000	0.0000	-0.6248	0.7500	0.0000	0.7945	0.7500	-0.7500	0.5000	0.5000	0.0000	0.7500	-0.7500	-0.7945	0.0000	-0.6248	0.7500	0.6248	0.0000	0.6248	-0.7500	0.7945
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5543	-0.7500	0.7500	0.7500	0.6696	0.0000	-0.6248	-0.6248	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6248	0.7945	-0.6248	-0.5000	-0.6248	-0.6248	0.7945	-0.5000	-0.5000	-0.6248	-0.6248	0.0000	0.7500	0.0000	0.7945	-0.5000	-0.6248	0.6248	-0.7945	0.6696	-0.7945
C14	-0.7500	0.0000	0.7945	-0.6248	0.0000	-0.6248	-0.7500	0.6696	-0.5000	-0.5000	0.0000	-0.5000	0.6696	0.0000	0.0000	0.6696	-0.6696	-0.6248	0.3752	-0.7500	0.7500	-0.7945
C15	-0.5000	-0.5000	0.5000	-0.5000	0.0000	-0.6248	-0.6248	0.6696	-0.6248	-0.6248	0.0000	-0.5000	0.6248	0.5000	0.0000	0.4823	0.0000	0.0000	0.0000	-0.6451	0.5000	-0.6248
C16	-0.6248	-0.6248	0.6248	-0.5000	-0.6696	-0.6248	0.0000	0.3752	0.0000	0.0000	0.0000	0.0000	0.3752	0.6248	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5450	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6248	0.7500	0.7500	-0.6248	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6248	0.0000	0.0000	0.0000	0.6248	-0.7945	0.7945
C18	0.0000	0.0000	-0.6248	0.5000	0.3752	0.7500	0.6248	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6696	-0.7945	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7945	0.6696	-0.6696	0.7945	0.0000	0.6248	0.6696	-0.6248	0.5000	0.5000	0.0000	0.6248	-0.6248	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7945
C20	0.0000	0.0000	-0.7500	0.7500	0.6696	0.7945	0.0000	-0.3752	0.7500	0.7500	0.7945	0.7945	-0.7500	-0.7500	-0.7945	-0.5000	0.6696	0.6248	0.5000	0.0000	-0.7945	0.7945
C21	0.0000	0.0000	0.6451	-0.6696	-0.5000	-0.6248	0.0000	0.6248	0.0000	0.0000	0.0000	-0.6248	0.6248	0.7500	0.0000	0.0000	-0.6248	-0.6248	0.0000	-0.7500	0.0000	-0.7945

Table A.7: Aggregated weights matrix for $\alpha - cut$ .70

α = 0.70	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7931	-0.6366	0.6248	0.7931	0.9162	0.6248	0.0000	0.7500	0.7500	0.6248	0.6248	-0.6248	-0.7735	-0.6248	-0.6248	0.7500	0.5000	0.0000	0.7500	-0.6248	0.7931
C2	0.7931	0.0000	-0.6683	0.7500	0.0000	0.6248	0.6248	-0.6248	0.6248	0.6248	0.7500	0.0000	-0.6661	-0.6248	-0.6248	0.0000	0.6248	0.5000	0.6248	0.6248	-0.6248	0.7931
C3	-0.6248	0.0000	0.0000	-0.7931	-0.5000	-0.7500	-0.6246	0.7931	-0.6248	-0.6248	0.0000	0.0000	0.6248	0.6248	0.0000	0.6248	-0.6248	-0.6248	0.0000	-0.6248	0.6248	-0.7500
C4	0.6443	0.7500	-0.6683	0.0000	0.7931	0.1245	0.0000	-0.6248	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7931	0.7931	-0.5000	0.7500	-0.6248	0.6683
C5	0.7500	0.6248	-0.7931	0.7931	0.0000	0.5000	0.0000	-0.5000	0.3752	0.3752	0.5000	0.0000	-0.5000	0.0000	0.0000	-0.7931	0.7931	0.7500	0.0000	0.6248	-0.6248	0.7500
C6	0.0000	0.0000	-0.3752	0.5525	0.0000	0.0000	0.0000	-0.6683	0.7931	0.7931	0.7931	0.6683	-0.6248	-0.7931	-0.6683	-0.6683	0.6683	0.7931	0.7500	0.7931	-0.7931	0.7931
C7	0.5000	0.6248	-0.6248	0.7500	0.0000	0.7500	0.0000	-0.7931	0.7931	0.7931	0.7500	0.6683	-0.7931	-0.7500	0.0000	-0.6248	0.6248	0.6248	0.0000	0.3752	-0.5000	0.6248
C8	0.0000	0.5000	0.6683	-0.3752	-0.6248	-0.6248	-0.6248	0.0000	0.0000	0.0000	-0.5000	-0.6683	0.6683	0.3309	0.0000	0.7931	-0.6683	-0.7500	0.6248	-0.7931	0.7931	-0.6248
C9	0.6248	0.5000	-0.6683	0.6683	0.6443	0.7931	0.7931	-0.6683	0.0000	0.0000	0.0000	0.7931	-0.6248	-0.7931	0.0000	-0.5000	0.0000	0.6248	-0.5000	0.5000	0.0000	0.6683
C10	0.6248	0.5000	-0.6683	0.6683	0.6443	0.7931	0.7931	-0.6683	0.0000	0.0000	0.0000	0.7931	-0.6248	-0.7931	0.0000	-0.5000	0.0000	0.6248	-0.5000	0.5000	0.0000	0.6683
C11	0.0000	0.0000	-0.6248	0.7500	0.0000	0.7931	0.7500	-0.7500	0.5000	0.5000	0.0000	0.7500	-0.7500	-0.7931	0.0000	-0.6248	0.7500	0.6248	0.0000	0.6248	-0.7500	0.7931
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5525	-0.7500	0.7500	0.7500	0.6683	0.0000	-0.6248	-0.6248	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6248	0.7931	-0.6248	-0.5000	-0.6248	-0.6248	0.7931	-0.5000	-0.5000	-0.6248	-0.6248	0.0000	0.7500	0.0000	0.7931	-0.5000	-0.6248	0.6248	-0.7931	0.6683	-0.7931
C14	-0.7500	0.0000	0.7931	-0.6248	0.0000	-0.6248	-0.7500	0.6683	-0.5000	-0.5000	0.0000	-0.5000	0.6683	0.0000	0.0000	0.6683	-0.6683	-0.6248	0.3752	-0.7500	0.7500	-0.7931
C15	-0.5000	-0.5000	0.5000	-0.5000	0.0000	-0.6248	-0.6248	0.6683	-0.6248	-0.6248	0.0000	-0.5000	0.6248	0.5000	0.0000	0.4812	0.0000	0.0000	0.0000	-0.6443	0.5000	-0.6248
C16	-0.6248	-0.6248	0.6248	-0.5000	-0.6683	-0.6248	0.0000	0.3752	0.0000	0.0000	0.0000	0.0000	0.3752	0.6248	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5437	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6248	0.7500	0.7500	-0.6248	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6248	0.0000	0.0000	0.0000	0.6248	-0.7931	0.7931
C18	0.0000	0.0000	-0.6248	0.5000	0.3752	0.7500	0.6248	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6683	-0.7931	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7931	0.6683	-0.6683	0.7931	0.0000	0.6248	0.6683	-0.6248	0.5000	0.5000	0.0000	0.6248	-0.6248	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7931
C20	0.0000	0.0000	-0.7500	0.7500	0.6683	0.7931	0.0000	-0.3752	0.7500	0.7500	0.7931	0.7931	-0.7500	-0.7500	-0.7931	-0.5000	0.6683	0.6248	0.5000	0.0000	-0.7931	0.7931
C21	0.0000	0.0000	0.6443	-0.6683	-0.5000	-0.6248	0.0000	0.6248	0.0000	0.0000	0.0000	-0.6248	0.6248	0.7500	0.0000	0.0000	-0.6248	-0.6248	0.0000	-0.7500	0.0000	-0.7931

Table A.8: Aggregated weights matrix for $\alpha - cut$ .65

α = 0.65	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7914	-0.6376	0.6249	0.7914	0.9143	0.6249	0.0000	0.7500	0.7500	0.6249	0.6249	-0.6249	-0.7764	-0.6249	-0.6249	0.7500	0.5000	0.0000	0.7500	-0.6249	0.7914
C2	0.7914	0.0000	-0.6668	0.7500	0.0000	0.6249	0.6249	-0.6249	0.6249	0.6249	0.7500	0.0000	-0.6553	-0.6249	-0.6249	0.0000	0.6249	0.5000	0.6249	0.6249	-0.6249	0.7914
C3	-0.6249	0.0000	0.0000	-0.7914	-0.5000	-0.7500	-0.6246	0.7914	-0.6249	-0.6249	0.0000	0.0000	0.6249	0.6249	0.0000	0.6249	-0.6249	-0.6249	0.0000	-0.6249	0.6249	-0.7500
C4	0.6434	0.7500	-0.6668	0.0000	0.7914	0.1247	0.0000	-0.6249	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7914	0.7914	-0.5000	0.7500	-0.6249	0.6668
C5	0.7500	0.6249	-0.7914	0.7914	0.0000	0.5000	0.0000	-0.5000	0.3751	0.3751	0.5000	0.0000	-0.5000	0.0000	0.0000	-0.7914	0.7914	0.7500	0.0000	0.6249	-0.6249	0.7500
C6	0.0000	0.0000	-0.3751	0.5503	0.0000	0.0000	0.0000	-0.6668	0.7914	0.7914	0.7914	0.6668	-0.6249	-0.7914	-0.6668	-0.6668	0.6668	0.7914	0.7500	0.7914	-0.7914	0.7914
C7	0.5000	0.6249	-0.6249	0.7500	0.0000	0.7500	0.0000	-0.7914	0.7914	0.7914	0.7500	0.6668	-0.7914	-0.7500	0.0000	-0.6249	0.6249	0.6249	0.0000	0.3751	-0.5000	0.6249
C8	0.0000	0.5000	0.6668	-0.3751	-0.6249	-0.6249	-0.6249	0.0000	0.0000	0.0000	-0.5000	-0.6668	0.6668	0.3276	0.0000	0.7914	-0.6668	-0.7500	0.6249	-0.7914	0.7914	-0.6249
C9	0.6249	0.5000	-0.6668	0.6668	0.6434	0.7914	0.7914	-0.6668	0.0000	0.0000	0.0000	0.7914	-0.6249	-0.7914	0.0000	-0.5000	0.0000	0.6249	-0.5000	0.5000	0.0000	0.6668
C10	0.6249	0.5000	-0.6668	0.6668	0.6434	0.7914	0.7914	-0.6668	0.0000	0.0000	0.0000	0.7914	-0.6249	-0.7914	0.0000	-0.5000	0.0000	0.6249	-0.5000	0.5000	0.0000	0.6668
C11	0.0000	0.0000	-0.6249	0.7500	0.0000	0.7914	0.7500	-0.7500	0.5000	0.5000	0.0000	0.7500	-0.7500	-0.7914	0.0000	-0.6249	0.7500	0.6249	0.0000	0.6249	-0.7500	0.7914
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5503	-0.7500	0.7500	0.7500	0.6668	0.0000	-0.6249	-0.6249	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6249	0.7914	-0.6249	-0.5000	-0.6249	-0.6249	0.7914	-0.5000	-0.5000	-0.6249	-0.6249	0.0000	0.7500	0.0000	0.7914	-0.5000	-0.6249	0.6249	-0.7914	0.6668	-0.7914
C14	-0.7500	0.0000	0.7914	-0.6249	0.0000	-0.6249	-0.7500	0.6668	-0.5000	-0.5000	0.0000	-0.5000	0.6668	0.0000	0.0000	0.6668	-0.6668	-0.6249	0.3751	-0.7500	0.7500	-0.7914
C15	-0.5000	-0.5000	0.5000	-0.5000	0.0000	-0.6249	-0.6249	0.6668	-0.6249	-0.6249	0.0000	-0.5000	0.6249	0.5000	0.0000	0.4801	0.0000	0.0000	0.0000	-0.6434	0.5000	-0.6249
C16	-0.6249	-0.6249	0.6249	-0.5000	-0.6668	-0.6249	0.0000	0.3751	0.0000	0.0000	0.0000	0.0000	0.3751	0.6249	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5422	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6249	0.7500	0.7500	-0.6249	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6249	0.0000	0.0000	0.0000	0.6249	-0.7914	0.7914
C18	0.0000	0.0000	-0.6249	0.5000	0.3751	0.7500	0.6249	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6668	-0.7914	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7914	0.6668	-0.6668	0.7914	0.0000	0.6249	0.6668	-0.6249	0.5000	0.5000	0.0000	0.6249	-0.6249	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7914
C20	0.0000	0.0000	-0.7500	0.7500	0.6668	0.7914	0.0000	-0.3751	0.7500	0.7500	0.7914	0.7914	-0.7500	-0.7500	-0.7914	-0.5000	0.6668	0.6249	0.5000	0.0000	-0.7914	0.7914
C21	0.0000	0.0000	0.6434	-0.6668	-0.5000	-0.6249	0.0000	0.6249	0.0000	0.0000	0.0000	-0.6249	0.6249	0.7500	0.0000	0.0000	-0.6249	-0.6249	0.0000	-0.7500	0.0000	-0.7914

Table A.9: Aggregated weights matrix for $\alpha - cut$ .60

$\alpha =$ 0.60	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7897	-0.6387	0.6247	0.7897	0.9122	0.6247	0.0000	0.7500	0.7500	0.6247	0.6247	-0.6247	-0.7791	-0.6247	-0.6247	0.7500	0.5000	0.0000	0.7500	-0.6247	0.7897
C2	0.7897	0.0000	-0.6650	0.7500	0.0000	0.6247	0.6247	-0.6247	0.6247	0.6247	0.7500	0.0000	-0.6450	-0.6247	-0.6247	0.0000	0.6247	0.5000	0.6247	0.6247	-0.6247	0.7897
C3	-0.6247	0.0000	0.0000	-0.7897	-0.5000	-0.7500	-0.6249	0.7897	-0.6247	-0.6247	0.0000	0.0000	0.6247	0.6247	0.0000	0.6247	-0.6247	-0.6247	0.0000	-0.6247	0.6247	-0.7500
C4	0.6425	0.7500	-0.6650	0.0000	0.7897	0.1238	0.0000	-0.6247	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7897	0.7897	-0.5000	0.7500	-0.6247	0.6650
C5	0.7500	0.6247	-0.7897	0.7897	0.0000	0.5000	0.0000	-0.5000	0.3754	0.3754	0.5000	0.0000	-0.5000	0.0000	0.0000	-0.7897	0.7897	0.7500	0.0000	0.6247	-0.6247	0.7500
C6	0.0000	0.0000	-0.3754	0.5480	0.0000	0.0000	0.0000	-0.6650	0.7897	0.7897	0.7897	0.6650	-0.6247	-0.7897	-0.6650	-0.6650	0.6650	0.7897	0.7500	0.7897	-0.7897	0.7897
C7	0.5000	0.6247	-0.6247	0.7500	0.0000	0.7500	0.0000	-0.7897	0.7897	0.7897	0.7500	0.6650	-0.7897	-0.7500	0.0000	-0.6247	0.6247	0.6247	0.0000	0.3754	-0.5000	0.6247
C8	0.0000	0.5000	0.6650	-0.3754	-0.6247	-0.6247	-0.6247	0.0000	0.0000	0.0000	-0.5000	-0.6650	0.6650	0.3241	0.0000	0.7897	-0.6650	-0.7500	0.6247	-0.7897	0.7897	-0.6247
C9	0.6247	0.5000	-0.6650	0.6650	0.6425	0.7897	0.7897	-0.6650	0.0000	0.0000	0.0000	0.7897	-0.6247	-0.7897	0.0000	-0.5000	0.0000	0.6247	-0.5000	0.5000	0.0000	0.6650
C10	0.6247	0.5000	-0.6650	0.6650	0.6425	0.7897	0.7897	-0.6650	0.0000	0.0000	0.0000	0.7897	-0.6247	-0.7897	0.0000	-0.5000	0.0000	0.6247	-0.5000	0.5000	0.0000	0.6650
C11	0.0000	0.0000	-0.6247	0.7500	0.0000	0.7897	0.7500	-0.7500	0.5000	0.5000	0.0000	0.7500	-0.7500	-0.7897	0.0000	-0.6247	0.7500	0.6247	0.0000	0.6247	-0.7500	0.7897
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5480	-0.7500	0.7500	0.7500	0.6650	0.0000	-0.6247	-0.6247	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6247	0.7897	-0.6247	-0.5000	-0.6247	-0.6247	0.7897	-0.5000	-0.5000	-0.6247	-0.6247	0.0000	0.7500	0.0000	0.7897	-0.5000	-0.6247	0.6247	-0.7897	0.6650	-0.7897
C14	-0.7500	0.0000	0.7897	-0.6247	0.0000	-0.6247	-0.7500	0.6650	-0.5000	-0.5000	0.0000	-0.5000	0.6650	0.0000	0.0000	0.6650	-0.6650	-0.6247	0.3754	-0.7500	0.7500	-0.7897
C15	-0.5000	-0.5000	0.5000	-0.5000	0.0000	-0.6247	-0.6247	0.6650	-0.6247	-0.6247	0.0000	-0.5000	0.6247	0.5000	0.0000	0.4796	0.0000	0.0000	0.0000	-0.6425	0.5000	-0.6247
C16	-0.6247	-0.6247	0.6247	-0.5000	-0.6650	-0.6247	0.0000	0.3754	0.0000	0.0000	0.0000	0.0000	0.3754	0.6247	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5406	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6247	0.7500	0.7500	-0.6247	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6247	0.0000	0.0000	0.0000	0.6247	-0.7897	0.7897
C18	0.0000	0.0000	-0.6247	0.5000	0.3754	0.7500	0.6247	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6650	-0.7897	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7897	0.6650	-0.6650	0.7897	0.0000	0.6247	0.6650	-0.6247	0.5000	0.5000	0.0000	0.6247	-0.6247	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7897
C20	0.0000	0.0000	-0.7500	0.7500	0.6650	0.7897	0.0000	-0.3754	0.7500	0.7500	0.7897	0.7897	-0.7500	-0.7500	-0.7897	-0.5000	0.6650	0.6247	0.5000	0.0000	-0.7897	0.7897
C21	0.0000	0.0000	0.6425	-0.6650	-0.5000	-0.6247	0.0000	0.6247	0.0000	0.0000	0.0000	-0.6247	0.6247	0.7500	0.0000	0.0000	-0.6247	-0.6247	0.0000	-0.7500	0.0000	-0.7897

Table A.10: Aggregated weights matrix for $\alpha - cut$ .55

α = 0.55	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7875	-0.6397	0.6249	0.7875	0.9101	0.6249	0.0000	0.7500	0.7500	0.6249	0.6249	-0.6249	-0.7822	-0.6249	-0.6249	0.7500	0.5000	0.0000	0.7500	-0.6249	0.7875
C2	0.7875	0.0000	-0.6629	0.7500	0.0000	0.6249	0.6249	-0.6249	0.6249	0.6249	0.7500	0.0000	-0.6348	-0.6249	-0.6249	0.0000	0.6249	0.5000	0.6249	0.6249	-0.6249	0.7875
C3	-0.6249	0.0000	0.0000	-0.7875	-0.5000	-0.7500	-0.6246	0.7875	-0.6249	-0.6249	0.0000	0.0000	0.6249	0.6249	0.0000	0.6249	-0.6249	-0.6249	0.0000	-0.6249	0.6249	-0.7500
C4	0.6416	0.7500	-0.6629	0.0000	0.7875	0.1247	0.0000	-0.6249	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7875	0.7875	-0.5000	0.7500	-0.6249	0.6629
C5	0.7500	0.6249	-0.7875	0.7875	0.0000	0.5000	0.0000	-0.5000	0.3752	0.3752	0.5000	0.0000	-0.5000	0.0000	0.0000	-0.7875	0.7875	0.7500	0.0000	0.6249	-0.6249	0.7500
C6	0.0000	0.0000	-0.3752	0.5448	0.0000	0.0000	0.0000	-0.6629	0.7875	0.7875	0.7875	0.6629	-0.6249	-0.7875	-0.6629	-0.6629	0.6629	0.7875	0.7500	0.7875	-0.7875	0.7875
C7	0.5000	0.6249	-0.6249	0.7500	0.0000	0.7500	0.0000	-0.7875	0.7875	0.7875	0.7500	0.6629	-0.7875	-0.7500	0.0000	-0.6249	0.6249	0.6249	0.0000	0.3752	-0.5000	0.6249
C8	0.0000	0.5000	0.6629	-0.3752	-0.6249	-0.6249	-0.6249	0.0000	0.0000	0.0000	-0.5000	-0.6629	0.6629	0.3191	0.0000	0.7875	-0.6629	-0.7500	0.6249	-0.7875	0.7875	-0.6249
C9	0.6249	0.5000	-0.6629	0.6629	0.6416	0.7875	0.7875	-0.6629	0.0000	0.0000	0.0000	0.7875	-0.6249	-0.7875	0.0000	-0.5000	0.0000	0.6249	-0.5000	0.5000	0.0000	0.6629
C10	0.6249	0.5000	-0.6629	0.6629	0.6416	0.7875	0.7875	-0.6629	0.0000	0.0000	0.0000	0.7875	-0.6249	-0.7875	0.0000	-0.5000	0.0000	0.6249	-0.5000	0.5000	0.0000	0.6629
C11	0.0000	0.0000	-0.6249	0.7500	0.0000	0.7875	0.7500	-0.7500	0.5000	0.5000	0.0000	0.7500	-0.7500	-0.7875	0.0000	-0.6249	0.7500	0.6249	0.0000	0.6249	-0.7500	0.7875
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5448	-0.7500	0.7500	0.7500	0.6629	0.0000	-0.6249	-0.6249	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6249	0.7875	-0.6249	-0.5000	-0.6249	-0.6249	0.7875	-0.5000	-0.5000	-0.6249	-0.6249	0.0000	0.7500	0.0000	0.7875	-0.5000	-0.6249	0.6249	-0.7875	0.6629	-0.7875
C14	-0.7500	0.0000	0.7875	-0.6249	0.0000	-0.6249	-0.7500	0.6629	-0.5000	-0.5000	0.0000	-0.5000	0.6629	0.0000	0.0000	0.6629	-0.6629	-0.6249	0.3752	-0.7500	0.7500	-0.7875
C15	-0.5000	-0.5000	0.5000	-0.5000	0.0000	-0.6249	-0.6249	0.6629	-0.6249	-0.6249	0.0000	-0.5000	0.6249	0.5000	0.0000	0.4781	0.0000	0.0000	0.0000	-0.6416	0.5000	-0.6249
C16	-0.6249	-0.6249	0.6249	-0.5000	-0.6629	-0.6249	0.0000	0.3752	0.0000	0.0000	0.0000	0.0000	0.3752	0.6249	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5383	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6249	0.7500	0.7500	-0.6249	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6249	0.0000	0.0000	0.0000	0.6249	-0.7875	0.7875
C18	0.0000	0.0000	-0.6249	0.5000	0.3752	0.7500	0.6249	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6629	-0.7875	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7875	0.6629	-0.6629	0.7875	0.0000	0.6249	0.6629	-0.6249	0.5000	0.5000	0.0000	0.6249	-0.6249	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7875
C20	0.0000	0.0000	-0.7500	0.7500	0.6629	0.7875	0.0000	-0.3752	0.7500	0.7500	0.7875	0.7875	-0.7500	-0.7500	-0.7875	-0.5000	0.6629	0.6249	0.5000	0.0000	-0.7875	0.7875
C21	0.0000	0.0000	0.6416	-0.6629	-0.5000	-0.6249	0.0000	0.6249	0.0000	0.0000	0.0000	-0.6249	0.6249	0.7500	0.0000	0.0000	-0.6249	-0.6249	0.0000	-0.7500	0.0000	-0.7875

Table A.11: Aggregated weights matrix for $\alpha - cut$ .50

α = 0.50	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7849	-0.6407	0.6248	0.7849	0.9078	0.6248	0.0000	0.7500	0.7500	0.6248	0.6248	-0.6248	-0.7849	-0.6248	-0.6248	0.7500	0.5000	0.0000	0.7500	-0.6248	0.7849
C2	0.7849	0.0000	-0.6602	0.7500	0.0000	0.6248	0.6248	-0.6248	0.6248	0.6248	0.7500	0.0000	-0.6248	-0.6248	-0.6248	0.0000	0.6248	0.5000	0.6248	0.6248	-0.6248	0.7849
C3	-0.6248	0.0000	0.0000	-0.7849	-0.5000	-0.7500	-0.6248	0.7849	-0.6248	-0.6248	0.0000	0.0000	0.6248	0.6248	0.0000	0.6248	-0.6248	-0.6248	0.0000	-0.6248	0.6248	-0.7500
C4	0.6407	0.7500	-0.6602	0.0000	0.7849	0.1243	0.0000	-0.6248	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7849	0.7849	-0.5000	0.7500	-0.6248	0.6602
C5	0.7500	0.6248	-0.7849	0.7849	0.0000	0.5000	0.0000	-0.5000	0.3752	0.3752	0.5000	0.0000	-0.5000	0.0000	0.0000	-0.7849	0.7849	0.7500	0.0000	0.6248	-0.6248	0.7500
C6	0.0000	0.0000	-0.3752	0.5412	0.0000	0.0000	0.0000	-0.6602	0.7849	0.7849	0.7849	0.6602	-0.6248	-0.7849	-0.6602	-0.6602	0.6602	0.7849	0.7500	0.7849	-0.7849	0.7849
C7	0.5000	0.6248	-0.6248	0.7500	0.0000	0.7500	0.0000	-0.7849	0.7849	0.7849	0.7500	0.6602	-0.7849	-0.7500	0.0000	-0.6248	0.6248	0.6248	0.0000	0.3752	-0.5000	0.6248
C8	0.0000	0.5000	0.6602	-0.3752	-0.6248	-0.6248	-0.6248	0.0000	0.0000	0.0000	-0.5000	-0.6602	0.6602	0.3133	0.0000	0.7849	-0.6602	-0.7500	0.6248	-0.7849	0.7849	-0.6248
C9	0.6248	0.5000	-0.6602	0.6602	0.6407	0.7849	0.7849	-0.6602	0.0000	0.0000	0.0000	0.7849	-0.6248	-0.7849	0.0000	-0.5000	0.0000	0.6248	-0.5000	0.5000	0.0000	0.6602
C10	0.6248	0.5000	-0.6602	0.6602	0.6407	0.7849	0.7849	-0.6602	0.0000	0.0000	0.0000	0.7849	-0.6248	-0.7849	0.0000	-0.5000	0.0000	0.6248	-0.5000	0.5000	0.0000	0.6602
C11	0.0000	0.0000	-0.6248	0.7500	0.0000	0.7849	0.7500	-0.7500	0.5000	0.5000	0.0000	0.7500	-0.7500	-0.7849	0.0000	-0.6248	0.7500	0.6248	0.0000	0.6248	-0.7500	0.7849
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5412	-0.7500	0.7500	0.7500	0.6602	0.0000	-0.6248	-0.6248	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6248	0.7849	-0.6248	-0.5000	-0.6248	-0.6248	0.7849	-0.5000	-0.5000	-0.6248	-0.6248	0.0000	0.7500	0.0000	0.7849	-0.5000	-0.6248	0.6248	-0.7849	0.6602	-0.7849
C14	-0.7500	0.0000	0.7849	-0.6248	0.0000	-0.6248	-0.7500	0.6602	-0.5000	-0.5000	0.0000	-0.5000	0.6602	0.0000	0.0000	0.6602	-0.6602	-0.6248	0.3752	-0.7500	0.7500	-0.7849
C15	-0.5000	-0.5000	0.5000	-0.5000	0.0000	-0.6248	-0.6248	0.6602	-0.6248	-0.6248	0.0000	-0.5000	0.6248	0.5000	0.0000	0.4772	0.0000	0.0000	0.0000	-0.6407	0.5000	-0.6248
C16	-0.6248	-0.6248	0.6248	-0.5000	-0.6602	-0.6248	0.0000	0.3752	0.0000	0.0000	0.0000	0.0000	0.3752	0.6248	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5357	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6248	0.7500	0.7500	-0.6248	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6248	0.0000	0.0000	0.0000	0.6248	-0.7849	0.7849
C18	0.0000	0.0000	-0.6248	0.5000	0.3752	0.7500	0.6248	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6602	-0.7849	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7849	0.6602	-0.6602	0.7849	0.0000	0.6248	0.6602	-0.6248	0.5000	0.5000	0.0000	0.6248	-0.6248	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7849
C20	0.0000	0.0000	-0.7500	0.7500	0.6602	0.7849	0.0000	-0.3752	0.7500	0.7500	0.7849	0.7849	-0.7500	-0.7500	-0.7849	-0.5000	0.6602	0.6248	0.5000	0.0000	-0.7849	0.7849
C21	0.0000	0.0000	0.6407	-0.6602	-0.5000	-0.6248	0.0000	0.6248	0.0000	0.0000	0.0000	-0.6248	0.6248	0.7500	0.0000	0.0000	-0.6248	-0.6248	0.0000	-0.7500	0.0000	-0.7849

Table A.12: Aggregated weights matrix for $\alpha - cut$ .45

α = 0.45	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7822	-0.6416	0.6246	0.7822	0.9053	0.6246	0.0000	0.7500	0.7500	0.6246	0.6246	-0.6246	-0.7875	-0.6246	-0.6246	0.7500	0.5000	0.0000	0.7500	-0.6246	0.7822
C2	0.7822	0.0000	-0.6572	0.7500	0.0000	0.6246	0.6246	-0.6246	0.6246	0.6246	0.7500	0.0000	-0.6147	-0.6246	-0.6246	0.0000	0.6246	0.5000	0.6246	0.6246	-0.6246	0.7822
C3	-0.6246	0.0000	0.0000	-0.7822	-0.5000	-0.7500	-0.6249	0.7822	-0.6246	-0.6246	0.0000	0.0000	0.6246	0.6246	0.0000	0.6246	-0.6246	-0.6246	0.0000	-0.6246	0.6246	-0.7500
C4	0.6397	0.7500	-0.6572	0.0000	0.7822	0.1239	0.0000	-0.6246	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7822	0.7822	-0.5000	0.7500	-0.6246	0.6572
C5	0.7500	0.6246	-0.7822	0.7822	0.0000	0.5000	0.0000	-0.5000	0.3754	0.3754	0.5000	0.0000	-0.5000	0.0000	0.0000	-0.7822	0.7822	0.7500	0.0000	0.6246	-0.6246	0.7500
C6	0.0000	0.0000	-0.3754	0.5372	0.0000	0.0000	0.0000	-0.6572	0.7822	0.7822	0.7822	0.6572	-0.6246	-0.7822	-0.6572	-0.6572	0.6572	0.7822	0.7500	0.7822	-0.7822	0.7822
C7	0.5000	0.6246	-0.6246	0.7500	0.0000	0.7500	0.0000	-0.7822	0.7822	0.7822	0.7500	0.6572	-0.7822	-0.7500	0.0000	-0.6246	0.6246	0.6246	0.0000	0.3754	-0.5000	0.6246
C8	0.0000	0.5000	0.6572	-0.3754	-0.6246	-0.6246	-0.6246	0.0000	0.0000	0.0000	-0.5000	-0.6572	0.6572	0.3070	0.0000	0.7822	-0.6572	-0.7500	0.6246	-0.7822	0.7822	-0.6246
C9	0.6246	0.5000	-0.6572	0.6572	0.6397	0.7822	0.7822	-0.6572	0.0000	0.0000	0.0000	0.7822	-0.6246	-0.7822	0.0000	-0.5000	0.0000	0.6246	-0.5000	0.5000	0.0000	0.6572
C10	0.6246	0.5000	-0.6572	0.6572	0.6397	0.7822	0.7822	-0.6572	0.0000	0.0000	0.0000	0.7822	-0.6246	-0.7822	0.0000	-0.5000	0.0000	0.6246	-0.5000	0.5000	0.0000	0.6572
C11	0.0000	0.0000	-0.6246	0.7500	0.0000	0.7822	0.7500	-0.7500	0.5000	0.5000	0.0000	0.7500	-0.7500	-0.7822	0.0000	-0.6246	0.7500	0.6246	0.0000	0.6246	-0.7500	0.7822
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5372	-0.7500	0.7500	0.7500	0.6572	0.0000	-0.6246	-0.6246	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6246	0.7822	-0.6246	-0.5000	-0.6246	-0.6246	0.7822	-0.5000	-0.5000	-0.6246	-0.6246	0.0000	0.7500	0.0000	0.7822	-0.5000	-0.6246	0.6246	-0.7822	0.6572	-0.7822
C14	-0.7500	0.0000	0.7822	-0.6246	0.0000	-0.6246	-0.7500	0.6572	-0.5000	-0.5000	0.0000	-0.5000	0.6572	0.0000	0.0000	0.6572	-0.6572	-0.6246	0.3754	-0.7500	0.7500	-0.7822
C15	-0.5000	-0.5000	0.5000	-0.5000	0.0000	-0.6246	-0.6246	0.6572	-0.6246	-0.6246	0.0000	-0.5000	0.6246	0.5000	0.0000	0.4763	0.0000	0.0000	0.0000	-0.6397	0.5000	-0.6246
C16	-0.6246	-0.6246	0.6246	-0.5000	-0.6572	-0.6246	0.0000	0.3754	0.0000	0.0000	0.0000	0.0000	0.3754	0.6246	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5328	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6246	0.7500	0.7500	-0.6246	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6246	0.0000	0.0000	0.0000	0.6246	-0.7822	0.7822
C18	0.0000	0.0000	-0.6246	0.5000	0.3754	0.7500	0.6246	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6572	-0.7822	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7822	0.6572	-0.6572	0.7822	0.0000	0.6246	0.6572	-0.6246	0.5000	0.5000	0.0000	0.6246	-0.6246	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7822
C20	0.0000	0.0000	-0.7500	0.7500	0.6572	0.7822	0.0000	-0.3754	0.7500	0.7500	0.7822	0.7822	-0.7500	-0.7500	-0.7822	-0.5000	0.6572	0.6246	0.5000	0.0000	-0.7822	0.7822
C21	0.0000	0.0000	0.6397	-0.6572	-0.5000	-0.6246	0.0000	0.6246	0.0000	0.0000	0.0000	-0.6246	0.6246	0.7500	0.0000	0.0000	-0.6246	-0.6246	0.0000	-0.7500	0.0000	-0.7822

Table A.13: Aggregated weights matrix for $\alpha - cut$ .40

α = 0.40	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7791	-0.6425	0.6249	0.7791	0.9029	0.6249	0.0000	0.7500	0.7500	0.6249	0.6249	-0.6249	-0.7897	-0.6249	-0.6249	0.7500	0.5000	0.0000	0.7500	-0.6249	0.7791
C2	0.7791	0.0000	-0.6544	0.7500	0.0000	0.6249	0.6249	-0.6249	0.6249	0.6249	0.7500	0.0000	-0.6046	-0.6249	-0.6249	0.0000	0.6249	0.5000	0.6249	0.6249	-0.6249	0.7791
C3	-0.6249	0.0000	0.0000	-0.7791	-0.5000	-0.7500	-0.6247	0.7791	-0.6249	-0.6249	0.0000	0.0000	0.6249	0.6249	0.0000	0.6249	-0.6249	-0.6249	0.0000	-0.6249	0.6249	-0.7500
C4	0.6387	0.7500	-0.6544	0.0000	0.7791	0.1250	0.0000	-0.6249	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7791	0.7791	-0.5000	0.7500	-0.6249	0.6544
C5	0.7500	0.6249	-0.7791	0.7791	0.0000	0.5000	0.0000	-0.5000	0.3751	0.3751	0.5000	0.0000	-0.5000	0.0000	0.0000	-0.7791	0.7791	0.7500	0.0000	0.6249	-0.6249	0.7500
C6	0.0000	0.0000	-0.3751	0.5330	0.0000	0.0000	0.0000	-0.6544	0.7791	0.7791	0.7791	0.6544	-0.6249	-0.7791	-0.6544	-0.6544	0.6544	0.7791	0.7500	0.7791	-0.7791	0.7791
C7	0.5000	0.6249	-0.6249	0.7500	0.0000	0.7500	0.0000	-0.7791	0.7791	0.7791	0.7500	0.6544	-0.7791	-0.7500	0.0000	-0.6249	0.6249	0.6249	0.0000	0.3751	-0.5000	0.6249
C8	0.0000	0.5000	0.6544	-0.3751	-0.6249	-0.6249	-0.6249	0.0000	0.0000	0.0000	-0.5000	-0.6544	0.6544	0.3005	0.0000	0.7791	-0.6544	-0.7500	0.6249	-0.7791	0.7791	-0.6249
C9	0.6249	0.5000	-0.6544	0.6544	0.6387	0.7791	0.7791	-0.6544	0.0000	0.0000	0.0000	0.7791	-0.6249	-0.7791	0.0000	-0.5000	0.0000	0.6249	-0.5000	0.5000	0.0000	0.6544
C10	0.6249	0.5000	-0.6544	0.6544	0.6387	0.7791	0.7791	-0.6544	0.0000	0.0000	0.0000	0.7791	-0.6249	-0.7791	0.0000	-0.5000	0.0000	0.6249	-0.5000	0.5000	0.0000	0.6544
C11	0.0000	0.0000	-0.6249	0.7500	0.0000	0.7791	0.7500	-0.7500	0.5000	0.5000	0.0000	0.7500	-0.7500	-0.7791	0.0000	-0.6249	0.7500	0.6249	0.0000	0.6249	-0.7500	0.7791
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5330	-0.7500	0.7500	0.7500	0.6544	0.0000	-0.6249	-0.6249	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6249	0.7791	-0.6249	-0.5000	-0.6249	-0.6249	0.7791	-0.5000	-0.5000	-0.6249	-0.6249	0.0000	0.7500	0.0000	0.7791	-0.5000	-0.6249	0.6249	-0.7791	0.6544	-0.7791
C14	-0.7500	0.0000	0.7791	-0.6249	0.0000	-0.6249	-0.7500	0.6544	-0.5000	-0.5000	0.0000	-0.5000	0.6544	0.0000	0.0000	0.6544	-0.6544	-0.6249	0.3751	-0.7500	0.7500	-0.7791
C15	-0.5000	-0.5000	0.5000	-0.5000	0.0000	-0.6249	-0.6249	0.6544	-0.6249	-0.6249	0.0000	-0.5000	0.6249	0.5000	0.0000	0.4748	0.0000	0.0000	0.0000	-0.6387	0.5000	-0.6249
C16	-0.6249	-0.6249	0.6249	-0.5000	-0.6544	-0.6249	0.0000	0.3751	0.0000	0.0000	0.0000	0.0000	0.3751	0.6249	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5296	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6249	0.7500	0.7500	-0.6249	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6249	0.0000	0.0000	0.0000	0.6249	-0.7791	0.7791
C18	0.0000	0.0000	-0.6249	0.5000	0.3751	0.7500	0.6249	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6544	-0.7791	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7791	0.6544	-0.6544	0.7791	0.0000	0.6249	0.6544	-0.6249	0.5000	0.5000	0.0000	0.6249	-0.6249	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7791
C20	0.0000	0.0000	-0.7500	0.7500	0.6544	0.7791	0.0000	-0.3751	0.7500	0.7500	0.7791	0.7791	-0.7500	-0.7500	-0.7791	-0.5000	0.6544	0.6249	0.5000	0.0000	-0.7791	0.7791
C21	0.0000	0.0000	0.6387	-0.6544	-0.5000	-0.6249	0.0000	0.6249	0.0000	0.0000	0.0000	-0.6249	0.6249	0.7500	0.0000	0.0000	-0.6249	-0.6249	0.0000	-0.7500	0.0000	-0.7791

Table A.14: Aggregated weights matrix for $\alpha - cut$ .35

α = 0.35	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7764	-0.6434	0.6246	0.7764	0.9002	0.6246	0.0000	0.7500	0.7500	0.6246	0.6246	-0.6246	-0.7914	-0.6246	-0.6246	0.7500	0.5000	0.0000	0.7500	-0.6246	0.7764
C2	0.7764	0.0000	-0.6512	0.7500	0.0000	0.6246	0.6246	-0.6246	0.6246	0.6246	0.7500	0.0000	-0.5942	-0.6246	-0.6246	0.0000	0.6246	0.5000	0.6246	0.6246	-0.6246	0.7764
C3	-0.6246	0.0000	0.0000	-0.7764	-0.5000	-0.7500	-0.6249	0.7764	-0.6246	-0.6246	0.0000	0.0000	0.6246	0.6246	0.0000	0.6246	-0.6246	-0.6246	0.0000	-0.6246	0.6246	-0.7500
C4	0.6376	0.7500	-0.6512	0.0000	0.7764	0.1237	0.0000	-0.6246	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7764	0.7764	-0.5000	0.7500	-0.6246	0.6512
C5	0.7500	0.6246	-0.7764	0.7764	0.0000	0.5000	0.0000	-0.5000	0.3754	0.3754	0.5000	0.0000	-0.5000	0.0000	0.0000	-0.7764	0.7764	0.7500	0.0000	0.6246	-0.6246	0.7500
C6	0.0000	0.0000	-0.3754	0.5295	0.0000	0.0000	0.0000	-0.6512	0.7764	0.7764	0.7764	0.6512	-0.6246	-0.7764	-0.6512	-0.6512	0.6512	0.7764	0.7500	0.7764	-0.7764	0.7764
C7	0.5000	0.6246	-0.6246	0.7500	0.0000	0.7500	0.0000	-0.7764	0.7764	0.7764	0.7500	0.6512	-0.7764	-0.7500	0.0000	-0.6246	0.6246	0.6246	0.0000	0.3754	-0.5000	0.6246
C8	0.0000	0.5000	0.6512	-0.3754	-0.6246	-0.6246	-0.6246	0.0000	0.0000	0.0000	-0.5000	-0.6512	0.6512	0.2950	0.0000	0.7764	-0.6512	-0.7500	0.6246	-0.7764	0.7764	-0.6246
C9	0.6246	0.5000	-0.6512	0.6512	0.6376	0.7764	0.7764	-0.6512	0.0000	0.0000	0.0000	0.7764	-0.6246	-0.7764	0.0000	-0.5000	0.0000	0.6246	-0.5000	0.5000	0.0000	0.6512
C10	0.6246	0.5000	-0.6512	0.6512	0.6376	0.7764	0.7764	-0.6512	0.0000	0.0000	0.0000	0.7764	-0.6246	-0.7764	0.0000	-0.5000	0.0000	0.6246	-0.5000	0.5000	0.0000	0.6512
C11	0.0000	0.0000	-0.6246	0.7500	0.0000	0.7764	0.7500	-0.7500	0.5000	0.5000	0.0000	0.7500	-0.7500	-0.7764	0.0000	-0.6246	0.7500	0.6246	0.0000	0.6246	-0.7500	0.7764
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5295	-0.7500	0.7500	0.7500	0.6512	0.0000	-0.6246	-0.6246	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6246	0.7764	-0.6246	-0.5000	-0.6246	-0.6246	0.7764	-0.5000	-0.5000	-0.6246	-0.6246	0.0000	0.7500	0.0000	0.7764	-0.5000	-0.6246	0.6246	-0.7764	0.6512	-0.7764
C14	-0.7500	0.0000	0.7764	-0.6246	0.0000	-0.6246	-0.7500	0.6512	-0.5000	-0.5000	0.0000	-0.5000	0.6512	0.0000	0.0000	0.6512	-0.6512	-0.6246	0.3754	-0.7500	0.7500	-0.7764
C15	-0.5000	-0.5000	0.5000	-0.5000	0.0000	-0.6246	-0.6246	0.6512	-0.6246	-0.6246	0.0000	-0.5000	0.6246	0.5000	0.0000	0.4742	0.0000	0.0000	0.0000	-0.6376	0.5000	-0.6246
C16	-0.6246	-0.6246	0.6246	-0.5000	-0.6512	-0.6246	0.0000	0.3754	0.0000	0.0000	0.0000	0.0000	0.3754	0.6246	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5268	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6246	0.7500	0.7500	-0.6246	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6246	0.0000	0.0000	0.0000	0.6246	-0.7764	0.7764
C18	0.0000	0.0000	-0.6246	0.5000	0.3754	0.7500	0.6246	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6512	-0.7764	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7764	0.6512	-0.6512	0.7764	0.0000	0.6246	0.6512	-0.6246	0.5000	0.5000	0.0000	0.6246	-0.6246	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7764
C20	0.0000	0.0000	-0.7500	0.7500	0.6512	0.7764	0.0000	-0.3754	0.7500	0.7500	0.7764	0.7764	-0.7500	-0.7500	-0.7764	-0.5000	0.6512	0.6246	0.5000	0.0000	-0.7764	0.7764
C21	0.0000	0.0000	0.6376	-0.6512	-0.5000	-0.6246	0.0000	0.6246	0.0000	0.0000	0.0000	-0.6246	0.6246	0.7500	0.0000	0.0000	-0.6246	-0.6246	0.0000	-0.7500	0.0000	-0.7764

Table A.15: Aggregated weights matrix for $\alpha - cut$ .30

$\alpha =$ 0.30	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7735	-0.6443	0.6246	0.7735	0.8975	0.6246	0.0000	0.7500	0.7500	0.6246	0.6246	-0.6246	-0.7931	-0.6246	-0.6246	0.7500	0.5000	0.0000	0.7500	-0.6246	0.7735
C2	0.7735	0.0000	-0.6483	0.7500	0.0000	0.6246	0.6246	-0.6246	0.6246	0.6246	0.7500	0.0000	-0.5834	-0.6246	-0.6246	0.0000	0.6246	0.5000	0.6246	0.6246	-0.6246	0.7735
C3	-0.6246	0.0000	0.0000	-0.7735	-0.5000	-0.7500	-0.6248	0.7735	-0.6246	-0.6246	0.0000	0.0000	0.6246	0.6246	0.0000	0.6246	-0.6246	-0.6246	0.0000	-0.6246	0.6246	-0.7500
C4	0.6366	0.7500	-0.6483	0.0000	0.7735	0.1240	0.0000	-0.6246	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7735	0.7735	-0.5000	0.7500	-0.6246	0.6483
C5	0.7500	0.6246	-0.7735	0.7735	0.0000	0.5000	0.0000	-0.5000	0.3754	0.3754	0.5000	0.0000	-0.5000	0.0000	0.0000	-0.7735	0.7735	0.7500	0.0000	0.6246	-0.6246	0.7500
C6	0.0000	0.0000	-0.3754	0.5258	0.0000	0.0000	0.0000	-0.6483	0.7735	0.7735	0.7735	0.6483	-0.6246	-0.7735	-0.6483	-0.6483	0.6483	0.7735	0.7500	0.7735	-0.7735	0.7735
C7	0.5000	0.6246	-0.6246	0.7500	0.0000	0.7500	0.0000	-0.7735	0.7735	0.7735	0.7500	0.6483	-0.7735	-0.7500	0.0000	-0.6246	0.6246	0.6246	0.0000	0.3754	-0.5000	0.6246
C8	0.0000	0.5000	0.6483	-0.3754	-0.6246	-0.6246	-0.6246	0.0000	0.0000	0.0000	-0.5000	-0.6483	0.6483	0.2892	0.0000	0.7735	-0.6483	-0.7500	0.6246	-0.7735	0.7735	-0.6246
C9	0.6246	0.5000	-0.6483	0.6483	0.6366	0.7735	0.7735	-0.6483	0.0000	0.0000	0.0000	0.7735	-0.6246	-0.7735	0.0000	-0.5000	0.0000	0.6246	-0.5000	0.5000	0.0000	0.6483
C10	0.6246	0.5000	-0.6483	0.6483	0.6366	0.7735	0.7735	-0.6483	0.0000	0.0000	0.0000	0.7735	-0.6246	-0.7735	0.0000	-0.5000	0.0000	0.6246	-0.5000	0.5000	0.0000	0.6483
C11	0.0000	0.0000	-0.6246	0.7500	0.0000	0.7735	0.7500	-0.7500	0.5000	0.5000	0.0000	0.7500	-0.7500	-0.7735	0.0000	-0.6246	0.7500	0.6246	0.0000	0.6246	-0.7500	0.7735
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5258	-0.7500	0.7500	0.7500	0.6483	0.0000	-0.6246	-0.6246	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6246	0.7735	-0.6246	-0.5000	-0.6246	-0.6246	0.7735	-0.5000	-0.5000	-0.6246	-0.6246	0.0000	0.7500	0.0000	0.7735	-0.5000	-0.6246	0.6246	-0.7735	0.6483	-0.7735
C14	-0.7500	0.0000	0.7735	-0.6246	0.0000	-0.6246	-0.7500	0.6483	-0.5000	-0.5000	0.0000	-0.5000	0.6483	0.0000	0.0000	0.6483	-0.6483	-0.6246	0.3754	-0.7500	0.7500	-0.7735
C15	-0.5000	-0.5000	0.5000	-0.5000	0.0000	-0.6246	-0.6246	0.6483	-0.6246	-0.6246	0.0000	-0.5000	0.6246	0.5000	0.0000	0.4730	0.0000	0.0000	0.0000	-0.6366	0.5000	-0.6246
C16	-0.6246	-0.6246	0.6246	-0.5000	-0.6483	-0.6246	0.0000	0.3754	0.0000	0.0000	0.0000	0.0000	0.3754	0.6246	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5238	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6246	0.7500	0.7500	-0.6246	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6246	0.0000	0.0000	0.0000	0.6246	-0.7735	0.7735
C18	0.0000	0.0000	-0.6246	0.5000	0.3754	0.7500	0.6246	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6483	-0.7735	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7735	0.6483	-0.6483	0.7735	0.0000	0.6246	0.6483	-0.6246	0.5000	0.5000	0.0000	0.6246	-0.6246	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7735
C20	0.0000	0.0000	-0.7500	0.7500	0.6483	0.7735	0.0000	-0.3754	0.7500	0.7500	0.7735	0.7735	-0.7500	-0.7500	-0.7735	-0.5000	0.6483	0.6246	0.5000	0.0000	-0.7735	0.7735
C21	0.0000	0.0000	0.6366	-0.6483	-0.5000	-0.6246	0.0000	0.6246	0.0000	0.0000	0.0000	-0.6246	0.6246	0.7500	0.0000	0.0000	-0.6246	-0.6246	0.0000	-0.7500	0.0000	-0.7735

Table A.16: Aggregated weights matrix for $\alpha - cut$ .25

α = 0.25	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7705	-0.6451	0.6248	0.7705	0.8948	0.6248	0.0000	0.7500	0.7500	0.6248	0.6248	-0.6248	-0.7945	-0.6248	-0.6248	0.7500	0.5000	0.0000	0.7500	-0.6248	0.7705
C2	0.7705	0.0000	-0.6453	0.7500	0.0000	0.6248	0.6248	-0.6248	0.6248	0.6248	0.7500	0.0000	-0.5722	-0.6248	-0.6248	0.0000	0.6248	0.5000	0.6248	0.6248	-0.6248	0.7705
C3	-0.6248	0.0000	0.0000	-0.7705	-0.5000	-0.7500	-0.6248	0.7705	-0.6248	-0.6248	0.0000	0.0000	0.6248	0.6248	0.0000	0.6248	-0.6248	-0.6248	0.0000	-0.6248	0.6248	-0.7500
C4	0.6355	0.7500	-0.6453	0.0000	0.7705	0.1244	0.0000	-0.6248	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7705	0.7705	-0.5000	0.7500	-0.6248	0.6453
C5	0.7500	0.6248	-0.7705	0.7705	0.0000	0.5000	0.0000	-0.5000	0.3753	0.3753	0.5000	0.0000	-0.5000	0.0000	0.0000	-0.7705	0.7705	0.7500	0.0000	0.6248	-0.6248	0.7500
C6	0.0000	0.0000	-0.3753	0.5221	0.0000	0.0000	0.0000	-0.6453	0.7705	0.7705	0.7705	0.6453	-0.6248	-0.7705	-0.6453	-0.6453	0.6453	0.7705	0.7500	0.7705	-0.7705	0.7705
C7	0.5000	0.6248	-0.6248	0.7500	0.0000	0.7500	0.0000	-0.7705	0.7705	0.7705	0.7500	0.6453	-0.7705	-0.7500	0.0000	-0.6248	0.6248	0.6248	0.0000	0.3753	-0.5000	0.6248
C8	0.0000	0.5000	0.6453	-0.3753	-0.6248	-0.6248	-0.6248	0.0000	0.0000	0.0000	-0.5000	-0.6453	0.6453	0.2834	0.0000	0.7705	-0.6453	-0.7500	0.6248	-0.7705	0.7705	-0.6248
C9	0.6248	0.5000	-0.6453	0.6453	0.6355	0.7705	0.7705	-0.6453	0.0000	0.0000	0.0000	0.7705	-0.6248	-0.7705	0.0000	-0.5000	0.0000	0.6248	-0.5000	0.5000	0.0000	0.6453
C10	0.6248	0.5000	-0.6453	0.6453	0.6355	0.7705	0.7705	-0.6453	0.0000	0.0000	0.0000	0.7705	-0.6248	-0.7705	0.0000	-0.5000	0.0000	0.6248	-0.5000	0.5000	0.0000	0.6453
C11	0.0000	0.0000	-0.6248	0.7500	0.0000	0.7705	0.7500	-0.7500	0.5000	0.5000	0.0000	0.7500	-0.7500	-0.7705	0.0000	-0.6248	0.7500	0.6248	0.0000	0.6248	-0.7500	0.7705
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5221	-0.7500	0.7500	0.7500	0.6453	0.0000	-0.6248	-0.6248	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6248	0.7705	-0.6248	-0.5000	-0.6248	-0.6248	0.7705	-0.5000	-0.5000	-0.6248	-0.6248	0.0000	0.7500	0.0000	0.7705	-0.5000	-0.6248	0.6248	-0.7705	0.6453	-0.7705
C14	-0.7500	0.0000	0.7705	-0.6248	0.0000	-0.6248	-0.7500	0.6453	-0.5000	-0.5000	0.0000	-0.5000	0.6453	0.0000	0.0000	0.6453	-0.6453	-0.6248	0.3753	-0.7500	0.7500	-0.7705
C15	-0.5000	-0.5000	0.5000	-0.5000	0.0000	-0.6248	-0.6248	0.6453	-0.6248	-0.6248	0.0000	-0.5000	0.6248	0.5000	0.0000	0.4716	0.0000	0.0000	0.0000	-0.6355	0.5000	-0.6248
C16	-0.6248	-0.6248	0.6248	-0.5000	-0.6453	-0.6248	0.0000	0.3753	0.0000	0.0000	0.0000	0.0000	0.3753	0.6248	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5206	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6248	0.7500	0.7500	-0.6248	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6248	0.0000	0.0000	0.0000	0.6248	-0.7705	0.7705
C18	0.0000	0.0000	-0.6248	0.5000	0.3753	0.7500	0.6248	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6453	-0.7705	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7705	0.6453	-0.6453	0.7705	0.0000	0.6248	0.6453	-0.6248	0.5000	0.5000	0.0000	0.6248	-0.6248	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7705
C20	0.0000	0.0000	-0.7500	0.7500	0.6453	0.7705	0.0000	-0.3753	0.7500	0.7500	0.7705	0.7705	-0.7500	-0.7500	-0.7705	-0.5000	0.6453	0.6248	0.5000	0.0000	-0.7705	0.7705
C21	0.0000	0.0000	0.6355	-0.6453	-0.5000	-0.6248	0.0000	0.6248	0.0000	0.0000	0.0000	-0.6248	0.6248	0.7500	0.0000	0.0000	-0.6248	-0.6248	0.0000	-0.7500	0.0000	-0.7705

Table A.17: Aggregated weights matrix for $\alpha - cut$ .20

α = 0.20	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7678	-0.6459	0.6240	0.7678	0.8915	0.6240	0.0000	0.7500	0.7500	0.6240	0.6240	-0.6240	-0.7955	-0.6240	-0.6240	0.7500	0.5000	0.0000	0.7500	-0.6240	0.7678
C2	0.7678	0.0000	-0.6419	0.7500	0.0000	0.6240	0.6240	-0.6240	0.6240	0.6240	0.7500	0.0000	-0.5599	-0.6240	-0.6240	0.0000	0.6240	0.5000	0.6240	0.6240	-0.6240	0.7678
C3	-0.6240	0.0000	0.0000	-0.7678	-0.5000	-0.7500	-0.6249	0.7678	-0.6240	-0.6240	0.0000	0.0000	0.6240	0.6240	0.0000	0.6240	-0.6240	-0.6240	0.0000	-0.6240	0.6240	-0.7500
C4	0.6343	0.7500	-0.6419	0.0000	0.7678	0.1222	0.0000	-0.6240	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7678	0.7678	-0.5000	0.7500	-0.6240	0.6419
C5	0.7500	0.6240	-0.7678	0.7678	0.0000	0.5000	0.0000	-0.5000	0.3760	0.3760	0.5000	0.0000	-0.5000	0.0000	0.0000	-0.7678	0.7678	0.7500	0.0000	0.6240	-0.6240	0.7500
C6	0.0000	0.0000	-0.3760	0.5189	0.0000	0.0000	0.0000	-0.6419	0.7678	0.7678	0.7678	0.6419	-0.6240	-0.7678	-0.6419	-0.6419	0.6419	0.7678	0.7500	0.7678	-0.7678	0.7678
C7	0.5000	0.6240	-0.6240	0.7500	0.0000	0.7500	0.0000	-0.7678	0.7678	0.7678	0.7500	0.6419	-0.7678	-0.7500	0.0000	-0.6240	0.6240	0.6240	0.0000	0.3760	-0.5000	0.6240
C8	0.0000	0.5000	0.6419	-0.3760	-0.6240	-0.6240	-0.6240	0.0000	0.0000	0.0000	-0.5000	-0.6419	0.6419	0.2785	0.0000	0.7678	-0.6419	-0.7500	0.6240	-0.7678	0.7678	-0.6240
C9	0.6240	0.5000	-0.6419	0.6419	0.6343	0.7678	0.7678	-0.6419	0.0000	0.0000	0.0000	0.7678	-0.6240	-0.7678	0.0000	-0.5000	0.0000	0.6240	-0.5000	0.5000	0.0000	0.6419
C10	0.6240	0.5000	-0.6419	0.6419	0.6343	0.7678	0.7678	-0.6419	0.0000	0.0000	0.0000	0.7678	-0.6240	-0.7678	0.0000	-0.5000	0.0000	0.6240	-0.5000	0.5000	0.0000	0.6419
C11	0.0000	0.0000	-0.6240	0.7500	0.0000	0.7678	0.7500	-0.7500	0.5000	0.5000	0.0000	0.7500	-0.7500	-0.7678	0.0000	-0.6240	0.7500	0.6240	0.0000	0.6240	-0.7500	0.7678
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5189	-0.7500	0.7500	0.7500	0.6419	0.0000	-0.6240	-0.6240	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6240	0.7678	-0.6240	-0.5000	-0.6240	-0.6240	0.7678	-0.5000	-0.5000	-0.6240	-0.6240	0.0000	0.7500	0.0000	0.7678	-0.5000	-0.6240	0.6240	-0.7678	0.6419	-0.7678
C14	-0.7500	0.0000	0.7678	-0.6240	0.0000	-0.6240	-0.7500	0.6419	-0.5000	-0.5000	0.0000	-0.5000	0.6419	0.0000	0.0000	0.6419	-0.6419	-0.6240	0.3760	-0.7500	0.7500	-0.7678
C15	-0.5000	-0.5000	0.5000	-0.5000	0.0000	-0.6240	-0.6240	0.6419	-0.6240	-0.6240	0.0000	-0.5000	0.6240	0.5000	0.0000	0.4714	0.0000	0.0000	0.0000	-0.6343	0.5000	-0.6240
C16	-0.6240	-0.6240	0.6240	-0.5000	-0.6419	-0.6240	0.0000	0.3760	0.0000	0.0000	0.0000	0.0000	0.3760	0.6240	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5179	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6240	0.7500	0.7500	-0.6240	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6240	0.0000	0.0000	0.0000	0.6240	-0.7678	0.7678
C18	0.0000	0.0000	-0.6240	0.5000	0.3760	0.7500	0.6240	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6419	-0.7678	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7678	0.6419	-0.6419	0.7678	0.0000	0.6240	0.6419	-0.6240	0.5000	0.5000	0.0000	0.6240	-0.6240	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7678
C20	0.0000	0.0000	-0.7500	0.7500	0.6419	0.7678	0.0000	-0.3760	0.7500	0.7500	0.7678	0.7678	-0.7500	-0.7500	-0.7678	-0.5000	0.6419	0.6240	0.5000	0.0000	-0.7678	0.7678
C21	0.0000	0.0000	0.6343	-0.6419	-0.5000	-0.6240	0.0000	0.6240	0.0000	0.0000	0.0000	-0.6240	0.6240	0.7500	0.0000	0.0000	-0.6240	-0.6240	0.0000	-0.7500	0.0000	-0.7678

Table A.18: Aggregated weights matrix for $\alpha - cut$ .15

α = 0.15	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7646	-0.6466	0.6246	0.7646	0.8890	0.6246	0.0000	0.7500	0.7500	0.6246	0.6246	-0.6246	-0.7966	-0.6246	-0.6246	0.7500	0.5000	0.0000	0.7500	-0.6246	0.7646
C2	0.7646	0.0000	-0.6392	0.7500	0.0000	0.6246	0.6246	-0.6246	0.6246	0.6246	0.7500	0.0000	-0.5472	-0.6246	-0.6246	0.0000	0.6246	0.5000	0.6246	0.6246	-0.6246	0.7646
C3	-0.6246	0.0000	0.0000	-0.7646	-0.5000	-0.7500	-0.6248	0.7646	-0.6246	-0.6246	0.0000	0.0000	0.6246	0.6246	0.0000	0.6246	-0.6246	-0.6246	0.0000	-0.6246	0.6246	-0.7500
C4	0.6333	0.7500	-0.6392	0.0000	0.7646	0.1241	0.0000	-0.6246	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7646	0.7646	-0.5000	0.7500	-0.6246	0.6392
C5	0.7500	0.6246	-0.7646	0.7646	0.0000	0.5000	0.0000	-0.5000	0.3754	0.3754	0.5000	0.0000	-0.5000	0.0000	0.0000	-0.7646	0.7646	0.7500	0.0000	0.6246	-0.6246	0.7500
C6	0.0000	0.0000	-0.3754	0.5152	0.0000	0.0000	0.0000	-0.6392	0.7646	0.7646	0.7646	0.6392	-0.6246	-0.7646	-0.6392	-0.6392	0.6392	0.7646	0.7500	0.7646	-0.7646	0.7646
C7	0.5000	0.6246	-0.6246	0.7500	0.0000	0.7500	0.0000	-0.7646	0.7646	0.7646	0.7500	0.6392	-0.7646	-0.7500	0.0000	-0.6246	0.6246	0.6246	0.0000	0.3754	-0.5000	0.6246
C8	0.0000	0.5000	0.6392	-0.3754	-0.6246	-0.6246	-0.6246	0.0000	0.0000	0.0000	-0.5000	-0.6392	0.6392	0.2729	0.0000	0.7646	-0.6392	-0.7500	0.6246	-0.7646	0.7646	-0.6246
C9	0.6246	0.5000	-0.6392	0.6392	0.6333	0.7646	0.7646	-0.6392	0.0000	0.0000	0.0000	0.7646	-0.6246	-0.7646	0.0000	-0.5000	0.0000	0.6246	-0.5000	0.5000	0.0000	0.6392
C10	0.6246	0.5000	-0.6392	0.6392	0.6333	0.7646	0.7646	-0.6392	0.0000	0.0000	0.0000	0.7646	-0.6246	-0.7646	0.0000	-0.5000	0.0000	0.6246	-0.5000	0.5000	0.0000	0.6392
C11	0.0000	0.0000	-0.6246	0.7500	0.0000	0.7646	0.7500	-0.7500	0.5000	0.5000	0.0000	0.7500	-0.7500	-0.7646	0.0000	-0.6246	0.7500	0.6246	0.0000	0.6246	-0.7500	0.7646
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5152	-0.7500	0.7500	0.7500	0.6392	0.0000	-0.6246	-0.6246	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6246	0.7646	-0.6246	-0.5000	-0.6246	-0.6246	0.7646	-0.5000	-0.5000	-0.6246	-0.6246	0.0000	0.7500	0.0000	0.7646	-0.5000	-0.6246	0.6246	-0.7646	0.6392	-0.7646
C14	-0.7500	0.0000	0.7646	-0.6246	0.0000	-0.6246	-0.7500	0.6392	-0.5000	-0.5000	0.0000	-0.5000	0.6392	0.0000	0.0000	0.6392	-0.6392	-0.6246	0.3754	-0.7500	0.7500	-0.7646
C15	-0.5000	-0.5000	0.5000	-0.5000	0.0000	-0.6246	-0.6246	0.6392	-0.6246	-0.6246	0.0000	-0.5000	0.6246	0.5000	0.0000	0.4695	0.0000	0.0000	0.0000	-0.6333	0.5000	-0.6246
C16	-0.6246	-0.6246	0.6246	-0.5000	-0.6392	-0.6246	0.0000	0.3754	0.0000	0.0000	0.0000	0.0000	0.3754	0.6246	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5146	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6246	0.7500	0.7500	-0.6246	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6246	0.0000	0.0000	0.0000	0.6246	-0.7646	0.7646
C18	0.0000	0.0000	-0.6246	0.5000	0.3754	0.7500	0.6246	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6392	-0.7646	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7646	0.6392	-0.6392	0.7646	0.0000	0.6246	0.6392	-0.6246	0.5000	0.5000	0.0000	0.6246	-0.6246	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7646
C20	0.0000	0.0000	-0.7500	0.7500	0.6392	0.7646	0.0000	-0.3754	0.7500	0.7500	0.7646	0.7646	-0.7500	-0.7500	-0.7646	-0.5000	0.6392	0.6246	0.5000	0.0000	-0.7646	0.7646
C21	0.0000	0.0000	0.6333	-0.6392	-0.5000	-0.6246	0.0000	0.6246	0.0000	0.0000	0.0000	-0.6246	0.6246	0.7500	0.0000	0.0000	-0.6246	-0.6246	0.0000	-0.7500	0.0000	-0.7646

Table A.19: Aggregated weights matrix for $\alpha - cut$ .10

α = 0.10	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7619	-0.6472	0.6240	0.7619	0.8858	0.6240	0.0000	0.7500	0.7500	0.6240	0.6240	-0.6240	-0.7973	-0.6240	-0.6240	0.7500	0.5000	0.0000	0.7500	-0.6240	0.7619
C2	0.7619	0.0000	-0.6359	0.7500	0.0000	0.6240	0.6240	-0.6240	0.6240	0.6240	0.7500	0.0000	-0.5330	-0.6240	-0.6240	0.0000	0.6240	0.5000	0.6240	0.6240	-0.6240	0.7619
C3	-0.6240	0.0000	0.0000	-0.7619	-0.5000	-0.7500	-0.6248	0.7619	-0.6240	-0.6240	0.0000	0.0000	0.6240	0.6240	0.0000	0.6240	-0.6240	-0.6240	0.0000	-0.6240	0.6240	-0.7500
C4	0.6322	0.7500	-0.6359	0.0000	0.7619	0.1224	0.0000	-0.6240	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7619	0.7619	-0.5000	0.7500	-0.6240	0.6359
C5	0.7500	0.6240	-0.7619	0.7619	0.0000	0.5000	0.0000	-0.5000	0.3760	0.3760	0.5000	0.0000	-0.5000	0.0000	0.0000	-0.7619	0.7619	0.7500	0.0000	0.6240	-0.6240	0.7500
C6	0.0000	0.0000	-0.3760	0.5123	0.0000	0.0000	0.0000	-0.6359	0.7619	0.7619	0.7619	0.6359	-0.6240	-0.7619	-0.6359	-0.6359	0.6359	0.7619	0.7500	0.7619	-0.7619	0.7619
C7	0.5000	0.6240	-0.6240	0.7500	0.0000	0.7500	0.0000	-0.7619	0.7619	0.7619	0.7500	0.6359	-0.7619	-0.7500	0.0000	-0.6240	0.6240	0.6240	0.0000	0.3760	-0.5000	0.6240
C8	0.0000	0.5000	0.6359	-0.3760	-0.6240	-0.6240	-0.6240	0.0000	0.0000	0.0000	-0.5000	-0.6359	0.6359	0.2685	0.0000	0.7619	-0.6359	-0.7500	0.6240	-0.7619	0.7619	-0.6240
C9	0.6240	0.5000	-0.6359	0.6359	0.6322	0.7619	0.7619	-0.6359	0.0000	0.0000	0.0000	0.7619	-0.6240	-0.7619	0.0000	-0.5000	0.0000	0.6240	-0.5000	0.5000	0.0000	0.6359
C10	0.6240	0.5000	-0.6359	0.6359	0.6322	0.7619	0.7619	-0.6359	0.0000	0.0000	0.0000	0.7619	-0.6240	-0.7619	0.0000	-0.5000	0.0000	0.6240	-0.5000	0.5000	0.0000	0.6359
C11	0.0000	0.0000	-0.6240	0.7500	0.0000	0.7619	0.7500	-0.7500	0.5000	0.5000	0.0000	0.7500	-0.7500	-0.7619	0.0000	-0.6240	0.7500	0.6240	0.0000	0.6240	-0.7500	0.7619
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5123	-0.7500	0.7500	0.7500	0.6359	0.0000	-0.6240	-0.6240	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6240	0.7619	-0.6240	-0.5000	-0.6240	-0.6240	0.7619	-0.5000	-0.5000	-0.6240	-0.6240	0.0000	0.7500	0.0000	0.7619	-0.5000	-0.6240	0.6240	-0.7619	0.6359	-0.7619
C14	-0.7500	0.0000	0.7619	-0.6240	0.0000	-0.6240	-0.7500	0.6359	-0.5000	-0.5000	0.0000	-0.5000	0.6359	0.0000	0.0000	0.6359	-0.6359	-0.6240	0.3760	-0.7500	0.7500	-0.7619
C15	-0.5000	-0.5000	0.5000	-0.5000	0.0000	-0.6240	-0.6240	0.6359	-0.6240	-0.6240	0.0000	-0.5000	0.6240	0.5000	0.0000	0.4690	0.0000	0.0000	0.0000	-0.6322	0.5000	-0.6240
C16	-0.6240	-0.6240	0.6240	-0.5000	-0.6359	-0.6240	0.0000	0.3760	0.0000	0.0000	0.0000	0.0000	0.3760	0.6240	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5120	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6240	0.7500	0.7500	-0.6240	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6240	0.0000	0.0000	0.0000	0.6240	-0.7619	0.7619
C18	0.0000	0.0000	-0.6240	0.5000	0.3760	0.7500	0.6240	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6359	-0.7619	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7619	0.6359	-0.6359	0.7619	0.0000	0.6240	0.6359	-0.6240	0.5000	0.5000	0.0000	0.6240	-0.6240	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7619
C20	0.0000	0.0000	-0.7500	0.7500	0.6359	0.7619	0.0000	-0.3760	0.7500	0.7500	0.7619	0.7619	-0.7500	-0.7500	-0.7619	-0.5000	0.6359	0.6240	0.5000	0.0000	-0.7619	0.7619
C21	0.0000	0.0000	0.6322	-0.6359	-0.5000	-0.6240	0.0000	0.6240	0.0000	0.0000	0.0000	-0.6240	0.6240	0.7500	0.0000	0.0000	-0.6240	-0.6240	0.0000	-0.7500	0.0000	-0.7619

Table A.20: Aggregated weights matrix for $\alpha - cut$ .05

α = 0.05	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	HR
C1	0.0000	0.7600	-0.6478	0.6220	0.7600	0.8819	0.6220	0.0000	0.7500	0.7500	0.6220	0.6220	-0.6220	-0.7979	-0.6220	-0.6220	0.7500	0.5000	0.0000	0.7500	-0.6220	0.7600
C2	0.7600	0.0000	-0.6320	0.7500	0.0000	0.6220	0.6220	-0.6220	0.6220	0.6220	0.7500	0.0000	-0.5172	-0.6220	-0.6220	0.0000	0.6220	0.5000	0.6220	0.6220	-0.6220	0.7600
C3	-0.6220	0.0000	0.0000	-0.7600	-0.5000	-0.7500	-0.6249	0.7600	-0.6220	-0.6220	0.0000	0.0000	0.6220	0.6220	0.0000	0.6220	-0.6220	-0.6220	0.0000	-0.6220	0.6220	-0.7500
C4	0.6307	0.7500	-0.6320	0.0000	0.7600	0.1173	0.0000	-0.6220	0.0000	0.0000	0.7500	0.0000	-0.7500	-0.7500	0.0000	-0.5000	0.7600	0.7600	-0.5000	0.7500	-0.6220	0.6320
C5	0.7500	0.6220	-0.7600	0.7600	0.0000	0.5000	0.0000	-0.5000	0.3780	0.3780	0.5000	0.0000	-0.5000	0.0000	0.0000	-0.7600	0.7600	0.7500	0.0000	0.6220	-0.6220	0.7500
C6	0.0000	0.0000	-0.3780	0.5102	0.0000	0.0000	0.0000	-0.6320	0.7600	0.7600	0.7600	0.6320	-0.6220	-0.7600	-0.6320	-0.6320	0.6320	0.7600	0.7500	0.7600	-0.7600	0.7600
C7	0.5000	0.6220	-0.6220	0.7500	0.0000	0.7500	0.0000	-0.7600	0.7600	0.7600	0.7500	0.6320	-0.7600	-0.7500	0.0000	-0.6220	0.6220	0.6220	0.0000	0.3780	-0.5000	0.6220
C8	0.0000	0.5000	0.6320	-0.3780	-0.6220	-0.6220	-0.6220	0.0000	0.0000	0.0000	-0.5000	-0.6320	0.6320	0.2653	0.0000	0.7600	-0.6320	-0.7500	0.6220	-0.7600	0.7600	-0.6220
C9	0.6220	0.5000	-0.6320	0.6320	0.6307	0.7600	0.7600	-0.6320	0.0000	0.0000	0.0000	0.7600	-0.6220	-0.7600	0.0000	-0.5000	0.0000	0.6220	-0.5000	0.5000	0.0000	0.6320
C10	0.6220	0.5000	-0.6320	0.6320	0.6307	0.7600	0.7600	-0.6320	0.0000	0.0000	0.0000	0.7600	-0.6220	-0.7600	0.0000	-0.5000	0.0000	0.6220	-0.5000	0.5000	0.0000	0.6320
C11	0.0000	0.0000	-0.6220	0.7500	0.0000	0.7600	0.7500	-0.7500	0.5000	0.5000	0.0000	0.7500	-0.7500	-0.7600	0.0000	-0.6220	0.7500	0.6220	0.0000	0.6220	-0.7500	0.7600
C12	0.0000	0.0000	-0.7500	0.5000	0.0000	0.7500	0.5102	-0.7500	0.7500	0.7500	0.6320	0.0000	-0.6220	-0.6220	0.0000	-0.7500	0.7500	0.5000	0.0000	0.5000	-0.2500	0.7500
C13	-0.5000	-0.6220	0.7600	-0.6220	-0.5000	-0.6220	-0.6220	0.7600	-0.5000	-0.5000	-0.6220	-0.6220	0.0000	0.7500	0.0000	0.7600	-0.5000	-0.6220	0.6220	-0.7600	0.6320	-0.7600
C14	-0.7500	0.0000	0.7600	-0.6220	0.0000	-0.6220	-0.7500	0.6320	-0.5000	-0.5000	0.0000	-0.5000	0.6320	0.0000	0.0000	0.6320	-0.6320	-0.6220	0.3780	-0.7500	0.7500	-0.7600
C15	-0.5000	-0.5000	0.5000	-0.5000	0.0000	-0.6220	-0.6220	0.6320	-0.6220	-0.6220	0.0000	-0.5000	0.6220	0.5000	0.0000	0.4698	0.0000	0.0000	0.0000	-0.6307	0.5000	-0.6220
C16	-0.6220	-0.6220	0.6220	-0.5000	-0.6320	-0.6220	0.0000	0.3780	0.0000	0.0000	0.0000	0.0000	0.3780	0.6220	0.0000	0.0000	-0.7500	0.0000	0.0000	0.0000	0.5100	-0.5000
C17	0.0000	0.0000	-0.7500	0.7500	0.6220	0.7500	0.7500	-0.6220	0.0000	0.0000	0.0000	0.7500	-0.5000	-0.7500	0.0000	-0.6220	0.0000	0.0000	0.0000	0.6220	-0.7600	0.7600
C18	0.0000	0.0000	-0.6220	0.5000	0.3780	0.7500	0.6220	-0.7500	0.0000	0.0000	0.0000	0.7500	-0.6320	-0.7600	0.0000	-0.7500	0.7500	0.0000	0.0000	0.7500	-0.7500	0.0000
C19	0.7600	0.6320	-0.6320	0.7600	0.0000	0.6220	0.6320	-0.6220	0.5000	0.5000	0.0000	0.6220	-0.6220	-0.5000	0.0000	0.0000	0.7500	0.0000	0.0000	0.7500	-0.7500	0.7600
C20	0.0000	0.0000	-0.7500	0.7500	0.6320	0.7600	0.0000	-0.3780	0.7500	0.7500	0.7600	0.7600	-0.7500	-0.7500	-0.7600	-0.5000	0.6320	0.6220	0.5000	0.0000	-0.7600	0.7600
C21	0.0000	0.0000	0.6307	-0.6320	-0.5000	-0.6220	0.0000	0.6220	0.0000	0.0000	0.0000	-0.6220	0.6220	0.7500	0.0000	0.0000	-0.6220	-0.6220	0.0000	-0.7500	0.0000	-0.7600

B VARIATION TABLES FOR POSITIVE PIFS RELATIONS

Table B.1: Variations of positive relationship weights for different $\alpha - cuts$

	C1-C2	C1-C5	C1-C6	C1-HR	C6-C4	C6-C17	C6-C20	C6-HR	C7-C9	C7-C10
α-cut 1.00	0.7985	0.7985	0.9231	0.7985	0.5591	0.6732	0.7985	0.7985	0.7985	0.7985
α-cut 0.95	0.7979	0.7979	0.9225	0.7979	0.5584	0.6728	0.7979	0.7979	0.7979	0.7979
α-cut 0.90	0.7973	0.7973	0.9218	0.7973	0.5578	0.6723	0.7973	0.7973	0.7973	0.7973
α-cut 0.85	0.7966	0.7966	0.9207	0.7966	0.5569	0.6715	0.7966	0.7966	0.7966	0.7966
α-cut 0.80	0.7955	0.7955	0.9194	0.7955	0.5555	0.6707	0.7955	0.7955	0.7955	0.7955
α-cut 0.75	0.7945	0.7945	0.9179	0.7945	0.5543	0.6696	0.7945	0.7945	0.7945	0.7945
α-cut 0.70	0.7931	0.7931	0.9162	0.7931	0.5525	0.6683	0.7931	0.7931	0.7931	0.7931
α-cut 0.65	0.7914	0.7914	0.9143	0.7914	0.5503	0.6668	0.7914	0.7914	0.7914	0.7914
α-cut 0.60	0.7897	0.7897	0.9122	0.7897	0.5480	0.6650	0.7897	0.7897	0.7897	0.7897
α-cut 0.55	0.7875	0.7875	0.9101	0.7875	0.5448	0.6629	0.7875	0.7875	0.7875	0.7875
α-cut 0.50	0.7849	0.7849	0.9078	0.7849	0.5412	0.6602	0.7849	0.7849	0.7849	0.7849
α-cut 0.45	0.7822	0.7822	0.9053	0.7822	0.5372	0.6572	0.7822	0.7822	0.7822	0.7822
α-cut 0.40	0.7791	0.7791	0.9029	0.7791	0.5330	0.6544	0.7791	0.7791	0.7791	0.7791
α-cut 0.35	0.7764	0.7764	0.9002	0.7764	0.5295	0.6512	0.7764	0.7764	0.7764	0.7764
α-cut 0.30	0.7735	0.7735	0.8975	0.7735	0.5258	0.6483	0.7735	0.7735	0.7735	0.7735
α-cut 0.25	0.7705	0.7705	0.8948	0.7705	0.5221	0.6453	0.7705	0.7705	0.7705	0.7705
α-cut 0.20	0.7678	0.7678	0.8915	0.7678	0.5189	0.6419	0.7678	0.7678	0.7678	0.7678
α-cut 0.15	0.7646	0.7646	0.8890	0.7646	0.5152	0.6392	0.7646	0.7646	0.7646	0.7646
α-cut 0.10	0.7619	0.7619	0.8858	0.7619	0.5123	0.6359	0.7619	0.7619	0.7619	0.7619
α-cut 0.05	0.7600	0.7600	0.8819	0.7600	0.5102	0.6320	0.7600	0.7600	0.7600	0.7600

Table B.2: Variations of positive relationship weights for different $\alpha - cuts$

	C7-C12	C8-C3	C8-C14	C8-C16	C8-C21	C9-C4	C9-C6	C9-C7	C9-HR	C10-C4
α-cut 1.00	0.6732	0.6732	0.3410	0.7985	0.7985	0.6732	0.7985	0.7985	0.6732	0.6732
α-cut 0.95	0.6728	0.6728	0.3399	0.7979	0.7979	0.6728	0.7979	0.7979	0.6728	0.6728
α-cut 0.90	0.6723	0.6723	0.3389	0.7973	0.7973	0.6723	0.7973	0.7973	0.6723	0.6723
α-cut 0.85	0.6715	0.6715	0.3376	0.7966	0.7966	0.6715	0.7966	0.7966	0.6715	0.6715
α-cut 0.80	0.6707	0.6707	0.3356	0.7955	0.7955	0.6707	0.7955	0.7955	0.6707	0.6707
α-cut 0.75	0.6696	0.6696	0.3337	0.7945	0.7945	0.6696	0.7945	0.7945	0.6696	0.6696
α-cut 0.70	0.6683	0.6683	0.3309	0.7931	0.7931	0.6683	0.7931	0.7931	0.6683	0.6683
α-cut 0.65	0.6668	0.6668	0.3276	0.7914	0.7914	0.6668	0.7914	0.7914	0.6668	0.6668
α-cut 0.60	0.6650	0.6650	0.3241	0.7897	0.7897	0.6650	0.7897	0.7897	0.6650	0.6650
α-cut 0.55	0.6629	0.6629	0.3191	0.7875	0.7875	0.6629	0.7875	0.7875	0.6629	0.6629
α-cut 0.50	0.6602	0.6602	0.3133	0.7849	0.7849	0.6602	0.7849	0.7849	0.6602	0.6602
α-cut 0.45	0.6572	0.6572	0.3070	0.7822	0.7822	0.6572	0.7822	0.7822	0.6572	0.6572
α-cut 0.40	0.6544	0.6544	0.3005	0.7791	0.7791	0.6544	0.7791	0.7791	0.6544	0.6544
α-cut 0.35	0.6512	0.6512	0.2950	0.7764	0.7764	0.6512	0.7764	0.7764	0.6512	0.6512
α-cut 0.30	0.6483	0.6483	0.2892	0.7735	0.7735	0.6483	0.7735	0.7735	0.6483	0.6483
α-cut 0.25	0.6453	0.6453	0.2834	0.7705	0.7705	0.6453	0.7705	0.7705	0.6453	0.6453
α-cut 0.20	0.6419	0.6419	0.2785	0.7678	0.7678	0.6419	0.7678	0.7678	0.6419	0.6419
α-cut 0.15	0.6392	0.6392	0.2729	0.7646	0.7646	0.6392	0.7646	0.7646	0.6392	0.6392
α-cut 0.10	0.6359	0.6359	0.2685	0.7619	0.7619	0.6359	0.7619	0.7619	0.6359	0.6359
α-cut 0.05	0.6320	0.6320	0.2653	0.7600	0.7600	0.6320	0.7600	0.7600	0.6320	0.6320

Table B.3: Variations of positive relationship weights for different $\alpha - cuts$

	C10-C6	C10-C7	C10-C12	C10-HR	C11-C6	C11-HR	C12-C7	C12-C11	C13-C3	C13-C8
α-cut 1.00	0.7985	0.7985	0.7985	0.6732	0.7985	0.7985	0.5591	0.6732	0.7985	0.7985
α-cut 0.95	0.7979	0.7979	0.7979	0.6728	0.7979	0.7979	0.5584	0.6728	0.7979	0.7979
α-cut 0.90	0.7973	0.7973	0.7973	0.6723	0.7973	0.7973	0.5578	0.6723	0.7973	0.7973
α-cut 0.85	0.7966	0.7966	0.7966	0.6715	0.7966	0.7966	0.5569	0.6715	0.7966	0.7966
α-cut 0.80	0.7955	0.7955	0.7955	0.6707	0.7955	0.7955	0.5555	0.6707	0.7955	0.7955
α-cut 0.75	0.7945	0.7945	0.7945	0.6696	0.7945	0.7945	0.5543	0.6696	0.7945	0.7945
α-cut 0.70	0.7931	0.7931	0.7931	0.6683	0.7931	0.7931	0.5525	0.6683	0.7931	0.7931
α-cut 0.65	0.7914	0.7914	0.7914	0.6668	0.7914	0.7914	0.5503	0.6668	0.7914	0.7914
α-cut 0.60	0.7897	0.7897	0.7897	0.6650	0.7897	0.7897	0.5480	0.6650	0.7897	0.7897
α-cut 0.55	0.7875	0.7875	0.7875	0.6629	0.7875	0.7875	0.5448	0.6629	0.7875	0.7875
α-cut 0.50	0.7849	0.7849	0.7849	0.6602	0.7849	0.7849	0.5412	0.6602	0.7849	0.7849
α-cut 0.45	0.7822	0.7822	0.7822	0.6572	0.7822	0.7822	0.5372	0.6572	0.7822	0.7822
α-cut 0.40	0.7791	0.7791	0.7791	0.6544	0.7791	0.7791	0.5330	0.6544	0.7791	0.7791
α-cut 0.35	0.7764	0.7764	0.7764	0.6512	0.7764	0.7764	0.5295	0.6512	0.7764	0.7764
α-cut 0.30	0.7735	0.7735	0.7735	0.6483	0.7735	0.7735	0.5258	0.6483	0.7735	0.7735
α-cut 0.25	0.7705	0.7705	0.7705	0.6453	0.7705	0.7705	0.5221	0.6453	0.7705	0.7705
α-cut 0.20	0.7678	0.7678	0.7678	0.6419	0.7678	0.7678	0.5189	0.6419	0.7678	0.7678
α-cut 0.15	0.7646	0.7646	0.7646	0.6392	0.7646	0.7646	0.5152	0.6392	0.7646	0.7646
α-cut 0.10	0.7619	0.7619	0.7619	0.6359	0.7619	0.7619	0.5123	0.6359	0.7619	0.7619
α-cut 0.05	0.7600	0.7600	0.7600	0.6320	0.7600	0.7600	0.5102	0.6320	0.7600	0.7600

Table B.4: Variations of positive relationship weights for different $\alpha - cuts$

	C13-C16	C13-C21	C14-C3	C14-C8	C14-C13	C14-C16	C15-C8	C16-C21	C17-CHR	C19-C1
α-cut 1.00	0.7985	0.6732	0.7985	0.6732	0.6732	0.6732	0.6732	0.5485	0.7985	0.7985
α-cut 0.95	0.7979	0.6728	0.7979	0.6728	0.6728	0.6728	0.6728	0.5480	0.7979	0.7979
α-cut 0.90	0.7973	0.6723	0.7973	0.6723	0.6723	0.6723	0.6723	0.5475	0.7973	0.7973
α-cut 0.85	0.7966	0.6715	0.7966	0.6715	0.6715	0.6715	0.6715	0.5468	0.7966	0.7966
α-cut 0.80	0.7955	0.6707	0.7955	0.6707	0.6707	0.6707	0.6707	0.5459	0.7955	0.7955
α-cut 0.75	0.7945	0.6696	0.7945	0.6696	0.6696	0.6696	0.6696	0.5450	0.7945	0.7945
α-cut 0.70	0.7931	0.6683	0.7931	0.6683	0.6683	0.6683	0.6683	0.5437	0.7931	0.7931
α-cut 0.65	0.7914	0.6668	0.7914	0.6668	0.6668	0.6668	0.6668	0.5422	0.7914	0.7914
α-cut 0.60	0.7897	0.6650	0.7897	0.6650	0.6650	0.6650	0.6650	0.5406	0.7897	0.7897
α-cut 0.55	0.7875	0.6629	0.7875	0.6629	0.6629	0.6629	0.6629	0.5383	0.7875	0.7875
α-cut 0.50	0.7849	0.6602	0.7849	0.6602	0.6602	0.6602	0.6602	0.5357	0.7849	0.7849
α-cut 0.45	0.7822	0.6572	0.7822	0.6572	0.6572	0.6572	0.6572	0.5328	0.7822	0.7822
α-cut 0.40	0.7791	0.6544	0.7791	0.6544	0.6544	0.6544	0.6544	0.5296	0.7791	0.7791
α-cut 0.35	0.7764	0.6512	0.7764	0.6512	0.6512	0.6512	0.6512	0.5268	0.7764	0.7764
α-cut 0.30	0.7735	0.6483	0.7735	0.6483	0.6483	0.6483	0.6483	0.5238	0.7735	0.7735
α-cut 0.25	0.7705	0.6453	0.7705	0.6453	0.6453	0.6453	0.6453	0.5206	0.7705	0.7705
α-cut 0.20	0.7678	0.6419	0.7678	0.6419	0.6419	0.6419	0.6419	0.5179	0.7678	0.7678
α-cut 0.15	0.7646	0.6392	0.7646	0.6392	0.6392	0.6392	0.6392	0.5146	0.7646	0.7646
α-cut 0.10	0.7619	0.6359	0.7619	0.6359	0.6359	0.6359	0.6359	0.5120	0.7619	0.7619
α-cut 0.05	0.7600	0.6320	0.7600	0.6320	0.6320	0.6320	0.6320	0.5100	0.7600	0.7600

Table B.5: Variations of positive relationship weights for different $\alpha - cuts$

	C19-C2	C19-C4	C19-C7	C19-CHR	C20-C5	C20-C6	C20-C11	C20-C12	C20-C17	C20-CHR
α-cut 1.00	0.6732	0.7985	0.6732	0.7985	0.6732	0.7985	0.7985	0.7985	0.6732	0.7985
α-cut 0.95	0.6728	0.7979	0.6728	0.7979	0.6728	0.7979	0.7979	0.7979	0.6728	0.7979
α-cut 0.90	0.6723	0.7973	0.6723	0.7973	0.6723	0.7973	0.7973	0.7973	0.6723	0.7973
α-cut 0.85	0.6715	0.7966	0.6715	0.7966	0.6715	0.7966	0.7966	0.7966	0.6715	0.7966
α-cut 0.80	0.6707	0.7955	0.6707	0.7955	0.6707	0.7955	0.7955	0.7955	0.6707	0.7955
α-cut 0.75	0.6696	0.7945	0.6696	0.7945	0.6696	0.7945	0.7945	0.7945	0.6696	0.7945
α-cut 0.70	0.6683	0.7931	0.6683	0.7931	0.6683	0.7931	0.7931	0.7931	0.6683	0.7931
α-cut 0.65	0.6668	0.7914	0.6668	0.7914	0.6668	0.7914	0.7914	0.7914	0.6668	0.7914
α-cut 0.60	0.6650	0.7897	0.6650	0.7897	0.6650	0.7897	0.7897	0.7897	0.6650	0.7897
α-cut 0.55	0.6629	0.7875	0.6629	0.7875	0.6629	0.7875	0.7875	0.7875	0.6629	0.7875
α-cut 0.50	0.6602	0.7849	0.6602	0.7849	0.6602	0.7849	0.7849	0.7849	0.6602	0.7849
α-cut 0.45	0.6572	0.7822	0.6572	0.7822	0.6572	0.7822	0.7822	0.7822	0.6572	0.7822
α-cut 0.40	0.6544	0.7791	0.6544	0.7791	0.6544	0.7791	0.7791	0.7791	0.6544	0.7791
α-cut 0.35	0.6512	0.7764	0.6512	0.7764	0.6512	0.7764	0.7764	0.7764	0.6512	0.7764
α-cut 0.30	0.6483	0.7735	0.6483	0.7735	0.6483	0.7735	0.7735	0.7735	0.6483	0.7735
α-cut 0.25	0.6453	0.7705	0.6453	0.7705	0.6453	0.7705	0.7705	0.7705	0.6453	0.7705
α-cut 0.20	0.6419	0.7678	0.6419	0.7678	0.6419	0.7678	0.7678	0.7678	0.6419	0.7678
α-cut 0.15	0.6392	0.7646	0.6392	0.7646	0.6392	0.7646	0.7646	0.7646	0.6392	0.7646
α-cut 0.10	0.6359	0.7619	0.6359	0.7619	0.6359	0.7619	0.7619	0.7619	0.6359	0.7619
α-cut 0.05	0.6320	0.7600	0.6320	0.7600	0.6320	0.7600	0.7600	0.7600	0.6320	0.7600

C VARIATION TABLES FOR NEGATIVE PIFS RELATIONS

Table C.1: Variations of negative relationship weights for different $\alpha - cuts$

	C2-C3	C2-C13	C3-C4	C4-C3	C5-C3	C5-C16	C6-C8	C6-C14	C6-C15	C6-C16
α-cut 1.00	-0.6732	-0.7500	-0.7985	-0.6732	-0.7985	-0.7985	-0.6732	-0.7985	-0.6732	-0.6732
α-cut 0.95	-0.6728	-0.7320	-0.7979	-0.6728	-0.7979	-0.7979	-0.6728	-0.7979	-0.6728	-0.6728
α-cut 0.90	-0.6723	-0.7165	-0.7973	-0.6723	-0.7973	-0.7973	-0.6723	-0.7973	-0.6723	-0.6723
α-cut 0.85	-0.6715	-0.7024	-0.7966	-0.6715	-0.7966	-0.7966	-0.6715	-0.7966	-0.6715	-0.6715
α-cut 0.80	-0.6707	-0.6893	-0.7955	-0.6707	-0.7955	-0.7955	-0.6707	-0.7955	-0.6707	-0.6707
α-cut 0.75	-0.6696	-0.6775	-0.7945	-0.6696	-0.7945	-0.7945	-0.6696	-0.7945	-0.6696	-0.6696
α-cut 0.70	-0.6683	-0.6661	-0.7931	-0.6683	-0.7931	-0.7931	-0.6683	-0.7931	-0.6683	-0.6683
α-cut 0.65	-0.6668	-0.6553	-0.7914	-0.6668	-0.7914	-0.7914	-0.6668	-0.7914	-0.6668	-0.6668
α-cut 0.60	-0.6650	-0.6450	-0.7897	-0.6650	-0.7897	-0.7897	-0.6650	-0.7897	-0.6650	-0.6650
α-cut 0.55	-0.6629	-0.6348	-0.7875	-0.6629	-0.7875	-0.7875	-0.6629	-0.7875	-0.6629	-0.6629
α-cut 0.50	-0.6602	-0.6248	-0.7849	-0.6602	-0.7849	-0.7849	-0.6602	-0.7849	-0.6602	-0.6602
α-cut 0.45	-0.6572	-0.6147	-0.7822	-0.6572	-0.7822	-0.7822	-0.6572	-0.7822	-0.6572	-0.6572
α-cut 0.40	-0.6544	-0.6046	-0.7791	-0.6544	-0.7791	-0.7791	-0.6544	-0.7791	-0.6544	-0.6544
α-cut 0.35	-0.6512	-0.5942	-0.7764	-0.6512	-0.7764	-0.7764	-0.6512	-0.7764	-0.6512	-0.6512
α-cut 0.30	-0.6483	-0.5834	-0.7735	-0.6483	-0.7735	-0.7735	-0.6483	-0.7735	-0.6483	-0.6483
α-cut 0.25	-0.6453	-0.5722	-0.7705	-0.6453	-0.7705	-0.7705	-0.6453	-0.7705	-0.6453	-0.6453
α-cut 0.20	-0.6419	-0.5599	-0.7678	-0.6419	-0.7678	-0.7678	-0.6419	-0.7678	-0.6419	-0.6419
α-cut 0.15	-0.6392	-0.5472	-0.7646	-0.6392	-0.7646	-0.7646	-0.6392	-0.7646	-0.6392	-0.6392
α-cut 0.10	-0.6359	-0.5330	-0.7619	-0.6359	-0.7619	-0.7619	-0.6359	-0.7619	-0.6359	-0.6359
α-cut 0.05	-0.6320	-0.5172	-0.7600	-0.6320	-0.7600	-0.7600	-0.6320	-0.7600	-0.6320	-0.6320

Table C.2: Variations of negative relationship weights for different $\alpha - cuts$

	C6-C21	C7-C8	C7-C13	C8-C12	C8-C17	C8-C20	C9-C3	C9-C8	C9-C14	C10-C3
α-cut 1.00	-0.79846	-0.79846	-0.79846	-0.67320	-0.67320	-0.79846	-0.67320	-0.67320	-0.79846	-0.67320
α-cut 0.95	-0.79789	-0.79789	-0.79789	-0.67283	-0.67283	-0.79789	-0.67283	-0.67283	-0.79789	-0.67283
α-cut 0.90	-0.79733	-0.79733	-0.79733	-0.67225	-0.67225	-0.79733	-0.67225	-0.67225	-0.79733	-0.67225
α-cut 0.85	-0.79658	-0.79658	-0.79658	-0.67151	-0.67151	-0.79658	-0.67151	-0.67151	-0.79658	-0.67151
α-cut 0.80	-0.79550	-0.79550	-0.79550	-0.67070	-0.67070	-0.79550	-0.67070	-0.67070	-0.79550	-0.67070
α-cut 0.75	-0.79445	-0.79445	-0.79445	-0.66955	-0.66955	-0.79445	-0.66955	-0.66955	-0.79445	-0.66955
α-cut 0.70	-0.79305	-0.79305	-0.79305	-0.66831	-0.66831	-0.79305	-0.66831	-0.66831	-0.79305	-0.66831
α-cut 0.65	-0.79144	-0.79144	-0.79144	-0.66684	-0.66684	-0.79144	-0.66684	-0.66684	-0.79144	-0.66684
α-cut 0.60	-0.78972	-0.78972	-0.78972	-0.66496	-0.66496	-0.78972	-0.66496	-0.66496	-0.78972	-0.66496
α-cut 0.55	-0.78745	-0.78745	-0.78745	-0.66290	-0.66290	-0.78745	-0.66290	-0.66290	-0.78745	-0.66290
α-cut 0.50	-0.78494	-0.78494	-0.78494	-0.66023	-0.66023	-0.78494	-0.66023	-0.66023	-0.78494	-0.66023
α-cut 0.45	-0.78216	-0.78216	-0.78216	-0.65722	-0.65722	-0.78216	-0.65722	-0.65722	-0.78216	-0.65722
α-cut 0.40	-0.77913	-0.77913	-0.77913	-0.65437	-0.65437	-0.77913	-0.65437	-0.65437	-0.77913	-0.65437
α-cut 0.35	-0.77644	-0.77644	-0.77644	-0.65124	-0.65124	-0.77644	-0.65124	-0.65124	-0.77644	-0.65124
α-cut 0.30	-0.77350	-0.77350	-0.77350	-0.64830	-0.64830	-0.77350	-0.64830	-0.64830	-0.77350	-0.64830
α-cut 0.25	-0.77047	-0.77047	-0.77047	-0.64533	-0.64533	-0.77047	-0.64533	-0.64533	-0.77047	-0.64533
α-cut 0.20	-0.76777	-0.76777	-0.76777	-0.64185	-0.64185	-0.76777	-0.64185	-0.64185	-0.76777	-0.64185
α-cut 0.15	-0.76457	-0.76457	-0.76457	-0.63921	-0.63921	-0.76457	-0.63921	-0.63921	-0.76457	-0.63921
α-cut 0.10	-0.76194	-0.76194	-0.76194	-0.63594	-0.63594	-0.76194	-0.63594	-0.63594	-0.76194	-0.63594
α-cut 0.05	-0.76000	-0.76000	-0.76000	-0.63196	-0.63196	-0.76000	-0.63196	-0.63196	-0.76000	-0.63196

Table C.3: Variations of negative relationship weights for different $\alpha - cuts$

	C10-C8	C10-C14	C11-C14	C13-C20	C13-CHR	C14-C17	C14-CHR	C15-C20	C16-C5	C17-C21
α-cut 1.00	-0.6732	-0.7985	-0.7985	-0.7985	-0.7985	-0.6732	-0.7985	-0.6483	-0.6732	-0.7985
α-cut 0.95	-0.6728	-0.7979	-0.7979	-0.7979	-0.7979	-0.6728	-0.7979	-0.6478	-0.6728	-0.7979
α-cut 0.90	-0.6723	-0.7973	-0.7973	-0.7973	-0.7973	-0.6723	-0.7973	-0.6472	-0.6723	-0.7973
α-cut 0.85	-0.6715	-0.7966	-0.7966	-0.7966	-0.7966	-0.6715	-0.7966	-0.6466	-0.6715	-0.7966
α-cut 0.80	-0.6707	-0.7955	-0.7955	-0.7955	-0.7955	-0.6707	-0.7955	-0.6459	-0.6707	-0.7955
α-cut 0.75	-0.6696	-0.7945	-0.7945	-0.7945	-0.7945	-0.6696	-0.7945	-0.6451	-0.6696	-0.7945
α-cut 0.70	-0.6683	-0.7931	-0.7931	-0.7931	-0.7931	-0.6683	-0.7931	-0.6443	-0.6683	-0.7931
α-cut 0.65	-0.6668	-0.7914	-0.7914	-0.7914	-0.7914	-0.6668	-0.7914	-0.6434	-0.6668	-0.7914
α-cut 0.60	-0.6650	-0.7897	-0.7897	-0.7897	-0.7897	-0.6650	-0.7897	-0.6425	-0.6650	-0.7897
α-cut 0.55	-0.6629	-0.7875	-0.7875	-0.7875	-0.7875	-0.6629	-0.7875	-0.6416	-0.6629	-0.7875
α-cut 0.50	-0.6602	-0.7849	-0.7849	-0.7849	-0.7849	-0.6602	-0.7849	-0.6407	-0.6602	-0.7849
α-cut 0.45	-0.6572	-0.7822	-0.7822	-0.7822	-0.7822	-0.6572	-0.7822	-0.6397	-0.6572	-0.7822
α-cut 0.40	-0.6544	-0.7791	-0.7791	-0.7791	-0.7791	-0.6544	-0.7791	-0.6387	-0.6544	-0.7791
α-cut 0.35	-0.6512	-0.7764	-0.7764	-0.7764	-0.7764	-0.6512	-0.7764	-0.6376	-0.6512	-0.7764
α-cut 0.30	-0.6483	-0.7735	-0.7735	-0.7735	-0.7735	-0.6483	-0.7735	-0.6366	-0.6483	-0.7735
α-cut 0.25	-0.6453	-0.7705	-0.7705	-0.7705	-0.7705	-0.6453	-0.7705	-0.6355	-0.6453	-0.7705
α-cut 0.20	-0.6419	-0.7678	-0.7678	-0.7678	-0.7678	-0.6419	-0.7678	-0.6343	-0.6419	-0.7678
α-cut 0.15	-0.6392	-0.7646	-0.7646	-0.7646	-0.7646	-0.6392	-0.7646	-0.6333	-0.6392	-0.7646
α-cut 0.10	-0.6359	-0.7619	-0.7619	-0.7619	-0.7619	-0.6359	-0.7619	-0.6322	-0.6359	-0.7619
α-cut 0.05	-0.6320	-0.7600	-0.7600	-0.7600	-0.7600	-0.6320	-0.7600	-0.6307	-0.6320	-0.7600

Table C.4: Variations of negative relationship weights for different $\alpha - cuts$

	C18-C13	C18-C14	C19-C3	C20-C15	C20-C21	C21-C4	C21-CHR
α-cut 1.00	-0.6732	-0.7985	-0.6732	-0.7985	-0.7985	-0.6732	-0.7985
α-cut 0.95	-0.6728	-0.7979	-0.6728	-0.7979	-0.7979	-0.6728	-0.7979
α-cut 0.90	-0.6723	-0.7973	-0.6723	-0.7973	-0.7973	-0.6723	-0.7973
α-cut 0.85	-0.6715	-0.7966	-0.6715	-0.7966	-0.7966	-0.6715	-0.7966
α-cut 0.80	-0.6707	-0.7955	-0.6707	-0.7955	-0.7955	-0.6707	-0.7955
α-cut 0.75	-0.6696	-0.7945	-0.6696	-0.7945	-0.7945	-0.6696	-0.7945
α-cut 0.70	-0.6683	-0.7931	-0.6683	-0.7931	-0.7931	-0.6683	-0.7931
α-cut 0.65	-0.6668	-0.7914	-0.6668	-0.7914	-0.7914	-0.6668	-0.7914
α-cut 0.60	-0.6650	-0.7897	-0.6650	-0.7897	-0.7897	-0.6650	-0.7897
α-cut 0.55	-0.6629	-0.7875	-0.6629	-0.7875	-0.7875	-0.6629	-0.7875
α-cut 0.50	-0.6602	-0.7849	-0.6602	-0.7849	-0.7849	-0.6602	-0.7849
α-cut 0.45	-0.6572	-0.7822	-0.6572	-0.7822	-0.7822	-0.6572	-0.7822
α-cut 0.40	-0.6544	-0.7791	-0.6544	-0.7791	-0.7791	-0.6544	-0.7791
α-cut 0.35	-0.6512	-0.7764	-0.6512	-0.7764	-0.7764	-0.6512	-0.7764
α-cut 0.30	-0.6483	-0.7735	-0.6483	-0.7735	-0.7735	-0.6483	-0.7735
α-cut 0.25	-0.6453	-0.7705	-0.6453	-0.7705	-0.7705	-0.6453	-0.7705
α-cut 0.20	-0.6419	-0.7678	-0.6419	-0.7678	-0.7678	-0.6419	-0.7678
α-cut 0.15	-0.6392	-0.7646	-0.6392	-0.7646	-0.7646	-0.6392	-0.7646
α-cut 0.10	-0.6359	-0.7619	-0.6359	-0.7619	-0.7619	-0.6359	-0.7619
α-cut 0.05	-0.6320	-0.7600	-0.6320	-0.7600	-0.7600	-0.6320	-0.7600

D TABLES FOR UNVARYING PIFS RELATIONS

Table D.1: Unvarying relationship weights for different $\alpha - cuts$

	C1-C9	C1-C10	C1-C18	C1-C20	C4-C20	C10-C1	C12-C3	C13-C7	C18-C20	C19-C20
α-cut 1.00	0.7500	0.7500	0.5000	0.7500	0.7500	0.6247	-0.7500	-0.6247	0.7500	0.7500
α-cut 0.95	0.7500	0.7500	0.5000	0.7500	0.7500	0.6249	-0.7500	-0.6249	0.7500	0.7500
α-cut 0.90	0.7500	0.7500	0.5000	0.7500	0.7500	0.6248	-0.7500	-0.6248	0.7500	0.7500
α-cut 0.85	0.7500	0.7500	0.5000	0.7500	0.7500	0.6248	-0.7500	-0.6248	0.7500	0.7500
α-cut 0.80	0.7500	0.7500	0.5000	0.7500	0.7500	0.6249	-0.7500	-0.6249	0.7500	0.7500
α-cut 0.75	0.7500	0.7500	0.5000	0.7500	0.7500	0.6248	-0.7500	-0.6248	0.7500	0.7500
α-cut 0.70	0.7500	0.7500	0.5000	0.7500	0.7500	0.6248	-0.7500	-0.6248	0.7500	0.7500
α-cut 0.65	0.7500	0.7500	0.5000	0.7500	0.7500	0.6249	-0.7500	-0.6249	0.7500	0.7500
α-cut 0.60	0.7500	0.7500	0.5000	0.7500	0.7500	0.6247	-0.7500	-0.6247	0.7500	0.7500
α-cut 0.55	0.7500	0.7500	0.5000	0.7500	0.7500	0.6249	-0.7500	-0.6249	0.7500	0.7500
α-cut 0.50	0.7500	0.7500	0.5000	0.7500	0.7500	0.6248	-0.7500	-0.6248	0.7500	0.7500
α-cut 0.45	0.7500	0.7500	0.5000	0.7500	0.7500	0.6246	-0.7500	-0.6246	0.7500	0.7500
α-cut 0.40	0.7500	0.7500	0.5000	0.7500	0.7500	0.6249	-0.7500	-0.6249	0.7500	0.7500
α-cut 0.35	0.7500	0.7500	0.5000	0.7500	0.7500	0.6246	-0.7500	-0.6246	0.7500	0.7500
α-cut 0.30	0.7500	0.7500	0.5000	0.7500	0.7500	0.6246	-0.7500	-0.6246	0.7500	0.7500
α-cut 0.25	0.7500	0.7500	0.5000	0.7500	0.7500	0.6248	-0.7500	-0.6248	0.7500	0.7500
α-cut 0.20	0.7500	0.7500	0.5000	0.7500	0.7500	0.6240	-0.7500	-0.6240	0.7500	0.7500
α-cut 0.15	0.7500	0.7500	0.5000	0.7500	0.7500	0.6246	-0.7500	-0.6246	0.7500	0.7500
α-cut 0.10	0.7500	0.7500	0.5000	0.7500	0.7500	0.6240	-0.7500	-0.6240	0.7500	0.7500
α-cut 0.05	0.7500	0.7500	0.5000	0.7500	0.7500	0.6220	-0.7500	-0.6220	0.7500	0.7500

Table D.2: Unvarying relationship weights for different $\alpha - cuts$

	C20-C3	C20-C4	C20-C9	C20-C10	C20-C13	C20-C14	C20-C16	C20-C19	C21-C5	C21-C20
α-cut 1.00	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	0.0000	-0.7500
α-cut 0.95	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	-0.5000	-0.7500
α-cut 0.90	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	-0.5000	-0.7500
α-cut 0.85	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	-0.5000	-0.7500
α-cut 0.80	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	-0.5000	-0.7500
α-cut 0.75	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	-0.5000	-0.7500
α-cut 0.70	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	-0.5000	-0.7500
α-cut 0.65	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	-0.5000	-0.7500
α-cut 0.60	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	-0.5000	-0.7500
α-cut 0.55	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	-0.5000	-0.7500
α-cut 0.50	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	-0.5000	-0.7500
α-cut 0.45	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	-0.5000	-0.7500
α-cut 0.40	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	-0.5000	-0.7500
α-cut 0.35	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	-0.5000	-0.7500
α-cut 0.30	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	-0.5000	-0.7500
α-cut 0.25	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	-0.5000	-0.7500
α-cut 0.20	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	-0.5000	-0.7500
α-cut 0.15	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	-0.5000	-0.7500
α-cut 0.10	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	-0.5000	-0.7500
α-cut 0.05	-0.7500	0.7500	0.7500	0.7500	-0.7500	-0.7500	-0.5000	0.5000	-0.5000	-0.7500

E FULL DATA FOR INDEGREE, OUTDEGREE AND CENTRALITY VALUES OF EACH PIF

Table E.1: Indegree Values of Each PIF

IN DEGREES	α-cut: 1.00	α-cut: 0.95	α-cut: 0.90	α-cut: 0.85	α-cut: 0.80	α-cut: 0.75	α-cut: 0.70	α-cut: 0.65	α-cut: 0.60	α-cut: 0.55	α-cut: 0.50	α-cut: 0.45	α-cut: 0.40	α-cut: 0.35	α-cut: 0.30	α-cut: 0.25	α-cut: 0.20	α-cut: 0.15	α-cut: 0.10	α-cut: 0.5	α-cut: 0.0
C1	7.24	7.74	7.74	7.74	7.74	7.73	7.73	7.73	7.72	7.72	7.71	7.7	7.7	7.69	7.68	7.68	7.67	7.66	7.65	7.64	0.5
C2	5.72	6.72	6.72	6.72	6.72	6.71	6.71	6.71	6.7	6.7	6.69	6.69	6.68	6.68	6.67	6.66	6.66	6.65	6.64	6.63	1
C3	12.71	13.33	13.33	13.32	13.32	13.31	13.29	13.28	13.26	13.25	13.22	13.2	13.17	13.14	13.12	13.09	13.06	13.03	13	12.97	0.65
C4	12.47	12.97	12.97	12.96	12.95	12.95	12.94	12.92	12.91	12.9	12.88	12.85	12.83	12.81	12.79	12.77	12.75	12.73	12.7	12.68	0.5
C5	6.36	7.36	7.36	7.35	7.35	7.34	7.34	7.33	7.32	7.31	7.3	7.28	7.27	7.26	7.24	7.23	7.21	7.2	7.18	7.17	1
C6	13.49	13.49	13.48	13.48	13.48	13.47	13.46	13.45	13.44	13.43	13.42	13.41	13.39	13.38	13.36	13.35	13.33	13.32	13.3	13.26	0
C7	8.83	9.45	9.45	9.44	9.44	9.44	9.43	9.42	9.42	9.41	9.39	9.38	9.37	9.36	9.34	9.33	9.32	9.31	9.29	9.27	0.62
C8	12.39	12.38	12.38	12.37	12.36	12.36	12.35	12.33	12.32	12.3	12.28	12.26	12.23	12.21	12.19	12.16	12.13	12.11	12.09	12.06	0
C9	7.6	8.1	8.09	8.09	8.09	8.09	8.09	8.08	8.08	8.07	8.07	8.06	8.06	8.05	8.05	8.04	8.03	8.03	8.02	8.01	0.5
C10	7.6	8.1	8.09	8.09	8.09	8.09	8.09	8.08	8.08	8.07	8.07	8.06	8.06	8.05	8.05	8.04	8.03	8.03	8.02	8.01	0.5
C11	6.27	6.77	6.77	6.76	6.76	6.76	6.75	6.75	6.74	6.74	6.73	6.72	6.71	6.7	6.69	6.69	6.68	6.67	6.66	6.65	0.5
C12	9.66	10.16	10.16	10.15	10.15	10.14	10.13	10.12	10.11	10.1	10.08	10.07	10.05	10.03	10.01	10	9.97	9.96	9.94	9.91	0.5
C13	12.32	12.8	12.78	12.76	12.75	12.73	12.71	12.7	12.68	12.66	12.64	12.62	12.6	12.57	12.55	12.53	12.5	12.48	12.44	12.4	1
C14	12.33	13.09	13.09	13.08	13.08	13.08	13.07	13.06	13.05	13.04	13.02	13	12.99	12.97	12.95	12.93	12.91	12.89	12.87	12.85	0.8
C15	2.72	2.72	2.72	2.72	2.72	2.71	2.71	2.71	2.7	2.7	2.69	2.69	2.68	2.68	2.67	2.67	2.66	2.65	2.65	2.64	0
C16	10.85	10.85	10.85	10.84	10.84	10.83	10.82	10.81	10.8	10.79	10.78	10.76	10.75	10.73	10.71	10.7	10.68	10.66	10.65	10.62	0
C17	11.79	11.79	11.78	11.78	11.77	11.77	11.76	11.75	11.74	11.73	11.71	11.69	11.68	11.66	11.64	11.62	11.6	11.58	11.56	11.54	0
C18	10.22	10.22	10.22	10.22	10.22	10.21	10.21	10.21	10.2	10.2	10.19	10.19	10.18	10.17	10.17	10.16	10.15	10.15	10.14	10.12	0
C19	3.5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4.99	1.5
C20	11.54	12.54	12.54	12.54	12.53	12.53	12.52	12.52	12.51	12.5	12.49	12.48	12.48	12.47	12.46	12.45	12.43	12.43	12.41	12.4	1
C21	11.29	11.79	11.78	11.78	11.77	11.77	11.76	11.75	11.74	11.73	11.71	11.69	11.68	11.66	11.64	11.62	11.6	11.59	11.57	11.54	0.5
HR	14.63	14.62	14.61	14.6	14.59	14.58	14.56	14.54	14.52	14.49	14.45	14.42	14.38	14.34	14.3	14.26	14.23	14.19	14.15	14.11	0

Table E.2: Outdegree Values of Each PIF

OUT DEGREES	α-cut: 1.00	α-cut: 0.95	α-cut: 0.90	α-cut: 0.85	α-cut: 0.80	α-cut: 0.75	α-cut: 0.70	α-cut: 0.65	α-cut: 0.60	α-cut: 0.55	α-cut: 0.50	α-cut: 0.45	α-cut: 0.40	α-cut: 0.35	α-cut: 0.30	α-cut: 0.25	α-cut: 0.20	α-cut: 0.15	α-cut: 0.10	α-cut: 0.05	α-cut: 0.0
C1	11.82	13.21	13.21	13.21	13.21	13.21	13.2	13.2	13.2	13.19	13.19	13.18	13.17	13.16	13.15	13.14	13.13	13.12	13.11	13.08	1.45
C2	11.89	11.87	11.86	11.84	11.83	11.81	11.79	11.78	11.76	11.75	11.73	11.71	11.69	11.67	11.65	11.63	11.6	11.59	11.56	11.51	0.5
C3	9.84	10.47	10.47	10.47	10.46	10.46	10.46	10.46	10.45	10.45	10.44	10.44	10.43	10.42	10.42	10.41	10.4	10.4	10.39	10.36	0.62
C4	10.01	10.51	10.51	10.5	10.5	10.49	10.48	10.48	10.46	10.45	10.44	10.42	10.41	10.39	10.38	10.36	10.34	10.33	10.31	10.29	0.5
C5	9.57	10.07	10.06	10.06	10.06	10.05	10.05	10.04	10.03	10.02	10.01	10	9.99	9.98	9.97	9.96	9.95	9.93	9.92	9.91	0.5
C6	12.06	12.06	12.05	12.04	12.02	12.01	11.99	11.97	11.94	11.91	11.87	11.83	11.79	11.75	11.71	11.66	11.62	11.58	11.54	11.5	0
C7	10.99	11.99	11.99	11.98	11.98	11.97	11.96	11.96	11.95	11.94	11.92	11.91	11.9	11.88	11.87	11.85	11.83	11.82	11.8	11.78	1
C8	10.18	10.67	10.67	10.66	10.65	10.64	10.63	10.62	10.6	10.58	10.56	10.53	10.51	10.48	10.45	10.43	10.4	10.37	10.34	10.31	0.5
C9	8.91	10.41	10.4	10.39	10.39	10.38	10.36	10.35	10.34	10.32	10.3	10.27	10.25	10.22	10.2	10.17	10.14	10.12	10.1	10.06	1.5
C10	8.91	10.41	10.4	10.39	10.39	10.38	10.36	10.35	10.34	10.32	10.3	10.27	10.25	10.22	10.2	10.17	10.14	10.12	10.1	10.06	1.5
C11	10.14	11.14	11.14	11.14	11.14	11.13	11.13	11.12	11.12	11.11	11.1	11.1	11.09	11.08	11.07	11.06	11.05	11.04	11.03	11.02	1
C12	10.23	10.23	10.23	10.23	10.23	10.22	10.22	10.22	10.21	10.21	10.2	10.19	10.19	10.18	10.17	10.17	10.16	10.15	10.15	10.14	0
C13	12.41	12.91	12.91	12.9	12.9	12.89	12.88	12.87	12.86	12.85	12.83	12.82	12.8	12.78	12.76	12.75	12.72	12.71	12.69	12.66	0.5
C14	11.04	11.04	11.03	11.03	11.02	11.02	11.01	11	10.99	10.98	10.96	10.94	10.93	10.91	10.89	10.87	10.85	10.84	10.82	10.79	0
C15	8.06	9.06	9.05	9.05	9.05	9.05	9.04	9.04	9.03	9.03	9.03	9.02	9.02	9.01	9.01	9	8.99	8.99	8.98	8.96	1
C16	6.85	6.85	6.84	6.84	6.84	6.84	6.84	6.83	6.83	6.83	6.82	6.81	6.81	6.8	6.8	6.79	6.78	6.78	6.77	6.76	0
C17	9.1	9.1	9.09	9.09	9.09	9.09	9.09	9.08	9.08	9.07	9.07	9.06	9.06	9.05	9.05	9.04	9.03	9.03	9.02	9.01	0
C18	8.85	8.85	8.84	8.84	8.84	8.84	8.84	8.83	8.83	8.83	8.82	8.81	8.81	8.8	8.8	8.79	8.78	8.78	8.77	8.76	0
C19	10.66	10.66	10.66	10.65	10.65	10.64	10.63	10.62	10.61	10.6	10.58	10.57	10.55	10.53	10.51	10.5	10.47	10.46	10.44	10.41	0
C20	12.64	12.63	12.63	12.62	12.61	12.61	12.59	12.58	12.57	12.55	12.53	12.51	12.48	12.46	12.44	12.41	12.39	12.37	12.34	12.32	0
C21	7.37	7.87	7.87	7.86	7.86	7.86	7.85	7.85	7.85	7.84	7.83	7.83	7.82	7.81	7.81	7.8	7.79	7.78	7.77	7.75	0.5
HR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table E.3: Centrality Values of Each PIF

CENTRALITY	α-cut: 1.00	α-cut: 0.95	α-cut: 0.90	α-cut: 0.85	α-cut: 0.80	α-cut: 0.75	α-cut: 0.70	α-cut: 0.65	α-cut: 0.60	α-cut: 0.55	α-cut: 0.50	α-cut: 0.45	α-cut: 0.40	α-cut: 0.35	α-cut: 0.30	α-cut: 0.25	α-cut: 0.20	α-cut: 0.15	α-cut: 0.10	α-cut: 0.5	α-cut: 0.0
C1	19.06	20.95	20.95	20.95	20.94	20.94	20.93	20.93	20.92	20.91	20.9	20.88	20.87	20.85	20.83	20.82	20.79	20.78	20.76	20.72	1.95
C2	17.61	18.59	18.58	18.56	18.54	18.52	18.5	18.49	18.46	18.45	18.42	18.4	18.37	18.34	18.32	18.3	18.26	18.24	18.2	18.14	1.5
C3	22.55	23.8	23.8	23.79	23.78	23.77	23.75	23.74	23.71	23.69	23.66	23.63	23.6	23.56	23.53	23.5	23.46	23.43	23.39	23.33	1.27
C4	22.49	23.48	23.47	23.46	23.45	23.44	23.42	23.4	23.38	23.35	23.32	23.28	23.24	23.2	23.17	23.13	23.09	23.05	23.01	22.97	1
C5	15.93	17.43	17.42	17.42	17.41	17.4	17.38	17.37	17.35	17.33	17.31	17.29	17.26	17.24	17.21	17.18	17.16	17.13	17.11	17.08	1.5
C6	25.55	25.54	25.53	25.52	25.5	25.48	25.45	25.42	25.38	25.34	25.29	25.24	25.18	25.12	25.07	25.01	24.95	24.9	24.84	24.76	0
C7	19.82	21.44	21.43	21.43	21.42	21.41	21.39	21.38	21.36	21.34	21.32	21.29	21.27	21.24	21.21	21.18	21.15	21.13	21.09	21.05	1.62
C8	22.56	23.06	23.05	23.03	23.02	23	22.98	22.95	22.92	22.88	22.84	22.79	22.74	22.69	22.64	22.59	22.53	22.49	22.43	22.37	0.5
C9	16.51	18.5	18.49	18.49	18.48	18.46	18.45	18.43	18.41	18.39	18.37	18.33	18.31	18.27	18.24	18.21	18.18	18.15	18.12	18.08	2
C10	16.51	18.5	18.49	18.49	18.48	18.46	18.45	18.43	18.41	18.39	18.37	18.33	18.31	18.27	18.24	18.21	18.18	18.15	18.12	18.08	2
C11	16.41	17.91	17.91	17.9	17.9	17.89	17.88	17.87	17.86	17.85	17.83	17.82	17.8	17.78	17.76	17.75	17.72	17.71	17.69	17.66	1.5
C12	19.9	20.39	20.39	20.38	20.37	20.36	20.35	20.34	20.32	20.31	20.29	20.26	20.24	20.21	20.19	20.16	20.13	20.11	20.09	20.05	0.5
C13	24.73	25.71	25.69	25.66	25.64	25.62	25.59	25.57	25.54	25.51	25.47	25.43	25.4	25.35	25.31	25.27	25.22	25.19	25.13	25.06	1.5
C14	23.37	24.13	24.12	24.11	24.1	24.09	24.08	24.06	24.04	24.01	23.98	23.95	23.91	23.87	23.84	23.8	23.76	23.73	23.69	23.64	0.8
C15	10.78	11.78	11.77	11.77	11.77	11.76	11.75	11.75	11.74	11.73	11.72	11.71	11.7	11.69	11.68	11.67	11.65	11.64	11.63	11.6	1
C16	17.7	17.69	17.69	17.68	17.68	17.67	17.66	17.65	17.63	17.62	17.6	17.57	17.55	17.53	17.51	17.49	17.46	17.44	17.42	17.38	0
C17	20.88	20.88	20.88	20.87	20.86	20.85	20.84	20.83	20.82	20.8	20.78	20.75	20.73	20.71	20.68	20.66	20.63	20.61	20.58	20.54	0
C18	19.07	19.07	19.06	19.06	19.06	19.05	19.05	19.04	19.03	19.02	19.01	19	18.99	18.98	18.97	18.95	18.94	18.93	18.91	18.88	0
C19	14.16	15.66	15.66	15.65	15.65	15.64	15.63	15.62	15.61	15.6	15.58	15.57	15.55	15.53	15.51	15.5	15.47	15.46	15.44	15.41	1.5
C20	24.18	25.17	25.17	25.16	25.15	25.13	25.12	25.1	25.08	25.05	25.02	24.99	24.96	24.93	24.89	24.86	24.82	24.79	24.76	24.72	1
C21	18.66	19.65	19.65	19.64	19.63	19.62	19.61	19.6	19.58	19.57	19.54	19.52	19.5	19.47	19.45	19.42	19.39	19.37	19.34	19.3	1
HR	14.63	14.62	14.61	14.6	14.59	14.58	14.56	14.54	14.52	14.49	14.45	14.42	14.38	14.34	14.3	14.26	14.23	14.19	14.15	14.11	0

BIOGRAPHICAL SKETCH

Yesim Kop Naskali was born in Istanbul on August 06, 1982. She received her B.S. degree in industrial engineering from Galatasaray University in 2005 and M.S. degree in Industrial Engineering from the same university in 2007. Since 2006, she works as a research assistant in Industrial Engineering Department of Galatasaray University. She is currently a PhD candidate. Her published works are as follows:

Kop Naskali, Y., Gurbuz, T., Albayrak, Y.E. (2018). Human Reliability Assessment in Healthcare Operations Using Fuzzy Cognitive Maps. *Journal of Multiple-Valued Logic Soft Computing*, article in press.

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