ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL

LONG TERM COMPETITIVE ADVANTAGE EFFECT ON COMPANY VALUE WITH FUZZY LOGIC AND MACHINE LEARNING APPLICATIONS

Ph.D. THESIS

Zekeriya BİLDİK

Department of Management

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İSTANBUL TEKNİK ÜNİVERSİTESİ ★ LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ

BULANIK MANTIK VE MAKİNE ÖĞRENME UYGULAMALARI İLE UZUN VADELİ REKABET AVANTAJININ ŞİRKET DEĞERİ ÜZERİNE ETKİSİ

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Zekeriya BİLDİK, a Ph.D. student of ITU Graduate School student ID 403202008, successfully defended the thesis/dissertation entitled "LONG TERM COMPETITIVE ADVANTAGE EFFECT ON COMPANY VALUE WITH FUZZY LOGIC AND MACHINE LEARNING APPLICATIONS", which he prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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To my precious family ,

FOREWORD

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April 2024

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ABBREVIATIONS

BIST 30	**:** Borsa Istanbul Stock Exchange 30 index
BIST 100	**:** Borsa Istanbul Stock Exchange 100 index
BS	**:** Balance Sheet
C	**:** Copper price USD
DAX	**:** Deutscher Aktien Index
DJIA	**:** Dow Jones Industrial Average
EM	**:** Emerging Markets
EPS	**:** Earning Per Share
EPU	**:** European Policy Uncertainty
FED	**:** Federal Reserve
GAMs	**:** Generalized Additive Models
IPI	**:** Industrial Production Index
IPO	**:** Initial Public Offering
KOSPI	**:** Korea Composite Stock Price Index
ML	**:** Machine Learning
MSE	**:** Mean Square Error
M2	**:** M2 money supply
NI225	**:** Nikkei 225 Index
NYSE	**:** New York Stock Exchange
ONCF	**:** Operating Net Cash Flow
P&L	**:** Profit and Loss table
PPI	**:** Producer Price Index
PB	**:** Price to Book ratio
P/E	**:** Price to Earnings ratio
ROA	**:** Return On Asset
ROE	**:** Return On Equity
RBV	**:** Resource Base View

SFS **:** Spherical Fuzzy Set

S&P 500 **:** Standard & Poor's 500 index

SWAM **:** Spherical Weighted Arithmetic Mean

TRSFS **:** Triangular Spherical Fuzzy Set

TRSWAM **:** Triangular Spherical Weighted Arithmetic Mean

SYMBOLS

μ	: Membership degree
ν	: Nonmembership degree
π	: Hesitancy degree
U	: Universe of discourse
SFS_A, SFS_B	: Spherical Fuzzy Numbers
$TRSFS_A$, $TRSFS_B$	: Triangular Spherical Fuzzy Numbers
w_i	: weight of j^{th} criterion

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LONG TERM COMPETITIVE ADVANTAGE EFFECT ON COMPANY VALUE WITH FUZZY LOGIC AND MACHINE LEARNING APPLICATIONS

SUMMARY

Humankind feels incredible desire for these three things along the history: accumulating a fortune, getting respect in society and independence. Actually, it is not possible to separate these notions from each other, because they are fully interconnected with each other and feed themselves in the different degree from different aspects. But it is clear that the fortune is the most effective one, will bring respect and independence certainly. Some jealous too. Even if not putting that idea in theoretical framework, it is widely accepted from all society expect marginal outlooks which respected a lot.

Driven by the inherent instinct to amass wealth, humanity moved away from the carpe-diem mentality that prevailed during the Middle Ages. Instead, individuals began saving and exploring alternative investments, driven by the aspiration for a better future and potential fortune. However, the reckless adherence to self-assumptions, trading impulsively based on populist market news, and neglecting psychological well-being can result in substantial losses for investors, thwarting the very goal of accumulating wealth. The significance of safeguarding one's principal has been widely recognized. In the midst of the Great Depression in the 1930s, Benjamin Graham introduced the concept of value investing, offering a groundbreaking perspective. Graham advocated for purchasing stocks based on the current and anticipated business performance rather than succumbing to the erratic swings of the market pendulum. Building upon Graham's seminal work, his student and financial market legend, Warren Buffett, expanded the scope of value investing methodology. Buffett emphasized the paramount importance of long-term sustainable competitive advantage in the market. According to Buffett, a company's ability to maintain a lasting competitive edge is the primary catalyst for achieving higher valuations through increases in stock prices. Competitive advantage does not only allow company to put higher price tags but also creates efficiencies within organization with value added activities which are compatible between themselves and reinforced each other. These lead higher profit margins in P&L table. Companies with competitive advantage generally dominate the market as leader yield enhanced revenue stream, customer portfolio, bargaining power with supplier and B2B retailers ended up with better financial performance. In turbulent economic environment, robust customer base, secure revenue streams with associated cost saving countermeasures provide stability to these organizations. At the end of the day, whatever activities a business engages in over a period of time, their numerical impact is reflected in the profit and loss (P&L) statement, the cash perspective results are presented in the cash flow statement, and the assets and liabilities are observed in the balance sheet (BS). Therefore, the outcome of long-term competitive power can be discerned in financial statements as proxies.

Traditional financial models often rely on precise inputs and deterministic calculations for expected values assume that all relevant information is known and can be expressed with certainty. Moreover, the expected value is computed based on accurate and definite data points. Adhering risk aversion tendency, there is not possible to give decision on rigid numbers. In reality, individuals opt for guaranteed profits over engaging in fair gambling, making the expected value mindset ineffective. Fuzzy logic acknowledges the inherent uncertainty and imprecision in financial data that allows for the representation of information using linguistic variables and fuzzy sets. Thereby, the expected value becomes a fuzzy set, capturing the uncertainty in the decision-making process. Thereby we introduce a novel triangular spherical fuzzy sets based on the assumption that the degree of long-term competitive advantage a company possesses is the crucial factor influencing variations in company valuations, aligning with the core principles of the value investing methodology. Novel triangular spherical fuzzy set enable to express evaluations as medians, maximums, and minimums presented within an interval structure via membership, non-membership, and hesitancy values.

In the first part of thesis, BIST 100 index companies has been analyzed with employed triangular spherical fuzzy set over five long term competitive power key performance indicators by five experts. Upon applying created framework, final long term competitive power scores has been derived for 70 stocks in BIST 100 index, consecutively traded between 2018-2022. Financial institutions excluded from scope due to non-compitability of balance sheet structures. These 70 stocks have been categorized into four distinctive competitive power groups: Bloody Red Ocean, Red Ocean, Blue Ocean, and Extra Clear Blue Ocean, based on linear scores. To validate this classification, intuitionistic fuzzy sets were employed, and the categorization was reassessed for all 70 stocks to identify potential variations. We have acquainted vey minor changes that approves robustness of methodology. However, it became evident that the data might exhibit significant divergence across various indicators, rather than conforming linearly to a unified final score. To address this, additional hierarchical and non-hierarchical clustering methods were employed and applied to the data. As anticipated, substantial discrepancies were observed in certain key performance indicators (KPIs). In line with the theoretical alignment with the framework and the aspiration to establish a robust mathematical foundation that ensures maximum homogeneity within clusters and maximum heterogeneity between clusters, the ward method combined with euclidean distance was chosen for the final clustering. Subsequently, machine learning models were developed for each cluster, and the results were thoroughly analyzed.

In the second part of thesis, the framework is applied to 42 initial public offering, realized in 2023 at Borsa Istanbul, with new set of indicators using the past three years financial statements, IPO price detection report, and offering circular. In addition to the generic five financial Key Performance Indicators (KPIs) — gross profit margin, cash flow from investments/net sales, cash flow from operations/total liabilities, net working capital/net sales, and total liability/shareholder equity — we introduce factors such as management

competence and experience, utilization of IPO funds, price stability commitments, Pre-IPO valuation approach, and business & growth strategy. In the final phase, long-term competitive power scores are determined and compared with the actual price increase performance rank, employing the Spearman rank correlation test. The comparison of these two rankings using Spearman's rho yielded a value of 0.67, indicating a high positive monotonic relationship. As the final robustness test, genetic algorithm has been applied and relative rank is compared with framework.

In the last part of thesis, the framework is applied to BIST 30 companies with addition of corporate govarnance and sustainability perspectives. In the final score list of BIST 30 index, four company affiliated with the Koc Group attract the attention in the first two quartile companies, with three of them holding positions within the top eight in terms of the highest points. This accomplishment serves as evidence not only of their commitment to corporate governance principles but also of their stable finance execution. Among the top 10 ranked companies, all except Turkish Airlines belong to the production sector. This observation suggests a potential division between production and service companies

As overall, This study showcases the utilization of fuzzy logic to evaluate the enduring competitive strength of companies, providing insights into their market standings and potential for sustained growth and long term company valuation. It not only adheres to the principles of value investing, as endorsed by Benjamin Graham and Warren Buffett but also contributes to the modeling approach within the framework of the Turkish public stock exchange.

BULANIK MANTIK VE MAKİNE ÖĞRENMESİ UYGULAMALARI İLE UZUN VADELİ REKABET AVANTAJININ ŞİRKET DEĞERİ ÜZERİNE ETKİSİ

ÖZET

İnsanlık, tarih boyunca bu üç şeye karşı inanılmaz bir arzu duymuştur: servet biriktirmek, toplumda saygı görmek ve bağımsızlık elde etmek. Biribirlerini farklı açıdan değişik miktarlarda etkileyen bu idealları birbirinden ayırmak mümkün değildir. Ancak bunlar arasında en etkili olan, kesin olarak saygı ve bağımsızlığı getiren servetttir. Bunun yanında biraz da kıskançlık getirecektir. Bunu teorik bir çerçeveye koymasak da saygı duyduğum marjinal görüşler haricinde, bu olgu toplumun geneli tarafından kabul edilir.

Servet biriktirme içgüdüsüyle hareket eden insanoğlu, orta çağ ile birlikte egemen olan anı-yaşa zihniyetinden uzaklaşmaya başladı. Bunun yerine, bireyler daha iyi bir gelecek ve potansiyel servet arayışıyla alternatif yatırımlar yapmaya başladı. Ancak, kendi önyargılarına körü körüne bağlılık, popüler piyasa haberlerine dayalı düşüncesiz hisse senedi alım-satımı ve psikolojik hazırlığı ihmal etmek, yatırımcılar için önemli kayıplara neden oldu, servet biriktirme hedeflerini sekteğe uğrattı. Bu şekilde, ana paranın korumasının önemi yaygın olarak kabul edilmeye başlandı. 1930' lardaki büyük buhran sırasında Benjamin Graham, değer yatırımı kavramını tanıtarak çığır açan bir perspektif sundu. Graham, hisse senetlerini piyasa dalgalanmalarına boyun eğmek yerine mevcut ve beklenen iş performansına dayanarak satın almayı savundu. Graham'ın çalışmalarını temel alan öğrencisi ve finans piyasası efsanesi Warren Buffett, değer yatırım metodolojisinin kapsamını genişletti. Buffett, piyasadaki uzun vadeli sürdürülebilir rekabet avantajının öneminin altını çizdi. Buffett'a göre, bir şirketin kalıcı rekabet avantajını koruma yeteneği, hisse fiyatlarındaki artışlar aracılığıyla daha yüksek değerlendirmeler elde etmek için temel katalizatördür. Uzun vadeli rekabet avantajı, şirketin yalnızca daha yüksek fiyatlamalar yapmasına izin vermekle kalmaz, aynı zamanda birbirleriyle uyumlu ve birbirini güçlendiren ve nihayetinde değer yaratan aktivitelerle, örgüt içinde verimlilik yaratır. Bu, gelir tablosundaki daha yüksek kar marjlarına yol açar. Rekabet avantajına sahip şirketler genellikle lider olarak pazarı domine eden, sürekli artan gelir akışına, müşteri portföyüne, tedarikçi ve perakendecilere karşı pazarlık gücüne sahip olan ve daha iyi finansal performans elde eden şirketlerdir. Ekonomik belirsizlik ortamında, sağlam bir müşteri tabanı, ilişkili maliyet tasarrufu gibi ek tedbirlerle güvence altına alınan gelir akışları, bu organizasyonlara istikrar sağlar. Günün sonunda, bir işletmenin belirli süre içerisindeki tüm faliyetlerinin sayısal sonuçları, gelir tablosunda yansır, nakit giriş ve çıkışları kategorik olarak nakit akış tablosunda sunulur, varlıklar ile borçlar bilançoda gözlemlenir. Bu nedenle, uzun vadeli rekabet avantajının sonucunu, finansal tablolarda birinci dereceden görmek mümkündür.

Geleneksel finansal modeller genellikle beklenen değerler için kesin değerlere ve matematiksel modellere dayanır. Bunun yanında tüm ilgili bilgilerin bilindiğini ve

modelde ifade edilebileceği varsayılır. Ayrıca, beklenen değer, kesin ve belirli olasılık ve seçeneklerlere dayanarak hesaplanır. Riskten kaçınma eğiliminde olan gene yatırımcı profilinin bu şekilde beklenen değere göre karar alması mantıklı değildir. Gerçek hayatta, insanlar kesin kazançları adil kumara tercih eder ve bu nedenle beklenen değer mantığı çalışmaz. Bulanık mantık, finansal verilerdeki belirsizlik kabul eder, bilgiyi dilsel değişkenler ve bulanık kümeler kullanarak temsil etme olanağı sağlar. Bu sayede, beklenen değer üzerine karar alma sürecindeki belirsizlik eklenerek bulanık bir küme haline getirilir. Bu nedenle, değer yatırım metodolojisinin temel prensipleriyle uyumlu olarak, bir şirketin sahip olduğu uzun vadeli rekabet avantajının derecesinin, şirket değerlemelerindeki kritik bir faktör olduğunu varsayımı ile yeni bir üçgen küresel bulanık küme metodu yarattık. Yeni üçgen küresel bulanık küme metodu, uzman değerlendirmelerindeki medyan, maksimum ve minimum olarak verilen aralığı üyelik, üye olmama ve tereddüt dereceleri ile bulanıklaştırma olanağı sağlar.

Tezin ilk bölümünde, uzun vadeli rekabetçi avantajın göstegesi olduğuna inanılan beş adet performans göstergesi, beş uzman tarafından üçgen küresel bulanık küme metodu ile değerlendirilmiştir. Buradan 2018-2022 yılları arasında, beş yıl boyunca BIST 100 endeksinde yer alan 70 adet hisse senedi için uzun vadeli rekabet avantajı gücünü yansıtan skorlar üretilmiştir. BIST 100 indeksi içinde yer alan finansal kurumlar da bilanço yapısı, metodoloji uyumsuzluğu nedeniyle kapsam dışı bırakılmıştır. Bu 70 hisse senedi, doğrusal skorlara dayanarak dört ayrı rekabet avantajı grubuna (kanlı kırmızı okyanus, kırmız okyanus, mavi okyanus ve berrak mavi okyanus) kategorize edilmiştir. Bu sınıflandırmanın doğrulama testi için, sezgisel bulanık kümeler kullanılarak tüm 70 hisse senedi için yeniden sınıflandırma yapılarak, karşılaştırma yapılmıştır. Bu karşılaştırmada değişikliklerin çok az olduğu görülerek, metodolojinin sağlamlığını onaylanmıştır. Ancak yine de doğrusal tabanda oluşturulan doğrusal bir kümeleme yöntemini kullanmak sadece belirli göstergeler üzerinden ayrışan veri seti için bir sapma gösterebilir. Bunu ele almak için veri seti üzerinde hiyerarşik ve hiyerarşik olmayan kümeleme yöntemleri kullanılmıştır. Beklendiği gibi, belirli anahtar performans göstergeleri üzerinden kümeler üzerinde daha belirgin ayrışmalar gözlemlenmiştir. Kümeler içinde maksimum homojenlik ve kümeler arasında maksimum heterojenlik teorik çerçevesine uyumlu olarak nihai kümeleme metodu olarak ward metodu ve euclidean uzaklığı seçilerek bir sonraki aşamaya geçilmiştir. Daha sonra, her küme için makine öğrenimi modelleri geliştirilerek sonuçlar detaylı bir şekilde analiz edilmiştir.

Tezin ikinci bölümünde, teorik çerçeve, 2023'te Borsa Istanbul'da gerçekleşen 42 halka arz için uygulanmıştır. Yeni bir dizi gösterge kullanılarak geçmiş üç yılın finansal tabloları, halka arz fiyatı belirleme raporu ve izahnameler detaylı olarak incelenmiştir. Genel beş finansal performans göstergesi (KPI) - brüt kar marjı, yatırımlardan nakit akışı/net satışlar, operasyonlardan nakit akışı/ toplam borçlar, net işletme sermayesi/net satışlar ve toplam borç/öz kaynak - dışında yönetim yeterliliği ve deneyimi, halka arz fonlarının kullanımı, fiyat istikrarı taahhütleri, halka arz öncesi değerleme yaklaşımı, iş ve büyüme stratejisi gibi faktörler de dahil edilmiştir. Son aşamada, uzun vadeli rekabet

gücü puanları belirlenmiş ve spearman sıralama korelasyon testi kullanılarak gerçek fiyat artış performansı sıralaması ile karşılaştırılmıştır. Spearman'ın rho kullanılarak yapılan bu iki sıralamanın karşılaştırılması, yüksek pozitif monoton ilişkiyi gösteren 0.67 değerini vermiştir. Ayrıca genetik algoritması ile uzun vadeli değerleme potansiyeli sıralaması oluşturularak methodun sağlamlığı test edilmiştir.

Tezin son bölümünde, teorik çerçeve, kurumsal yönetişim ve sürdürülebilirlik perspektiflerinin eklenmesiyle BIST 30 şirketlerine uygulanmıştır. BIST 30 endeksi final puan listesinde,ilk iki çeyrek içinde yer alan Koc Grubu'na ait dört şirket dikkat çekmektedir ve bunlardan üçü en yüksek puanlar bakımından ilk sekiz içerisinde yer almaktadır. Bu başarı, sadece kurumsal yönetişim prensiplerine bağlılıklarının değil, aynı zamanda istikrarlı finans yönetimi uygulamalarının da bir göstergesi olarak ortaya çıkmaktadır. İlk 10 sıradaki şirketler arasında Türk Hava Yolları dışındaki şirketlerin tümü üretim sektörüne aittir. Bu gözlem, üretim ve hizmet şirketleri arasında potansiyel bir ayrımı işaret etmektedir.

Genel olarak, bu çalışma, şirketlerin kalıcı rekabet gücünü değerlendirmek için bulanık mantığı kullanmanın yanı sıra, onların pazar durumlarına ve sürdürülebilir büyüme potansiyellerine dair içgörüler sunmaktadır. Yaratılan teorik çerçeveyle, Benjamin Graham ve Warren Buffett tarafından savunulan değer yatırımı prensiplerine uyarak, Türkiye menkul kıymetler borsa literatürüne katkı sağlamak amaçlanmıştır.

1. INTRODUCTION

The intrinsic drive for wealth and financial advancement is an inherent motivator ingrained in human being, persisting throughout the course of one's life. The pursuit of lucrative investments has expanded ahead individuals with boumded earnings to enclose large corporations. A significant transformation took place during the Renaissance and Middle Age Europe reforms, reshaping societal attitudes from a 'carpe diem' (seize the moment) philosophy to a more vigilant outlook (Rickards, 2019). This paradigm shift emphasized the importance of future gains over immediate pleasure, leading to the formulation of long-term plans and the development of various investment instruments. This evolution encouraged individuals to save and invest with the expectation of higher returns in the future.

The advancement of computing capabilities, common internet accessibility, and fast technological growth have increased the efficiency of financial markets by providing universal access to information for all investors (Ariely, 2010). Benjamin Graham, a prominent figure on Wall Street, embraced a value investing strategy that involves favoring stocks based on their market price relative to their book value. Graham proposed that the market behaves like a tick-tock, rhythm between unendurable hopefullness and baseless hopelessness. The intelligent investor, according to Graham, is a realist who buys from hopeless and sells to pollyanna. Furthermore, he emphasized that the future value of any investment is contingent on its present price — the higher the price paid, the lower the potential profit (Graham, 2003). However, Warren Buffett identified limitations in Graham's mentality, highlighting instances where companies adhering to this model eventually faced financial insolvency (Rajaratnam et al., 2014). Buffett recognized the importance of assessing a company's sustained long term competitive advantage in the market, introducing the term “superstars” to characterize such firms. He acknowledged their ability to maintain a sustainable competitive edge, significantly boosting their market prices over the long term compared to the broader market (Zhang, 2022).

A company's enduring competitive advantage is rooted in its unique selling proposition and its ability to provide cost-effective services for widely consumed products. These factors are evident in a company's financial records, acting as indicators of its competitive edge. While a standardized evaluation method for this advantage is absent, financial Key Performance Indicators (KPIs) can serve as proxies to assess a company's competitive strength.

1.1 Significance of Thesis

Increasing enterprise value is the one of the primary aims of companies in business regardless of business life cycle phase which they are in; start up or mature. Market share donimation, more financial stability, creating funds for future possible acquasition are leading factors behind that motivation. Our study aims to address a fundamental question: What distinguishes certain companies, making them more valuable? This inquiry has captivated both scholars and industry professionals in the field of finance. To investigate this, we introduce a unique perspective by categorizing companies listed on the BIST 100 (Turkiye Public Stock Exchange) into four distinct groups: extra clear blue ocean, blue ocean, red ocean, and bloody red ocean (Porter, 2011). This classification stems from evaluating the long-term competitive advantage of these companies using Triangular Spherical Fuzzy Sets and clustering methodologies. Subsequently, prominent machine learning techniques were employed to predict stock returns for each cluster. This methodology provides valuable insights into the competitive strength of these entities. Furthermore, the study has expanded into two additional research endeavors. In the first, an analysis of 42 initial public offerings (IPOs) in 2023 was conducted, utilizing a varied set of KPIs and a distinct perspective on corporate govarnance and sustainability dimensions.

In the second research phase, corporate dimensions for BIST 30 have been incorporated into the existing key performance indicator (KPI) sets. A triangular spherical fuzzy set, guided by expert insights, was applied, and stocks were ranked based on their long-term valuation potential.

1.2 Purpose and Scope of the Thesis

The purpose of this thesis is to introduce a novel approach based on the assumption that the degree of long-term competitive advantage a company possesses is the crucial factor influencing variations in company valuations, aligning with the core principles of the value investing methodology. By doing so, we aim to provide a comprehensive understanding of the significant disparities in stock prices within the market, approaching this phenomenon from diverse perspectives. Our primary focus will be on companies listed on the Borsa Istanbul Stock Exchange, including those in the BIST 100 index, BIST 30 index, and the 42 companies that went public in 2023 (BIST 2023 IPOs). We will employ three differentiating methodologies using novel triangular spherical fuzzy sets, with different set of perpectives.

The BIST 100, formally known as the Borsa Istanbul 100 index, stands as the primary indicator for the Turkish stock exchange. Comprising 100 of the most influential publicly traded companies in the service, technology, financial, and industrial sectors, it serves as the mainstream index for market performance. As of January 12, 2024, the BIST 100 index reflects an actual floating share value of 2.147.368.068.589,82 Turkish liras (Url-1). The significance of categorizing listed companies based on their long-term competitive power and analyzing the key drivers behind it cannot be overstated. This approach not only aids in comprehending similarities between companies from a financial perspective but also provides a structured framework through the creation and analysis of financial models.

BIST 30 more specifically idetifies Borsa Istanbul 30 index, composed of largest 30 companies from the aspect of company value compared to BIST 100 index with 1.540.832.967.896,64 Turkish Liras actual floating share value as of 12 January 2024 (Url-2). Moreover, twenty one of them blongs to BIST Sustainability Index and nine also belongs to BIST Govarnance Index includes long term competitive power corporate governance indicators that used in this extention as additional indicators of long term competitive power (Url-3). These may be enumarated as shareholder perspective, transparency and public relations, stakeholders' perpective, board of directors, business and growth strategy.

Initial Public Offerings (IPOs), refers to the procedure wherein a privately held company makes its shares accessible to the public for the first time, allowing interested investors to buy them on a stock exchange (Kim and Wu, 2008). At the contemporary times, the expanding middle class and heightened consumer spending have established favorable circumstances for companies to undergo initial public offerings (IPOs) and leverage the market's potential as a new funding strategy in emerging markets. Government initiatives aimed at promoting capital markets and fostering private sector growth have contributed to the creation of a productive ecosystem. The count of active individual investors in the Turkish common stock market has witnessed a substantial surge, reaching 7,65 million as of December 2023 (Url-4). This figure represents a significant increase compared to the 3.34 million documented twelve months ago, as illustrated in Figure 1. That paramount investor number walk from 3,34 Million to 7,65 Million in just one year lead us to examine 2023 IPOs too as a second extended scope with different set of indicators from the aspect of long term valuation potential. It will be an opportunity for us to compared with their potential to actual stock performance and give the answer of possible financial bubble availability.

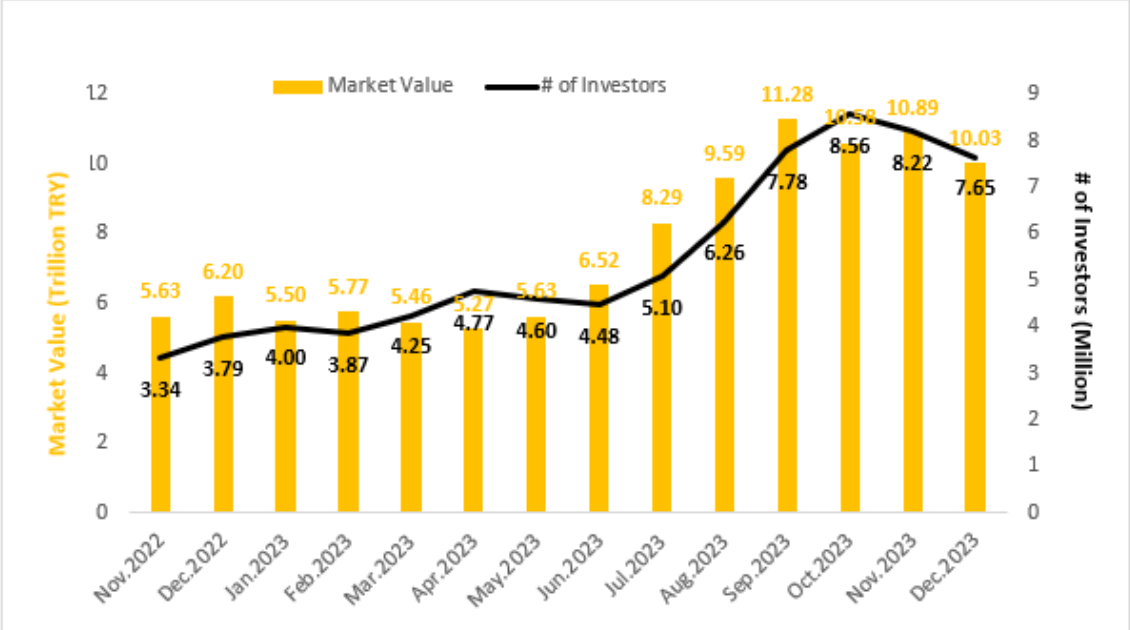

Figure 1.1: The number of active individual stock market investor

In thesis statement, a novel fuzzy theory; triangular spherical fuzzy set has been introduced with liturature with new set of competitive force group and various set of indicators. The Fuzzy Theory, originated by Zadeh in 1965, was conceived to tackle the complexities arising in an era marked by heightened uncertainty and increased data influx. It employs the principles of membership and non-membership degrees (Zadeh, 1965). Over the ensuing decade, its practices spanned various disciplines, from social sciences to applied sciences. As the concept evolved, diverse variations emerged, including type-2 fuzzy sets, intuitionistic fuzzy sets, neutrosophic fuzzy sets, hesitant fuzzy sets, Pythagorean fuzzy sets, and spherical fuzzy sets. Kahraman and Gundogdu (2018) introduced Spherical Fuzzy sets, which offer a broader scope through the squared sum of membership degree, non-membership degree, and hesitancy degree, equal to one or less. This extended domain allows for independent hesitancy values, expanding the potential on the surface and within the inner area of a sphere, represented by points such as [1,0,0], [0,1,0], and [0,0,1] where [μ,ν,π] stands for membership degree, non-membership degree, and hesitancy degree, respectively (Kahraman and Gundogdu, 2018; Gundogdu, 2019). In the financial realm, experts typically express opinions with a range denoting key expectations and intervals. Platforms like Bloomberg often present these projections as medians, maximums, and minimums in an interval format. To align this interval representation with spherical fuzzy sets, we have developed triangular spherical fuzzy sets. In this framework, the primary evaluation by experts reciprotes to the midpoint, while the minimum and maximum points represent the lower and higher limits for membership, non-membership, and hesitancy values.

Under the light of this novel methodology, amalgamating strategic frameworks with micro and macroeconomic indicators to appraise company valuations, our study establishes the foundation for assessing the enduring competitive advantage of publicly traded firms. Furthermore, it provides insights into the anticipated trajectory of stock prices under standard market conditions. This investigation not only elucidates Warren Buffett's value investing strategy but also introduces a modeling approach relevant to the Turkish public stock exchange context.

2. LITERATURE REVIEW

In this section, our focus will be on long-term competitive power, the value investing methodology, and its microeconomic financial indicators. Subsequently, we will delve into a fuzzy logic perspective in financial analysis, introducing novel triangular spherical fuzzy sets applied in financial analysis. We will conduct an in-depth exploration of existing literature on fuzzy logic applications in financial evaluation and decision-making. The crucial financial components will be illustrated to extract accurate figures from financial statements, with manual adjustments made, if necessary, before deriving final ratios. In the concluding stage, machine learning applications will be introduced, and previous research in finance will be analyzed.

It is imperative to acknowledge that the only indisputable lesson history imparts is that the future will always hold surprises. Therefore, in this study, we approach the results and models with humility, aiming to avoid excessive risk based on a potentially incorrect outlook on the future. This approach serves as one of the most potent tools, ensuring constant vigilance for both investors and researchers.

2.1 Long-Term Competitive Advantage and Value Investing

The concept of long-term competitive advantage holds a central position in the value investing methodology. This paradigm asserts that the enduring competitive strengths a company possesses significantly influence its valuation in the market. Value investing, as introduced by investment luminaries like Benjamin Graham and Warren Buffett, emphasizes the importance of identifying companies with sustainable competitive advantages, often referred to as an "economic moat".

The core premise is rooted in the notion that companies possessing durable competitive advantages are better positioned to generate consistent profits and maintain stability in the face of market fluctuations and has higher company valuations. This academic exploration

delves into the intricate relationship between long-term competitive advantage and value investing, aiming to unravel the mechanisms through which such advantages impact a company's valuation.

2.1.1 Historical perspectives on value investing

From the past to the present, humankind have invested their existing resources by saving with the belief and planning for better returns in the future. The innate impulse to test one's luck and achieve prosperity has triggered this behavior. However, due to the exaggerated arrogance regarding their capabilities and competences as investors, senseless love to assumptions, acting according to market trends, and not demonstrating sufficient patience and psychological resilience, humans have experienced significant losses instead of increasing prosperity (Seybert and Bloomfield, 2009).

Since around the year 1300 A.D., science has gained a superior position over mysticism. Humanity began to adopt the idea that it is not passive in the face of fate and that the future is predictable. After the renaissance and reform movements in medieval Europe, trade gained new momentum, and the foundations of capitalism, the embodiment of taking risks, were laid (Malik and Amjad, 2013). Wealth was no longer considered a possession that should be rooted from previous generations but had become a phenomenon that could be earned and increased through investments (Goldberg, 2006). It became essential for a good trader to be, above all, a good predictor. The term "stock-jobber," the precursor to the term "stockbroker" that refers to someone involved in stock trading, began to be used in the United Kingdom in 1688 for individuals who mediated the buying and selling of shares of companies such as Lute-String, Tapestry, and Diving (Bernstein, 2016). Swiss mathematician Daniel Bernoulli' s St. Petersburg article revealed a new paradigm to investment world with new concept about decision making under uncertainty. Bernoulli (1954) presented a well-known problem called the "St. Petersburg Paradox," which involves a speculative gambling game with a fair coin is tossed, and the payout doubles with each consecutive head. Surprisingly, this game has not been preferred by individuals, despite its increasing expected value. The paradox introduces utility theory, revealing that individuals naturally exhibit a spectrum of risk preferences, ranging from risk-averse to risk-seeking, influenced by factors such as age and perceived utility (Kahneman, 1973;

Neal and Kathleen, 2012). In addition to these behavioral factors affecting investors' decisions, it has been widely accepted since the 1900s that the priority for intelligent investors is to protect their principal investment while also seeking significant profits in the market (Kahneman and Tversky, 1979). Benjamin Graham, a prominent advocate of the idea, introduced a significant investment theory in the 1930s. In their seminal work, Graham and Dodd (1934) delved deeply into financial statements to analyze the intrinsic value of traded stocks. They formulated a novel investment concept known as "value investing," asserting that investors should purchase stocks based on the current and anticipated business performance that reflects the company's value. By doing so, investors can identify undervalued stocks with strong business performance, potentially yielding excess profits compared to the market index. Graham (2003) introduced “intelligent investor” and “Mr. market” term with the literature and plotting the fundamental pillars of the value investing methodology. Graham’s definition of investment could not be clearer: investment is protecting principal and promising an adequate return based on detailed and trustable analysis (Knight, 1964). According to Graham, value investing involves three equal elements: detail analysis of company’s business activity and historical financial filings, protecting yourself against serious loses, aiming “adequate” performance rather than exceptional. He underlined that stock market performance is directly linked with real growth (enhancements in company earnings and dividends), inflationary growth (price level hikes in economy), speculative growth or contraction (change of mood for risky investments). Value investing principal propose that intelligent investor calculates the value of a stock based on the company's value, while a speculator bets on the rise in the stock price because they believe someone else will pay more at that moment or in the future. Evaluating the success of the commonly believed investment technique in a short period is quite misleading. Temporary increases prove nothing. Traveling from Istanbul to Cesme at a speed of 100 km/h in 5.5 hours is much safer, whereas traveling at an average speed of 150 km/h in 3.5 hours increases the risk of death. Similarly, chasing short-term high gains in the stock market brings us closer to danger (Kutan and Aksoy, 2003).

An intelligent investor prioritizes the safety of the principal, takes advantage of market fluctuations, identifies well-managed companies with lower pricing than their intrinsic

values, and invests in them timely, enjoying the returns. An intelligent investor is aware that stocks are riskier when prices rise and less risky when prices fall, and they know how to turn this awareness into action with high mental discipline. On the other hand, an ignorant, unconscious speculator chasing short-term high returns sells their shares with the unbearable pain of loss when the market falls and buys at high prices with the expectation that prices will rise further when they go up. An intelligent investor is somewhat a contrarian. They don't succumb to the roar of the crowd, holds onto their papers when they are cheap, sells when prices exceed their intrinsic values, and then dives into the treasury of bonds and cash, patiently waiting until the stocks reach the buyback level (Lee, 1992). It's essential to remember that life can only be understood and acknowledged looking to history and past, but it must be experienced through forward (Kierkegaard, 2020). Looking back, you can always see exactly when to buy and when to sell. However, determining when to enter and exit the stock market in reality requires great discipline, expertise, and deep knowledge and analytical power.

The value investor does not evaluate their benchmark based on market movements and the rises within a specific period for higher returns or lower losses (Graham, 2003). This is merely a performance measurement method for fund managers who focus on demonstrating their annual premiums' performance in the market. This premium expectation leads to constantly buying and selling stocks, creating market volume, not remaining indifferent when the market rises for no apparent reason, and buying stocks, and, conversely, selling them without reason when the market falls. They cannot adjust their cash and stock positions in a way that increases stocks in downturns and sells in upturns. Therefore, there can be no situations of consistently beating the market (Marques et al., 2013). They may achieve extraordinary but very deceptive profits for a short period, but history has shown that there have been severe losses afterward. This is because the fiscal year-focused premium constitutes their main objectives. While achieving better returns than the market, when examined, it has caused significant losses and erosion of their capital for these investors. So, why should we trust those who are incapable of even winning their own games as financial professionals? A long-term value investor is aware of this. They do not evaluate their success entirely based on the bets of the players we call the market. In this case, the value investor does not constantly mainstay their stock to the

market price created by other market players due to their judgment errors, inadequate psychologies, and lack of strong will.

2.1.2 The role of competitive advantage in financial evaluation

Competitive advantage plays crucial role in financial health of the companies. It directly effects companies ability to generate higher profits via perceived value on the side of the customer.

Competitive advantage not only allow company to put higher price tags but also creates efficiencies within organization with value added activities which are compitible between themselves and reinforced each other. These lead higher profit margins in P&L table; higher margin in gross profit, operational profit, net profit. Companies with competitive advantage generally dominate the market as leader yield enhaced revenue stream, customer portfolio, bargaining power with supplier and B2B retailers ended up with better financial performance (Porter, 2011). In turbulent economic environment, robust customer base, secure revenue streams with associated cost saving countermeasures provide stability to these organizations. In a human context, the perception of investment security is bolstered by an increased level of participation in a shared destiny. From this perspective, a robust competitive advantage provides not only higher growth but also instills confidence in investors. Less risky companies finance itself with lower interest rates, yield lower financing cost and increased net profit (Margoshes, 1961). All of these enhancements in financial performance, in turn, contribute to a competitive advantage by facilitating increased investment in a company's core competences and resources. This creates a virtuous circle.

2.1.3 Strategies for sustainable competitive edge

Perception of competitive force has been shuffled along the history. Companies are forced to be flexible to adopt these rapid changes. Porter (1980) proposed a new framework to understand an industry competition reveals why industry profitability is what it is. It is the main framework the industry dynamics through competiton level. It comprimise of “threat of entry”, gauged by entry barriers' strength; “bargaining power of buyers”, influenced by their negotiation strength impacting discounts and supplier exclusivity; “bargaining power of suppliers”,determined by their ability to influence prices;, “threat of

substitution", considering available substitutes; and "intensity of rivalry", reflecting competition driven by market demand (IMA, 2016).

Table 2.1 : Long term sustainable competitive power concepts

Authors	Article/Book	Competitive Advantage Contributions
Porter (1980)	"Competitive Strategy: Techniques for Analyzing Industries and Competitors"	Five Forces framework
Wernerfelt (1984)	"A Resource-Based View of the Firm"	RBV theory
Porter (1985)	"Competitive Advantage: Creating and Sustaining Superior Performance"	Concept of value chain analysis
Ghemawat (1986)	"Sustainable Advantage"	AAA Triangle: Adaptability, Aggregation, and Arbitrage strategy
Hamel and Prahalad (1990)	"The Core Competence of the Corporation"	Core competencies, resources and capabilities
Barney (1991)	"Firm Resources and Sustained Competitive Advantage"	Firm-specific resources and capabilities
Berry (1991)	"Relationship Marketing of Services— Growing Interest, Emerging Perspectives"	Customer relationships
Peteraf (1993)	"The Cornerstones of Competitive Advantage: A Resource-Based View"	Further exploration to RBV theory,
Markides and Williamson (1994)	"Related Diversification, Core Competences and Corporate Performance"	Diversification and core competencies
Barney & Hesterly (2006)	"Strategic Management and Competitive Advantage: Concepts and Cases"	Application of the RBV theory to strategic management
Laufer (2006)	"Social Accountability and Corporate Greenwashing"	Social accountability on corporate behavior, role for sustainable competitive advantage
Teece (2007)	"Explicating Dynamic Capabilities: The Nature and Microfoundations of (Sustainable) Enterprise Performance"	Dynamic capabilities framework
Tao & Hutchinson (2012)	"Corporate Governance and Risk Management: The Role of Risk Management and Compensation Committees"	Corporate governance for sustained competitive advantage
Mai et al. (2024)	" Key leaders' sustainable decision making: The roles of key leaders' sustainability mindset."	Sustainable decision making of organization' s key leaders

Wernerfelt (1984) introduces a new perspective, emphasizing that any strategy within the market cannot exist independently of an organization's resources. These resources

encompass various aspects such as machine capacity, customer loyalty, production experience, and technological leadership, which are further extended through developed capabilities (Gignac et al., 2003). When confronted with a strategy-blocking resource, organizations have two options: either adapt the strategy to align with the available resources or make the necessary resources available to align with the strategy. Porter (1985) expanded the five forces framework by introducing the value chain concept, suggesting the optimization of an organization's primary activities: inbound logistics, operations, outbound logistics, marketing and sales, and service, along with supporting activities such as purchasing, technology, human resources, and infrastructure. The optimization of these components can generate efficiencies, resulting in cost advantages, particularly when combined with value-added activities. Ghemawat (1986) introduced the concept of sustainable competitive advantage within the Triple A triangle, emphasizing adaptability, aggregation, and arbitrage strategies. Adaptation involves tailoring products and services throughout the value chain to suit the preferences and cultures of customers in various geographical locations. Aggregation seeks to capitalize on economies of scale/scope, facilitating cost leadership in the market. Arbitrage entails leveraging the best value opportunities globally and delivering them to customers.Prahalad & Hamel (1990) posited that the creation of sustained competitive advantage is contingent upon the existence of core competences intricately woven into the customer experience journey facilitated by the offered product or service. These competences, to be effective, should embody characteristics such as high perceived value from the customer's perspective, inherent difficulty of imitation, and an elusive quality that sets them apart. Barney (1991) proposed new framework that only valueable, rare company resources create sustainable advantage, required heterogenity from industry standards, build internal capabilities accepted by customer. It is extended trough VRIO concept; valuable, rare, and difficult-to-imitate resources (Peteraf, 1993).Cases studies with real life problems examined by Barney & Hesterly (2006) at the context of strategic management. Berry (1991) highlights the importance of maintaining relationships as a valuable aspect of service-oriented businesses, which, in turn, can contribute to a competitive edge by fostering customer loyalty and differentiation. The work lays a foundation for understanding how customer focus can play a role in achieving a sustained competitive advantage. Markides and

Williamson (1994) underline the relationship between diversification, core competences, and corporate performance and reveals diversifying business activities & leveraging core competences contribute corporate performance with created unique strength. Laufer (2006) introduce SRI (socially responsible investing) and CSR (corporate socail responsibility) concept under corporate governance as as indicator of long term competitive power. Decisions that are devoid of principles and values, disregarding society, and aiming to maximize individual benefit will bring total benefits to the organization in the long run that are certainly no greater than decisions based on principles and values, considering society. This is because a rational and unbiased decision that does not rely on any principle or value cannot win every struggle it enters. Absolute defeat against a more rational decision is certain. Teece (2007) emphasizes dynamic capabilities, stating that employee competences, processes, organizational culture, and business units collectively establish an ever-evolving infrastructure with an unlimited potential to create intangible assets. This, in turn, supports business performance and fosters a sustained competitive advantage in the long run. Tao & Hutchinson (2012) asserted that effective corporate governance and risk management practices contribute to a business's long-term competitive strength. Foundational principles include Shareholder Rights and Equitable Treatment, Media Relations and Public Perception Management, Director Qualifications and Expertise, and Long-Term Vision and Goals Alignment. Mai et al. (2024) conducted a survey involving 142 key business people, revealing that mental wellness significantly influences the sustainable decision-making of organizational leaders. The study proposes that key leaders play a pivotal role in shaping an organization's infrastructure through their decisions and influence on others. As a result, they emerge as crucial sources of long-term competitive advantage.

2.1.4 Financial indicators for long term competitiveness

Accounting serves as the language of business, and financial statements are undoubtedly the means of articulating it. Whatever activities a business engages in over a period of time, their numerical impact is reflected in the profit and loss (P&L) statement, the cash perspective results are presented in the cash flow statement, and the assets and liabilities

are observed in the balance sheet (BS). Therefore, the outcome of sustained competitive power can be discerned in financial statements as proxies (Gervais and Odean, 2001).

The first line of the income statement (P&L) consistently represents the total revenue, indicating the overall earnings within a specified period, as outlined in financial statements. It is imperative for the total revenue not only to sufficiently cover total expenses but also to be effectively distributed across geographical locations, various channels, and relative customer shares. On the other hand first profitability ratio of the P&L is gross profit margin reflects the percentage of revenue after deducted cost of goods sold (COGS). Outstanding companies, with long term competitive power, has higher profit margins with the independence of pricing considerable over COGS with superiority in the market (Bayaraa, 2017). If there is not available any superiority arisen from competitive power, companies in the market needs to make discounts to get market share in competition. A gross profit margin of 40% or above is generally considered an indicator of sustained competitive strength, signifying a favorable market position with fewer concessions required (Basyith et al., 2021). Business owners typically prioritize operating net cash flow (ONCF) over net profit on the profit and loss (P&L) statement. Operating cash flow is a crucial indicator that reflects how much money a company generates from its core operations. A higher operating cash flow signifies material cash reserves for potential investments, as well as the capability to settle financial debts, all while supporting the company's rapid growth (Lin et al., 2022). Selling a product or service, without the necessity for constant tangible asset investments, yields continuous profits for a business and is undoubtedly a preliminary indicator of long-term sustainable competitive advantage. On the contrary, recurrent investments in tangible assets may create an illusion of size but essentially means to connect a pipe to ONCF by machine sellers and suppliers (Porter, 1985). In such a competitive market, it eventually leads to market overcapacity, resulting in declines for companies in the long run. Organic growth may impose limitations on growth potential, especially in the early stages of a business, with the surrounding environment providing an infinite source (Mukherjee and Naka, 1995). In a market where timing is a unique source of competition, being the first promoted by customers is crucial. Hence, the strategic use of debt can be a valuable instrument for companies until the point where the company's growth rate begins to decline (Fatouh et

al., 2024). In this context, the total liability/shareholder equity ratio serves as an important indicator for every business seeking a competitive edge. Recent studies about stock return prediction studies, employed econometric models and main findings given at Table 2.2.

Table 2.2 : Financial models for stock return predictability

Authors	Dataset	Econometric Model	Study Result
Akben-Selcuk (2016)	2005-2014 Borsa Istanbul companies	Regression analysis	ROA has positive corelation with gross profit margin, firm size, international sales.
Zeng et al. (2022)	1985-2001 S&P 500 companies	Linear Regression & Prinpical component analysis	Economic policy uncertainity index is a good predictor of long term stock performance. EPU index outperform 14 traditional macroeconomic variables.
Do et al. (2022)	1970-2016 NYSE/Amex and Nasdaq listed leveraged and zero leveraged companies	Linear regression	Financial leveraged stocks perform better than zero leveraged companies. Considering FED low interest rate policy, It is expected result.
Smith (2021)	1973-2017 (divided to five regimes) 17 countries stock exchange monthly excess stock return	Bayesian framework	Dividend yield, t-bill, inflation and US stock return is strong indicators in stock return prediction under bayesian framework
Chen et al. (2022)	1901-2015 annual stock return and demographics of S&P 500 index	Linear & non-linear regression	Middle age (40-49) / young age (20-29) population ratio is an important indicator on company valuation calculated by dividend-price ratio
Ma et al. (2022)	1980-2020 Standard & Poor's 500 index excess returns	Partial least square lasso	Macroeconomic attetion indices of Fisher have superiority over traditional economic variables.
Yu et al. (2023)	1927-2018 Standard & Poor's 500 index excess returns	Linear regression	Financial valuation ratios is more successful predictors or stock return and future cash flow prediction when split up into slow-moving and clylical components
Beniwal et al. (2023)	Nifty Dow Jones Industrial Average DAX performance Index Nikkei 225 Shanghai Stock Exc.	Genetic algorithm optimization & support vector regression	Forward validating approach gives best result in long run stock prediction. In the dataset no predictor is used. Daily stock prices have been used as input with normalized according to daily max and min values.
Wang et al. (2024)	2018-2022 Shenzhen A-share listed companies in China	Linear regression	ESG rating divergence has negative effect on excess stock returns

2.1.5 Important nuances for financial statement make ups

Financial statements are indispensable tools for stakeholders seeking insights into a company's financial health and performance. However, the integrity of these statements relies on adherence to ethical accounting practices. Unethical manipulations of financial statements can distort the true financial position of a company, compromising transparency and eroding trust (Patelis, 1997). Understanding the nuances associated with financial statement make-ups is paramount for investors, regulators, and other stakeholders to spot potential red flags and guard the reliability of reported financial information. This discussion sheds light on various manipulations that have been employed, albeit unethically, to present a misleading picture of a company's financial standing. It is important to read each piece of financial reports to assess the right valuation of company. Accelerating income by recording it in advance and invoicing upfront without actual cash inflow through a partner is a common practice, especially in startups and companies in the scale-up process (Hirshleifer and Teoh, 2003). This can mislead the reader in financial statements. Footnotes should be read carefully. In financial reports, attention should be paid, especially to the last pages. What the company does not want you to find is usually placed at the very end.

Robust companies used to create "unexpected situation reserves" from the profits of good years to offset the adverse effects of future recession years. The underlying idea was to proportionally equalize accrued earnings to net sales revenue and improve the stability factor in the company's records. However, it distorts not only financial ratios but also dividend potentials to shareholders. Typically, such rules are specified in the articles of association, mandating a certain percentage of the net profit as a minimum threshold.

The method of handling depreciation is another factor that provides the opportunity to avoid taxes based on the projected profit amount. Companies that have high profit projections often switch to accelerated depreciation, while those with lower profit amounts tend to use straight-line depreciation. Additionally, fixed assets that are put into use but not yet generating sales in the accounting system can be kept in the "258-investment in progress" account without writing depreciation, creating a fictitious increase in profit. Another important factor at times is the optimization of R&D costs through incentives and

taxes. Recording R&D costs as direct expenses instead of capitalizing them on the balance sheet will facilitate tax avoidance.

The issuance of a large number of stock options without appropriate performance criteria can lead to excessive number of share numbers and dilution of return on shareholder equity.

2.2 Fuzzy Logic in Financial Evaluation

Traditional financial models often rely on precise inputs and deterministic calculations for expected values assume that all relevant information is known and can be expressed with certainty. Moreover, the expected value is computed based on accurate and definite data points. Adhering risk aversion tendency, there is not possible to give decision on rigid numbers. In reality, individuals opt for guaranteed profits over engaging in fair gambling, making the expected value mindset ineffective. Fuzzy logic acknowledges the inherent uncertainty and imprecision in financial data that allows for the representation of information using linguistic variables and fuzzy sets. Thereby, the expected value becomes a fuzzy set, capturing the uncertainty in the decision-making process.

Subjectivity to objectivity transformation leads many scientific progresses along the history. The financial problems initially have been formulated with rigid mathematics that yields failure due to lack of human contribution feed by observations. After the process of introduction binary logic by Leibniz at 17^{th} century, human-machine interaction contributes to scientific progress. Despite the dominance of binary logic, human thought encompasses nuances, often characterized by imprecision, vagueness, and fuzziness, prompting the transition to multivalent logic. Emphasizing the existence of infinite alternatives between truth and falseness, complex models have been created reflects to human logic. In addressing real financial challenges, the logical approach, whether numerical or otherwise, involves diverse information sources. Some data are derived from formal or probable measurements, while others reflect expert opinions and carry a subjective nature. Evaluating the truth value of a proposition extends beyond binary outcomes of 1 (truth) or 0 (falseness). Language encompasses a spectrum of adjectives and adverbs, offering expressions between truth and falseness. Precision characterizes certain statements like specifying Turkiye Central Bank reference interest rate is 42.5%

as of 25 January 2024, while imprecision occurs in statements such as "operating net cash flow must be positive." The use of both precise and imprecise data is pervasive in our communications, influenced by our knowledge level and the inherent subjectivity of our reasoning. Consequently, the human treatment of information is not bivalent or binary but multivalent (Dompere, 2004). Real-world problems cannot be simplistically evaluated using a binary framework of 0 (false) or 1 (truth). This challenge extends beyond scientific contexts and is fundamentally a societal concern. We will denote and introduce the term FSFE means fullpackage stigmatize from first evaluation. It refers that evaluation bias through with upper points of a scale for a circumstance as o or 1, good or bad. Between 0 and 1, intermediary positions match better with reality of life. This estimate including subjectivity better correspond all matters in the world.

2.2.1 Introduction to fuzzy logic in finance

The adoption of a fuzzy mentality in the realm of finance is rooted in studies that grapple with a high degree of uncertainty, particularly concerning parameters crucial for future forecasting. Consequently, it can be asserted that sensitivity and scenario analysis stand out as the initial modern practical applications of fuzzy logic in finance.

The pivotal aspect of business planning lies in the preparation of proforma financial statements, encompassing the proforma P&L, BS, and cash flow statements. Commencing with foundational assumptions such as interest rates, tax rates, and fx rates, the process sequentially unfolds through sales, production, headcount, manufacturing overhead, capital expenditures, and general & administrative planning, culminating in proforma financial statements. Data flows both top-down and bottom-up, accumulating in these tables. Acknowledging the inherent bias in estimations, it necessitates interactive discussions with budget owners for detailed insights, allowing for the estimation of potential buffers and fine-tuning. Despite these efforts, precise forecasts for market rivalry and macroeconomic conditions remain elusive. To surmount such challenges, a dynamic assumption list, as illustrated in Figure 2.1, is employed for rolling forecasts and scenarios depicted in Figure 2.2, presenting scenarios with various conditions and corresponding countermeasures. This pragmatic approach mirrors the application of fuzzy logic mentality in financial practices.

COMPANY XYZ CONSOLIDATED BDG 2024 All amounts in K USD by Zekeriya Bildik	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sep-24	Oct-24	Nov-24	Dec-24
Balance Sheet Check	-	-	-	-	-	-	-	-	-	-	-	-
End of Period	31.01.2024	29.02.2024	31.03.2024	30.04.2024	31.05.2024	30.06.2024	31.07.2024	31.08.2024	30.09.2024	31.10.2024	30.11.2024	31.12.2024
Days in Period	31	29	31	30	31	30	31	31	30	31	30	31
Fraction of Month	1	1	1	1	1	1	1	1	1	1	1	1
General Assumptions												
Budget Fixed Date	2.12.2023											
Fiscal Year-End	31.12.2024											
Tax Rate	25%											
Risk-Free Rate	29.75%											
Equity Risk Premium	5%											
Interest Rate	51%											
Lifetime of New PP&E	6											
Long Term Debt Maturity												
EUR	41.32 TL	36.74	37.12	38.59	38.24	39.41	43.17	42.61	43.82	43.54	43.79	43.91	44.92
USD	39.76 TL	32.45	32.72	35.02	35.24	37.28	40.77	41.73	43.22	43.86	44.55	44.63	45.65
GBP	48.39 TL	43.91	44.23	46.08	45.66	46.31	50.30	49.99	51.81	49.80	50.11	50.62	51.79
CHF	41.09 TL	35.26	35.36	37.59	37.34	37.99	41.99	43.01	45.13	45.00	44.71	44.34	45.36
INFLATION	64.0%											

Figure 2.1: Dynamic assumption list as fuzzy logic mentality application

Scenario // Assumptions	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sep-24	Oct-24	Nov-24	Dec-24
	1	BASE CASE										
LIVE SCENARIO												
Revenue (% Change) From Base	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Interest (% of Debt)	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%
Tax Rate (% of Earnings Before Tax)	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%
Accounts Receivable (Days)	45	45	45	45	45	45	45	45	45	45	45	45
Accounts Payable (Days)	60	60	60	60	60	60	60	60	60	60	60	60
Debt Issuance (Repayment) ($000's)	-	-	0	0	0	0	0	0	0	0	0	-
Equity Issued (Repaid) ($000's)	-	-	0	0	0	0	0	0	0	0	0	-
Payment of Dividends	-	-	-	-	-	-	-	-	-	-	-	-
Cost Saving Countermeasures	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BASE CASE												
Revenue (% Change) From Base	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Interest (% of Debt)	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%
Tax Rate (% of Earnings Before Tax)	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%
Accounts Receivable (Days)	45	45	45	45	45	45	45	45	45	45	45	45
Accounts Payable (Days)	60	60	60	60	60	60	60	60	60	60	60	60
Debt Issuance (Repayment) ($000's)	0	0	0	0	0	0	0	0	0	0	0	0
Equity Issued (Repaid) ($000's)	0	0	0	0	0	0	0	0	0	0	0	0
Payment of Dividends	0	0	0	0	0	0	0	0	0	0	0	0
Cost Saving Countermeasures	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
WORST CASE												
Revenue (% Change) From Base	-15.0%	-15.0%	-15.0%	-15.0%	-15.0%	-15.0%	-15.0%	-15.0%	-15.0%	-15.0%	-15.0%	-15.0%
Interest (% of Debt)	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%
Tax Rate (% of Earnings Before Tax)	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%
Accounts Receivable (Days)	50	50	50	50	50	50	50	50	50	50	50	50
Accounts Payable (Days)	50	50	50	50	50	50	50	50	50	50	50	50
Debt Issuance (Repayment) ($000's)	0	0	0	0	0	0	0	0	0	0	0	0
Equity Issued (Repaid) ($000's)	0	0	0	0	0	0	0	0	0	0	0	0
Payment of Dividends	0	0	0	0	0	0	0	0	0	0	0	0
Cost Saving Countermeasures	-10.0%	-10.0%	-10.0%	-10.0%	-10.0%	-10.0%	-10.0%	-10.0%	-10.0%	-10.0%	-10.0%	-10.0%
HIGH CASE												
Revenue (% Change) From Base	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
Interest (% of Debt)	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%	51.1%
Tax Rate (% of Earnings Before Tax)	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%
Accounts Receivable (Days)	30	30	30	30	30	30	30	30	30	30	30	30
Accounts Payable (Days)	70	70	70	70	70	70	70	70	70	70	70	70
Debt Issuance (Repayment) ($000's)	0	0	0	0	0	0	0	0	0	0	0	0
Equity Issued (Repaid) ($000's)	0	0	0	0	0	0	0	0	0	0	0	0
Payment of Dividends	0	0	0	0	0	0	0	0	0	0	0	0
Cost Saving Countermeasures	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
DOOMSDAY CASE												
Revenue (% Change) From Base	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%
Interest (% of Debt)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Tax Rate (% of Earnings Before Tax)	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%
Accounts Receivable (Days)	60	60	60	60	60	60	60	60	60	60	60	60
Accounts Payable (Days)	50	50	50	50	50	50	50	50	50	50	50	50
Debt Issuance (Repayment) ($000's)	0	0	0	0	0	0	0	0	0	0	0	0
Equity Issued (Repaid) ($000's)	0	0	0	0	0	0	0	0	0	0	0	0
Payment of Dividends	0	0	0	0	0	0	0	0	0	0	0	0
Cost Saving Countermeasures	-15%	-15%	-15%	-15%	-15%	-15%	-15%	-15%	-15%	-15%	-15%	-15%

Figure 2.2: Scenario analysis as fuzzy logic mentality application

First finance application of fuzzy logic introduced by Buckley (1985) with applying mathematical foundation of fuzzy with time value of money. Li Calzi (1990) extends studies on value of money and creates the first financial models.

Subsequently, the application of fuzzy logic in finance gained popularity in the 2000s. Up until 2019, a total of 921 research articles related to finance were published on Web of Science and Scopus databases. Among these, 60% pertained to the financial market scope, 35% focused on corporate finance, 3% addressed public finance, and the remaining 2% covered various other scopes (Sanchez-Roger et al., 2019).

2.2.2 Spherical fuzzy sets

The Fuzzy Theory, originated by Zadeh in 1965, was conceived to tackle the complexities arising in an era marked by heightened uncertainty and increased information influx. It employs the principles of membership and non-membership degrees (Zadeh, 1965). Over the ensuing decade, its application spanned various disciplines, from social sciences to applied sciences. As the concept evolved, diverse variations emerged, including type-2 fuzzy sets, intuitionistic fuzzy sets, neutrosophic fuzzy sets, hesitant fuzzy sets, Pythagorean fuzzy sets, and spherical fuzzy sets (Zadeh, 1965; Zadeh,1975; Atanasov,1986; Yager & Abbasov, 2013; Smarandache, 1998). Kahraman and Gundogdu (2018) introduced Spherical Fuzzy sets, which offer a broader scope through the squared sum of membership degree, non-membership degree, and hesitancy degree, equal to one or less. This extended domain allows for independent hesitancy values, extending the potential on the surface and within the inner area of a sphere, represented by points such as [1,0,0], [0,1,0], and [0,0,1] where [μ,ν,π] stands for membership degree, non-membership degree, and hesitancy degree, respectively (Kahraman and Gundogdu, 2018; Gundogdu, 2019).

Within spherical fuzzy sets, it is noteworthy that the squared sum of membership, non-membership, and hesitancy parameters has a range between 0 and 1.More importantly, each of these parameters can be individually defined within the 0 to 1 range to ensure that their squared sum does not exceed 1. Figure 2.1 represent the visual illustration of spherical fuzzy sets and domain differences within other fuzzy sets mentioned above.

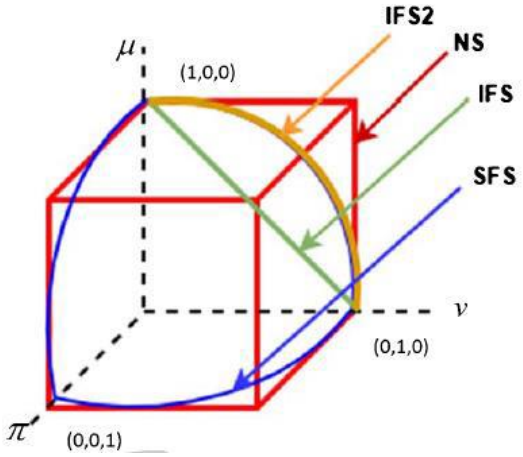

Figure 2.3: Representation of spherical fuzzy sets

Spherical fuzzy sets are the extension of Picture Fuzzy Sets. This Fuzzy Sets basic arithmetical operations have been given as below (Kahraman and Gundogdu, 2018):

Definition 1.1

Spherical Fuzzy Sets (SFS) of the universe of discourse Fuzzy Sets (FS) is indicated by:

$$SFS = \{u, ([\mu_{SFS}(x), \nu_{SFS}(x), \pi_{SFS}(x)]) \mid u \in U\} \quad (2.1)$$

where

$$\mu_{SFS} : FS \rightarrow [0,1], \nu_{SFS} : FS \rightarrow [0,1], \pi_{SFS} : FS \rightarrow [0,1] \quad (2.2)$$

and

$$0 \leq (\mu^2_{SFS}(x) + \nu^2_{SFS}(x) + \pi^2_{SFS}(x)]) \leq 1 \quad \forall x \in FS \quad (2.3)$$

$\mu_{SFS}(x)$, $\nu_{SFS}(x)$ and $\pi_{SFS}(x)$ is degrees of membership, non-membership and hesitancy of x to FS,

Definition 1.2

Spherical Fuzzy Sets arithmetical operations**:**

Union function;

$$SFS_A \cup SFS_B = \{\max\{\mu_{SFS_A}, \mu_{SFS_B}\}, \min\{\nu_{SFS_A}, \nu_{SFS_B}\}, \min\{1 - ((\min\{\mu_{SFS_A}, \mu_{SFS_B}\})^2 + (\max\{\nu_{SFS_A}, \mu_{SFS_B}\})^2), \min\{\pi_{SFS_A}, \pi_{SFS_B}\}\}\} \quad (2.4)$$

Addition operation;

$$SFS_A \oplus SFS_B = \{(\mu^2_{SFSA} + \mu^2_{SFSB} - \mu^2_{SFSA}\,\mu^2_{SFSB})^{1/2},\ \nu_{SFSA}\,\nu_{SFSB}\ ,\ ((1-\mu^2_{SFSB})\,\pi^2_{SFSA} + (1-\mu^2_{SFSA})\,\pi^2_{SFSB} - \pi^2_{SFSA}\pi^2_{SFSB})^{1/2}\} \quad (2.5)$$

Multiplication operation;

$$SFS_A \otimes SFS_B = \{\mu_{SFSA}\mu_{SFSB}\ ,\ (\nu^2_{SFSA} + \nu^2_{SFSB} - \nu^2_{SFSA}\,\nu^2_{SFSB})^{1/2},\ ((1-\nu^2_{SFSB})\,\pi^2_{SFSA} + (1-\nu^2_{SFSA})\,\pi^2_{SFSB} - \pi^2_{SFSA}\pi^2_{SFSB})^{1/2}\} \quad (2.6)$$

Definition 1.3

Let $SFS_A = (\mu_{SFS(A)}, \nu_{SFS(A)}, \pi_{SFS(A)})$ and $SFS_B = (\mu_{SFS(B)}, \nu_{SFS(B)}, \pi_{SFS(B)})$

$$SFS_A \oplus SFS_B = SFS_B \oplus SFS_A \quad (2.7)$$

$$SFS_A \otimes SFS_B = SFS_B \otimes SFS_A \quad (2.8)$$

$$(SFS_A \otimes SFS_B)^{\lambda} = SFS_A{}^{\lambda} \otimes SFS_B{}^{\lambda} \quad (2.9)$$

$$SFS_A{}^{\lambda 1} \otimes SFS_A{}^{\lambda 2} = SFS_A{}^{\lambda 2+ \lambda 1} \quad (2.10)$$

Definition 1.4

(SWAM) Spherical weighted arithmetic mean operator with $w = (w_1, w_2, w_3, \ldots\ldots\ldots\ldots, w_n)$; $w_i \in [0,1]$; $\sum_{i=1}^{n} w_i = 1$, SWAM is defined as:

$$SWAM_w(SFS_1, \ldots\ldots\ldots, SFS_n) = w_1 SFS_1 + w_2 SFS_2 + \ldots\ldots\ldots + w_n SFS_n \quad (2.11)$$

$$= \{[1-\prod_{i=1}^{n} (1-\mu^2_{SFSi})^{w_i}]^{1/2}\ ,\ \prod_{i=1}^{n} \nu^{wi}_{SFSi}\ ,\ [\prod_{i=1}^{n} (1-\mu^2_{SFSi})^{w_i} - \prod_{i=1}^{n} (1-\mu^2_{SFSi} - \pi^2_{SFSi})^{w_i}]^{1/2}\}$$

Definition 1.5

Spherical Fuzzy Sets score function is expressed as:

$$Score\ (SFS) = (\mu_{SFS} - \pi_{SFS})^2 - (\nu_{SFS} - \pi_{SFS})^2$$

2.2.3 Novel triangular spherical fuzzy sets

In the financial realm, experts typically express opinions with a range denoting key expectations and intervals. Platforms like Bloomberg often present these projections as medians, maximums, and minimums in an interval format. To align this interval representation with spherical fuzzy sets, we have developed triangular spherical fuzzy sets. In this framework, the primary evaluation by experts corresponds to the midpoint, while the minimum and maximum points represent the lower and higher limits for membership, non-membership, and hesitancy values.

Triangular spherical fuzzy sets are extension of spherical fuzzy sets. This Fuzzy Sets basic Arithmetical operations have been given as below:

Definition 2.1

Triangular spherical fuzzy sets (SFS) A_{TrS} spherical fuzzy set of the universe of discourse U is given by

$A_{TrS} = \{u, ([\mu_l(u), \mu_m(u), \mu_h(u)], [\nu_l(u), \nu_m(u), \nu_h(u)], [(\pi_l(u), \pi_m(u), \pi_h(u)]) \mid u \in U$ (2.12)

where

$\mu_{ATrS} : U \rightarrow [0,1]$, $\nu_{ATrS} : U \rightarrow [0,1]$, $\pi_{ATrS} : U \rightarrow [0,1]$

μ: membership degree, ν: non-membership degree, π: hesitancy degree

$$0 \leq \mu_l(u) \leq \mu_m(u) \leq \mu_h(u) \leq 1 \quad (2.13)$$

$$0 \leq \nu_l(u) \leq \nu_m(u) \leq \nu_h(u) \leq 1 \quad (2.14)$$

$$0 \leq \pi_l(u) \leq \pi_m(u) \leq \pi_h(u) \leq 1 \quad (2.15)$$

Definition 2.2

Triangular Spherical Fuzzy Set fit test is defined as:

$0 \leq (\mu_h(u))^2 + (\nu_h(u))^2 + (\pi_h(u))^2 \leq 1$

where

$\mu_h(u)$: Higher value of membership interval

$\mu_m(u)$: Middle value of membership interval

$\mu_l(u)$: Lower value of membership interval

$\nu_h(u)$: Higher value of non-membership interval

$\nu_m(u)$: Middle value of non-membership interval

$\nu_l(u)$: Lower value of non-membership interval

$\pi_h(u)$: Higher value of hesitancy interval

$\pi_m(u)$: Middle value of hesitancy interval

$\pi_l(u)$: Lower value of hesitancy interval

Definition 2.3

Main triangular spherical fuzzy set is originated from triangular spherical fuzzy set in the universe U in case of:

$\mu_l(u) = \mu_m(u) = \mu_h(u)$

$\nu_l(u) = \nu_m(u) = \nu_h(u)$

$\pi_l(u) = \pi_m(u) = \pi_h(u)$

Definition 2.4

In triangular spherical fuzzy sets, largest, smallest and most hesitant values have been expressed as below:

A_{TrS} spherical fuzzy set of the universe of discourse U is given by

$A_{TrS} = ([\mu_l(u), \mu_m(u), \mu_h(u)], [\nu_l(u), \nu_m(u), \nu_h(u)], [(\pi_l(u), \pi_m(u), \pi_h(u)])$,

The largest TrSFN is [[1, 1, 1], [0, 0, 0], [0, 0, 0]].

The smallest TrSFN is [[0, 0, 0], [1, 1, 1], [0, 0, 0]].

Then, with the highest hesitancy [[0, 0, 0], [0, 0, 0], [1, 1, 1]].

Definition 2.5

Triangular spherical weighted arithmetic mean (TRSWAM) operator ; w_i represent expert weight of number i expert, TRSWAM is defined as

$w = (w_1, w_2, w_3, \ldots\ldots\ldots\ldots, w_n)$; $w_i \in [0,1]$; $\sum_{i=1}^{n} w_i = 1$,

$$TRSWAM_w(TRSFS_1, \ldots\ldots\ldots, TRSFS_n) = w_1 TRSFS_1 + w_2 TRSFS_2 + \ldots\ldots\ldots + w_n TRSFS_n$$

$$= \{[1-\prod_{i=1}^{n}(1-\mu^2_{TRSFSi})^{wi}]^{1/2}, \prod_{i=1}^{n} \nu_{TRSFSi}^{wi}, [\prod_{i=1}^{n}(1-\mu^2_{TRSFSi})^{w_i} - \prod_{i=1}^{n}(1-\mu^2_{TRSFSi} - \pi^2_{TRSFSi})^{w_i}]^{1/2}\} \quad (2.16)$$

If we examine it with detailed two phases; *weighting* and *aggregation.*

Weighting

TRSwi represent Triangular Spherical Fuzzy SWAM operation weighting for expert i.

Expert 1: $TRS_{w1}=\{(\mu_{TRS_{1l}}, \mu_{TRS_{1m}}, \mu_{TRS_{1h}}), (\nu_{TRS_{1l}}, \nu_{TRS_{1m}}, \nu_{TRS_{1h}}), (\pi_{TRS_{1l}}, \pi_{TRS_{1m}}, \pi_{TRS_{1h}})\}$

Expert 2: $TRS_{w2}=\{(\mu_{TRS_{2l}}, \mu_{TRS_{2m}}, \mu_{TRS_{2h}}), (\nu_{TRS_{2l}}, \nu_{TRS_{2m}}, \nu_{TRS_{2h}}), (\pi_{TRS_{2l}}, \pi_{TRS_{2m}}, \pi_{TRS_{2h}})\}$

Expert 3: $TRS_{w3}=\{(\mu_{TRS_{3l}}, \mu_{TRS_{3m}}, \mu_{TRS_{3h}}), (\nu_{TRS_{3l}}, \nu_{TRS_{3m}}, \nu_{TRS_{3h}}), (\pi_{TRS_{3l}}, \pi_{TRS_{3m}}, \pi_{TRS_{3h}})\}$

where

TRS_w Membership (μ) values:

For i=1 Expert 1**:** $\mu_{TRS_{1l}} = (1-(\mu_{1l}(u))^2)^{w(i)}$ $\mu_{TRS_{1m}} = (1-(\mu_{1m}(u))^2)^{w(i)}$ $\mu_{TRS_{1h}} = (1-(\mu_{1h}(u))^2)^{w(i)}$

For i=2 Expert 2**:** $\mu_{TRS_{2l}} = (1-(\mu_{2l}(u))^2)^{w(i)}$ $\mu_{TRS_{2m}} = (1-(\mu_{2m}(u))^2)^{w(i)}$ $\mu_{TRS_{2h}} = (1-(\mu_{2h}(u))^2)^{w(i)}$

For i=3 Expert 3**:** $\mu_{TRS3l} = (1-(\mu_{3l}(u))^{2})^{w(i)}$ $\mu_{TRS3m} = (1-(\mu_{3m}(u))^{2})^{w(i)}$ $\mu_{TRS3h} = (1-(\mu_{3h}(u))^{2})^{w(i)}$

TRS_w Non-membership (ν) values:

For i=1 Expert 1**:** $\nu_{TRS1l} = (1-(\nu_{1l}(u))^{2})^{w(i)}$ $\nu_{TRS1m} = (1-(\nu_{1m}(u))^{2})^{w(i)}$ $\nu_{TRS1h} = (1-(\nu_{1h}(u))^{2})^{w(i)}$

For i=2 Expert 2**:** $\nu_{TRS2l} = (1-(\nu_{2l}(u))^{2})^{w(i)}$ $\nu_{TRS2m} = (1-(\nu_{2m}(u))^{2})^{w(i)}$ $\nu_{TRS2h} = (1-(\nu_{2h}(u))^{2})^{w(i)}$

For i=3 Expert 3**:** $\nu_{TRS3l} = (1-(\nu_{3l}(u))^{2})^{w(i)}$ $\nu_{TRS3m} = (1-(\nu_{3m}(u))^{2})^{w(i)}$ $\nu_{TRS3h} = (1-(\nu_{3h}(u))^{2})^{w(i)}$

TRS_w Hesitancy (π) values:

For i=1 Expert 1**:** $\nu_{TRS1l} = (1-(\nu_{1l}(u))^{2})^{w(i)}$ $\nu_{TRS1m} = (1-(\nu_{1m}(u))^{2})^{w(i)}$ $\nu_{TRS1h} = (1-(\nu_{1h}(u))^{2})^{w(i)}$

For i=2 Expert 2**:** $\nu_{TRS2l} = (1-(\nu_{2l}(u))^{2})^{w(i)}$ $\nu_{TRS2m} = (1-(\nu_{2m}(u))^{2})^{w(i)}$ $\nu_{TRS2h} = (1-(\nu_{2h}(u))^{2})^{w(i)}$

For i=3 Expert 3**:** $\nu_{TRS3l} = (1-(\nu_{3l}(u))^{2})^{w(i)}$ $\nu_{TRS3m} = (1-(\nu_{3m}(u))^{2})^{w(i)}$ $\nu_{TRS3h} = (1-(\nu_{3h}(u))^{2})^{w(i)}$

Aggregation

$TRSWAM_w(SFS_{1,.....,}SFS_n) = \{(a\mu_l, a\mu_m, a\mu_h), (a\nu_l, a\nu_m, a\nu_h), (a\pi_l, a\pi_m, a\pi_h)\}$

where

$a\mu_l$, $a\mu_m$, $a\mu_h$ represents aggregated membership lower, middle and higher point respectively.

$a\nu_l$, $a\nu_m$, $a\nu_h$ represents aggregated non-membership lower, middle and higher point respectively.

$a\pi_l$, $a\pi_m$, $a\pi_h$ represents aggregated hesitancy lower, middle and higher point respectively.

Aggregated membership values:

$a\mu_l = (1-(\mu_{TRS_l}(u)* \mu_{TRS_l}(u)* \mu_{TRS_l}(u))^{1/2}$

$a\mu_m = (1-(\mu_{TRS}(u)* \mu_m(u)* \mu_m(u))^{1/2}$

$a\mu_h = (1-(\mu_h(u)* \mu_h(u)* \mu_h(u))^{1/2}$

Aggregated non-membership values:

$a\mu_l = (1-(\mu_{TRS_l}(u)* \mu_{TRS_l}(u)* \mu_{TRS_l}(u))^{1/2}$

$a\mu_m = (1-(\mu_{TRS}(u)* \mu_m(u)* \mu_m(u))^{1/2}$

$a\mu_h = (1-(\mu_h(u)* \mu_h(u)* \mu_h(u))^{1/2}$

Aggregated hesitancy values:

$a\mu_l = (1-(\mu_{TRS_l}(u)* \mu_{TRS_l}(u)* \mu_{TRS_l}(u))^{1/2}$

$a\mu_m = (1-(\mu_{TRS}(u)* \mu_m(u)* \mu_m(u))^{1/2}$

$a\mu_h = (1-(\mu_h(u)* \mu_h(u)* \mu_h(u))^{1/2}$

2.2.4 Applications of fuzzy logic in financial decision-making

Goonatilake et al. (1995) developed a decision support tool for currency trading that utilizes a genetic fuzzy algorithm to determine the optimal creation of fuzzy methodologies. The identification of buy and sell points is determined by employing four fuzzy rules generated over smoothed clusters through this methodology. Takahashi & Takahashi (2021) advocate for the use of online learning interval type-2 fuzzy sets, incorporating Bayesian filtering for financial investment decisions. They find that this approach, utilizing average returns and Sharpe/Sortino ratios, outperforms a set of alternative fuzzy models in terms of performance. Salahli and Suleymanov (2022) employs heuristic fuzzy logic with multi-criteria decision manking method to analyze Azerbaijan furniture industry and evaluate the success aof companies over five main criteria groupped over growth, activity, levarage, profitability and liquidity. Zhang (2020) addresses credit risk decisions in loan financing on crowdfunding platforms by employing a fuzzy neural network. This research is motivated by the rapid growth of venture capital not being adequately associated with effective risk management. Zhang utilizes four groups of indices, including business scale, flow, operating capacity, and growth capacity, which are proxied by financial data such as total assets, bank loans, operating income, net cash flow from operating activities, and more. Sevastianov & Dymova (2009) evaluate the effectiveness of traditional trading indicators in providing accurate decision advice for buying or selling. They compare two alternative fuzzy models, one derived from Yager's implication and the other from the combination of a fuzzy expert system with Dempster–

Shafer Theory. Results from real-time NYSE simulations highlight the superiority of the fuzzy expert system with Dempster–Shafer Theory. Janková & Dostál (2021) conducted a comparison of time series performance versus type-2 fuzzy sets with dual membership functions for stock return prediction across three dimensions: return, risk, and performance. Their findings suggest that type-2 fuzzy sets yield superior results, exhibiting higher R-square values and lower mean square errors compared to traditional time series methods. Quek et al. (2023) combines picture fuzzy sets with machine learning algorithms over decision making methods TOPSIS (Technique for Order Preferenceby Similarity to Ideal Solution) and EDAS (Evaluation Based on Distance from Average Solution) employing investor characteristics (aggressive, conservative; optimistic,pessimistic;long term, short term) for stock selection for future expected returns.

2.2.5 Advantages and challenges of using fuzzy logic in finance

Fuzzy logic has emerged as a valuable tool in financial modeling, offering several advantages via addressing uncertainties and complexities of financial systems. However, its adoption also poses certain challenges that necessitate careful consideration.

We can enumerate the main advantages under three subtitles: supervision uncertainty, resilience in decision-making, and adaptability to a dynamic environment. Traditional financial models encounter challenges when dealing with the vagueness inherent in real-life practices related to numerous parameters. Fuzzy logic, incorporating membership, non-membership, and hesitancy evaluations, broadens the scope of domains and converts linguistic evaluations into precise values. This capability facilitates the integration of diverse perspectives into mathematical models, providing a more comprehensive foundation. In the decision-making process, fuzzy logic enables expert evaluations based on qualitative assessments, incorporating them into quantitative models. Its robust adaptability to the rapidly changing financial market environment allows for fast analysis in fluctuating conditions.

Computational complexity, interpretibility and data requirements may be enumarated as the challenges of fuzzy logic applications in finance. Employing fuzzy logic models can pose computational challenges, particularly when handling extensive datasets or intricate

rule sets. This computational intensity might impede real-time applications in high-frequency trading or necessitate optimization strategies to bolster efficiency. Despite their proficiency in capturing intricate relationships, the interpretability of fuzzy logic models can be heavy. Comprehending the implications of fuzzy rules and their influence on decision outcomes may require expertise in both finance and fuzzy logic, constraining the widespread adoption of these models. Effective training and validation of fuzzy logic models may demand substantial data. In scenarios where obtaining reliable historical data is arduous, the performance of fuzzy logic models may face compromise.

2.3 Machine Learning Applications in Financial Analysis

The field of finance, along with its sub-domains, has been extensively researched for over a century. The introduction of the risk mentality by Markowitz (1952) significantly accelerated the pace of research. Machine learning (ML) models have emerged as transformative tools in finance, allowing the analysis of large volumes of data efficiently and at a lower cost, providing valuable insights through advanced algorithms and computational power. ML research in finance predominantly revolves around six categories: stock market prediction, portfolio management, cryptocurrency prediction, foreign exchange, financial crisis prediction, and insolvency and bankruptcy prediction (Nazareth & Ramana Reddy, 2023).

2.3.1 Overview of machine learning in finance

One key utilization of machine learning within the finance domain is predictive analytics. Machine learning algorithms make a deep analyze historical data to discern patterns and trends, empowering institutions to formulate more precise forecasts regarding upcoming market dynamics. Predictive modeling finds application across diverse financial domains, encompassing stock prices, currency exchange rates, and interest rates.

Algorithmic trading has undergone a transformation with the integration of machine learning, empowering computers to analyze extensive financial data and carry out trades at speeds unattainable by humans. These algorithms have the capacity to adjust to dynamic market conditions, recognize lucrative opportunities, and execute trades with minimal

human involvement. Consequently, this development has resulted in heightened liquidity, diminished transaction costs, and an enhanced overall efficiency in the market.

Threats from fraudulent entities aiming to exploit system vulnerabilities pose a challenge for companies. Machine learning plays an important role in creating sophisticated models for detecting fraud, capable of identifying suspicious activities in real-time.

Machine learning models assume a vital function in credit scoring and risk management. Traditional credit scoring models frequently encounter limitations in accurately evaluating an individual's creditworthiness. Machine learning algorithms, however, have the capacity to integrate a wider array of data sources, including unconventional data like social media activity. This integration enables financial institutions to make more informed lending decisions and proficiently manage credit risk.

2.3.2 Applications of machine learning models in financial markets

Wyrobek (2020) investigated irregularities in financial statements with the potential for fraud using machine learning and artificial intelligence algorithms. The research focused on 54 companies involved in what is considered the 20th century's most significant 54 accounting scandal, along with an additional 58 companies in a similar industry and size. The analysis encompassed a total of 1317 financial statements. Cam et al. (2024) sought to comprehend public sentiment expressed through Twitter messages, particularly those associated with Borsa Istanbul, using six distinct machine learning algorithms. Their aim was to gauge the relationship between positive and negative sentiments on Twitter and the corresponding movement in stock prices over a one-week period. Murugan & T (2023) conduct a study upon credit assessment in loan service and try to predict loan defaults using K-nearest neighbor, cluster based logistic regression and cluster based XG boost. Bluwstein et al. (2023) employs macroeconomic data of 17 countries over one century and try to predict most important indicators of financial crisis. He stressed that volume of societies total debt and yield curve are the most important indicators for financial crisis. Henrique et al. (2023) try to predict daily direction of the financial markets employing five different machine learning algorithms from support vector machines to random forest. Grudniewicz & Ślepaczuk (2023) compares different machine learning algorithms to generate trading signals for WIG20, DAX and S&P 500 indexes. The best results have

been derived with polynomial support vector machines and linear support vector machines. Najem et al. (2024) investigate top machine learning and artificial intelligence algorithms developed for stock market prediction. They explored seven widely-used methods, noting that wavelet transform, stacked autoencoders, and gated recurrent unit models have gained popularity in recent times. Çelik et al. (2023) developed an explainable artificial intelligence methodology with a focus on the constancy of created models rather than marginal accuracy increases. They opted to evaluate multiple valuations on financial assets and proposed an interval-based prediction approach.

Table 2.3 : Machine learning applications on financial markets

Authors	Dataset	Machine Learning Model	Study Result
Wyrobek (2020)	54 accounting scandalized companies 58 random companies in similar chracteristic	Genetic algorithm, logistic regression, linear discriminant analysis, deep neural network, gradient boosted decision trees	Gradient boosted decision trees, linear disciriminant and random forest has over 90 % performance to detect accounting scandals
Cam et al. (2024)	7-15 November 2022 Borsa Istanbul 30 index companies	Naive bayes, logistic regression, support vector machine, KNN, decision trees, multilayer perceptual	Suppurt vector machines and multilayer perceptual outperform than other with respectively 87% and 94% accuracy rates
(Murugan & T) (2023)	Confidential Financial institution data	K-nearest neighbor cluster based logistic regression cluster based XG boost	All three methods perform better than traditional risk assessment model from the aspect of loan defaults loss
Bluwstein et al. (2023)	1870–2016 macroeconomic data of 17 countries	Decision tree, random forest logistic regression, support vector machines, artificial neural networks	Slope of the yield curve and credit volume of the society are the main indicators of possible financial crisis
Henrique et al. (2023)	2007-2017 10 distinct market 11 securities from each	Artificial neural networks, support vector machines, random forest, naive-bayes	All these machine learning models are unsuccesful to predict next day return or direction. It conforms Graham 's proverb:"Stock market is voting mechanism in short run."
Grudniewicz & Ślepaczuk (2023)	2022-2023 WIG20, DAX, S&P500	Neural networks, k nearest neighbor, regression trees, random forests, naïve bayes	All machine learning methods perform better than benchmark methods. Polynomial support vector machines and linear support vector machinesa appears as the best ones
Najem et al. (2024)	Literature review about popular machine learning and artifical intelligence algorithm	Support vector machine, random forest K-nearest neighbor, naïve bayes long short-term memory artificial neural network	wavelet transform, gated recurrent unit Stacked AutoEncoders are recently popular algoritms
Çelik et al. (2023)	2012-2021 S&P 500 Index, Nikkei 255, KOSPI, DAX, FTSE 100 Nikkei 225 Shanghai Stock Exc.	Explainable artificial intelligence, Interpretable model agnostic explanations	Novel framework enables multiple prediction on financial assets and present and interval- based predcition approach

3. RESEARCH BASELINE FRAMEWORK

Value investing methodology assumes that the market moves in a horologe-like motion. An investor should aim to benefit and profit from this movement with "correct timing" and "correct price" (Lou, 2014). The correct price, mean purchasing a stock at a price at least 20%-25% below the intrinsic value calculated by the investor, while to sell, it indicates a price 30%-70% above. These percentages are fictitious values and will vary based on the daily trading volume and the country's macroeconomic conditions (Sukruoglu and Nalin, 2014). The investor should assess this by examining past price levels and sector-specific pricing. Timing, on the other hand, is related to the suitability of the political, economic, sociological, technological, ecological, and legal environment, referred to by Porter as the PESTEL framework. A value investor seeking long-term returns can afford to wait for an adequate period after buying a stock to make a profit, while a speculator, eager for immediate gains, may be impatient and pursue investments made by the crowd. This approach, easily describable, is relatively simple and straightforward for making money and being consistent. It should be remembered that perfect things are rare, finding them is difficult, and it requires perseverance.

The mission, vision, core values, culture, and goals of each company are distinct. These organizational dynamics, combined with the resources and capabilities the company possesses or acquires, create its competitive advantage. By developing and implementing strategies aligned with this competitive advantage, a business model is created and efforts are made to gain acceptance from customers. The performance indicator of this acceptance is reflected in financial statements. Financial results is by far best proxy for performance of macroeconomic environment, industry competition, company resources, competitive competencies, culture, and the strategies and business model created. Interpreting these performance indicators based on rigid mathematical models devoid of subjectivity and relying on 100% rational data is reasonable but becomes disconnected from real life. This is because human decisions inherently involve subjective evaluations that include past

experiences, family structure, social and cultural environment, religious beliefs, and a set of genetic factors inherited from ancestors. Therefore, novel triangular spherical fuzzy set has been created to take expert views or gut feeling into calculation combined with rigid mathematical calculations (Leibowitz et al., 2019). In our defined methodology in Figure 3.1, considering the literature review and the foundation of value investing, we have identified gross profit margin, cash flow from investments/net sales, cash flow from operations/total liabilities, net working capital/net sales, and total liability/shareholder equity as proxies for long-term competitive power. Subsequently, cluster analysis was employed to assess the relative long-term competitive power of companies listed on the BIST 100, using linear clustering, hierarchical clustering, and non-hierarchical clustering. After determining the best optimal clustering, machine learning models were constructed, incorporating new predictors such as copper price increases, Turkey's industrial production index as macroeconomic indicators, and market value/book value as a microeconomic variable. Market value / book value serves to indicate the undervalued/overvalued condition of stocks compared to industry averages.

As the first extention of our metholodogy, 2023 Borsa Istanbul initial public offerings has been handled due to huge investor number hike from 3,34 Million to 7,65 Million in just one year lead us to examine 2023 IPOs. As different from BIST 100 framework five additional indicators have been included into study that show potential of IPOs as Figure 3.2. Reason of these indicator choice will be detailed in data and methodlogy section.

As the second extention, BIST 30 index companies have been analyzed with additional four corporate govarnance dimension, one strategic planing quality indicator and market /book value have been included as Figure 3.3.

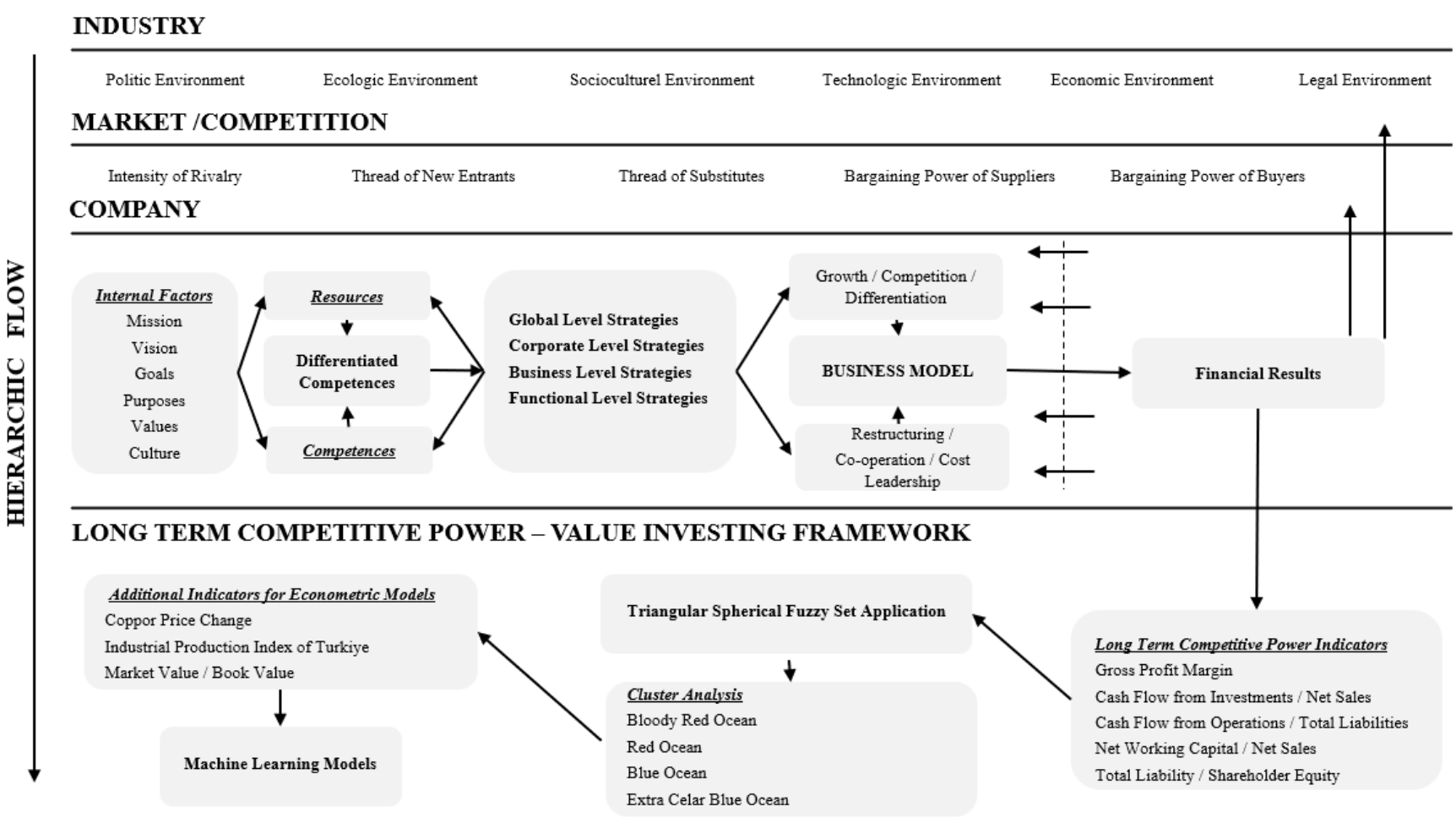

Figure 3.1: Long term competitive power effect on company value – BIST 100 Companies

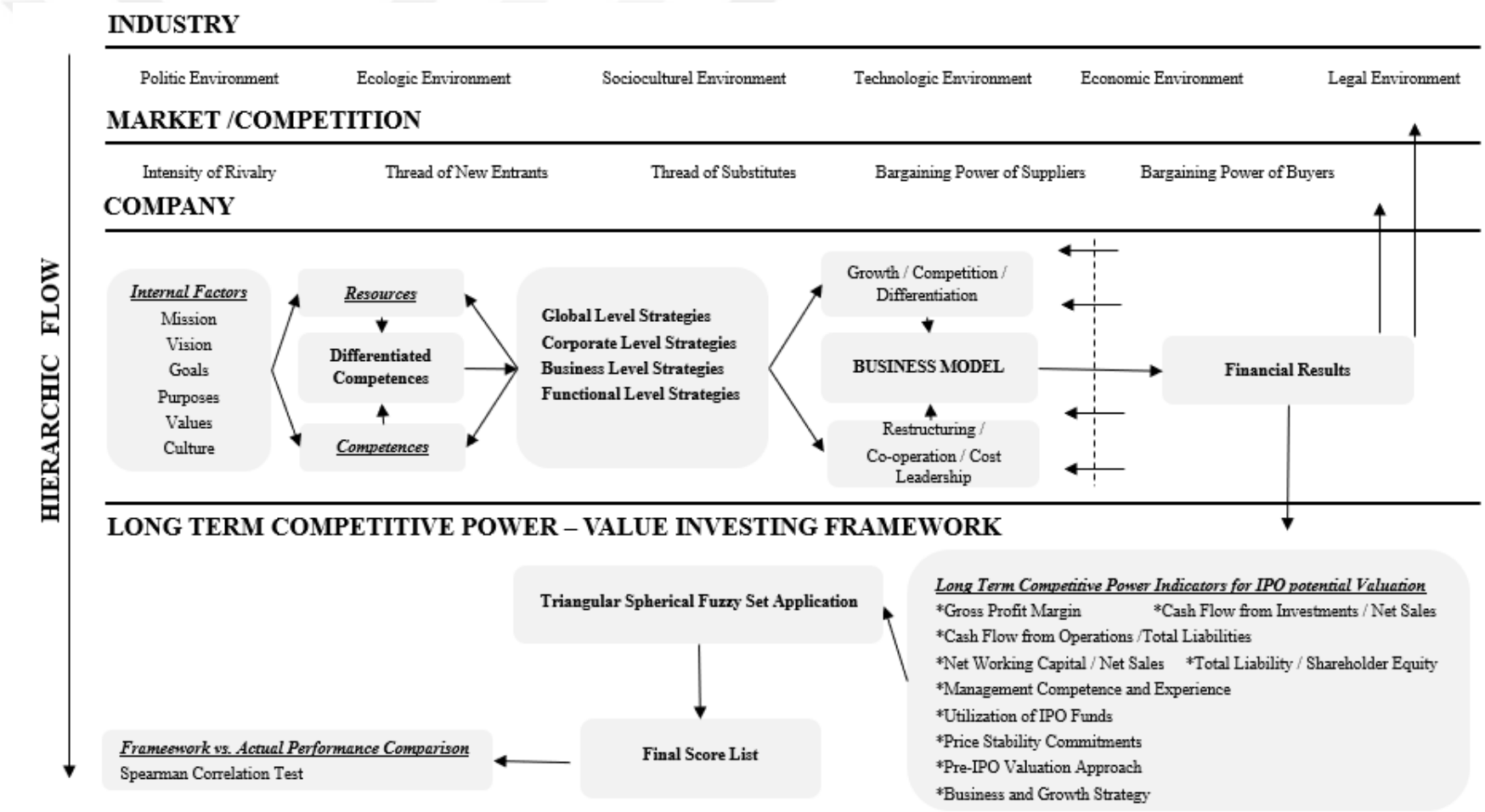

Figure 3.2: Long term competitive power effect on company value – 2023 Borsa Istanbul IPOs

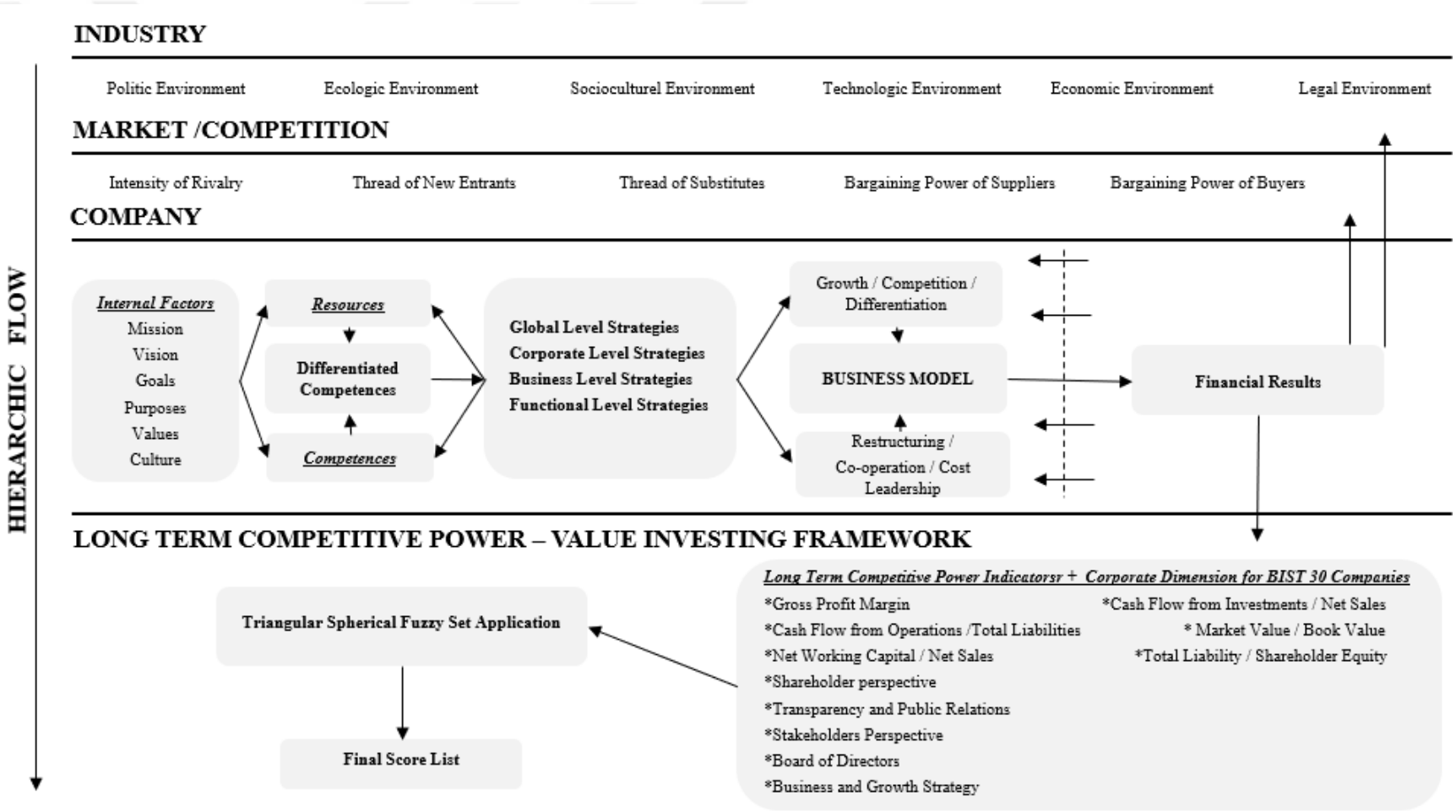

Figure 3.3: Long term competitive power effect on company value – BIST 30 companies

4. DATA AND METHODOLOGY

In the introductory section of the thesis statement, we conducted a comprehensive review of the literature, exploring advancements in long-term competitive power, the application of fuzzy logic in finance, and studies related to machine learning and artificial intelligence in the finance domain. We introduced novel triangular spherical fuzzy sets designed for interval-based assessments, encompassing lower point, median, and upper point evaluations of robust long-term competitive power financial indicators.

In this section; we present full scope of methodolody from data preperation to final econometric models using a series of application combined with fuzzy logic and machine learning applications. After full scope analysis of BIST 100 index companies, the research will be extended with BIST 2023 IPOs and BIST 30 index companies with adjusted set of framework depicted with Figure 3.2 and Figure 3.3.

4.1 Research Design & Approach

Considering literature review long term competitive advantage proxies in financial statements five key performance indicators have been determined to be employed in the research as:

Gross profit margin: This KPI signifies a company's core operational profitability. A higher gross profit margin indicates effective cost management, successful pricing strategies, and the potential for increased profitability (Bayar, 2016). Investors are drawn to this metric, positively influencing the company's valuation by showcasing its ability to generate higher returns from sales (Bondia et al., 2019).

Cash flow from investments/net sales: This KPI assesses the efficiency of a company's investments concerning its revenue, reflecting competence in generating cash flow from investment endeavors (Boyd et al., 2001). A higher ratio signifies sound investment decisions, amplifying the company's prospects for long-term growth and making it an

appealing choice for investors seeking enduring value appreciation (Budsayaplakorn et al., 2010).

Cash flow from operations/total liabilities: This KPI evaluates the company's capacity to generate sufficient cash flow from daily operations to cover total liabilities (Chang et al., 2019). A higher ratio indicates robust cash flow generation and financial stability, reducing the risk associated with debt repayment (Cherif and Gazdar, 2010). This enhances the company's valuation by instilling confidence in investors regarding Its capacity to fulfill financial responsibilities and explore avenues for expansion.

Net working capital/net sales: This KPI examines a company's effectiveness in managing working capital (Flanery and Protopapadakis, 2002). A higher ratio denotes efficient management of current assets and liabilities, resulting in enhanced liquidity and operational flexibility. Positively impacting the company's valuation, it demonstrates the ability to meet short-term obligations, invest in growth initiatives, and maintain a competitive position (Gallea and Patalon, 2016).

Total liability/shareholder equity: This KPI evaluates the proportion of debt in relation to shareholders' equity. A lower ratio signifies a more robust financial position with less reliance on debt financing, conducive to creating value through growth and innovation potential (Da and Engelberg, 2011). It contributes to increasing the company's valuation by demonstrating stability and potential for sustainable growth.

BIST 100 index companies were chosen for analysis due to their familiarity and active follow-up experience. The time horizon was set as the last five years, during which the financial statements of all BIST 100 index companies were collected from the public disclosure platform. (Url-5).

The final scope comprised 70 stocks that were consistently traded on the BIST 100 index over the last five years. Some stocks were excluded due to their absence in the index during the period from 2018 to 2022. Additionally, financial institutions were omitted from the study due to their incompatible balance sheet structures.

To make a remind about economic activity in that specific years, three macronomic indicators have been presented to experts as:

Copper Price Increase: Copper holds significant importance across industries such as construction, manufacturing, electronics (Gennaioli and Shleifer, 2018). Hence,

fluctuations in copper prices serve as an indicator of global economic activity and commodity demand (Gordon, 1962). Elevated economic activity raises the demand for copper, resulting in price surges. Particularly crucial in construction and infrastructure, copper's increased demand aligns with robust economic growth, driving prices upward. The sensitivity of copper prices to global economic sentiment is acknowledged (Ozgur and Akkoc, 2021). Economic conditions in major economies like Japan, the China, and Europe heavily influence the demand for copper as an industrial metal, with positive market sentiment and improved economic conditions propelling copper prices (Url-6).

U.S. Government 2-10 Year Bond Interest Spread: The 2–10-year bond interest spread, signifying the difference in yields between 2-year and 10-year U.S. government bonds, acts as an indicator of market expectations for future economic growth and inflation (Url-7). A widening spread implies anticipations of increased economic growth, leading to higher long-term interest rates. The yield curve's slope, represented by the 2-10 year spread, mirrors the market's outlook on future economic conditions. A steepening yield curve signals optimism for economic expansion, heightened borrowing and lending activities. The monetary policy choices of the U.S. Federal Reserve have a substantial impact on short-term interest rates (Huang and Wang, 2017). Changes in the 2–10-year spread reflect market expectations for potential monetary policy actions, such as interest rate hikes or cuts, based on assessments of economic conditions and the central bank's targets for inflation and growth.

Industrial Production Index: Measuring the output of manufacturing, mining, and utility sectors, the industrial production index provides insights into economic activity related to industrial production (Url-8). Increases in the index indicate expansion in manufacturing and production sectors, crucial contributors to economic growth. Closely tied to capacity utilization, higher utilization rates signify increased demand for goods and services, potentially leading to higher employment, investment, and overall economic activity. Changes in the industrial production index are commonly used as leading or coincident indicators of business cycles (Al Janabi, 2022). Economic downturns typically witness a contraction in industrial production, while expansions are accompanied by increased industrial output.

5 Expert evaluations over KPI year by year has been derived and preliminary litmus check applied to see any possible inconsistency. After adjusted inconsistency, triangular spherical fuzzy set methodology employed and final scores have been derived as phases are given in the following parts.

As a part of robustness test, intuitionistic fuzzy sets, hierarchical clustering and non-hierarchical clustering methods have been applied via SPSS package software and four long term competitive power group has been identified as bloody red ocean, red ocean, blue ocean, extra clear blue ocean for these methods. Hierarchical clustering method has been chosen due to theoretical alignment with dataset. In the last phase different machine learning algorithms have been applied via R package software for each cluster and econometric models created.

Following a comprehensive analysis of BIST 100 index companies, the study will expand to include BIST 2023 IPOs and BIST 30 index companies, employing a modified framework as illustrated in Figures 3.2 and 3.3.

4.2 Long Term Competitive Power of BIST 100 Companies

4.2.1 Selection of experts/evaluators

A panel consisting of five experts has been carefully chosen to evaluate the yearly significance of five Key Performance Indicators (KPIs) related to long-term competitive advantages. The qualifications and details of the experts can be found in Table 4.1.

Table 4.1 : Selection of experts for BIST 100 indicators

# of Expert	Person	Scope of Work	Length of Service (years)	Fuzzy Logic Base Level
1	Expert 1	Finance PHD Student	13	Deep expertise
2	Expert 2	Finance PHD Student	10	Deep expertise
3	Expert 3	Finance Employee	10	2 Hour Fuzzy Logic bootcamp
4	Expert 4	Finance Employee	17	2 Hour Fuzzy Logic bootcamp
5	Expert 5	Business Professional	22	2 Hour Fuzzy Logic bootcamp

In the phase of expert selection finance domain expertise with fuzzy logic background has been considered and highly valued. As we indicated previously; real-world problems cannot be simplistically evaluated using a binary framework of 0 (false) or 1 (truth). Interpreting the performance indicators based on rigid mathematical models devoid of

subjectivity and relying on 100% rational data is disconnected from real life. This is because we bring expert evaluations feed by experiences and gut feelings, combined with rigid mathematical calculations in there (Miller, 1989).

4.2.2 Economic activity reminders for analyzed term

In order to equip the experts with broad insights into economic trends from 2018 to 2022, they were furnished with reminders of economic activities. These reminders were instrumental in offering contextual information to facilitate their assessment of the significance of the five KPIs as indicators of long-term competitive prowess as Table 4.2.

Table 4.2 : Economic activity reminders

YEAR	Copper Price Increase	US 2-10 Bond Interest rate Spread	Industrial Production Index change of Turkey
2018	4.3%	0.38%	-6.8%
2019	-7.2%	0.17%	6.6%
2020	2.9%	0.50%	11.3%
2021	51.5%	1.18%	12.6%
2022	-5.8%	-0.04%	-0.5%

*Copper price increase and US 2-10 year bond rate spread is calculated over daily basis annual average prices

4.2.3 Key performance indicators selection for BIST 100

Company valuation plays a crucial role as a benchmark for investors, stakeholders, and potential buyers in assessing a company's value. The improvement of a company's valuation is inherently linked to the establishment of a sustainable competitive advantage (Takamatsu and Favero, 2019). A more robust competitive advantage results in more profitable and financially resilient companies. To tackle this, five Key Performance Indicators (KPIs) have been identified as dependable indicators of long-term competitive advantage:

*Gross profit margin
*Cash flow from investments/net sales
*Cash flow from operations/total liabilities
*Net working capital/net sales
*Total liability/shareholder equity

4.2.4 Initial expert assessment and validation

The study initiated with initial expert assessments utilizing triangular spherical fuzzy sets, a potent methodology for gauging the relative significance of various key performance indicators (KPIs) across the years 2018 to 2022. It is crucial to validate that these initial assessments adhere to specific criteria. Consequently, a litmus check was executed to ascertain whether these preliminary evaluations conform to the principles of fuzzy sets. This check aimed to secure those expert evaluations for each KPI did not concurrently exhibit high membership, non-membership, and hesitancy, as such a scenario would be logically inconsistent.

In the expert evaluation of KPIs within the specified timeframe, experts were tasked with providing their assessments using the Triangular Spherical Fuzzy Sets for membership (μ), non-membership (ν), and hesitancy (π) values given at Table 4.3. In the initial evaluation, a litmus check for triangular spherical fuzzy sets was applied with the following formula:

$$0 \leq (\mu_h(u))^2 + (\nu_h(u))^2 + (\pi_h(u))^2 \leq 1 \quad (4.1)$$

As seen at Table 4.5, expert with the number 5 litmus test has been failed due to non-fit above formula exceeding the value of 1 in a few cases marked with orange. Expert 5 give high membership, non-membership and hesitancy values at the same time for long term competitive advantage power of KPI violating the litmus test and diverging from the principles of fuzzy logic. Evaluating a situation with high membership, non-membership, and hesitancy simultaneously is not permissible. Following feedback provided to Expert 5, an adjustment was requested. Post-adjustment, the final expert assessment, as presented in Table 4.4, adheres to the litmus test.

4.2.5 Expert' s view weighting & aggregation & defuzzification process

To ensure a thorough and equitable assessment, experts are assigned weights corresponding to their expertise and knowledge levels.

The process of aggregation involves consolidating expert evaluations according to their designated weights. Employing aggregation and defuzzification techniques results in precise values for each Key Performance Indicator (KPI) spanning the years 2018 to 2022. Relative weights, denoted as w(i), are assigned to each expert evaluation based on their respective levels of expertise and knowledge. The assignment of these weights, where i ranges from 1 to 5, is conducted to satisfy the condition $\sum wi = w1 + w2 + w3 + w4 + w5 = 1$, as illustrated in Table 4.6 (Kahraman et al., 2020).

Table 4.3 : Initial expert assessments for BIST 100 indicators

Year	Competitive Advantage KPIs	Expert 1								
		μ			ν			π		
		l	m	h	l	m	h	l	m	h
2018	Gross Profit Margin	0.82	0.94	0.96	0.06	0.08	0.10	0.13	0.15	0.17
2019	Gross Profit Margin	0.80	0.93	0.95	0.08	0.10	0.12	0.13	0.15	0.17
2020	Gross Profit Margin	0.79	0.92	0.94	0.07	0.09	0.11	0.13	0.15	0.17
2021	Gross Profit Margin	0.80	0.93	0.95	0.08	0.10	0.12	0.13	0.15	0.17
2022	Gross Profit Margin	0.83	0.96	0.98	0.05	0.07	0.09	0.13	0.15	0.17
2018	Cash Flow from Investments / Net Sales	0.90	0.92	0.94	0.07	0.08	0.09	0.04	0.06	0.09
2019	Cash Flow from Investments / Net Sales	0.90	0.91	0.93	0.07	0.08	0.10	0.06	0.08	0.10
2020	Cash Flow from Investments / Net Sales	0.90	0.91	0.93	0.07	0.08	0.10	0.06	0.08	0.10
2021	Cash Flow from Investments / Net Sales	0.90	0.91	0.93	0.07	0.08	0.10	0.06	0.08	0.10
2022	Cash Flow from Investments / Net Sales	0.93	0.94	0.95	0.07	0.07	0.08	0.04	0.04	0.06
2018	Cash Flow from Operations / Total Liabilities	0.95	0.97	0.99	0.01	0.03	0.05	0.01	0.03	0.06
2019	Cash Flow from Operations / Total Liabilities	0.95	0.96	0.98	0.01	0.03	0.05	0.03	0.05	0.07
2020	Cash Flow from Operations / Total Liabilities	0.95	0.96	0.98	0.01	0.03	0.04	0.03	0.05	0.07
2021	Cash Flow from Operations / Total Liabilities	0.95	0.96	0.98	0.01	0.03	0.06	0.03	0.05	0.07
2022	Cash Flow from Operations / Total Liabilities	0.98	0.98	0.99	0.01	0.02	0.03	0.01	0.01	0.03
2018	Net Working Capital /Net Sales	0.80	0.82	0.84	0.16	0.17	0.18	0.21	0.23	0.26
2019	Net Working Capital /Net Sales	0.80	0.81	0.83	0.16	0.17	0.19	0.23	0.25	0.27
2020	Net Working Capital /Net Sales	0.80	0.81	0.83	0.16	0.17	0.19	0.23	0.25	0.27
2021	Net Working Capital /Net Sales	0.80	0.81	0.83	0.16	0.17	0.19	0.23	0.25	0.27
2022	Net Working Capital /Net Sales	0.83	0.84	0.85	0.16	0.16	0.17	0.21	0.21	0.23
2018	Total Liability / Shareholder Equity	0.65	0.72	0.76	0.20	0.27	0.32	0.11	0.13	0.16
2019	Total Liability / Shareholder Equity	0.64	0.71	0.75	0.20	0.27	0.33	0.13	0.15	0.17
2020	Total Liability / Shareholder Equity	0.64	0.71	0.75	0.21	0.27	0.33	0.13	0.15	0.17
2021	Total Liability / Shareholder Equity	0.64	0.71	0.75	0.21	0.27	0.34	0.13	0.15	0.17
2022	Total Liability / Shareholder Equity	0.70	0.74	0.80	0.20	0.26	0.35	0.11	0.11	0.13

Year	Competitive Advantage KPIs	Expert 2								
		μ			ν			π		
		l	m	h	l	m	h	l	m	h
2018	Gross Profit Margin	0.82	0.86	0.95	0.01	0.04	0.07	0.20	0.22	0.25
2019	Gross Profit Margin	0.80	0.83	0.95	0.03	0.06	0.09	0.22	0.25	0.28
2020	Gross Profit Margin	0.80	0.83	0.94	0.03	0.06	0.09	0.22	0.25	0.28
2021	Gross Profit Margin	0.80	0.83	0.95	0.03	0.06	0.09	0.22	0.25	0.28
2022	Gross Profit Margin	0.83	0.87	0.90	0.01	0.03	0.05	0.13	0.15	0.17
2018	Cash Flow from Investments / Net Sales	0.79	0.83	0.92	0.15	0.19	0.22	0.10	0.12	0.15
2019	Cash Flow from Investments / Net Sales	0.77	0.80	0.92	0.15	0.19	0.23	0.12	0.14	0.16
2020	Cash Flow from Investments / Net Sales	0.77	0.80	0.91	0.15	0.19	0.23	0.12	0.14	0.16
2021	Cash Flow from Investments / Net Sales	0.77	0.80	0.92	0.15	0.19	0.23	0.12	0.14	0.16
2022	Cash Flow from Investments / Net Sales	0.80	0.84	0.87	0.13	0.18	0.22	0.10	0.10	0.12
2018	Cash Flow from Operations / Total Liabilities	0.88	0.92	0.99	0.03	0.04	0.05	0.03	0.05	0.12
2019	Cash Flow from Operations / Total Liabilities	0.87	0.92	0.96	0.03	0.04	0.06	0.05	0.07	0.13
2020	Cash Flow from Operations / Total Liabilities	0.87	0.93	0.96	0.03	0.04	0.06	0.05	0.07	0.14
2021	Cash Flow from Operations / Total Liabilities	0.87	0.94	0.96	0.03	0.04	0.06	0.05	0.07	0.14
2022	Cash Flow from Operations / Total Liabilities	0.90	0.95	0.97	0.02	0.03	0.04	0.03	0.03	0.07
2018	Net Working Capital /Net Sales	0.71	0.75	0.84	0.13	0.20	0.27	0.25	0.32	0.39
2019	Net Working Capital /Net Sales	0.69	0.72	0.84	0.13	0.20	0.27	0.25	0.32	0.39
2020	Net Working Capital /Net Sales	0.69	0.72	0.83	0.13	0.20	0.27	0.25	0.32	0.39
2021	Net Working Capital /Net Sales	0.69	0.72	0.84	0.13	0.20	0.27	0.25	0.32	0.39
2022	Net Working Capital /Net Sales	0.72	0.76	0.79	0.14	0.19	0.29	0.26	0.31	0.41
2018	Total Liability / Shareholder Equity	0.61	0.65	0.74	0.23	0.30	0.40	0.15	0.17	0.20
2019	Total Liability / Shareholder Equity	0.59	0.62	0.74	0.23	0.33	0.41	0.17	0.19	0.21
2020	Total Liability / Shareholder Equity	0.59	0.62	0.73	0.24	0.32	0.41	0.17	0.19	0.21
2021	Total Liability / Shareholder Equity	0.59	0.62	0.74	0.24	0.30	0.41	0.17	0.19	0.21
2022	Total Liability / Shareholder Equity	0.62	0.66	0.69	0.23	0.29	0.38	0.15	0.15	0.17

Year	Competitive Advantage KPIs	Expert 3								
		μ			ν			π		
		l	m	h	l	m	h	l	m	h
2018	Gross Profit Margin	0.65	0.75	0.85	0.08	0.10	0.12	0.20	0.30	0.40
2019	Gross Profit Margin	0.65	0.75	0.85	0.08	0.10	0.12	0.20	0.30	0.40
2020	Gross Profit Margin	0.65	0.75	0.85	0.08	0.10	0.12	0.20	0.30	0.40
2021	Gross Profit Margin	0.65	0.75	0.85	0.08	0.10	0.12	0.20	0.30	0.40
2022	Gross Profit Margin	0.75	0.80	0.90	0.02	0.05	0.07	0.10	0.20	0.30
2018	Cash Flow from Investments / Net Sales	0.64	0.68	0.77	0.14	0.21	0.25	0.12	0.16	0.19
2019	Cash Flow from Investments / Net Sales	0.62	0.65	0.77	0.15	0.22	0.26	0.13	0.17	0.20
2020	Cash Flow from Investments / Net Sales	0.62	0.65	0.76	0.15	0.22	0.27	0.13	0.17	0.20
2021	Cash Flow from Investments / Net Sales	0.62	0.65	0.77	0.16	0.23	0.28	0.13	0.17	0.20
2022	Cash Flow from Investments / Net Sales	0.65	0.69	0.72	0.13	0.20	0.28	0.11	0.15	0.21
2018	Cash Flow from Operations / Total Liabilities	0.75	0.80	0.85	0.05	0.10	0.15	0.03	0.07	0.12
2019	Cash Flow from Operations / Total Liabilities	0.74	0.79	0.84	0.06	0.12	0.18	0.05	0.08	0.13
2020	Cash Flow from Operations / Total Liabilities	0.72	0.77	0.82	0.06	0.11	0.18	0.05	0.08	0.14
2021	Cash Flow from Operations / Total Liabilities	0.69	0.76	0.82	0.06	0.12	0.18	0.05	0.09	0.14
2022	Cash Flow from Operations / Total Liabilities	0.75	0.83	0.88	0.09	0.15	0.18	0.02	0.06	0.10
2018	Net Working Capital /Net Sales	0.65	0.70	0.77	0.18	0.25	0.31	0.13	0.19	0.25
2019	Net Working Capital /Net Sales	0.66	0.71	0.77	0.19	0.26	0.32	0.14	0.20	0.26
2020	Net Working Capital /Net Sales	0.64	0.71	0.78	0.19	0.26	0.32	0.13	0.19	0.27
2021	Net Working Capital /Net Sales	0.66	0.72	0.79	0.20	0.28	0.33	0.12	0.18	0.25
2022	Net Working Capital /Net Sales	0.70	0.76	0.82	0.18	0.24	0.26	0.05	0.12	0.16
2018	Total Liability / Shareholder Equity	0.75	0.81	0.83	0.05	0.10	0.15	0.06	0.11	0.15
2019	Total Liability / Shareholder Equity	0.74	0.80	0.85	0.06	0.11	0.15	0.07	0.12	0.16
2020	Total Liability / Shareholder Equity	0.73	0.80	0.86	0.06	0.12	0.15	0.07	0.12	0.16
2021	Total Liability / Shareholder Equity	0.72	0.82	0.86	0.06	0.11	0.15	0.07	0.13	0.16
2022	Total Liability / Shareholder Equity	0.73	0.82	0.88	0.03	0.09	0.12	0.05	0.10	0.13

Year	Competitive Advantage KPIs	Expert 4								
		μ			ν			π		
		l	m	h	l	m	h	l	m	h
2018	Gross Profit Margin	0.82	0.88	0.94	0.10	0.15	0.20	0.02	0.05	0.06
2019	Gross Profit Margin	0.80	0.86	0.92	0.08	0.12	0.16	0.02	0.05	0.06
2020	Gross Profit Margin	0.82	0.88	0.94	0.10	0.15	0.20	0.02	0.05	0.06
2021	Gross Profit Margin	0.82	0.88	0.94	0.10	0.15	0.20	0.03	0.05	0.06
2022	Gross Profit Margin	0.85	0.90	0.95	0.06	0.10	0.14	0.01	0.03	0.04
2018	Cash Flow from Investments / Net Sales	0.84	0.86	0.88	0.11	0.12	0.13	0.09	0.11	0.14
2019	Cash Flow from Investments / Net Sales	0.84	0.85	0.87	0.11	0.12	0.14	0.11	0.13	0.15
2020	Cash Flow from Investments / Net Sales	0.84	0.85	0.87	0.11	0.12	0.14	0.11	0.13	0.15
2021	Cash Flow from Investments / Net Sales	0.84	0.85	0.87	0.11	0.12	0.14	0.11	0.13	0.15
2022	Cash Flow from Investments / Net Sales	0.87	0.88	0.89	0.11	0.11	0.12	0.09	0.09	0.11
2018	Cash Flow from Operations / Total Liabilities	0.92	0.94	0.96	0.05	0.06	0.07	0.07	0.09	0.12
2019	Cash Flow from Operations / Total Liabilities	0.92	0.93	0.95	0.05	0.06	0.08	0.09	0.11	0.13
2020	Cash Flow from Operations / Total Liabilities	0.92	0.93	0.95	0.05	0.06	0.08	0.09	0.11	0.13
2021	Cash Flow from Operations / Total Liabilities	0.92	0.93	0.95	0.05	0.06	0.08	0.09	0.11	0.13
2022	Cash Flow from Operations / Total Liabilities	0.95	0.96	0.97	0.03	0.05	0.06	0.07	0.07	0.09
2018	Net Working Capital /Net Sales	0.73	0.78	0.83	0.21	0.25	0.26	0.11	0.13	0.16
2019	Net Working Capital /Net Sales	0.69	0.75	0.78	0.21	0.25	0.27	0.13	0.15	0.17
2020	Net Working Capital /Net Sales	0.70	0.75	0.78	0.21	0.25	0.27	0.13	0.15	0.17
2021	Net Working Capital /Net Sales	0.71	0.75	0.78	0.21	0.25	0.27	0.13	0.15	0.17
2022	Net Working Capital /Net Sales	0.75	0.80	0.85	0.19	0.24	0.25	0.11	0.11	0.13
2018	Total Liability / Shareholder Equity	0.62	0.69	0.73	0.20	0.35	0.44	0.26	0.30	0.34
2019	Total Liability / Shareholder Equity	0.61	0.68	0.72	0.20	0.36	0.45	0.24	0.32	0.36
2020	Total Liability / Shareholder Equity	0.61	0.68	0.74	0.21	0.36	0.45	0.24	0.33	0.39
2021	Total Liability / Shareholder Equity	0.61	0.68	0.72	0.21	0.36	0.45	0.24	0.32	0.38
2022	Total Liability / Shareholder Equity	0.67	0.71	0.77	0.20	0.30	0.39	0.20	0.28	0.34

Year	Competitive Advantage KPIs	Expert 5								
		μ			ν			π		
		l	m	h	l	m	h	l	m	h
2018	Gross Profit Margin	0.84	0.92	0.94	0.10	0.15	0.18	0.10	0.30	0.50
2019	Gross Profit Margin	0.80	0.90	0.92	0.10	0.15	0.17	0.10	0.30	0.50
2020	Gross Profit Margin	0.82	0.92	0.94	0.11	0.15	0.18	0.10	0.30	0.50
2021	Gross Profit Margin	0.82	0.92	0.94	0.12	0.15	0.19	0.15	0.28	0.42
2022	Gross Profit Margin	0.85	0.95	0.96	0.06	0.10	0.15	0.15	0.28	0.32
2018	Cash Flow from Investments / Net Sales	0.73	0.75	0.77	0.47	0.48	0.49	0.04	0.06	0.09
2019	Cash Flow from Investments / Net Sales	0.73	0.74	0.76	0.47	0.48	0.50	0.06	0.08	0.10
2020	Cash Flow from Investments / Net Sales	0.73	0.74	0.76	0.47	0.48	0.50	0.06	0.08	0.10
2021	Cash Flow from Investments / Net Sales	0.73	0.74	0.76	0.47	0.48	0.50	0.06	0.08	0.10
2022	Cash Flow from Investments / Net Sales	0.76	0.77	0.78	0.47	0.47	0.48	0.04	0.04	0.06
2018	Cash Flow from Operations / Total Liabilities	0.80	0.90	0.96	0.10	0.11	0.12	0.37	0.39	0.42
2019	Cash Flow from Operations / Total Liabilities	0.80	0.90	0.95	0.10	0.11	0.13	0.39	0.41	0.43
2020	Cash Flow from Operations / Total Liabilities	0.80	0.90	0.95	0.10	0.11	0.13	0.39	0.41	0.43
2021	Cash Flow from Operations / Total Liabilities	0.80	0.90	0.95	0.10	0.11	0.13	0.39	0.41	0.43
2022	Cash Flow from Operations / Total Liabilities	0.90	0.97	0.99	0.08	0.10	0.11	0.37	0.37	0.39
2018	Net Working Capital /Net Sales	0.83	0.88	0.93	0.20	0.24	0.25	0.11	0.13	0.16
2019	Net Working Capital /Net Sales	0.79	0.85	0.88	0.20	0.24	0.26	0.13	0.15	0.17
2020	Net Working Capital /Net Sales	0.80	0.85	0.88	0.20	0.24	0.26	0.13	0.15	0.17
2021	Net Working Capital /Net Sales	0.81	0.85	0.88	0.20	0.24	0.26	0.13	0.15	0.17
2022	Net Working Capital /Net Sales	0.85	0.90	0.95	0.18	0.23	0.24	0.11	0.11	0.13
2018	Total Liability / Shareholder Equity	0.82	0.89	0.93	0.20	0.35	0.44	0.06	0.10	0.14
2019	Total Liability / Shareholder Equity	0.81	0.88	0.92	0.20	0.36	0.45	0.04	0.12	0.16
2020	Total Liability / Shareholder Equity	0.81	0.88	0.94	0.21	0.36	0.45	0.04	0.13	0.19
2021	Total Liability / Shareholder Equity	0.81	0.88	0.92	0.21	0.36	0.45	0.04	0.12	0.18
2022	Total Liability / Shareholder Equity	0.87	0.91	0.97	0.20	0.30	0.39	0.00	0.08	0.14

Table 4.4 : Final expert assessments for BIST 100 indicators

Year	Competitive Advantage KPIs	Expert 1								
		μ			ν			π		
		l	m	h	l	m	h	l	m	h
2018	Gross Profit Margin	0.82	0.94	0.96	0.06	0.08	0.10	0.13	0.15	0.17
2019	Gross Profit Margin	0.80	0.93	0.95	0.08	0.10	0.12	0.13	0.15	0.17
2020	Gross Profit Margin	0.79	0.92	0.94	0.07	0.09	0.11	0.13	0.15	0.17
2021	Gross Profit Margin	0.80	0.93	0.95	0.08	0.10	0.12	0.13	0.15	0.17
2022	Gross Profit Margin	0.83	0.96	0.98	0.05	0.07	0.09	0.13	0.15	0.17
2018	Cash Flow from Investments / Net Sales	0.90	0.92	0.94	0.07	0.08	0.09	0.04	0.06	0.09
2019	Cash Flow from Investments / Net Sales	0.90	0.91	0.93	0.07	0.08	0.10	0.06	0.08	0.10
2020	Cash Flow from Investments / Net Sales	0.90	0.91	0.93	0.07	0.08	0.10	0.06	0.08	0.10
2021	Cash Flow from Investments / Net Sales	0.90	0.91	0.93	0.07	0.08	0.10	0.06	0.08	0.10
2022	Cash Flow from Investments / Net Sales	0.93	0.94	0.95	0.07	0.07	0.08	0.04	0.04	0.06
2018	Cash Flow from Operations / Total Liabilities	0.95	0.97	0.99	0.01	0.03	0.05	0.01	0.03	0.06
2019	Cash Flow from Operations / Total Liabilities	0.95	0.96	0.98	0.01	0.03	0.05	0.03	0.05	0.07
2020	Cash Flow from Operations / Total Liabilities	0.95	0.96	0.98	0.01	0.03	0.04	0.03	0.05	0.07
2021	Cash Flow from Operations / Total Liabilities	0.95	0.96	0.98	0.01	0.03	0.06	0.03	0.05	0.07
2022	Cash Flow from Operations / Total Liabilities	0.98	0.98	0.99	0.01	0.02	0.03	0.01	0.01	0.03
2018	Net Working Capital /Net Sales	0.80	0.82	0.84	0.16	0.17	0.18	0.21	0.23	0.26
2019	Net Working Capital /Net Sales	0.80	0.81	0.83	0.16	0.17	0.19	0.23	0.25	0.27
2020	Net Working Capital /Net Sales	0.80	0.81	0.83	0.16	0.17	0.19	0.23	0.25	0.27
2021	Net Working Capital /Net Sales	0.80	0.81	0.83	0.16	0.17	0.19	0.23	0.25	0.27
2022	Net Working Capital /Net Sales	0.83	0.84	0.85	0.16	0.16	0.17	0.21	0.21	0.23
2018	Total Liability / Shareholder Equity	0.65	0.72	0.76	0.20	0.27	0.32	0.11	0.13	0.16
2019	Total Liability / Shareholder Equity	0.64	0.71	0.75	0.20	0.27	0.33	0.13	0.15	0.17
2020	Total Liability / Shareholder Equity	0.64	0.71	0.75	0.21	0.27	0.33	0.13	0.15	0.17
2021	Total Liability / Shareholder Equity	0.64	0.71	0.75	0.21	0.27	0.34	0.13	0.15	0.17
2022	Total Liability / Shareholder Equity	0.70	0.74	0.80	0.20	0.26	0.35	0.11	0.11	0.13

Year	Competitive Advantage KPIs	Expert 2								
		μ			ν			π		
		l	m	h	l	m	h	l	m	h
2018	Gross Profit Margin	0.82	0.86	0.95	0.01	0.04	0.07	0.20	0.22	0.25
2019	Gross Profit Margin	0.80	0.83	0.95	0.03	0.06	0.09	0.22	0.25	0.28
2020	Gross Profit Margin	0.80	0.83	0.94	0.03	0.06	0.09	0.22	0.25	0.28
2021	Gross Profit Margin	0.80	0.83	0.95	0.03	0.06	0.09	0.22	0.25	0.28
2022	Gross Profit Margin	0.83	0.87	0.90	0.01	0.03	0.05	0.13	0.15	0.17
2018	Cash Flow from Investments / Net Sales	0.79	0.83	0.92	0.15	0.19	0.22	0.10	0.12	0.15
2019	Cash Flow from Investments / Net Sales	0.77	0.80	0.92	0.15	0.19	0.23	0.12	0.14	0.16
2020	Cash Flow from Investments / Net Sales	0.77	0.80	0.91	0.15	0.19	0.23	0.12	0.14	0.16
2021	Cash Flow from Investments / Net Sales	0.77	0.80	0.92	0.15	0.19	0.23	0.12	0.14	0.16
2022	Cash Flow from Investments / Net Sales	0.80	0.84	0.87	0.13	0.18	0.22	0.10	0.10	0.12
2018	Cash Flow from Operations / Total Liabilities	0.88	0.92	0.99	0.03	0.04	0.05	0.03	0.05	0.12
2019	Cash Flow from Operations / Total Liabilities	0.87	0.92	0.96	0.03	0.04	0.06	0.05	0.07	0.13
2020	Cash Flow from Operations / Total Liabilities	0.87	0.93	0.96	0.03	0.04	0.06	0.05	0.07	0.14
2021	Cash Flow from Operations / Total Liabilities	0.87	0.94	0.96	0.03	0.04	0.06	0.05	0.07	0.14
2022	Cash Flow from Operations / Total Liabilities	0.90	0.95	0.97	0.02	0.03	0.04	0.03	0.03	0.07
2018	Net Working Capital /Net Sales	0.71	0.75	0.84	0.13	0.20	0.27	0.25	0.32	0.39
2019	Net Working Capital /Net Sales	0.69	0.72	0.84	0.13	0.20	0.27	0.25	0.32	0.39
2020	Net Working Capital /Net Sales	0.69	0.72	0.83	0.13	0.20	0.27	0.25	0.32	0.39
2021	Net Working Capital /Net Sales	0.69	0.72	0.84	0.13	0.20	0.27	0.25	0.32	0.39
2022	Net Working Capital /Net Sales	0.72	0.76	0.79	0.14	0.19	0.29	0.26	0.31	0.41
2018	Total Liability / Shareholder Equity	0.61	0.65	0.74	0.23	0.30	0.40	0.15	0.17	0.20
2019	Total Liability / Shareholder Equity	0.59	0.62	0.74	0.23	0.33	0.41	0.17	0.19	0.21
2020	Total Liability / Shareholder Equity	0.59	0.62	0.73	0.24	0.32	0.41	0.17	0.19	0.21
2021	Total Liability / Shareholder Equity	0.59	0.62	0.74	0.24	0.30	0.41	0.17	0.19	0.21
2022	Total Liability / Shareholder Equity	0.62	0.66	0.69	0.23	0.29	0.38	0.15	0.15	0.17

Year	Competitive Advantage KPIs	Expert 3								
		μ			ν			π		
		l	m	h	l	m	h	l	m	h
2018	Gross Profit Margin	0.65	0.75	0.85	0.08	0.10	0.12	0.20	0.30	0.40
2019	Gross Profit Margin	0.65	0.75	0.85	0.08	0.10	0.12	0.20	0.30	0.40
2020	Gross Profit Margin	0.65	0.75	0.85	0.08	0.10	0.12	0.20	0.30	0.40
2021	Gross Profit Margin	0.65	0.75	0.85	0.08	0.10	0.12	0.20	0.30	0.40
2022	Gross Profit Margin	0.75	0.80	0.90	0.02	0.05	0.07	0.10	0.20	0.30
2018	Cash Flow from Investments / Net Sales	0.64	0.68	0.77	0.14	0.21	0.25	0.12	0.16	0.19
2019	Cash Flow from Investments / Net Sales	0.62	0.65	0.77	0.15	0.22	0.26	0.13	0.17	0.20
2020	Cash Flow from Investments / Net Sales	0.62	0.65	0.76	0.15	0.22	0.27	0.13	0.17	0.20
2021	Cash Flow from Investments / Net Sales	0.62	0.65	0.77	0.16	0.23	0.28	0.13	0.17	0.20
2022	Cash Flow from Investments / Net Sales	0.65	0.69	0.72	0.13	0.20	0.28	0.11	0.15	0.21
2018	Cash Flow from Operations / Total Liabilities	0.75	0.80	0.85	0.05	0.10	0.15	0.03	0.07	0.12
2019	Cash Flow from Operations / Total Liabilities	0.74	0.79	0.84	0.06	0.12	0.12	0.12	0.12	0.12
2020	Cash Flow from Operations / Total Liabilities	0.72	0.77	0.82	0.06	0.11	0.18	0.05	0.08	0.14
2021	Cash Flow from Operations / Total Liabilities	0.69	0.76	0.82	0.06	0.12	0.18	0.05	0.09	0.14
2022	Cash Flow from Operations / Total Liabilities	0.75	0.83	0.88	0.09	0.15	0.18	0.02	0.06	0.10
2018	Net Working Capital /Net Sales	0.65	0.70	0.77	0.18	0.25	0.31	0.13	0.19	0.25
2019	Net Working Capital /Net Sales	0.66	0.71	0.77	0.19	0.26	0.32	0.14	0.20	0.26
2020	Net Working Capital /Net Sales	0.64	0.71	0.78	0.19	0.26	0.32	0.13	0.19	0.27
2021	Net Working Capital /Net Sales	0.66	0.72	0.79	0.20	0.28	0.33	0.12	0.18	0.25
2022	Net Working Capital /Net Sales	0.70	0.76	0.82	0.18	0.24	0.26	0.05	0.12	0.16
2018	Total Liability / Shareholder Equity	0.75	0.81	0.83	0.05	0.10	0.15	0.06	0.11	0.15
2019	Total Liability / Shareholder Equity	0.74	0.80	0.85	0.06	0.11	0.15	0.07	0.12	0.16
2020	Total Liability / Shareholder Equity	0.73	0.80	0.86	0.06	0.12	0.15	0.07	0.12	0.16
2021	Total Liability / Shareholder Equity	0.72	0.82	0.86	0.06	0.11	0.15	0.07	0.13	0.16
2022	Total Liability / Shareholder Equity	0.73	0.82	0.88	0.03	0.09	0.12	0.05	0.10	0.13

Year	Competitive Advantage KPIs	Expert 4								
		μ			ν			π		
		l	m	h	l	m	h	l	m	h
2018	Gross Profit Margin	0.82	0.88	0.94	0.10	0.15	0.20	0.02	0.05	0.06
2019	Gross Profit Margin	0.80	0.86	0.92	0.08	0.12	0.16	0.02	0.05	0.06
2020	Gross Profit Margin	0.82	0.88	0.94	0.10	0.15	0.20	0.02	0.05	0.06
2021	Gross Profit Margin	0.82	0.88	0.94	0.10	0.15	0.20	0.03	0.05	0.06
2022	Gross Profit Margin	0.85	0.90	0.95	0.06	0.10	0.14	0.01	0.03	0.04
2018	Cash Flow from Investments / Net Sales	0.84	0.86	0.88	0.11	0.12	0.13	0.09	0.11	0.14
2019	Cash Flow from Investments / Net Sales	0.84	0.85	0.87	0.11	0.12	0.14	0.11	0.13	0.15
2020	Cash Flow from Investments / Net Sales	0.84	0.85	0.87	0.11	0.12	0.14	0.11	0.13	0.15
2021	Cash Flow from Investments / Net Sales	0.84	0.85	0.87	0.11	0.12	0.14	0.11	0.13	0.15
2022	Cash Flow from Investments / Net Sales	0.87	0.88	0.89	0.11	0.11	0.12	0.09	0.09	0.11
2018	Cash Flow from Operations / Total Liabilities	0.92	0.94	0.96	0.05	0.06	0.07	0.07	0.09	0.12
2019	Cash Flow from Operations / Total Liabilities	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.11	0.13
2020	Cash Flow from Operations / Total Liabilities	0.92	0.93	0.95	0.05	0.06	0.08	0.09	0.11	0.13
2021	Cash Flow from Operations / Total Liabilities	0.92	0.93	0.95	0.05	0.06	0.08	0.09	0.11	0.13
2022	Cash Flow from Operations / Total Liabilities	0.95	0.96	0.97	0.03	0.05	0.06	0.07	0.07	0.09
2018	Net Working Capital /Net Sales	0.73	0.78	0.83	0.21	0.25	0.26	0.11	0.13	0.16
2019	Net Working Capital /Net Sales	0.69	0.75	0.78	0.21	0.25	0.27	0.13	0.15	0.17
2020	Net Working Capital /Net Sales	0.70	0.75	0.78	0.21	0.25	0.27	0.13	0.15	0.17
2021	Net Working Capital /Net Sales	0.71	0.75	0.78	0.21	0.25	0.27	0.13	0.15	0.17
2022	Net Working Capital /Net Sales	0.75	0.80	0.85	0.19	0.24	0.25	0.11	0.11	0.13
2018	Total Liability / Shareholder Equity	0.62	0.69	0.73	0.20	0.35	0.44	0.26	0.30	0.34
2019	Total Liability / Shareholder Equity	0.61	0.68	0.72	0.20	0.36	0.45	0.24	0.32	0.36
2020	Total Liability / Shareholder Equity	0.61	0.68	0.74	0.21	0.36	0.45	0.24	0.33	0.39
2021	Total Liability / Shareholder Equity	0.61	0.68	0.72	0.21	0.36	0.45	0.24	0.32	0.38
2022	Total Liability / Shareholder Equity	0.67	0.71	0.77	0.20	0.30	0.39	0.20	0.28	0.34

Year	Competitive Advantage KPIs	Expert 5								
		μ			ν			π		
		l	m	h	l	m	h	l	m	h
2018	Gross Profit Margin	0.84	0.92	0.94	0.10	0.15	0.18	0.02	0.05	0.07
2019	Gross Profit Margin	0.80	0.90	0.92	0.10	0.15	0.17	0.02	0.05	0.08
2020	Gross Profit Margin	0.82	0.92	0.94	0.11	0.15	0.18	0.02	0.05	0.08
2021	Gross Profit Margin	0.82	0.92	0.94	0.12	0.15	0.19	0.03	0.06	0.09
2022	Gross Profit Margin	0.85	0.95	0.96	0.06	0.10	0.15	0.02	0.03	0.09
2018	Cash Flow from Investments / Net Sales	0.73	0.75	0.77	0.47	0.48	0.49	0.04	0.06	0.09
2019	Cash Flow from Investments / Net Sales	0.73	0.74	0.76	0.47	0.48	0.50	0.06	0.08	0.10
2020	Cash Flow from Investments / Net Sales	0.73	0.74	0.76	0.47	0.48	0.50	0.06	0.08	0.10
2021	Cash Flow from Investments / Net Sales	0.73	0.74	0.76	0.47	0.48	0.50	0.06	0.08	0.10
2022	Cash Flow from Investments / Net Sales	0.76	0.77	0.78	0.47	0.47	0.48	0.04	0.04	0.06
2018	Cash Flow from Operations / Total Liabilities	0.80	0.90	0.96	0.10	0.11	0.12	0.05	0.11	0.15
2019	Cash Flow from Operations / Total Liabilities	0.80	0.90	0.95	0.10	0.11	0.13	0.06	0.12	0.14
2020	Cash Flow from Operations / Total Liabilities	0.80	0.90	0.95	0.10	0.11	0.13	0.05	0.13	0.15
2021	Cash Flow from Operations / Total Liabilities	0.80	0.90	0.95	0.10	0.11	0.13	0.04	0.11	0.15
2022	Cash Flow from Operations / Total Liabilities	0.90	0.97	0.99	0.08	0.10	0.11	0.05	0.05	0.08
2018	Net Working Capital /Net Sales	0.83	0.88	0.93	0.20	0.24	0.25	0.11	0.13	0.16
2019	Net Working Capital /Net Sales	0.79	0.85	0.88	0.20	0.24	0.26	0.13	0.15	0.17
2020	Net Working Capital /Net Sales	0.80	0.85	0.88	0.20	0.24	0.26	0.13	0.15	0.17
2021	Net Working Capital /Net Sales	0.81	0.85	0.88	0.20	0.24	0.26	0.13	0.15	0.17
2022	Net Working Capital /Net Sales	0.85	0.90	0.95	0.18	0.23	0.24	0.11	0.11	0.13
2018	Total Liability / Shareholder Equity	0.82	0.89	0.93	0.02	0.18	0.24	0.02	0.05	0.08
2019	Total Liability / Shareholder Equity	0.81	0.88	0.92	0.16	0.20	0.23	0.02	0.07	0.08
2020	Total Liability / Shareholder Equity	0.81	0.88	0.94	0.15	0.21	0.27	0.03	0.08	0.09
2021	Total Liability / Shareholder Equity	0.81	0.88	0.92	0.14	0.21	0.26	0.02	0.07	0.09
2022	Total Liability / Shareholder Equity	0.87	0.91	0.97	0.11	0.15	0.20	0.01	0.03	0.05

Table 4.5 : Initial expert assessments' litmus test

		Expert 1			Expert 2			Expert 3			Expert 4			Expert 5				
Year	Competitive Advantage KPIs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3		Check
2018	Gross Profit Margin	0.69	0.91	0.96	0.71	0.79	0.97	0.47	0.66	0.90	0.68	0.80	0.93	0.73	0.96	1.17	1.1660	FALSE
2019	Gross Profit Margin	0.66	0.90	0.95	0.69	0.76	0.99	0.47	0.66	0.90	0.65	0.76	0.88	0.66	0.92	1.13		
2020	Gross Profit Margin	0.65	0.88	0.92	0.69	0.76	0.97	0.47	0.66	0.90	0.68	0.80	0.93	0.69	0.96	1.17		
2021	Gross Profit Margin	0.66	0.90	0.95	0.69	0.76	0.99	0.47	0.66	0.90	0.68	0.80	0.93	0.71	0.95	1.10		
2022	Gross Profit Margin	0.71	0.95	1.00	0.71	0.78	0.84	0.57	0.68	0.90	0.73	0.82	0.92	0.75	0.99	1.05		
2018	Cash Flow from Investments / Net Sales	0.82	0.86	0.90	0.66	0.74	0.92	0.44	0.53	0.69	0.73	0.77	0.81	0.76	0.80	0.84		
2019	Cash Flow from Investments / Net Sales	0.82	0.84	0.88	0.63	0.70	0.92	0.42	0.50	0.70	0.73	0.75	0.80	0.76	0.78	0.84		
2020	Cash Flow from Investments / Net Sales	0.82	0.84	0.88	0.63	0.70	0.91	0.42	0.50	0.69	0.73	0.75	0.80	0.76	0.78	0.84		
2021	Cash Flow from Investments / Net Sales	0.82	0.84	0.88	0.63	0.70	0.92	0.43	0.50	0.71	0.73	0.75	0.80	0.76	0.78	0.84		
2022	Cash Flow from Investments / Net Sales	0.87	0.89	0.91	0.67	0.75	0.82	0.45	0.54	0.64	0.78	0.79	0.82	0.80	0.82	0.84		
2018	Cash Flow from Operations / Total Liabilities	0.90	0.94	0.99	0.78	0.85	1.00	0.57	0.65	0.76	0.85	0.90	0.94	0.79	0.97	1.11		
2019	Cash Flow from Operations / Total Liabilities	0.90	0.93	0.97	0.76	0.85	0.94	0.55	0.64	0.75	0.86	0.88	0.93	0.80	0.99	1.10		
2020	Cash Flow from Operations / Total Liabilities	0.90	0.93	0.97	0.76	0.87	0.94	0.52	0.61	0.72	0.86	0.88	0.93	0.80	0.99	1.10		
2021	Cash Flow from Operations / Total Liabilities	0.90	0.93	0.97	0.76	0.89	0.94	0.48	0.60	0.72	0.86	0.88	0.93	0.80	0.99	1.10		
2022	Cash Flow from Operations / Total Liabilities	0.96	0.96	0.98	0.81	0.90	0.95	0.57	0.72	0.82	0.91	0.93	0.95	0.95	1.09	1.14		
2018	Net Working Capital /Net Sales	0.71	0.75	0.81	0.58	0.70	0.93	0.47	0.59	0.75	0.59	0.69	0.78	0.74	0.85	0.95		
2019	Net Working Capital /Net Sales	0.72	0.75	0.80	0.56	0.66	0.93	0.49	0.61	0.76	0.54	0.65	0.71	0.68	0.80	0.87		
2020	Net Working Capital /Net Sales	0.72	0.75	0.80	0.56	0.66	0.91	0.46	0.61	0.78	0.55	0.65	0.71	0.70	0.80	0.87		
2021	Net Working Capital /Net Sales	0.72	0.75	0.80	0.56	0.66	0.93	0.49	0.63	0.80	0.57	0.65	0.71	0.71	0.80	0.87		
2022	Net Working Capital /Net Sales	0.75	0.78	0.80	0.61	0.71	0.88	0.52	0.65	0.77	0.61	0.71	0.80	0.77	0.88	0.98		
2018	Total Liability / Shareholder Equity	0.47	0.61	0.71	0.45	0.54	0.75	0.57	0.68	0.73	0.49	0.69	0.84	0.72	0.92	1.08		
2019	Total Liability / Shareholder Equity	0.47	0.60	0.70	0.43	0.53	0.76	0.56	0.67	0.77	0.47	0.69	0.85	0.70	0.92	1.07		
2020	Total Liability / Shareholder Equity	0.47	0.60	0.70	0.43	0.52	0.75	0.54	0.67	0.79	0.47	0.70	0.90	0.70	0.92	1.12		
2021	Total Liability / Shareholder Equity	0.47	0.60	0.71	0.43	0.51	0.76	0.53	0.70	0.79	0.47	0.69	0.87	0.70	0.92	1.08		
2022	Total Liability / Shareholder Equity	0.54	0.63	0.78	0.46	0.54	0.65	0.54	0.69	0.81	0.53	0.67	0.86	0.80	0.92	1.11		

Table 4.6 : Expert weights for BIST 100 indicator evaluation

# of Expert	Person	Expert Weights
1	Expert 1	30%
2	Expert 2	30%
3	Expert 3	10%
4	Expert 4	20%
5	Expert 5	10%
	Sum of Total	**100%**

Throughout the weighting and aggregation process, the TRSWAM operator, as outlined Definition 2.5, was utilized. Following this, three out of the top five most consistent expert evaluations, namely Expert 1, Expert 2, and Expert 3, were chosen for the aggregation of fuzzy numbers. The resultant aggregated values are detailed in Table 4.7.

In the subsequent defuzzification process, there was a reevaluation of the defuzzification of expert assessments pertaining to the significance of these five key performance indicators from 2018 to 2022.

For each value of n ranging from 1 to 5 and for each year j spanning from 2018 to 2022, the defuzzified value for the KPI with index "n" and year "j" is computed using the formula:

$$D(KPI_n)_j^* = ((a\mu_{jl} + a\mu_{jm} + a\mu_{jh}) - (a\nu_{jl} + a\nu_{jm} + a\nu_{jh}) - (a\nu_{jl} + a\nu_{jm} + a\nu_{jh})/2)/3 \quad (4.2)$$

Here, $D(KPI_n)_j$ represent the defuzzified KPI with number n for the year j. This mathematical operation process created defuzzified expert evaluations for each KPI, holding a important role in determining long-term competitive power scores.

4.2.6 Relative importance evaluation of key performance indicators

Not all Key Performance Indicators (KPIs) carry the same level of significance when gauging a company's long-term competitive advantage. In recognition of this variability, consultation with three ultimate experts was conducted. They were tasked with assessing the KPIs based on their significance as indicators of a company's enduring competitive prowess. The experts furnished their evaluations utilizing a five-scale linguistic scale outlined at Table 4.8.

Table 4.7 : Aggregated and defuzzified expert evaluations for BIST 100

	Aggregated Expert Evaluations									Expert 1									Expert 2									Expert 3					
	μ			ν			π			μ			ν			π			μ			ν			π			μ			ν			π		
Defuzzification	**l**	**m**	**h**	l	m	**h**	**l**	**m**	**h**	**l**	**m**	**h**	**l**	**m**	**h**	**l**	**m**	**h**	**l**	**m**	**h**	**l**	**m**	**h**	**l**	**m**	**h**	**l**	**m**	**h**	**l**	**m**	**h**	**l**	**m**	**h**
0.56	0.72	0.82	0.89	0.08	0.14	0.18	0.17	0.21	0.29	0.72	0.52	0.47	0.43	0.47	0.50	0.70	0.49	0.41	0.72	0.67	0.50	0.25	0.38	0.45	0.69	0.63	0.37	0.95	0.92	0.88	0.78	0.79	0.81	0.94	0.90	0.81
0.51	0.70	0.80	0.88	0.13	0.17	0.21	0.18	0.22	0.33	0.74	0.55	0.50	0.47	0.50	0.53	0.73	0.52	0.45	0.74	0.70	0.50	0.35	0.43	0.49	0.70	0.66	0.31	0.95	0.92	0.88	0.78	0.79	0.81	0.94	0.90	0.81
0.50	0.69	0.79	0.87	0.12	0.17	0.20	0.18	0.22	0.31	0.75	0.57	0.52	0.45	0.49	0.52	0.74	0.54	0.48	0.74	0.70	0.52	0.35	0.43	0.49	0.70	0.66	0.37	0.95	0.92	0.88	0.78	0.79	0.81	0.94	0.90	0.81
0.51	0.70	0.80	0.88	0.13	0.17	0.21	0.18	0.22	0.33	0.74	0.55	0.50	0.47	0.50	0.53	0.73	0.52	0.45	0.74	0.70	0.50	0.35	0.43	0.49	0.70	0.66	0.31	0.95	0.92	0.88	0.78	0.79	0.81	0.94	0.90	0.81
0.62	0.74	0.85	0.90	0.07	0.12	0.15	0.13	0.19	0.28	0.70	0.47	0.38	0.41	0.45	0.49	0.69	0.42	0.26	0.70	0.65	0.61	0.25	0.35	0.41	0.69	0.64	0.58	0.92	0.90	0.85	0.68	0.74	0.77	0.92	0.89	0.79
0.51	0.76	0.79	0.85	0.21	0.24	0.27	0.07	0.10	0.14	0.61	0.57	0.52	0.45	0.47	0.49	0.61	0.57	0.51	0.75	0.70	0.57	0.57	0.61	0.63	0.74	0.69	0.54	0.95	0.94	0.91	0.82	0.86	0.87	0.95	0.94	0.91
0.48	0.75	0.77	0.85	0.21	0.24	0.28	0.09	0.12	0.16	0.61	0.59	0.55	0.45	0.47	0.50	0.60	0.58	0.54	0.76	0.74	0.57	0.57	0.61	0.64	0.76	0.72	0.54	0.95	0.95	0.91	0.83	0.86	0.87	0.95	0.94	0.90
0.48	0.75	0.77	0.84	0.21	0.24	0.28	0.09	0.12	0.15	0.61	0.59	0.55	0.45	0.47	0.50	0.60	0.58	0.54	0.76	0.74	0.59	0.57	0.61	0.64	0.76	0.72	0.56	0.95	0.95	0.92	0.83	0.86	0.88	0.95	0.94	0.91
0.48	0.75	0.77	0.85	0.21	0.25	0.28	0.09	0.12	0.16	0.61	0.59	0.55	0.45	0.47	0.50	0.60	0.58	0.54	0.76	0.74	0.57	0.57	0.61	0.64	0.76	0.72	0.54	0.95	0.95	0.91	0.83	0.86	0.88	0.95	0.94	0.90
0.54	0.79	0.81	0.84	0.19	0.23	0.26	0.07	0.08	0.11	0.55	0.52	0.50	0.44	0.45	0.47	0.55	0.52	0.49	0.74	0.69	0.65	0.54	0.60	0.63	0.73	0.69	0.64	0.95	0.94	0.93	0.82	0.85	0.88	0.94	0.93	0.92
0.75	0.84	0.88	0.96	0.07	0.11	0.14	0.02	0.05	0.17	0.50	0.43	0.31	0.25	0.35	0.41	0.50	0.43	0.29	0.64	0.57	0.31	0.35	0.38	0.41	0.64	0.57	0.21	0.92	0.90	0.88	0.74	0.79	0.83	0.92	0.90	0.88
0.73	0.84	0.87	0.92	0.07	0.11	0.15	0.04	0.07	0.13	0.50	0.47	0.38	0.25	0.35	0.41	0.50	0.46	0.36	0.65	0.57	0.47	0.35	0.38	0.43	0.65	0.56	0.43	0.92	0.91	0.88	0.75	0.81	0.84	0.92	0.91	0.88
0.73	0.84	0.88	0.92	0.07	0.11	0.14	0.04	0.07	0.14	0.50	0.47	0.38	0.25	0.35	0.38	0.50	0.46	0.36	0.65	0.55	0.47	0.35	0.38	0.43	0.65	0.54	0.43	0.93	0.91	0.89	0.75	0.80	0.84	0.93	0.91	0.89
0.72	0.83	0.88	0.92	0.07	0.11	0.16	0.04	0.07	0.14	0.50	0.47	0.38	0.25	0.35	0.43	0.50	0.46	0.36	0.65	0.52	0.47	0.35	0.38	0.43	0.65	0.52	0.43	0.94	0.92	0.89	0.75	0.81	0.84	0.94	0.92	0.89
0.81	0.89	0.91	0.94	0.05	0.09	0.11	0.02	0.03	0.07	0.38	0.38	0.31	0.20	0.31	0.35	0.38	0.38	0.30	0.61	0.50	0.43	0.31	0.35	0.38	0.61	0.50	0.42	0.92	0.89	0.86	0.79	0.83	0.84	0.92	0.89	0.86
0.25	0.66	0.69	0.75	0.26	0.32	0.36	0.21	0.26	0.34	0.74	0.72	0.69	0.58	0.59	0.60	0.71	0.68	0.64	0.81	0.78	0.69	0.54	0.62	0.68	0.78	0.72	0.56	0.95	0.93	0.91	0.84	0.87	0.89	0.94	0.93	0.90
0.24	0.65	0.68	0.74	0.27	0.32	0.37	0.22	0.27	0.35	0.74	0.73	0.70	0.58	0.59	0.61	0.70	0.68	0.65	0.82	0.80	0.69	0.54	0.62	0.68	0.79	0.75	0.56	0.94	0.93	0.91	0.85	0.87	0.89	0.94	0.92	0.90
0.23	0.65	0.68	0.74	0.27	0.32	0.37	0.22	0.27	0.34	0.74	0.73	0.70	0.58	0.59	0.61	0.70	0.68	0.65	0.82	0.80	0.70	0.54	0.62	0.68	0.79	0.75	0.58	0.95	0.93	0.91	0.85	0.87	0.89	0.95	0.93	0.89
0.24	0.65	0.68	0.75	0.27	0.32	0.37	0.22	0.27	0.35	0.74	0.73	0.70	0.58	0.59	0.61	0.70	0.68	0.65	0.82	0.80	0.69	0.54	0.62	0.68	0.79	0.75	0.56	0.94	0.93	0.91	0.85	0.88	0.90	0.94	0.92	0.89
0.28	0.69	0.71	0.74	0.27	0.30	0.35	0.21	0.24	0.32	0.70	0.69	0.68	0.57	0.58	0.59	0.67	0.66	0.64	0.80	0.77	0.75	0.55	0.61	0.69	0.77	0.71	0.62	0.93	0.92	0.89	0.84	0.87	0.87	0.93	0.91	0.89
0.18	0.57	0.62	0.68	0.29	0.37	0.45	0.11	0.13	0.17	0.85	0.80	0.77	0.62	0.68	0.71	0.84	0.79	0.76	0.87	0.85	0.79	0.64	0.70	0.76	0.86	0.84	0.77	0.92	0.90	0.89	0.74	0.79	0.83	0.92	0.90	0.88
0.16	0.55	0.61	0.68	0.30	0.39	0.45	0.13	0.15	0.18	0.85	0.81	0.78	0.62	0.68	0.72	0.85	0.80	0.76	0.88	0.86	0.79	0.64	0.72	0.77	0.87	0.85	0.76	0.92	0.90	0.88	0.75	0.80	0.83	0.92	0.90	0.87
0.15	0.55	0.61	0.68	0.31	0.39	0.45	0.13	0.15	0.18	0.85	0.81	0.78	0.63	0.68	0.72	0.85	0.80	0.76	0.88	0.86	0.80	0.65	0.71	0.77	0.87	0.85	0.77	0.93	0.90	0.87	0.75	0.81	0.83	0.93	0.90	0.87
0.16	0.55	0.61	0.68	0.31	0.38	0.46	0.13	0.15	0.18	0.85	0.81	0.78	0.63	0.68	0.72	0.85	0.80	0.76	0.88	0.86	0.79	0.65	0.70	0.77	0.87	0.85	0.76	0.93	0.89	0.87	0.75	0.80	0.83	0.93	0.89	0.87
0.22	0.59	0.64	0.69	0.28	0.36	0.44	0.11	0.12	0.14	0.82	0.79	0.74	0.62	0.67	0.73	0.81	0.78	0.73	0.86	0.84	0.82	0.64	0.69	0.75	0.86	0.83	0.81	0.93	0.89	0.86	0.70	0.78	0.81	0.93	0.89	0.85

Table 4.8 : Linguistic variables for BIST 100 indicators

	l	m	h
Very Important	8	10	10
Important	6	8	10
Fairly important	4	6	8
Slighly Important	2	4	6
Not Important	0	2	4

Subsequently, these linguistic assessments underwent defuzzification using a triangular linguistic scale provided in Table 4.9. The ultimate crisp weight scores for the KPIs were then computed, portraying their respective importance levels, as depicted in Table 4.10.

Table 4.9 : Relative KPI weights evaluation for BIST 100

	Expert 1	Expert 2	Expert 3
Gross Profit Margin	Very Important	Very Important	Important
Cash Flow from Investments / Net Sales	Very Important	Important	Important
Cash Flow from Operations / Total Liabilities	Very Important	Very Important	Very Important
Net Working Capital /Net Sales	Fairly important	Slighly Important	Important
Total Liability / Shareholder Equity	Fairly important	Slighly Important	Slighly Important

Table 4.10 : Crips scores of KPI weights for BIST 100

	Gross Profit Margin	Cash Flow from Investments / Net Sales	Cash Flow from Operations / Total Liabilities	Net Working Capital /Net Sales	Total Liability / Shareholder Equity
Expert 1 Expert 2 Expert 3	Very Important Very Important Important	Very Important Important Important	Very Important Very Important Very Important	Fairly important Slighly Important Important	Fairly important Slighly Important Slighly Important
Expert 1 Expert 2 Expert 3	(8, 10, 10) (8, 10, 10) (6, 8, 10)	(8, 10, 10) (6, 8, 10) (6, 8, 10)	(8, 10, 10) (8, 10, 10) (8, 10, 10)	(4, 6, 8) (2, 4, 6) (6, 8, 10)	(4, 6, 8) (2, 4, 6) (2, 4, 6)
Average Expert evauation	(7.33, 9.33, 10)	(6.67, 8.67, 10)	(8, 10, 10)	(4, 6, 8)	(2.67, 4.67,6.67)
Triangular Fuzzy Crisp Formula	(l+4m+u) / 6				
Defuzzificated Crisp Value	9.11	8.56	9.67	6.00	4.67

4.2.7 Normalization of KPIs and relative point scoring

For the value of each KPI, various normalizations have been applied, detailed at below.

Gross Profit Margin: A higher gross profit margin reflects efficient cost management, effective pricing strategies, and the potential for enhanced profitability. To standardize this KPI, the max-min normalization method is applied. Box plot has been applied to detect and exclude outliers in data set. According to gross profit KPI sets, first 4 largest

values are outliers. So, we did not consider outliers, and than marked largest 5th value is global max. and max-min normalization has been applied for all years values

Cash Flow from Investments / Net Sales: A higher ratio indicates successful investment decisions, enhancing the company's growth prospects and attracting long-term value-seeking investors. Therefore, max-min normalization is preferred for this KPI. Box plot has been applied to detect and exclude outliers in data set. According to gross profit KPI sets, first 4 largest values are outliers. So, we did not considered outliers, and than marked largest 5th value is global max. and max-min normalization has been applied for all years values. The difference in there is that we expect cash flow from investments generally expected to be negative if company has no subsidiary that distribute share profit. Because of that condition max-min normalization adjustted upon addition +1 to denominator and denominator.

Cash Flow from Operations / Total Liabilities : This KPI reduces the risk related to debt repayment. By instilling confidence in investors regarding the companies' capacity to fulfill financial responsibilities and explore avenues for expansion, it positively impacts the company's valuation. Max-min normalization is employed for this KPI as well. Box plot has been applied to detect and exclude outliers in data set. According to KPI sets, first 8 largest values are outliers. SO we did not conmsidered outliers, and than marked largest 9th value is global max. and max-min normalization has been applied for all years values.

Net Working Capital /Net Sales : A higher ratio signifies effective management of current assets and liabilities, leading to improved liquidity and operational flexibility. To normalize this KPI, max-min normalization is used.

Total Liability / Shareholder Equity : A lower ratio implies reduced financial risk and potential for sustainable growth. The normalization methodology differs from the other mentioned KPIs because there is no specific best value within the data set, neither maximum nor minimum. For this KPI, the median value of the BIST 100 index is adopted as the best value in the normalization process.

For each iteration from n=1 to 5 and j=2018 to 2022, the chosen normalization method, either max-min normalization or optimum point normalization, is applied as follows:

$$\text{Normalized } (KPI_n)_j = (KPI_n)_j / (\text{Max } (KPI_n)_j) \quad (4.3)$$

After normalizing all KPIs, the defuzzified expert evaluations for each KPI are multiplied by their respective normalized values. Consequently, the relative point for each KPI is calculated according to the formula provided by Gundogdu (2019):

For each iteration from n=1 to 5 and j=2018 to 2022,

$$\text{Normalized } (KPI_n)_j * D(KPI_n)_j = \text{Relative Point of } (KPI_n)_j = RP(KPI_n)_j \quad (4.4)$$

where the median of $RP(KPI_n)$ for the years 2018 to 2022 is selected, resulting in the final relative point. This conclusive relative point serves as a crucial metric for evaluating the performance of each KPI and its influence on the overall long-term competitive power scores.

For 70 companies in scope for BIST 100 index, we prepare one pager with separate tab in excel and calculated relative points for each KPI value year by year with multiplication of normalized KPI values and defuzzified expert evaluations according to Triangular Spherical Fuzzy sets. Relative point scoring value for each KPI has been take into consider as median value of annual values from 2018 to 2022

4.2.8 Final scores of stocks and categorization

In the process of determining the ultimate scores for each stock, a straightforward method might involve summing up all the relative point scores derived from the five distinct Key Performance Indicators (KPIs). However, the understanding is acknowledged that these KPIs may carry varying degrees of significance in the assessment of a company's long-term competitive advantage. To address this consideration, step 4.2.6 is implemented, with a reminder of KPI weights provided in Table 4.11.

Table 4.11 : Scores of KPI weights for BIST 100

KPI	Relative Weight point
Gross Profit Margin	9.11
Cash Flow from Investments / Net Sales	8.56
Cash Flow from Operations / Total Liabilities	9.67
Net Working Capital /Net Sales	6.00
Total Liability / Shareholder Equity	4.67

For each KPI, the final score for a stock is computed using the formula:

$$\text{Final Score of Stock} = \sum_{n=1}^{5} RP(\text{KPI}_n) * \text{Relative weight of KPI}_n \quad (4.5)$$

$RP(KPI_n)$ represents relative point of KPI with number n.

A consolidated list of final scores is created for each (KPIn)j in the BIST 100 index. An illustrative calculation for the stock ticker AKSA, representing Aksa Akrilik Kimya Sanayi A.Ş. , is provided in Table 4.13.

Once the final scores for all 70 stocks are enumerated, a box plot is generated, outliers are eliminated, group widths are determined, and the stocks are categorized into distinct competitive power groups, as detailed in Tables 4.12. Full list of 70 stocks, as categorized given in Table 4.14 and Table 4.15.

The outcomes of our study led to the classification of these 70 stocks into four clearly defined groups, identified as:

*Bloody Red Ocean Company

*Red Ocean Company

*Blue Ocean Company

*Extra Clear Blue Ocean Company

Table 4.12 : Linear clustering categorization of BIST 100 companies

Max	11.76
Min	1.11
Range	10.65
Group width	2.66

	Lower bound	Upper bound	# of Member
Bloody Red Ocean Company	1.11	3.78	16
Red Ocean Company	3.78	6.44	28
Blue Ocean Company	6.44	9.10	16
Extra Clear Blue Ocean Company	9.10	11.76	10
Total # of company			**70**

Table 4.13 : AKSA final scoring process as a representative

Year	Competitive Advantage KPI	KPI value	Normalized KPI value	Relative Points	Defuzzification
2018	Gross Profit Margin	17,6%	29%	0,16	0,56
2019	Gross Profit Margin	17,0%	28%	0,14	0,51
2020	Gross Profit Margin	23,6%	39%	0,20	0,50
2021	Gross Profit Margin	22,1%	37%	0,18	0,51
2022	Gross Profit Margin	24,6%	41%	0,25	0,62
	Global max	**60%**	**Median of Relative Points =>**	**0,18**	
	Global min				
2018	Cash Flow from Investments / Net Sales	-10,1%	79%	0,40	0,51
2019	Cash Flow from Investments / Net Sales	-5,3%	83%	0,40	0,48
2020	Cash Flow from Investments / Net Sales	-9,9%	79%	0,38	0,48
2021	Cash Flow from Investments / Net Sales	-6,6%	82%	0,39	0,48
2022	Cash Flow from Investments / Net Sales	-6,2%	82%	0,44	0,54
	Global max	**14%**	**Median of Relative Points =>**	**0,40**	
	Global min				
2018	Cash Flow from Operations / Total Liabilities	10,3%	17%	0,12	0,75
2019	Cash Flow from Operations / Total Liabilities	25,5%	41%	0,30	0,73
2020	Cash Flow from Operations / Total Liabilities	28,2%	46%	0,33	0,73
2021	Cash Flow from Operations / Total Liabilities	44,0%	71%	0,52	0,72
2022	Cash Flow from Operations / Total Liabilities	23,7%	38%	0,31	0,81
	Global max	61,9%	**Median of Relative Points =>**	**0,31**	
	Global min				
2018	Net Working Capital /Net Sales	11,0%	10%	0,02	0,25
2019	Net Working Capital /Net Sales	3,0%	3%	0,01	0,24
2020	Net Working Capital /Net Sales	20,3%	18%	0,04	0,23
2021	Net Working Capital /Net Sales	1,4%	1%	0,00	0,24
2022	Net Working Capital /Net Sales	10,5%	9%	0,03	0,28
	Global max	115,0%	**Median of Relative Points =>**	**0,02**	
	Global min				
2018	Total Liability / Shareholder Equity	189,4%	86%	0,16	0,18
2019	Total Liability / Shareholder Equity	172,8%	91%	0,14	0,16
2020	Total Liability / Shareholder Equity	164,0%	93%	0,14	0,15
2021	Total Liability / Shareholder Equity	233,2%	74%	0,12	0,16
2022	Total Liability / Shareholder Equity	98,9%	89%	0,19	0,22
	Mix-Max Interval	358,3%	**Median of Relative Points =>**	**0,14**	0,16
	Median	139,2%			
			AKSA TOTAL POINT	**8,90**	

KPI	Relative Weight point
Gross Profit Margin	9,11
Cash Flow from Investments / Net Sales	8,56
Cash Flow from Operations / Total Liabilities	9,67
Net Working Capital /Net Sales	6,00
Total Liability / Shareholder Equity	4,67

Table 4.14 : BIST 100 linear clustering between # 1-35 stocks

#	Stock Ticker	Stock	Long Term Competitive Advantage Point	Groupping
1	AEFES	ANADOLU EFES BİRACILIK VE MALT SANAYİİ A.Ş.	6.48	Blue Ocean Company
2	AGHOL	AG ANADOLU GRUBU HOLDİNG A.Ş.	5.64	Red Ocean Company
3	AKFGY	AKFEN GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.	8.21	Blue Ocean Company
4	AKSA	AKSA AKRİLİK KİMYA SANAYİİ A.Ş.	6.12	Red Ocean Company
5	AKSEN	AKSA ENERJİ ÜRETİM A.Ş.	3.57	Bloody Red Ocean Company
6	ALARK	ALARKO HOLDİNG A.Ş.	7.10	Blue Ocean Company
7	ALKIM	ALKİM ALKALİ KİMYA A.Ş.	16.39	Extra Clear Blue Ocean Company
8	ASUZU	ANADOLU ISUZU OTOMOTİV SANAYİ VE TİCARET A.Ş.	4.74	Red Ocean Company
9	ARCLK	ARÇELİK A.Ş.	4.97	Red Ocean Company
10	ASELS	ASELSAN ELEKTRONİK SANAYİ VE TİCARET A.Ş.	5.23	Red Ocean Company
11	BAGFS	BAGFAŞ BANDIRMA GÜBRE FABRİKALARI A.Ş.	4.71	Red Ocean Company
12	BERA	BERA HOLDİNG A.Ş.	4.21	Red Ocean Company
13	BIMAS	BİM BİRLEŞİK MAĞAZALAR A.Ş.	5.90	Red Ocean Company
14	BUCIM	BURSA ÇİMENTO FABRİKASI A.Ş.	7.71	Blue Ocean Company
15	CCOLA	COCA-COLA İÇECEK A.Ş.	6.71	Blue Ocean Company
16	CEMTS	ÇEMTAŞ ÇELİK MAKİNA SANAYİ VE TİCARET A.Ş.	11.76	Extra Clear Blue Ocean Company
17	CIMSA	ÇİMSA ÇİMENTO SANAYİ VE TİCARET A.Ş.	5.44	Red Ocean Company
18	DOHOL	DOĞAN ŞİRKETLER GRUBU HOLDİNG A.Ş.	4.39	Red Ocean Company
19	DOAS	DOĞUŞ OTOMOTİV SERVİS VE TİCARET A.Ş.	6.54	Blue Ocean Company
20	EGEEN	EGE ENDÜSTRİ VE TİCARET A.Ş.	11.39	Extra Clear Blue Ocean Company
21	ECILC	EİS ECZACIBAŞI İLAÇ SINAİ VE FİNANSAL YATIRIMLAR SANAYİ VE TİCARET A.Ş.	8.20	Blue Ocean Company
22	EKGYO	EMLAK KONUT GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.	7.36	Blue Ocean Company
23	ENKAI	ENKA İNŞAAT VE SANAYİ A.Ş.	6.97	Blue Ocean Company
24	ERBOS	ERBOSAN ERCİYAS BORU SANAYİİ VE TİCARET A.Ş.	3.77	Bloody Red Ocean Company
25	EREGL	EREĞLİ DEMİR VE ÇELİK FABRİKALARI T.A.Ş.	8.68	Blue Ocean Company
26	FROTO	FORD OTOMOTİV SANAYİ A.Ş.	7.10	Blue Ocean Company
27	GLYHO	GLOBAL YATIRIM HOLDİNG A.Ş.	4.18	Red Ocean Company
28	GSDHO	GSD HOLDİNG A.Ş.	13.43	Extra Clear Blue Ocean Company
29	GUBRF	GÜBRE FABRİKALARI T.A.Ş.	2.33	Bloody Red Ocean Company
30	HEKTS	HEKTAŞ TİCARET T.A.Ş.	3.54	Bloody Red Ocean Company
31	IPEKE	İPEK DOĞAL ENERJİ KAYNAKLARI ARAŞTIRMA VE ÜRETİM A.Ş.	25.82	Extra Clear Blue Ocean Company
32	ISDMR	İSKENDERUN DEMİR VE ÇELİK A.Ş.	10.40	Extra Clear Blue Ocean Company
33	ISGYO	İŞ GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.	3.64	Bloody Red Ocean Company
34	IZMDC	İZMİR DEMİR ÇELİK SANAYİ A.Ş.	1.50	Bloody Red Ocean Company
35	KRDMD	KARDEMİR KARABÜK DEMİR ÇELİK SANAYİ VE TİCARET A.Ş.	5.68	Red Ocean Company

Table 4.15 : BIST 100 linear clustering between # 36-70 stocks

#	Stock Ticker	Stock	Long Term Competitive Advantage Point	Groupping
36	KARSN	KARSAN OTOMOTİV SANAYİİ VE TİCARET A.Ş.	3,18	Bloody Red Ocean Company
37	KERVT	KEREVİTAŞ GIDA SANAYİ VE TİCARET A.Ş.	4,65	Red Ocean Company
38	KCHOL	KOÇ HOLDİNG A.Ş.	4,01	Red Ocean Company
39	KONYA	KONYA ÇİMENTO SANAYİİ A.Ş.	4,54	Red Ocean Company
40	KORDS	KORDSA TEKNİK TEKSTİL A.Ş.	4,77	Red Ocean Company
41	KOZAL	KOZA ALTIN İŞLETMELERİ A.Ş.	27,80	Extra Clear Blue Ocean Company
42	KOZAA	KOZA ANADOLU METAL MADENCİLİK İŞLETMELERİ A.Ş.	25,64	Extra Clear Blue Ocean Company
43	MAVI	MAVİ GİYİM SANAYİ VE TİCARET A.Ş.	10,04	Extra Clear Blue Ocean Company
44	MGROS	MİGROS TİCARET A.Ş.	4,57	Red Ocean Company
45	ODAS	ODAŞ ELEKTRİK ÜRETİM SANAYİ TİCARET A.Ş.	10,17	Extra Clear Blue Ocean Company
46	OTKAR	OTOKAR OTOMOTİV VE SAVUNMA SANAYİ A.Ş.	6,96	Blue Ocean Company
47	OYAKC	OYAK ÇİMENTO FABRİKALARI A.Ş.	6,95	Blue Ocean Company
48	PGSUS	PEGASUS HAVA TAŞIMACILIĞI A.Ş.	3,36	Bloody Red Ocean Company
49	PETKM	PETKİM PETROKİMYA HOLDİNG A.Ş.	4,67	Red Ocean Company
50	SAHOL	HACI ÖMER SABANCI HOLDİNG A.Ş.	2,47	Bloody Red Ocean Company
51	SASA	SASA POLYESTER SANAYİ A.Ş.	3,96	Red Ocean Company
52	SELEC	SELÇUK ECZA DEPOSU TİCARET VE SANAYİ A.Ş.	2,27	Bloody Red Ocean Company
53	SISE	TÜRKİYE ŞİŞE VE CAM FABRİKALARI A.Ş.	6,32	Red Ocean Company
54	SNGYO	SİNPAŞ GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.	5,14	Red Ocean Company
55	SOKM	ŞOK MARKETLER TİCARET A.Ş.	4,85	Red Ocean Company
56	TAVHL	TAV HAVALİMANLARI HOLDİNG A.Ş.	6,02	Red Ocean Company
57	TKFEN	TEKFEN HOLDİNG A.Ş.	3,04	Bloody Red Ocean Company
58	TKNSA	TEKNOSA İÇ VE DIŞ TİCARET A.Ş.	3,76	Bloody Red Ocean Company
59	TOASO	TOFAŞ TÜRK OTOMOBİL FABRİKASI A.Ş.	4,08	Red Ocean Company
60	TUKAS	TUKAŞ GIDA SANAYİ VE TİCARET A.Ş.	4,84	Red Ocean Company
61	TCELL	TURKCELL İLETİŞİM HİZMETLERİ A.Ş.	8,95	Blue Ocean Company
62	TMSN	TÜMOSAN MOTOR VE TRAKTÖR SANAYİ A.Ş.	3,72	Bloody Red Ocean Company
63	TUPRS	TÜPRAŞ-TÜRKİYE PETROL RAFİNERİLERİ A.Ş.	3,18	Bloody Red Ocean Company
64	THYAO	TÜRK HAVA YOLLARI A.O.	4,16	Red Ocean Company
65	TTKOM	TÜRK TELEKOMÜNİKASYON A.Ş.	8,68	Blue Ocean Company
66	TTRAK	TÜRK TRAKTÖR VE ZİRAAT MAKİNELERİ A.Ş.	6,56	Blue Ocean Company
67	ULUUN	ULUSOY UN SANAYİ VE TİCARET A.Ş.	1,11	Bloody Red Ocean Company
68	ULKER	ÜLKER BİSKÜVİ SANAYİ A.Ş.	4,89	Red Ocean Company
69	VESBE	VESTEL BEYAZ EŞYA SANAYİ VE TİCARET A.Ş.	4,61	Red Ocean Company
70	VESTL	VESTEL ELEKTRONİK SANAYİ VE TİCARET A.Ş.	3,74	Bloody Red Ocean Company

4.2.9 Robustness test using intuitionistic fuzzy sets

To validate triangular spherical fuzzy set , intuitionistic fuzzy sets were employed and applied for all 70 stocks from the first phase until the last categarization. Our main motivation in there that while the conclusive scoring procedure entailed grouping based on linearity to construct a singular, comprehensive score, it is crucial to emphasize that the data might display substantial divergence across various indicators rather than conforming linearly into a unified final score.

For the preliminary validation approach, Intuitionistic Fuzzy Sets were employed, entailing a reevaluation of the experts' assessments to fulfill predetermined criteria involving membership, non-membership, and hesitancy values (Kahraman et al., 2015).

This methodology was customized to meet the specific conditions of Intuitionistic Fuzzy Sets outlined below, augmenting its resilience and accuracy in the analysis.

$$\mu_l(u) + \mu_m(u) + \mu_h(u) = 1 \quad (4.6)$$

$$\nu_l(u) + \nu_m(u) + \nu_h(u) = 1 \quad (4.7)$$

$$\pi_l(u) + \pi_m(u) + \pi_h(u) = 1 \quad (4.8)$$

Table 4.16 : Intiutionistic fuzzy sets clustering

Bloody Red Ocean Company	Red Ocean Company	Blue Ocean Company	Extra Clear Blue Ocean Company
GUBRF	AGHOL	AEFES	ALKIM
ISGYO	AKSA	AKFGY	CEMTS
IZMDC	AKSEN	ALARK	EGEEN
KARSN	ASUZU	BUCIM	EKGYO
KCHOL	ARCLK	CCOLA	GSDHO
PGSUS	ASELS	ECILC	IPEKE
SAHOL	BAGFS	ENKAI	ISDMR
SELEC	BERA	EREGL	KOZAL
TKFEN	BIMAS	FROTO	KOZAA
TKNSA	CIMSA	OTKAR	MAVI
TUPRS	DOHOL	OYAKC	ODAS
ULUUN	DOAS	SISE	TCELL
VESTL	ERBOS	TAVHL	
	GLYHO	TTKOM	
	HEKTS	TTRAK	
	KRDMD		
	KERVT		
	KONYA		
	KORDS		
	MGROS		
	PETKM		
	SASA		
	SNGYO		
	SOKM		
	TOASO		
	TUKAS		
	TMSN		
	THYAO		
	ULKER		
	VESBE		

Intiutionistic fuzzy set application results given Table 4.16, just three stocks moved from the category of Bloody Red Ocean to Red Ocean, while two stocks transitioned from Blue Ocean to the Extra Clear Blue Ocean category. As a reminder, triangular spherical fuzzy sets linear clustering results given as Table 4.17.

Table 4.17 : Categorization of BIST 100 companies with linear clustering

Bloody Red Ocean Company	Red Ocean Company	Blue Ocean Company	Extra Clear Blue Ocean Company
GUBRF	AGHOL	AEFES	ALKIM
ISGYO	AKSA	AKFGY	CEMTS
IZMDC	AKSEN	ALARK	EGEEN
KARSN	ASUZU	BUCIM	EKGYO
KCHOL	ARCLK	CCOLA	GSDHO
PGSUS	ASELS	ECILC	IPEKE
SAHOL	BAGFS	ENKAI	ISDMR
SELEC	BERA	EREGL	KOZAL
TKFEN	BIMAS	FROTO	KOZAA
TKNSA	CIMSA	OTKAR	MAVI
TUPRS	DOHOL	OYAKC	ODAS
ULUUN	DOAS	SISE	TCELL
VESTL	ERBOS	TAVHL	
	GLYHO	TTKOM	
	HEKTS	TTRAK	
	KRDMD		
	KERVT		
	KONYA		
	KORDS		
	MGROS		
	PETKM		
	SASA		
	SNGYO		
	SOKM		
	TOASO		
	TUKAS		
	TMSN		
	THYAO		
	ULKER		
	VESBE		

4.2.10 Hierarchical & non-hierarchical clustering

As a supplementary validation approach, two clustering method were implemented: the ward method using euclidean distance for hierarchical clustering and the k-means for non-hierarchical clustering method using SPSS software. The selection of these methods was based on their suitability for both the dataset and the analysis procedure. Reviewing Table 4.18 it is evident that the coefficients of variation for all five indicators are generally well distributed, without cash flow from investments/net sales. Based on this distribution, the euclidean distance method was deemed the most suitable choice for clustering, particularly with the default k-means clustering approach. Simultaneously, the ward method was opted for hierarchical clustering, leveraging its mathematical foundation to attain maximum heterogeneity between clusters and maximum homogeneity within clusters .

Table 4.18 : Coefficient of variation for key performance indicators

KPIs	Coeffient of variation
Gross Profit Margin	0.46
Cash Flow from Investments / Net Sales	0.10
Cash Flow from Operations / Total Liabilities	0.89
Net Working Capital /Net Sales	2.05
Total Liability / Shareholder Equity	0.39

Cluster analysis was conducted utilizing the final relative points of the five KPIs within the SPSS software. The efficiency of cluster separation was evaluated through Box M and Wilks' Lambda tests for both hierarchical and non-hierarchical methods, as depicted in Table 4.19, Table 4.20 (hierarchical method), and Table 4.21, Table 4.22 (non-hierarchical method). The analysis reveals that, in hierarchical clustering, the cluster variance-covariance matrix displays inequality, and the clusters demonstrate significant divorcement in three indicators, with the exception of cash flow from investments/net sales and total liability/shareholder equity as seen in Table 4.23. In non-hierarchical clustering, a similar pattern is observed, with an unequal cluster variance-covariance matrix, and the clusters exhibit effective split-up in four indicators, except for total liability/shareholder equity as seen at Table 4.24.

Table 4.19 : Ward method clustering test of equality of cluster means

	Wilks' Lambda	F	df1	df2	Sig.
Gross Profit Margin	0.826	4.632	3	66	0.005
Cash Flow from Investments / Net Sales	0.947	1.242	3	66	0.302
Cash Flow from Operations / Total Liabilities	0.084	240.474	3	66	0.000
Net Working Capital /Net Sales	0.903	2.368	3	66	0.079
Total Liability / Shareholder Equity	0.987	0.290	3	66	0.833

Table 4.20 : Ward method clustering variance-covariance test

Box's M		246.954
F	Approx.	4.307
	df1	45
	df2	1958.057
	Sig.	0.000

Tests null hypothesis of equal population covariance matrices.

Table 4.21 : K-means clustering test of equality of cluster means

	Wilks' Lambda	F	df1	df2	Sig.
Gross Profit Margin	0.551	17.962	3	66	0.000
Cash Flow from Investments / Net Sales	0.786	5.998	3	66	0.001
Cash Flow from Operations / Total Liabilities	0.136	139.210	3	66	0.000
Net Working Capital /Net Sales	0.828	4.573	3	66	0.006
Total Liability / Shareholder Equity	0.976	0.531	3	66	0.663

Table 4.22 : K-means clustering variance-covariance test

Box's M		120.053
F	Approx.	2.200
	df1	45
	df2	3817.506
	Sig.	0.000

Tests null hypothesis of equal population covariance matrices.

Table 4.23 : Ward method final cluster centers

	Cluster			
	Extra Clear Blue Ocean	Blue Ocean	Red Ocean	Bloody Red Ocean
Gross Profit Margin	3.10	2.09	2.17	1.69
Cash Flow from Investments / Net Sales	3.57	3.34	3.36	3.49
Cash Flow from Operations / Total Liabilities	7.03	4.35	0.61	2.06
Net Working Capital /Net Sales	0.74	0.34	0.17	0.21
Total Liability / Shareholder Equity	0.50	0.55	0.49	0.52
# of companies	7	12	27	24

Table 4.24 : K-means final cluster centers

	Cluster			
	Extra Clear Blue Ocean	Blue Ocean	Red Ocean	Bloody Red Ocean
Gross Profit Margin	3.20	1.88	2.73	1.48
Cash Flow from Investments / Net Sales	3.53	3.41	3.15	3.55
Cash Flow from Operations / Total Liabilities	6.70	3.56	1.05	1.06
Net Working Capital /Net Sales	0.69	0.34	-0.07	0.28
Total Liability / Shareholder Equity	0.51	0.54	0.46	0.52
# of companies	9	17	28	16

Utilizing both hierarchical (Ward method with Euclidean distance) and non-hierarchical (k-means clustering) approaches revealed more substantial alterations in clustering, as outlined in Table 4.25 and Table 4.26. These techniques yield a more thorough outcome by taking various indicators into account. In line with the theoretical goal of attaining maximum homogeneity within clusters and maximum heterogeneity between clusters, we will implement the hierarchical Ward clustering method with the data from Table 4.25 to develop machine learning models.

Table 4.25 : Categorization of BIST 100 companies on long term competitive force with ward clustering

Bloody Red Ocean Company	Red Ocean Company	Blue Ocean Company	Extra Clear Blue Ocean Company
AEFES	AKFGY	ALARK	ALKIM
AGHOL	ARCLK	BUCIM	CEMTS
AKSA	ASELS	BIMAS	IPEKE
AKSEN	BERA	DOAS	ISDMR
ASUZU	EKGYO	EGEEN	KOZAL
BAGFS	ERBOS	EREGL	KOZAA
CCOLA	GLYHO	FROTO	ODAS
CIMSA	GSDHO	MAVI	
DOHOL	GUBRF	OYAKC	
ECILC	HEKTS	TCELL	
ENKAI	ISGYO	TTKOM	
KONYA	IZMDC	TTRAK	
KORDS	KARSN		
KRDMD	KCHOL		
MGROS	KERVT		
OTKAR	SAHOL		
PETKM	SASA		
PGSUS	SELEC		
SOKM	SISE		
THYAO	SNGYO		
TKNSA	TAVHL		
TOASO	TKFEN		
TUPRS	TMSN		
VESBE	TUKAS		
	ULKER		
	ULUUN		
	VESTL		

Table 4.26 : Categorization of BIST 100 companies on long term competitive force with k-means clustering

Bloody Red Ocean Company	Red Ocean Company	Blue Ocean Company	Extra Clear Blue Ocean Company
AEFES	AKSEN	AKSA	ALKIM
AGHOL	ASELS	ALARK	CEMTS
AKFGY	ASUZU	BIMAS	EGEEN
ARCLK	BAGFS	BUCIM	IPEKE
GLYHO	BERA	CCOLA	ISDMR
HEKTS	DOHOL	CIMSA	KOZAL
ISGYO	EKGYO	DOAS	KOZAA
KCHOL	ERBOS	ECILC	MAVI
OTKAR	GSDHO	ENKAI	ODAS
SAHOL	GUBRF	EREGL	
SASA	IZMDC	FROTO	
SISE	KARSN	KRDMD	
SNGYO	KERVT	OYAKC	
TAVHL	KONYA	SOKM	
TUKAS	KORDS	TCELL	
VESTL	MGROS	TTKOM	
	PETKM	TTRAK	
	PGSUS		
	SELEC		
	THYAO		
	TKFEN		
	TKNSA		
	TMSN		
	TOASO		
	TUPRS		
	ULKER		
	ULUUN		
	VESBE		

4.2.11 Machine learning models

In the previous section, we categorized 70 stocks into four groups based on long-term competitive force using various methodologies. After consideration, we opted to advance with the hierarchical method (ward clustering + Euclidean distance) for machine learning models, as it aligns well with the data. This approach provides us with a more tailored model, resulting in relatively homogeneous groups.

As the first stage of model creation, we determine potential predictors for stock return for that specific groups. At this point, It is clear that evaluating the value increase capability of a stock requires an initial assessment to determine whether it is undervalued or overvalued. To achieve this, we incorporate the market value to book value at fiscal year-end, along with five essential micro key performance indicators (KPIs): gross profit margin, cash flow from investments to net sales, cash flow from operations to total liabilities, net working capital to net sales, and total liability to shareholder equity. Additionally, economic activity indicators, such as the increase in copper price, the US 2-10 bond interest rate spread, and Turkey's industrial production index, are introduced previously, expanding the list of indicators. In the end, a total of nine macro and micro KPIs are selected as reliable estimators of stock returns for the identified clusters.

Triangular spherical fuzzy sets streamline the assessment of stocks, leading to the formation of four clusters determined by ultimate points relative to the utilization of five indicators within hierarchical configurations. At this juncture, machine learning algorithms will be generated, incorporating the specified nine indicators over a span of five years, encompassing 70 stocks and totaling 350 data points segregated into four clusters. The decision between linear and nonlinear fits hinges on the trade-off between bias and variance, prioritizing the reduction of variance and alleviation of bias to uphold model robustness; thus, a linear foundation is pursued. In our approach, we've integrated a hybrid model that combines linear and nonlinear machine learning techniques, specifically the Generalized Additive Model (GAM). This hybridization allows us to leverage the strengths of both linear and nonlinear modeling, enhancing the overall predictive capabilities of our system.

Utilizing R package software with readx1, glmnet and mgcv libraries, various machine learning algorithms such as lasso regression, ridge regression, partial least squares and

generalized additive model will be deployed on the designated four clusters. The reliant variable consists of logarithmic returns derived from adjusted prices, while the autonomous variables encompass a set of nine indicators. In preliminary assessments, scrutiny was applied to identify leverage points and outliers within the dataset. Notably, observations featuring negative shareholder equity values for Sok Market, Teknosa,Migros and Oyak Cimento are attributed to substantial losses in their profit and loss statements, directly impacting the market-to-book value—were omitted from the dataset. It's noteworthy that the first three companies belong to the bloody red ocean cluster, while the fourth is affiliated with the blue ocean cluster.

After careful scrutiny, it was determined that six of the microeconomic variables exhibited no discernible correlation with one another. Nonetheless, a remarkably strong positive correlation was identified between the increase in copper price and the US 2-10 Bond Interest Rate Spread, as illustrated in Table 4.27. Consequently, the US 2-10 Bond Interest Rate Spread was eliminated from the roster of independent variables, culminating in the final selection of eight indicators following these initial examinations.

Table 4.27 : Correlation test of macroeconomic indicators

	Copper Price Increase	US 2-10 Bond Interest rate Spread	Industrial Production Index of Turkey
Copper Price Increase	1.00		
US 2-10 Bond Interest rate Spread	**0.96**	1.00	
Industrial Production Index of Turkey	0.50	0.58	1.00

The least squares regression method seeks to minimize the Residual Sum of Squares (RSS) to estimate coefficients. These coefficients, obtained through this approach, are unbiased, implying that the significance of variables is not considered when determining their values. Alternatively, for pinpointing the optimal subset of variables in the regression model, we will employ shrinkage techniques. The formulated model, expressed by the equation below, encompasses all predictors and contracts the coefficients toward zero using ridge regression. The tuning parameter λ governs the relative impact of two components on the regression coefficient estimates. When $\lambda = 0$, the penalty term is inactive, resulting in ridge regression estimates identical to those of least squares. As λ approaches infinity ($\lambda \rightarrow \infty$), ridge regression coefficients tend to zero. However, a

drawback of ridge regression is its inclusion of all predictors in the final model. Despite diminishing coefficient estimates toward zero, it does not entirely eliminate irrelevant predictors. While this might not significantly affect prediction accuracy, it poses challenges in terms of model interpretation due to the incorporation of a large number of predictors. The formulation for mean square error (MSE), representing the average squared difference between predicted values and actual values for ridge regression, is provided below (James et al., 2013):

$$\text{MSE Ridge} = \frac{1}{n}\sum_{i=1}^{n} (y_i - \hat{y}_i)^2 + (\lambda) \sum_{j=1}^{p} (\beta j)^2 \quad (4.9)$$

n represent number of observations,

y_i represent actual observation values,

$\hat{y}_i$ represents the predicted values,

λ is the tuning parameter,

βj is the coefficients,

p is the number of predictors.

Lasso regression provides a remedy for this problem by utilizing a distinct type of shrinkage penalty in contrast to ridge regression. Like ridge regression, lasso regression contracts the coefficient estimates toward zero. However, the distinctive feature of lasso regression is its penalty term, which actively compels certain coefficient estimates to be exactly zero as the tuning parameter lambda (λ) increases, as indicated by the following formula (James et al., 2013):

$$\text{MSE Lasso} = \frac{1}{n}\sum_{i=1}^{n} (y_i - \hat{y}_i)^2 + (\lambda) \sum_{j=1}^{p} |\beta j| \quad (4.10)$$

Conversely, as a method for dimension reduction, Partial Least Squares (PLS) generates new variates that not only combine specifications of independent variables but also have associations with the response. The formulation for Mean Squared Error (MSE) in the context of Partial Least Squares is provided in the following manner (James et al., 2013):

$$\text{MSE PLS} = \frac{1}{n}\sum_{i=1}^{n} (y_i - \hat{y}_i)^2 \quad (4.11)$$

n is the number of observations,

y_i represent actual observations,

$\hat{y}_i$ is the predicted response,

In addition to the linear methods, generalized additive models (GAMs) are employed to capture potential nonlinear relationships between predictors and the response variable. GAMs offer a unique possible superiority over linear models by incorporating smooth functions, allowing for the modeling of complex nonlinearities. One of the notable features of GAMs is their ability to perform variable selection through the smoothing process, automatically identifying relevant predictors and characterizing their relationships with the response. However, it's essential to consider the bias-variance tradeoff when using GAMs. While GAMs are effective in handling nonlinearity, the increased flexibility introduced by smooth functions may lead to a potential tradeoff, impacting the model's performance in terms of bias and variance. In certain situations, this increased flexibility may result in overfitting, particularly when the sample size is limited.

$$\text{MSE GAMs} = \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2 + (\lambda)\sum_{j=1}^{p}\int [s_j(x_j)]^2 dx_j \qquad (4.12)$$

n represent number of observations,

y_i represent actual observation values,

$\hat{y}_i$ represents the predicted values,

$s_j(x_j)$ is the smooth function for jth predictor,

λ is the penalty term that controls the smoothness of the functions.

p is the number of predictors.

In the first part of the machine learning models, we examine linear models (lasso and ridge) and partial least square. In the later process GAMs will be introduced for all four competitive power group.

Using indicators spanning the past consecutive five years across all 66 stocks, Table 4.28 displays the computed Mean Squared Errors (MSE). Except for the Blue Ocean cluster, the lasso regression model produces the lowest MSE values. In the case of the Blue Ocean cluster, the minimum MSE is 0.056, achieved with partial least squares. Table 4.29 exhibits the coefficients obtained from both ridge and lasso regression models. Additionally, Figure 4.1 demonstrates the fluctuation in MSE with varying variate numbers for the partial least squares method, as outlined in Table 4.30. Noteworthy is the model's presentation of high variance explanation percentages, reaching 82% and 73% for the Bloody Red Ocean and Extra Clear Ocean groups, while others show relatively lower

percentages. Without applying any clustering, and taking all 330 obervation as one bulk cluster, MSE of ridge, lasso and PLS would be 0.132, 0,127 and 0,152. It demonstrate us related efficiency of clustering.

Table 4.28 : Machine learning algorithm results for clusters

	Bloody Red Ocean	Red Ocean	Blue Ocean	Extra Clear Blue Ocean
n	21*5= 105	27*5=135	11*5=55	7*5=35
Ridge MSE	0.076	0.075	0.078	0.013
Lasso MSE	0.074	0.051	0.086	0.007
PLS MSE	0.074	0.056	0.056	0.008

n: observation number

Table 4.30 : Partial least square - explained variance with optimum variate numbers

		Number of Variate	Variance Explained
Bloody Red Ocean Companies	PLS	6	82%
Red Ocean Companies	PLS	4	47%
Blue Ocean Companies	PLS	3	36%
Extra Clear Blue Ocean Companies	PLS	4	73%

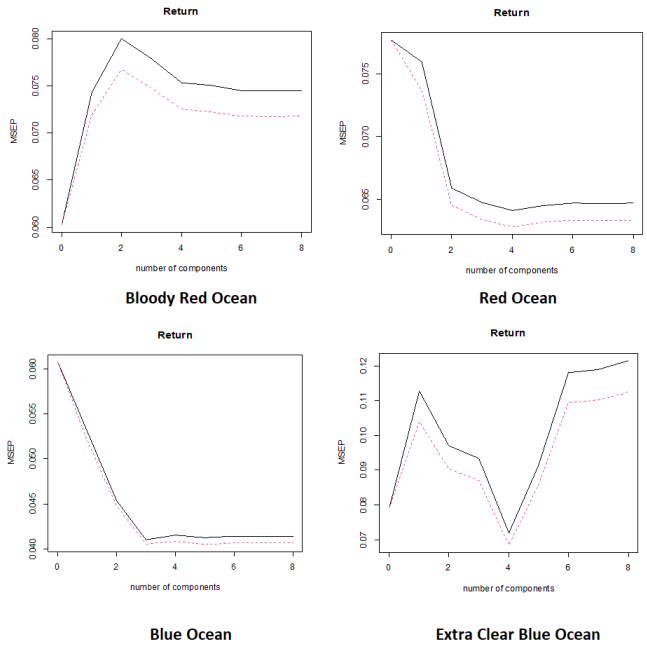

Figure 4.1: MSE of partial lease square according to number of variate

Table 4.29 : Lasso and ridge regression econometric models

	Log return	intercept	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
Bloody Red Ocean Companies	Ridge Regression	0.083	0.210	-0.212	0.044	-0.020	-0.002	0.015	-0.213	0.859
	Lasso Regression	0.100	0.140	-0.174				0.015	-0.221	0.927
Red Ocean Companies	Ridge Regression	0.086	0.133	-0.033	-0.035	0.005	-0.010	0.034	-0.477	1.029
	Lasso Regression	0.101	0.067	-0.011			-0.004	0.033	-0.397	0.770
Blue Ocean Companies	Ridge Regression	0.333	0.167	-0.048	-0.162	-0.241	-0.121	0.038	-0.555	1.525
	Lasso Regression	0.218			-0.080	-0.025	-0.061	0.032	-0.442	1.196
Extra Clear Blue Ocean Companies	Ridge Regression	0.131	0.367	0.138	-0.089	-0.041	-0.065	0.072	-0.228	0.150
	Lasso Regression	0.134	0.232	0.145	-0.090		-0.043	0.077	-0.171	

X1= Gross Profit Margin ; X2 = Cash Flow from Investments / Net Sales ; x3 = Cash Flow from Operations / Total Liabilities ; x4 = Net Working Capital /Net Sales

X5= Total Liability / Shareholder Equity ; X6 = Market Value / Book Value ; x7 = Copper Price Increase ; x8 = Industrial Production Index of Turkey

Table 4.31 : Lasso and ridge regression r-square

	Bloody Red Ocean	Red Ocean	Blue Ocean	Extra Clear Blue Ocean
n	21*5= 105	27*5=135	11*5=55	7*5=35
Ridge r square	3.8%	25.9%	35.8%	92.9%
Lasso r square	3.4%	28.3%	29.6%	87.6%

n: observation number

Examining the r-square values in the regression analysis presented in the table, it is evident that predictors within the extra clear blue ocean demonstrate a high level of success in explaining the variance in changing stock returns, with values reaching 92.9% and 87.6%. In contrast, both the Red Ocean and Blue Ocean clusters exhibit considerable effectiveness, with r-square values ranging between 25% and 36%. Conversely, the model indicators for the bloody red ocean perform poorly in explaining the variance in stock returns.

At this stage, we will employ GAMs to capture potential nonlinearities between predictors and stock returns. Predictors are coded with progressive numbers as below:

Gross profit margin: predictor1

Cash flow from investments / net sales: predictor2

Cash flow from operations / total liabilities: predictor3

Net working capital / net sales: predictor4

Total liability / shareholder equity: predictor5

Market value / book value: predictor6

Copper price increase: predictor7

Industrial production index of Turkey: predictor8

Bloody red ocean companies GAM model: We conducted research on potential nonlinearities using GAM fit functions of bloody red ocean cluster and illustrated the findings in the graphs presented in Figure 4.2. The analysis clearly indicates that predictor1, predictor6, and predictor8 exhibit nonlinear relationships in predicting stock returns. Consequently, we incorporated smooth functions specifically for these predictors, namely gross profit margin, market value/book value, and the industrial production index of Turkey. The model was then refitted. The final model includes only with f (predictor8) and intercept with 95% confidence level. Notably, the r-square value increased substantially, rising from the 3%-4% level observed in linear settings under ridge and lasso to a commendable 68.8%. Simultaneously, the mean squared error (MSE) reached its lowest value across all methods, decreasing to 0.019 as seen Table 4.32. This underscores the enhanced predictive performance achieved through the incorporation of nonlinearities and the refined model specifications.

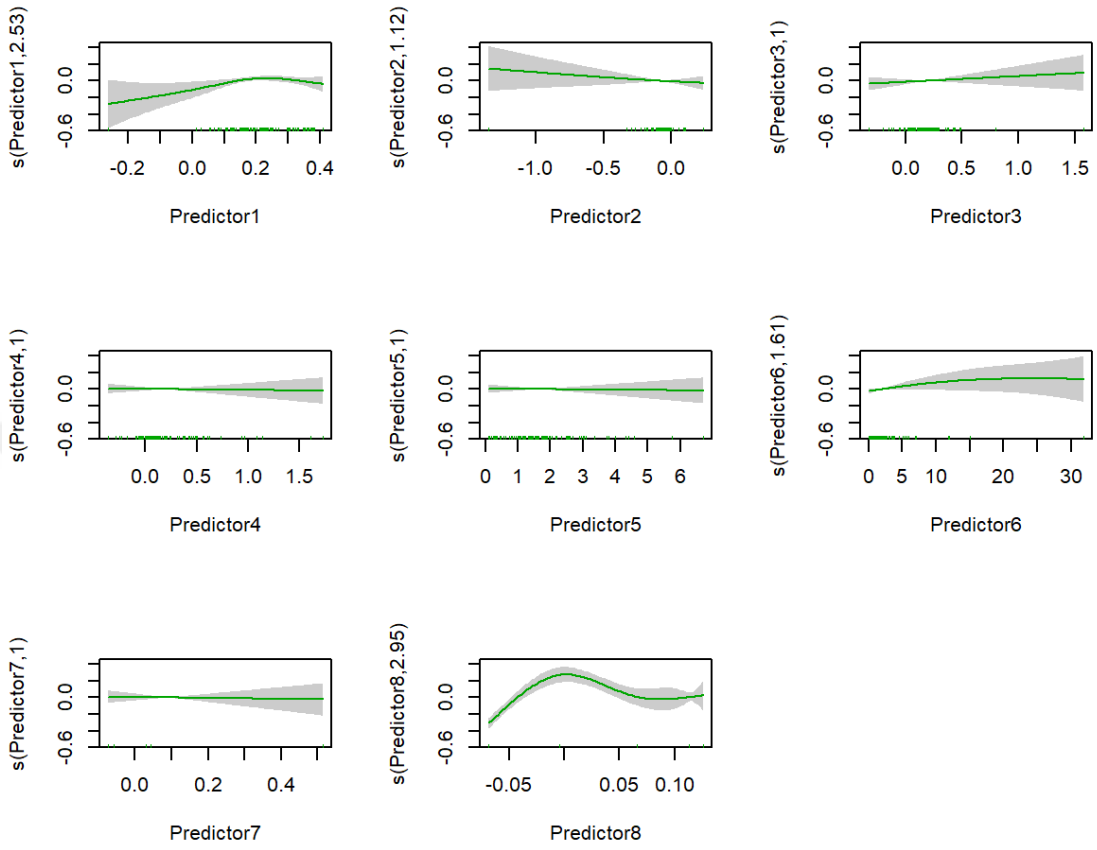

Figure 4.2: Bloody red ocean GAMs model non-linearities

Table 4.32 : GAMs econometric results

	Bloody Red Ocean	Red Ocean	Blue Ocean	Extra Clear Blue Ocean
n	21*5= 105	27*5=135	11*5=55	7*5=35
r square	68.8%	72.9%	76.8%	95.2%
MSE	0.019	0.021	0.015	0.003
n: observation number				

Red ocean companies GAM model: We conducted research on potential nonlinearities using GAM fit functions of red ocean cluster and and illustrated the findings in the graphs presented in Figure 4.3. The analysis clearly indicates that predictor1, predictor2, predictor6 and predictor8 exhibit nonlinear relationships in predicting stock returns. Consequently, we incorporated smooth functions specifically for these predictors, namely gross profit margin, cash flow from investments / net sales, market value / book value and the industrial production index of Turkey. The model was then refitted. The final model includes f(predictor1), f(predictor2), f(predictor6), f(predictor8) and intercept with 95% confidence level. Notably, the r-square value increased substantially, rising from the 26%-28% level observed in linear settings under ridge and lasso to a commendable 72.9%. Simultaneously, the mean squared error (MSE) reached its lowest value across all methods, decreasing to 0.021 as seen Table 4.32. This underscores the enhanced predictive performance achieved through the incorporation of nonlinearities and the refined model specifications.

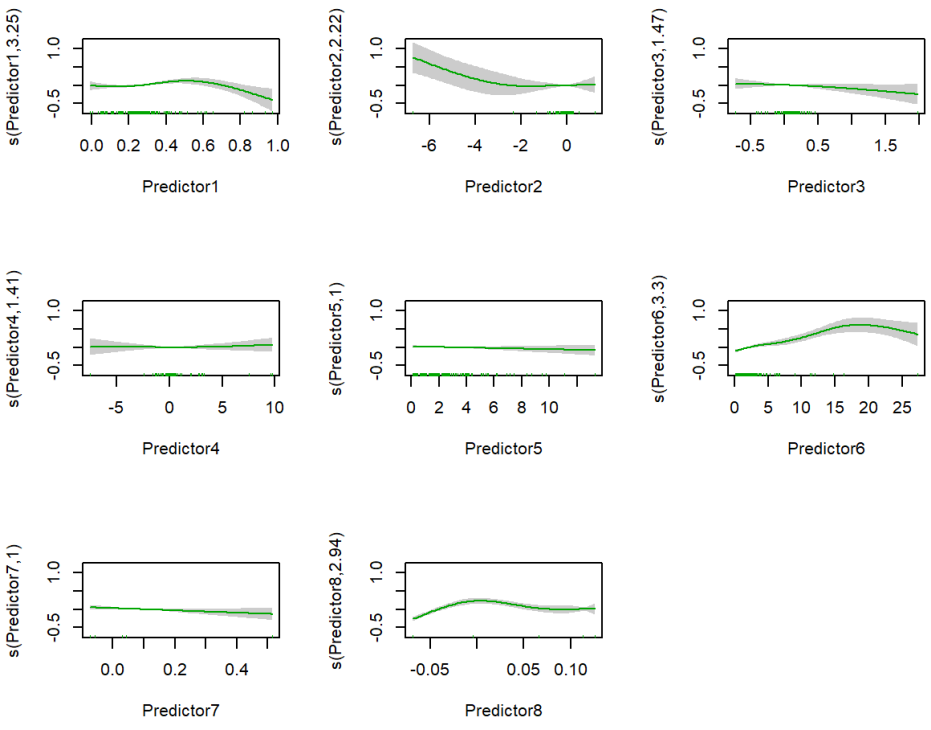

Figure 4.3: Red ocean GAMs model non-linearities

Blue ocean companies GAM model: We conducted research on potential nonlinearities using GAM fit functions of blue ocean cluster and and illustrated the findings in the graphs presented in Figure 4.4. The analysis clearly indicates that predictor2 and predictor8 exhibit nonlinear relationships in predicting stock returns. Consequently, we incorporated smooth functions specifically for these predictors, namely Cash flow from investments / net sales, and the industrial production index of Turkey. The model was then refitted. The final model includes predictor5, predictor6, f(predictor2), f(predictor8) and intercept with 95% confidence level. Notably, the r-square value increased substantially, rising from the 29%-36% level observed in linear settings under ridge and lasso to a commendable 76.8%. Simultaneously, the mean squared error (MSE) reached its lowest value across all methods, decreasing to 0.015 as seen Table 4.32. This underscores the enhanced predictive performance achieved through the incorporation of nonlinearities and the refined model specifications.

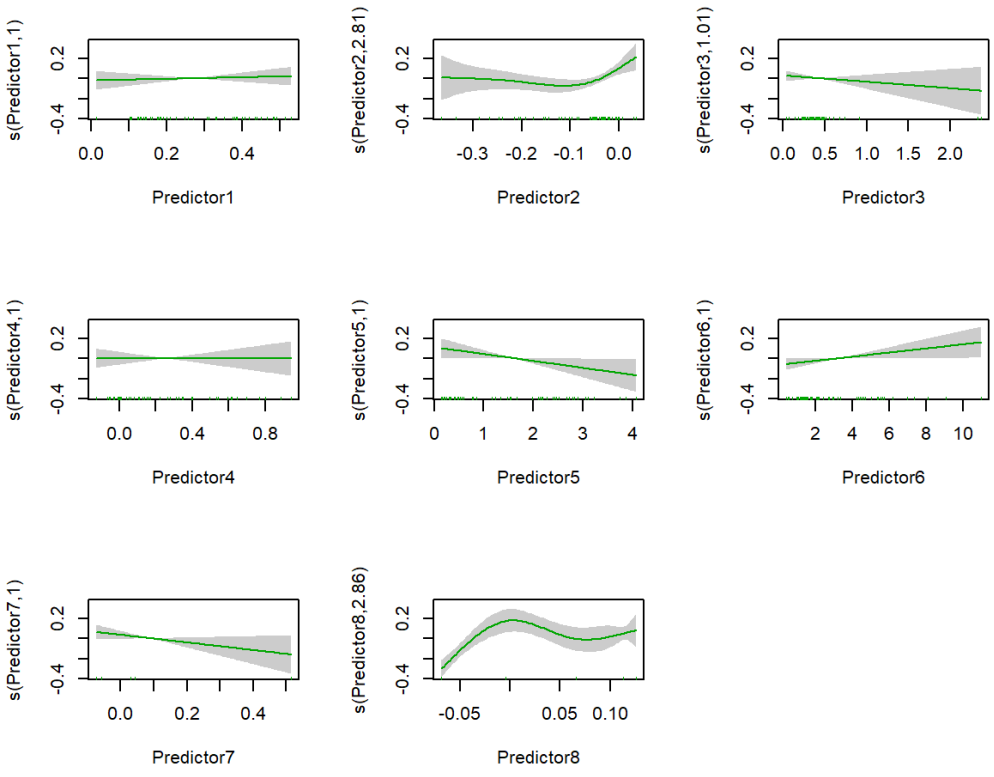

Figure 4.4: Blue ocean GAMs model non-linearities

Extra clear blue ocean companies GAM model: We conducted research on potential nonlinearities using GAM fit functions of blue ocean cluster and and illustrated the findings in the graphs presented in Figure 4.5. The analysis clearly indicates that predictor1, predictor2 and predictor4 exhibit nonlinear relationships in predicting stock returns. Consequently, we incorporated smooth functions specifically for these predictors, namely gross profit margin, cash flow from investments / net sales, and net working capital / net sales of Turkey. The model was then refitted. The final model includes predictor6, predictor7, predcitor8 f(predictor1), f(predictor2), f(predictor4) and intercept with 95% confidence level. Notably, the r-square value increased substantially, rising from the 87%-93% level observed in linear settings under ridge and lasso to a commendable 95,2%. Simultaneously, the mean squared error (MSE) reached its lowest value across all methods, decreasing to 0.003 as seen Table 4.32. This underscores the enhanced predictive performance achieved through the incorporation of nonlinearities and the refined model specifications.

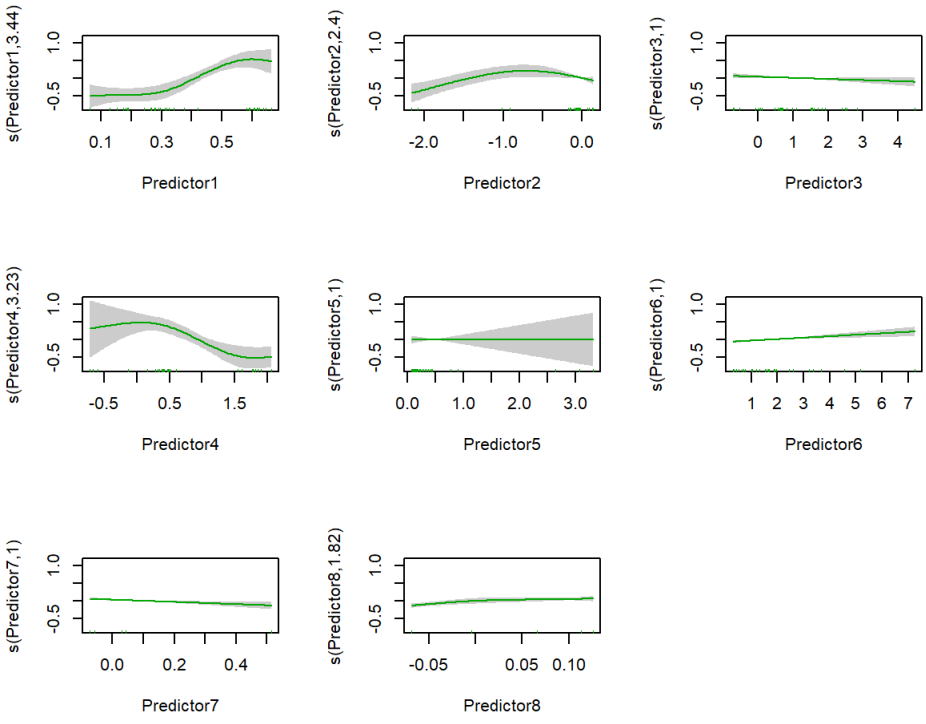

Figure 4.5: Extra clear ocean GAMs model non-linearities

4.3 Long Term Competitive Power of 2023 BIST IPOs

Decreasing prices in the cryptocurrency market have led to a growing interest in the stock market as an alternative investment avenue in Turkey. This shift is driven by the belief among the younger demographic that financial markets offer convenient opportunities for financial gains. With a limited understanding of investment knowledge, certain Initial Public Offerings (IPOs) have experienced daily price hikes of up to 10% during the initial trading period, fueled by robust public offerings. Building upon this foundation, our second extended research seeks to examine the long-term valuation potential of the 2023 IPOs on the Borsa Istanbul. To address this pivotal question, our study delves into the complexities of IPO valuations, aiming to pinpoint the factors that distinguish one IPO from another. Introducing a fresh perspective, we incorporate crucial financial Key Performance Indicators (KPIs) of companies, including gross profit margin, cash flow from investments/net sales, cash flow from operations/total liabilities, net working capital/net sales, and total liability/shareholder equity. Additionally, we integrate essential aspects derived from companies' IPO documents; management competence and experience, utilization of IPO funds, price stability commitments, Pre-IPO Valuation Approach, and business and growth strategy. 42 IPOs has been in scope in this study which addressed the total IPOs from 1 January 2023 until November 2023. Financial instituition, Katılımevim, has been excluded due to non-comtitability of balance sheet within anlaysis.

4.3.1 Expert selection

Taking into consideration of IPO trading experince, practical experience on company valuation and fuzzy logic knowledge, three experts have been chosen as Table 4.33.

Table 4.33 : Selection of experts for Borsa Istanbul 2023 IPOs

# of Expert	Person	Scope of Work	Length of Service (years)	Fuzzy Logic Base Level
1	Expert 1	Finance PHD Student	13	Deep expertise
2	Expert 2	Finance PHD Student	10	Deep expertise
3	Expert 3	Business Professional	22	2 Hour Fuzzy Logic bootcamp

4.3.2 Indicators selection for Borsa Istanbul 2023 IPOs

The potential valuation of Initial Public Offerings (IPOs) is closely linked to a thorough understanding of a company's overall management, financial strategies, market positioning, and growth trajectory. Assessing these pivotal factors empowers investors and stakeholders to make informed decisions about the company's potential for long-term success and its appeal as an investment opportunity. Therefore, expert assessments, grounded in meticulous analyses of the company's financial statements over the past three years, the IPO price detection report, and the offering circular, provide valuable insights. Upon generic 5 KPIs, additional 5 indicators has been chosen for evaluationg long term valuation potential of IPOs.

Management Competence and Experience: The proficiency and skill of a company's leadership has enormous effect on determining the firm's capacity to navigate challenges, capitalize on opportunities, and sustain long-term growth (Megaravalli, 2023). Competent leadership has the potential to instill confidence in investors and ensure effective decision-making, promoting stability and resilience within the company. The evaluation by experts in this aspect depends on the professional experiences and backgrounds of the leadership team, which includes their published articles and media interviews. It also involves a comprehensive analysis of the company's financial statements over the past three years, the IPO offering circular, and the company statistics available on its LinkedIn page.

Utilization of IPO Funds: The optimal and productive distribution of funds obtained from an Initial Public Offering (IPO) is pivotal in assessing a company's potential for sustainable growth and value generation (Ahmad-Zaluki & Badru, 2021). A transparent and strategic plan outlining the use of funds demonstrates management's foresight and the company's capability to invest in projects and initiatives that enhance long-term profitability and competitiveness. The experts' assessment in this aspect relies on the precise information outlined in the IPO offering circular concerning the planned allocation of the newly generated funds from the IPO.

Price Stability Commitments: Expressing a dedication to upholding stable pricing strategies and steering clear of undue price fluctuations has the potential to build trust and confidence among investors (Bell et al., 2012). Maintaining steadfast pricing commitments not only aids in cultivating a positive company reputation but also signifies

the management's devotion to the company's principles. The assessment by experts in this regard is based on the commitments delineated in the buy-back plan, the specified duration of commitment to avoid a paid capital increase, and the pledged timeframe of refraining from selling main shareholder shares, as outlined in the IPO offering circular.

Pre-IPO Valuation Approach: A thorough and well-organized pre-market valuation approach reflects the company's capability to precisely evaluate its own value and potential in the market. A strong valuation approach signifies transparency, effective financial management, and a clear comprehension of the company's standing in relation to industry norms and market dynamics. The evaluation by experts in this context relies on the importance assigned to the methods utilized in the valuation process, as well as fundamental assumptions such as the weighted average cost of capital, interest rate, EBITDA multiplier, perpetual growth rate, equity risk premium, among others. Additionally, a comprehensive analysis of comparable companies plays a vital role in this assessment, offering a comprehensive insight into the company's valuation compared to its industry peers. It is not uncommon for false income accruals and related-party transactions to occur during the pre-IPO process (Cheng et al., 2007). Such incidents can distort the pre-IPO valuation process, compromising its integrity and accuracy.

Business and Growth Strategy: A clearly defined business and growth strategy, in alignment with the company's long-term objectives, plays a crucial role in establishing a sustainable competitive advantage, forming the bedrock for the enduring valuation success of IPOs. A strategic plan that integrates market trends, consumer preferences, technological advancements, and potential risks showcases the company's adaptability and foresight, positioning it advantageously for sustained growth and success (Megaravalli, 2023). The experts' assessment of this aspect depends on the existence of a strong business strategy that either carves out a distinctive market niche (blue oceans) or establishes entirely new market spaces.

4.3.3 Initial expert assessment and validation

The methodology detailed at section 4.2.4 has been applied. There is no available any discrepancy within litmus test. Expert assessment and litmus test results are given at Table 4.34, Table 4.35 respectively.

4.3.4 Expert' s view weighting & aggregation & defuzzification process

The methodology detailed at section 4.2.5 has been applied. Expert weights has been given at Table 4.36. The resultant aggregated values are detailed in Table 4.37.

Table 4.36 : Expert weights for Borsa Istanbul 2023 IPOs indicator evaluation

Expert	Expert Weights
Expert 1	40%
Expert 2	30%
Expert 3	30%
Sum of Total	**100%**

Table 4.34 : Expert assessments for Borsa Istanbul 2023 IPOs

		Expert 1									Expert 2									Expert 3								
		μ			ν			π			μ			ν			π			μ			ν			π		
Year	Competitive Advantage KPIs	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h
2020	Gross Profit Margin	0.79	0.92	0.94	0.07	0.09	0.11	0.13	0.15	0.17	0.80	0.83	0.94	0.03	0.06	0.09	0.22	0.25	0.28	0.65	0.75	0.85	0.08	0.10	0.12	0.20	0.30	0.40
2021	Gross Profit Margin	0.80	0.93	0.95	0.08	0.10	0.12	0.13	0.15	0.17	0.80	0.83	0.95	0.03	0.06	0.09	0.22	0.25	0.28	0.65	0.75	0.85	0.08	0.10	0.12	0.20	0.30	0.40
2022	Gross Profit Margin	0.83	0.96	0.98	0.05	0.07	0.09	0.13	0.15	0.17	0.83	0.87	0.90	0.01	0.03	0.05	0.13	0.15	0.17	0.75	0.80	0.90	0.02	0.05	0.07	0.10	0.20	0.30
2020	Cash Flow from Operations / Total Liabilities	0.80	0.81	0.83	0.07	0.08	0.10	0.06	0.08	0.10	0.67	0.70	0.81	0.15	0.19	0.23	0.12	0.14	0.16	0.62	0.65	0.76	0.15	0.22	0.27	0.13	0.17	0.20
2021	Cash Flow from Operations / Total Liabilities	0.80	0.81	0.83	0.07	0.08	0.10	0.06	0.08	0.10	0.67	0.70	0.82	0.15	0.19	0.23	0.12	0.14	0.16	0.62	0.65	0.77	0.16	0.23	0.28	0.13	0.17	0.20
2022	Cash Flow from Operations / Total Liabilities	0.83	0.84	0.85	0.07	0.07	0.08	0.04	0.04	0.06	0.70	0.74	0.77	0.13	0.18	0.22	0.10	0.10	0.12	0.65	0.69	0.72	0.13	0.20	0.28	0.11	0.15	0.21
2020	Cash Flow from Operations / Total Liabilities	0.95	0.96	0.98	0.01	0.03	0.04	0.03	0.05	0.07	0.87	0.93	0.96	0.03	0.04	0.06	0.05	0.07	0.14	0.72	0.77	0.82	0.06	0.11	0.18	0.05	0.08	0.14
2021	Cash Flow from Operations / Total Liabilities	0.95	0.96	0.98	0.01	0.03	0.06	0.03	0.05	0.07	0.87	0.94	0.96	0.03	0.04	0.06	0.05	0.07	0.14	0.69	0.76	0.82	0.06	0.12	0.18	0.05	0.09	0.14
2022	Cash Flow from Operations / Total Liabilities	0.98	0.98	0.99	0.01	0.02	0.03	0.01	0.01	0.03	0.90	0.95	0.97	0.02	0.03	0.04	0.03	0.03	0.07	0.75	0.83	0.88	0.09	0.15	0.18	0.02	0.06	0.10
2020	Net Working Capital /Net Sales	0.80	0.81	0.83	0.16	0.17	0.19	0.23	0.25	0.27	0.69	0.72	0.83	0.13	0.20	0.27	0.25	0.32	0.39	0.64	0.71	0.78	0.19	0.26	0.32	0.13	0.19	0.27
2021	Net Working Capital /Net Sales	0.80	0.81	0.83	0.16	0.17	0.19	0.23	0.25	0.27	0.69	0.72	0.84	0.13	0.20	0.27	0.25	0.32	0.39	0.66	0.72	0.79	0.20	0.28	0.33	0.12	0.18	0.25
2022	Net Working Capital /Net Sales	0.83	0.84	0.85	0.16	0.16	0.17	0.21	0.21	0.23	0.72	0.76	0.79	0.14	0.19	0.29	0.26	0.31	0.41	0.70	0.76	0.82	0.18	0.24	0.26	0.05	0.12	0.16
2020	Total Liability / Shareholder Equity	0.64	0.71	0.75	0.21	0.27	0.33	0.13	0.15	0.17	0.59	0.62	0.73	0.24	0.32	0.41	0.17	0.19	0.21	0.73	0.80	0.86	0.06	0.12	0.15	0.07	0.12	0.16
2021	Total Liability / Shareholder Equity	0.64	0.71	0.75	0.21	0.27	0.34	0.13	0.15	0.17	0.59	0.62	0.74	0.24	0.30	0.41	0.17	0.19	0.21	0.72	0.82	0.86	0.06	0.11	0.15	0.07	0.13	0.16
2022	Total Liability / Shareholder Equity	0.70	0.74	0.80	0.20	0.26	0.35	0.11	0.11	0.13	0.62	0.66	0.69	0.23	0.29	0.38	0.15	0.15	0.17	0.73	0.82	0.88	0.03	0.09	0.12	0.05	0.10	0.13
-	Management Competence and Experience	0.86	0.91	0.95	0.02	0.03	0.04	0.01	0.02	0.03	0.82	0.88	0.90	0.03	0.05	0.07	0.02	0.04	0.06	0.80	0.85	0.90	0.03	0.06	0.09	0.01	0.02	0.03
-	Utilization of IPO Funds	0.83	0.88	0.92	0.04	0.08	0.09	0.01	0.02	0.03	0.79	0.85	0.87	0.05	0.07	0.10	0.02	0.04	0.06	0.74	0.79	0.80	0.05	0.08	0.10	0.05	0.07	0.09
-	Price Stability Commitments	0.65	0.72	0.75	0.10	0.15	0.20	0.06	0.10	0.14	0.60	0.65	0.70	0.06	0.10	0.14	0.05	0.10	0.15	0.56	0.62	0.66	0.12	0.16	0.19	0.07	0.10	0.13
-	Pre-IPO Valuation Approach	0.75	0.80	0.85	0.07	0.11	0.14	0.04	0.08	0.13	0.68	0.72	0.76	0.10	0.18	0.22	0.05	0.07	0.10	0.65	0.70	0.75	0.09	0.14	0.18	0.03	0.06	0.09
-	Business and Growth Strategy	0.86	0.90	0.94	0.04	0.08	0.12	0.02	0.03	0.04	0.80	0.88	0.96	0.10	0.12	0.14	0.02	0.04	0.06	0.86	0.90	0.94	0.04	0.06	0.08	0.03	0.06	0.09

Table 4.35 : Expert assessments litmus test for Borsa Istanbul 2023 IPOs

Year	Competitive Advantage KPIs	Expert 1			Expert 2			Expert 3		
		1	2	3	1	2	3	1	2	3
2020	Gross Profit Margin	0.65	0.88	0.92	0.69	0.76	0.97	0.47	0.66	0.90
2021	Gross Profit Margin	0.66	0.90	0.95	0.69	0.76	0.99	0.47	0.66	0.90
2022	Gross Profit Margin	0.71	0.95	1.00	0.71	0.78	0.84	0.57	0.68	0.90
2020	Cash Flow from Operations / Total Liabilities	0.65	0.67	0.71	0.49	0.55	0.73	0.42	0.50	0.69
2021	Cash Flow from Operations / Total Liabilities	0.65	0.67	0.71	0.49	0.55	0.75	0.43	0.50	0.71
2022	Cash Flow from Operations / Total Liabilities	0.69	0.71	0.73	0.52	0.59	0.66	0.45	0.54	0.64
2020	Cash Flow from Operations / Total Liabilities	0.90	0.93	0.97	0.76	0.87	0.94	0.52	0.61	0.72
2021	Cash Flow from Operations / Total Liabilities	0.90	0.93	0.97	0.76	0.89	0.94	0.48	0.60	0.72
2022	Cash Flow from Operations / Total Liabilities	0.96	0.96	0.98	0.81	0.90	0.95	0.57	0.72	0.82
2020	Net Working Capital /Net Sales	0.72	0.75	0.80	0.56	0.66	0.91	0.46	0.61	0.78
2021	Net Working Capital /Net Sales	0.72	0.75	0.80	0.56	0.66	0.93	0.49	0.63	0.80
2022	Net Working Capital /Net Sales	0.75	0.78	0.80	0.61	0.71	0.88	0.52	0.65	0.77
2020	Total Liability / Shareholder Equity	0.47	0.60	0.70	0.43	0.52	0.75	0.54	0.67	0.79
2021	Total Liability / Shareholder Equity	0.47	0.60	0.71	0.43	0.51	0.76	0.53	0.70	0.79
2022	Total Liability / Shareholder Equity	0.54	0.63	0.78	0.46	0.54	0.65	0.54	0.69	0.81
-	Management Competence and Experience	0.74	0.83	0.91	0.67	0.78	0.82	0.64	0.73	0.82
-	Utilization of IPO Funds	0.69	0.78	0.86	0.63	0.73	0.77	0.55	0.64	0.66
-	Price Stability Commitments	0.44	0.55	0.62	0.37	0.44	0.53	0.33	0.42	0.49
-	Pre-IPO Valuation Approach	0.57	0.66	0.76	0.47	0.56	0.64	0.43	0.51	0.60
-	Business and Growth Strategy	0.74	0.82	0.90	0.65	0.79	0.94	0.74	0.82	0.90
								Check	**0.997**	**TRUE**

Table 4.37 : Aggregated and defuzzified expert evaluations for Borsa Istanbul 2023 IPOs

			Aggregated Expert Evaluations									Expert 1									Expert 2									Expert 3								
			μ			ν			π			μ			ν			π			μ			ν			π			μ			ν			π		
Year	Competitive Advantage Indicators	Defuzzification	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h
2020	Gross Profit Margin	0.65	0.76	0.86	0.92	0.06	0.08	0.11	0.18	0.22	0.28	0.68	0.47	0.42	0.35	0.38	0.41	0.66	0.44	0.38	0.74	0.70	0.52	0.35	0.43	0.49	0.70	0.66	0.37	0.85	0.78	0.68	0.47	0.50	0.53	0.83	0.73	0.53
2021	Gross Profit Margin	0.66	0.76	0.87	0.93	0.06	0.09	0.11	0.18	0.22	0.28	0.66	0.45	0.39	0.36	0.40	0.43	0.65	0.42	0.34	0.74	0.70	0.50	0.35	0.43	0.49	0.70	0.66	0.31	0.85	0.78	0.68	0.47	0.50	0.53	0.83	0.73	0.53
2022	Gross Profit Margin	0.75	0.81	0.91	0.95	0.02	0.05	0.07	0.12	0.18	0.23	0.63	0.36	0.27	0.30	0.35	0.38	0.61	0.32	0.16	0.70	0.65	0.61	0.25	0.35	0.41	0.69	0.64	0.58	0.78	0.74	0.61	0.31	0.41	0.45	0.77	0.71	0.50
2020	Cash Flow from Investments / Net Sales	0.55	0.72	0.74	0.81	0.11	0.14	0.17	0.10	0.12	0.15	0.66	0.65	0.63	0.35	0.36	0.40	0.66	0.65	0.62	0.84	0.82	0.73	0.57	0.61	0.64	0.83	0.81	0.71	0.86	0.85	0.77	0.57	0.63	0.68	0.86	0.84	0.75
2021	Cash Flow from Investments / Net Sales	0.55	0.72	0.74	0.81	0.11	0.14	0.17	0.10	0.12	0.15	0.66	0.65	0.63	0.35	0.36	0.40	0.66	0.65	0.62	0.84	0.82	0.72	0.57	0.61	0.64	0.83	0.81	0.70	0.86	0.85	0.76	0.58	0.64	0.68	0.86	0.84	0.74
2022	Cash Flow from Investments / Net Sales	0.60	0.75	0.78	0.80	0.10	0.13	0.16	0.08	0.09	0.13	0.63	0.61	0.60	0.34	0.35	0.36	0.63	0.61	0.60	0.82	0.79	0.76	0.54	0.60	0.63	0.81	0.78	0.76	0.85	0.82	0.80	0.54	0.62	0.68	0.84	0.81	0.78
2020	Cash Flow from Operations / Total Liabilit	0.84	0.89	0.92	0.95	0.02	0.05	0.07	0.04	0.07	0.12	0.39	0.36	0.27	0.16	0.25	0.28	0.39	0.36	0.26	0.65	0.55	0.47	0.35	0.38	0.43	0.65	0.54	0.43	0.80	0.76	0.72	0.43	0.52	0.60	0.80	0.76	0.70
2021	Cash Flow from Operations / Total Liabilit	0.83	0.89	0.92	0.95	0.02	0.05	0.08	0.04	0.07	0.12	0.39	0.36	0.27	0.16	0.25	0.32	0.39	0.36	0.26	0.65	0.52	0.47	0.35	0.38	0.43	0.65	0.52	0.43	0.82	0.77	0.72	0.43	0.53	0.60	0.82	0.77	0.70
2022	Cash Flow from Operations / Total Liabilit	0.90	0.93	0.95	0.97	0.02	0.04	0.06	0.01	0.03	0.06	0.27	0.27	0.21	0.12	0.21	0.25	0.27	0.27	0.20	0.61	0.50	0.43	0.31	0.35	0.38	0.61	0.50	0.42	0.78	0.70	0.64	0.49	0.57	0.60	0.78	0.70	0.63
2020	Net Working Capital /Net Sales	0.43	0.73	0.76	0.82	0.16	0.20	0.25	0.22	0.26	0.32	0.66	0.65	0.63	0.48	0.49	0.51	0.62	0.60	0.56	0.82	0.80	0.70	0.54	0.62	0.68	0.79	0.75	0.58	0.85	0.81	0.75	0.61	0.67	0.71	0.85	0.79	0.71
2021	Net Working Capital /Net Sales	0.43	0.73	0.76	0.82	0.16	0.21	0.25	0.22	0.26	0.32	0.66	0.65	0.63	0.48	0.49	0.51	0.62	0.60	0.56	0.82	0.80	0.69	0.54	0.62	0.68	0.79	0.75	0.56	0.84	0.80	0.75	0.62	0.68	0.72	0.84	0.79	0.71
2022	Net Working Capital /Net Sales	0.49	0.77	0.80	0.82	0.16	0.19	0.23	0.20	0.23	0.28	0.63	0.61	0.60	0.47	0.48	0.49	0.59	0.57	0.55	0.80	0.77	0.75	0.55	0.61	0.69	0.77	0.71	0.62	0.82	0.77	0.72	0.60	0.65	0.67	0.82	0.76	0.70
2020	Total Liability / Shareholder Equity	0.43	0.66	0.72	0.79	0.15	0.22	0.28	0.13	0.15	0.18	0.81	0.76	0.72	0.54	0.59	0.64	0.80	0.74	0.70	0.88	0.86	0.80	0.65	0.71	0.77	0.87	0.85	0.77	0.79	0.74	0.67	0.43	0.53	0.57	0.79	0.73	0.65
2021	Total Liability / Shareholder Equity	0.43	0.65	0.73	0.79	0.15	0.21	0.28	0.13	0.15	0.18	0.81	0.76	0.72	0.54	0.59	0.65	0.80	0.74	0.70	0.88	0.86	0.79	0.65	0.70	0.77	0.87	0.85	0.76	0.80	0.72	0.67	0.43	0.52	0.57	0.80	0.70	0.65
2022	Total Liability / Shareholder Equity	0.50	0.69	0.75	0.81	0.12	0.19	0.26	0.10	0.12	0.14	0.76	0.73	0.66	0.53	0.58	0.66	0.76	0.72	0.65	0.86	0.84	0.82	0.64	0.69	0.75	0.86	0.83	0.81	0.80	0.72	0.64	0.35	0.48	0.53	0.79	0.71	0.62
-	Management Competence and Experience	0.82	0.83	0.89	0.92	0.03	0.04	0.06	0.01	0.03	0.04	0.58	0.49	0.39	0.21	0.25	0.28	0.58	0.49	0.39	0.72	0.64	0.61	0.35	0.41	0.45	0.72	0.64	0.60	0.74	0.68	0.61	0.35	0.43	0.49	0.74	0.68	0.61
-	Utilization of IPO Funds	0.75	0.79	0.85	0.88	0.05	0.08	0.09	0.03	0.04	0.06	0.63	0.55	0.47	0.28	0.36	0.38	0.63	0.55	0.47	0.75	0.68	0.65	0.41	0.45	0.50	0.75	0.68	0.65	0.79	0.75	0.74	0.41	0.47	0.50	0.79	0.74	0.73
-	Price Stability Commitments	0.48	0.61	0.67	0.71	0.09	0.14	0.18	0.06	0.10	0.14	0.80	0.75	0.72	0.40	0.47	0.53	0.80	0.74	0.71	0.87	0.85	0.82	0.43	0.50	0.55	0.87	0.84	0.81	0.89	0.86	0.84	0.53	0.58	0.61	0.89	0.86	0.83
-	Pre-IPO Valuation Approach	0.58	0.70	0.75	0.80	0.08	0.14	0.17	0.04	0.07	0.12	0.72	0.66	0.60	0.35	0.41	0.46	0.72	0.66	0.58	0.83	0.80	0.77	0.50	0.60	0.63	0.83	0.80	0.77	0.85	0.82	0.78	0.49	0.55	0.60	0.85	0.82	0.78
-	Business and Growth Strategy	0.79	0.84	0.89	0.95	0.05	0.08	0.11	0.02	0.04	0.06	0.58	0.51	0.42	0.28	0.36	0.43	0.58	0.51	0.42	0.74	0.64	0.47	0.50	0.53	0.55	0.74	0.64	0.46	0.67	0.61	0.52	0.38	0.43	0.47	0.67	0.60	0.51

4.3.5 Relative importance evaluation of indicators

The methodology detailed at section 4.2.6 has been applied. The experts furnished their evaluations utilizing a five-scale linguistic scale at Table 4.8. Subsequently, these linguistic assessments underwent defuzzification using a triangular linguistic scale provided in Table 4.38. The ultimate crisp weight scores for the KPIs were then computed, portraying their respective importance levels, as depicted in Table 4.39.

Table 4.38 : Linguistic evaluation of indicators for Borsa Istanbul 2023 IPOs

	Expert 1	**Expert 2**	**Expert 3**
Gross Profit Margin	Very Important	Very Important	Very Important
Cash Flow from Investments / Net Sales	Important	Important	Fairly important
Cash Flow from Operations / Total Liabilities	Very Important	Very Important	Very Important
Net Working Capital /Net Sales	Fairly important	Slighly Important	Important
Total Liability / Shareholder Equity	Fairly important	Important	Fairly important
Management Competence and Experience	Very Important	Important	Important
Utilization of IPO Funds	Important	Important	Very Important
Price Stability Commitments	Fairly important	Fairly important	Slighly Important
Pre-IPO Valuation Approach	Fairly important	Fairly important	Fairly important
Business and Growth Strategy	Very Important	Very Important	Important

4.3.6 Normalization of indicators and relative point scoring

For the normalization of first 5 KPIs, already transitioned from BIST 100 scope in the first research area, have been applied in the same way detailed at section 4.2.7. For Additional indicators from management competence&experince to business and growth strategy does not have any rigid value in the contrary of first five KPIs. Evaluations for these indicators are applied within more detailed linguistic variables given at Table 4.40. Later, Crips values at Table 4.41 are derived and regular max-min normalization has been applied, explained in previous scope.

Table 4.39 : Crips scores of indicators' weights for Borsa Istanbul 2023 IPOs

	Gross Profit Margin	Cash Flow from Investments / Net Sales	Cash Flow from Operations / Total Liabilities	Net Working Capital /Net Sales	Total Liability / Shareholder Equity	Management Competence and Experience	Utilization of IPO Funds	Price Stability Commitments	Premarket Valuation Approach	Business and Growth Strategy
Expert 1	Very Important	Important	Very Important	Fairly important	Fairly important	Very Important	Important	Fairly important	Fairly important	Very Important
Expert 2	Very Important	Important	Very Important	Slighly Important	Important	Important	Important	Fairly important	Fairly important	Very Important
Expert 3	Very Important	Fairly important	Very Important	Important	Fairly important	Important	Very Important	Slighly Important	Fairly important	Important
Expert 1	(8, 10, 10)	(6, 8, 10)	(8, 10, 10)	(4, 6, 8)	(4, 6, 8)	(8, 10, 10)	(6, 8, 10)	(4, 6, 8)	(4, 6, 8)	(8, 10, 10)
Expert 2	(8, 10, 10)	(6, 8, 10)	(8, 10, 10)	(2, 4, 6)	(6, 8, 10)	(6, 8, 10)	(6, 8, 10)	(4, 6, 8)	(4, 6, 8)	(8, 10, 10)
Expert 3	(8, 10, 10)	(4, 6, 8)	(8, 10, 10)	(6, 8, 10)	(4, 6, 8)	(6, 8, 10)	(8, 10, 10)	(2, 4, 6)	(4, 6, 8)	(6, 8, 10)
Average Expert evauation	(8,10,10)	(5.33, 7.33, 9.33)	(8, 10, 10)	(4, 6, 8)	(4.67, 6.67,8.67)	(6.67, 8.67, 10)	(6.67, 8.67, 10)	(3.33, 5.33, 7.33)	(4, 6, 8)	(7.33,9.33,10)
Triangular Fuzzy Crisp Formula	(l+4m+u) / 6									
Defuzzificated Crisp Value	9.67	7.33	9.67	6.00	6.67	8.56	8.56	5.33	6.00	9.11

Table 4.40 : Extended linguistic scale for additional indicators evaluations

	l	m	h
Outstanding	9	9	10
Very Good	8	8	9
Good	6	6	7
Mediocre	5	5	6
Poor	4	4	5
Very Poor	2	2	3
Disaster	0	0	1

Table 4.41 : Additional indicators - expert evaluation defuzzied crisp values

Additional indicators expert evaluation defuzzied crisp values

Stock Ticker	Stock Ticker Name	Management Competence and Experience	Utilization of IPO Funds	Price Stability Commitments	Premarket Valuation Approach	Business and Growth Strategy
SOKE	Söke Değirmencilik San. ve Tic. A.Ş.	5.83	6.50	6.17	5.50	6.83
TNZTP	Tapdi Oksijen Özel Sağlık ve Eğitim Hizmetleri San. Tic. A.Ş.	8.17	6.83	6.17	6.83	7.50
ASTOR	Astor Enerji A.Ş.	8.17	8.17	4.83	6.83	8.17
MACKO	Maçkolik İnternet Hizmetleri Tic. A.Ş.	5.50	4.17	5.83	5.83	5.50
BVSAN	Bülbüloğlu Vinç San. ve Tic. A.Ş.	6.17	7.50	6.17	5.50	5.83
GOKNR	Göknur Gıda Maddeleri Enerji İmalat İthalat İhracat Tic. ve San. A.Ş.	4.83	4.50	5.17	5.17	4.83
AKFYE	Akfen Yenilenebilir Enerji A.Ş.	6.17	2.17	5.83	5.17	5.50
EKSUN	Eksun Gıda Tarım San. ve Tic. A.Ş.	5.50	5.83	6.17	4.83	5.83
KOPOL	Koza Polyester San. ve Tic. A.Ş.	5.83	5.17	5.50	5.17	7.50
CVKMD	Cvk Maden İşletmeleri San. ve Tic. A.Ş.	7.50	7.50	4.83	5.83	7.50
EUPWR	Europower Enerji ve Otomasyon Teknolojileri San. Tic. A.Ş.	8.17	9.17	5.17	6.17	6.17
GRTRK	Grainturk Tarım A.Ş.	5.17	5.17	4.83	5.83	4.83
CWENE	Cw Enerji Mühendislik Tic. ve San. A.Ş.	6.83	6.17	5.50	5.83	5.83
BIGCH	(BigChefs) Büyük Şefler Gıda Turizm Tekstil Danışmanlık Organizasyon Eğitim San. ve Tic. A.Ş.	5.83	4.17	4.17	5.50	5.17
KAYSE	Kayseri Şeker Fabrikası A.Ş.	6.17	4.17	5.17	5.50	4.17
BIENY	Bien Yapı Ürünleri San. Turizm ve Tic. A.Ş.	4.17	5.17	5.17	4.17	4.50
PASEU	Pasifik Eurasia Lojistik Dış Ticaret A.Ş.	6.17	6.83	6.17	5.83	5.83
A1CAP	A1 Capital Yatırım Menkul Değerler A.Ş.	4.50	4.17	4.17	5.17	4.17
FORTE	Forte Bilgi İletişim Teknolojileri ve Savunma Sanayi A.Ş.	8.17	2.17	8.17	6.17	6.17
ATAKP	Atakey Patates Gıda San. ve Tic. A.Ş.	4.50	5.17	5.17	5.17	4.17
FZLGY	Fuzul Gayrimenkul Yatırım Ortaklığı A.Ş.	4.17	1.50	5.17	4.17	4.17
KLSER	Kaleseramik, Çanakkale Kalebodur Seramik Sanayi A.Ş.	7.50	7.50	5.17	6.17	6.17
ASGYO	Asce Gayrimenkul Yatırım Ortaklığı A.Ş.	4.17	1.50	5.17	4.17	4.17
IZENR	İzdemir Enerji Elektrik Üretim A.Ş.	5.83	5.17	5.17	4.83	5.50
OFSYM	Ofis Yem Gıda San. Tic. A.Ş.	5.83	5.17	5.17	5.17	5.17
TATEN	Tatlıpınar Enerji Üretim A.Ş.	5.50	4.83	4.17	5.17	5.50
ENERY	Enerya Enerji A.Ş.	5.50	4.17	5.17	5.17	4.50
BYDNR	Baydöner Restoranları A.Ş.	5.17	5.17	5.17	4.17	4.50
KZGYO	Kuzugrup Gayrimenkul Yatırım Ortaklığı A.Ş.	4.17	2.83	5.17	4.83	3.50
EBEBK	Ebebek Mağazacılık A.Ş	4.50	4.17	5.17	4.17	3.50
TARKM	Tarkim Bitki Koruma San. ve Tic. A.Ş.	8.50	8.17	4.17	5.50	8.50
GIPTA	Gıpta Ofis Kırtasiye ve Promosyon Ürünleri İmalat San. A.Ş.	4.50	4.17	4.83	4.83	4.17
REEDR	Reeder Teknoloji San. ve Tic. A.Ş.	5.50	5.17	8.83	3.50	4.17
HATSN	Hat-San Gemi İnşaa Bakım Onarım Deniz Nakliyat San. ve Tic. A.Ş.	6.83	7.50	4.83	6.17	7.50
ADGYO	Adra Gayrimenkul Yatırım Ortaklığı A.Ş.	5.83	5.50	5.17	4.83	4.17
DMRGD	Dmr Unlu Mamuller Üretim Gıda Toptan Perakende İhracat A.Ş.	4.50	4.83	4.17	4.83	4.50
MEKAG	Meka Beton Santralleri İmalat San. ve Tic. A.Ş.	6.17	5.83	5.17	5.50	6.83
DOFER	Dofer Yapı Malzemeleri San. ve Tic. A.Ş.	5.83	6.17	5.17	5.17	6.17
BORLS	Borlease Otomotiv A.Ş.	5.50	2.83	5.17	4.83	2.83
MHRGY	Mhr Gayrimenkul Yatırım Ortaklığı A.Ş.	5.83	5.17	5.17	5.50	5.50
VRGYO	Vera Konsept Gayrimenkul Yatırım Ortaklığı A.Ş.	6.17	6.17	5.17	5.17	5.50
TABGD	Tab Gıda San. ve Tic. A.Ş.	6.17	5.17	5.17	5.17	5.17
	Global Max	**8.50**	**9.17**	**8.83**	**6.83**	**8.50**

4.3.7 Final scoring and list

The methodology detailed at section 4.2.8 has been applied.

Final Score of Stock = $\sum_{n=1}^{10} RP(\text{KPI}_n)$ * Relative weight of KPI_n

$\text{RP}(\text{KPI}_n)$ represents relative point of KPI with number n.

A compiled list of calculated final scores is created for each (KPIn)j for 2023 BIST IPOs. An illustrative calculation for the stock ticker SOKE, representing Soke Degirmencilik, is provided in Table 4.42.

Table 4.43 presents the ultimate scores for all 42 stocks in a ranked sequence, reflecting their long-term competitive strength and significant potential for high valuation over time. Elevated scores indicate a higher valuation potential for the respective IPOs.

4.3.8 Actual vs. framework performance comparison

As part of the validation process, the ranking of research results underwent testing using Spearman's Rank Correlation Test. This test is advantageous for assessing relationships without the need for normality and measures monotonic relationships, making it an ideal fit for evaluating research outcomes. The actual performance of stocks following their initial public offerings, based on Borsa Istanbul day-end prices as of October 27, 2023, is presented in Table 13, with IPOs ranked according to the percentage increase from the IPO price to the October 27, 2023 price. The comparison of these two rankings using Spearman's rho resulted in a value of 0.67, indicating a high positive monotonic relationship.

4.3.9 Robustness test with genetic algorithm

Genetic algorithms have diverse applications, spanning optimization problem-solving to robotics, drawing inspiration from the principles of natural selection. To comprehend the fundamental aspects of a genetic algorithm, it is essential to focus on the core elements akin to the building blocks of life—chromosomes. Chromosomes, consisting of adenine, cytosine, thymine, and guanine, serve as the basic units of DNA. Figure 4.6 illustrates how the population of nucleotides undergoes mutations in response to various factors like feeding habits, cultural exposures, and body activity rates.

Table 4.42 : SOKE final scoring process as a representation

Year	Constant Competitive Advantage Indicators	Indicator value	Normalized Indicator value	Relative Points	Defuzzification
2020	Gross Profit Margin	13.7%	23%	0.15	0.65
2021	Gross Profit Margin	11.7%	20%	0.13	0.66
2022	Gross Profit Margin	15.9%	27%	0.20	0.75
	Global max	**59%**		**0.15**	
	Global min				
2020	Cash Flow from Investments / Net Sales	-0.4%	96%	0.53	0.55
2021	Cash Flow from Investments / Net Sales	-0.2%	96%	0.53	0.55
2022	Cash Flow from Investments / Net Sales	-2.4%	94%	0.56	0.60
	Global max	**4%**		**0.53**	
	Global min				
2020	Cash Flow from Operations / Total Liabilities	2.3%	3%	0.03	0.84
2021	Cash Flow from Operations / Total Liabilities	-5.0%	-7%	-0.05	0.83
2022	Cash Flow from Operations / Total Liabilities	33.4%	44%	0.39	0.90
	Global max	76.0%		**0.03**	
	Global min				
2020	Net Working Capital /Net Sales	2.3%	3%	0.01	0.43
2021	Net Working Capital /Net Sales	2.7%	3%	0.01	0.43
2022	Net Working Capital /Net Sales	14.6%	17%	0.08	0.49
	Global max	84.2%		**0.01**	
	Global min				
2020	Total Liability / Shareholder Equity	213.7%	52%	0.22	0.43
2021	Total Liability / Shareholder Equity	153.4%	84%	0.37	0.43
2022	Total Liability / Shareholder Equity	64.2%	68%	0.34	0.50
	Mix-Max Interval	374.2%		**0.34**	
	Median	124.2%			
	Management Competence and Experience	5.83	69%	**0.57**	0.43
	Global max	8.50			
	Global min				
	Utilization of IPO Funds	6.50	71%	**0.53**	0.75
	Global max	9.17			
	Global min				
	Price Stability Commitments	6.17	70%	**0.34**	0.48
	Global max	8.83			
	Global min				
	Pre-IPO Valuation Approach	5.50	80%	**0.47**	0.58
	Global max	6.83			
	Global min				
	Business and Growth Strategy	6.83	80%	**0.64**	0.79
	Global max	8.50			
	Global min				
				SOKE	27.69

Table 4.43 : Long-term competitive strength of Borsa Istanbul 2023 IPOs

Stock ticker	Stock	IPO Date	Valuation potential	#Rank
TNZTP	Tapdi Oksijen Özel Sağlık ve Eğitim Hizmetleri San. Tic. A.Ş.	11 January 2023	38.67	1
MACKO	Maçkolik İnternet Hizmetleri Tic. A.Ş.	26 January 2023	38.43	2
ADGYO	Adra Gayrimenkul Yatırım Ortaklığı A.Ş.	20 September 2023	34.64	3
ASTOR	Astor Enerji A.Ş.	18 January 2023	33.62	4
EUPWR	Europower Enerji ve Otomasyon Teknolojileri San. Tic. A.Ş.	20 April 2023	33.51	5
TARKM	Tarkim Bitki Koruma San. ve Tic. A.Ş.	12 September 2023	33.23	6
CVKMD	Cvk Maden İşletmeleri San. ve Tic. A.Ş.	13 April 2023	32.35	7
BYDNR	Baydöner Restoranları A.Ş.	21 August 2023	30.66	8
MHRGY	Mhr Gayrimenkul Yatırım Ortaklığı A.Ş.	18 October 2023	30.49	9
CWENE	Cw Enerji Mühendislik Tic. ve San. A.Ş.	05 May 2023	30.13	10
KLSER	Kaleseramik, Çanakkale Kalebodur Seramik Sanayi A.Ş.	27 July 2023	30.07	11
AKFYE	Akfen Yenilenebilir Enerji A.Ş.	16 March 2023	28.25	12
MEKAG	Meka Beton Santralleri İmalat San. ve Tic. A.Ş.	12 October 2023	28.04	13
FORTE	Forte Bilgi İletişim Teknolojileri ve Savunma Sanayi A.Ş.	14 June 2023	27.98	14
KOPOL	Koza Polyester San. ve Tic. A.Ş.	13 April 2023	27.87	15
SOKE	Söke Değirmencilik San. ve Tic. A.Ş.	12 January 2023	27.69	16
BVSAN	Bülbüloğlu Vinç San. ve Tic. A.Ş.	06 February 2023	27.35	17
BIGCH	(BigChefs) Büyük Şefler Gıda Turizm Tekstil Danışmanlık Organizasyon Eğitim San.	10 May 2023	26.89	18
GIPTA	Gıpta Ofis Kırtasiye ve Promosyon Ürünleri İmalat San. A.Ş.	14 September 2023	26.52	19
HATSN	Hat-San Gemi İnşaa Bakım Onarım Deniz Nakliyat San. ve Tic. A.Ş.	22 September 2023	26.20	20
DOFER	Dofer Yapı Malzemeleri San. ve Tic. A.Ş.	16 October 2023	25.99	21
PASEU	Pasifik Eurasia Lojistik Dış Ticaret A.Ş.	14 June 2023	25.87	22
KAYSE	Kayseri Şeker Fabrikası A.Ş.	18 May 2023	25.70	23
DMRGD	Dmr Unlu Mamuller Üretim Gıda Toptan Perakende İhracat A.Ş.	29 September 2023	25.04	24
GOKNR	Göknur Gıda Maddeleri Enerji İmalat İthalat İhracat Tic. ve San. A.Ş.	09 March 2023	24.90	25
BIENY	Bien Yapı Ürünleri San. Turizm ve Tic. A.Ş.	18 May 2023	24.82	26
ASGYO	Asce Gayrimenkul Yatırım Ortaklığı A.Ş.	03 August 2023	24.10	27
TATEN	Tatlıpınar Enerji Üretim A.Ş.	17 August 2023	23.60	28
TABGD	Tab Gıda San. ve Tic. A.Ş.	26 October 2023	23.47	29
FZLGY	Fuzul Gayrimenkul Yatırım Ortaklığı A.Ş.	28 July 2023	23.21	30
REEDR	Reeder Teknoloji San. ve Tic. A.Ş.	21 September 2023	22.29	31
IZENR	İzdemir Enerji Elektrik Üretim A.Ş.	16 August 2023	21.91	32
ATAKP	Atakey Patates Gıda San. ve Tic. A.Ş.	27 July 2023	21.79	33
EBEBK	Ebebek Mağazacılık A.Ş	07 September 2023	21.73	34
GRTRK	Graınturk Tarım A.Ş.	26 April 2023	21.51	35
EKSUN	Eksun Gıda Tarım San. ve Tic. A.Ş.	24 March 2023	21.09	36
ENERY	Enerya Enerji A.Ş.	23 August 2023	20.70	37
OFSYM	Ofis Yem Gıda San. Tic. A.Ş.	16 August 2023	20.29	38
BORLS	Borlease Otomotiv A.Ş.	19 October 2023	19.29	39
A1CAP	A1 Capital Yatırım Menkul Değerler A.Ş.	15 June 2023	18.75	40
KZGYO	Kuzugrup Gayrimenkul Yatırım Ortaklığı A.Ş.	29 August 2023	12.32	41
VRGYO	Vera Konsept Gayrimenkul Yatırım Ortaklığı A.Ş.	27 October 2023	7.71	42

During the creation of new individuals, nucleotides experience a crossover between male sperm and female ovum, leading to the formation of genotypes. Chromosomes play a pivotal role in determining an individual's characteristics and shaping its phenotype. Each phenotype possesses distinct competences and specifications crucial for survival. A fitness score is established based on these specifications to measure the survival ability. Subsequently, these fitness scores are transformed into probabilities that influence the specifications of the next generation (MIT, 2014). This iterative process continues for each successive generation.

Within the genetic algorithm framework, the fundamental concept revolves around generating the optimal phenotype by pairing individuals with the highest fitness scores with the most diverse ones, as depicted on the left side of Figure 4.7. This approach aligns with the belief that a blend of diverse genomes often results in aesthetically pleasing and intelligent individuals in the public perception. Additionally, we have devised a framework illustrated on the right side of Figure 4.7. The x-axis, representing the fitness score of phenotypes, indicates the set of abilities for survival or, in other words, the best genetic specifications (Feng et al., 2024). Accordingly, we have constructed a composite dimension incorporating financial indicators—gross profit margin, cash flow from investments/net sales, cash flow from operations/total liabilities, net working capital/net sales, total liability/shareholder equity—serving as a proxy for the financial health performance of an IPO. These key performance indicators (KPIs) directly reflect the current state of the financial health of the IPO.

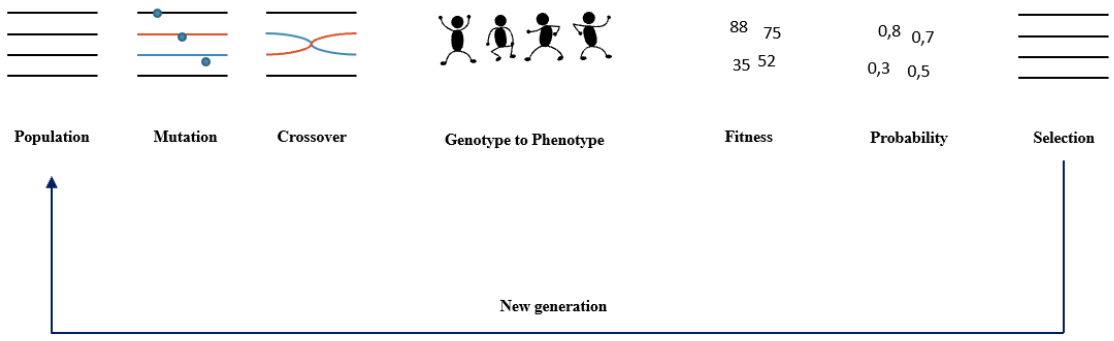

Figure 4.6: Fundamental of genetic algorithm

The variability depicted on the y-axis signifies the range of genetic specifications, serving as an inherent potential for future success and generation production. In this context, the excellence of the IPO and its future outlook can substitute diversity, encompassing factors such as management competence and experience, the strategic utilization of IPO funds, commitments to price stability, pre-IPO valuation approach, and business and growth strategy. Analogous to how genetic diversity contributes to the formation of a superior individual, the quality of the IPO and its future prospects reflects the intrinsic potential of the company, contributing to an increase in valuation during the post-IPO phase.

Dynamic alterations in the IPO's potential within the 'Quality of IPO and future prospects' dimension and its financial performance post-IPO are facilitated by mutation and crossover in the algorithm. This parameter spectrum ranges between [0,1], allowing for adaptability to changes in the model's environment. We constrain this value to 0.1, permitting only minor adjustments in an uncertain future environment. However, iterations over 0.5 and 0.9 will be considered, with no alterations accepted, given a well-defined fitness function based directly on the euclidean distance.

The curves illustrated in Figure 4.7 represent indifference curves, where all points on the curve share an equivalent level of goodness. The highest points on the x and y axes denote the maximum score for financial health and the quality of IPO and future prospects, respectively.

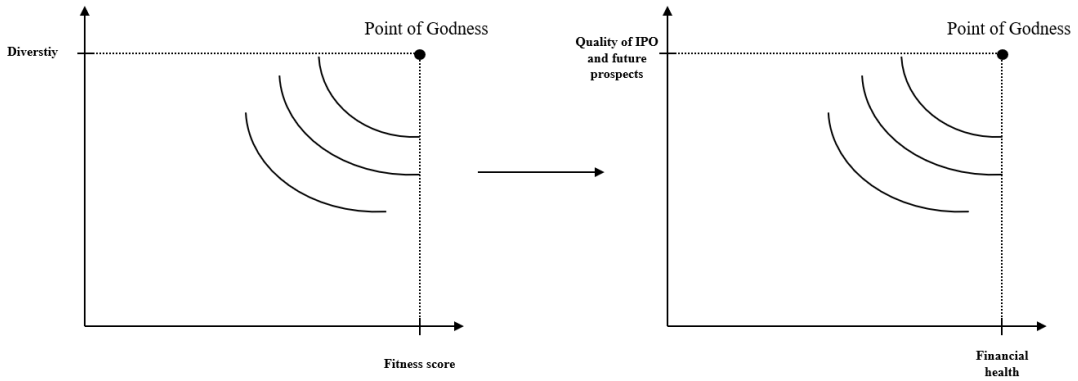

Figure 4.7: Genetic algorithm ranked space method framework

The computations for financial health and the dimension of the quality of IPO and future prospects are outlined below, and these calculations will be implemented for each stock ticker to ensure comprehensive analysis and evaluation.

Financial health = $\sum_{n=1}^{5} RP(I_n)$ * Relative weight of I_n where RP(In) represents relative point of indicator with number n. (4.13)

Quality of IPO and future prospect= $\sum_{n=6}^{10} RP(I_n)$ * Relative weight of I_n where RP(In) represents relative point of indicator with number n. (4.14)

Table 4.44 presents the conclusive scores for the dimensions of financial health and the quality of IPO and future prospects, corresponding to the 42 IPOs and their respective stock tickers. The analysis utilized the R package with GA and readxl libraries. The maximum points along the axes were determined by identifying the highest dimension scores among the 42 stocks. The fitness function was formulated based on the euclidean distance from the point of goodness, situated at the intersection of the maximum points on the axes.

The optimization process, facilitated by the genetic algorithm and based on L-BFGS-B (limited-memory Broyden-Fletcher-Goldfarb-Shanno) with bound constraints, was employed. This specific approach was chosen for its applicability to smooth objective functions and constraints.

Table 4.45 displays the outcomes derived from the genetic algorithm, considering various mutation and crossover parameters. As expected, the rankings exhibit consistency regardless of different parameter configurations. This stability can be ascribed to the stringent distance formulation and the range of scores within the dimensions of financial health and the quality of IPO and future prospects.

A Spearman correlation test was executed on the rankings obtained through the Triangular Spherical Fuzzy Set method and the Genetic Algorithm Rank Space method, as outlined in Table 4.46. The subsequent results, presented in Table 4.47, reveal an 89% correlation, affirming a robust monotonic relationship between these two ranking methodologies.

Table 4.44 : Dimension scores for GA algorithm

Stock ticker	Quality of IPO and future prospects	Financial health	Stock ticker	Quality of IPO and future prospects	Financial health
SOKE	19.76	7.92	KLSER	21.33	8.74
TNZTP	23.18	15.49	ASGYO	11.66	12.44
ASTOR	24.29	9.33	IZENR	17.07	4.84
MACKO	16.80	21.63	OFSYM	16.96	3.33
BVSAN	19.89	7.46	TATEN	16.44	7.15
GOKNR	15.38	9.52	ENERY	15.42	5.28
AKFYE	15.62	12.64	BYDNR	15.33	15.33
EKSUN	17.83	3.26	KZGYO	12.37	-0.05
KOPOL	19.03	8.83	EBEBK	13.23	8.49
CVKMD	22.19	10.16	TARKM	23.97	9.26
EUPWR	23.05	10.46	GIPTA	14.04	12.48
GRTRK	16.37	5.14	REEDR	16.05	6.24
CWENE	19.49	10.64	HATSN	21.81	4.39
BIGCH	16.14	10.74	ADGYO	16.18	18.46
KAYSE	15.86	9.84	DMRGD	14.60	10.45
BIENY	14.50	10.31	MEKAG	19.28	8.75
PASEU	19.60	6.27	DOFER	18.51	7.49
A1CAP	14.02	4.73	BORLS	12.91	6.38
FORTE	19.03	8.95	MHRGY	17.41	13.08
ATAKP	15.01	6.78	VRGYO	18.22	-10.51
FZLGY	11.66	11.55	TABGD	17.24	6.24

Table 4.45 : GA algorithm -ranked space method result

Stock ticker	Rank	Stock ticker	Rank
MACKO	1	KOPOL	22
ADGYO	2	GOKNR	23
TNZTP	3	SOKE	24
BYDNR	4	BVSAN	25
MHRGY	5	DOFER	26
EUPWR	6	EBEBK	27
ASTOR	7	PASEU	28
AKFYE	8	TATEN	29
TARKM	9	HATSN	30
CVKMD	10	TABGD	31
GIPTA	11	ATAKP	32
ASGYO	12	REEDR	33
CWENE	13	BORLS	34
FZLGY	14	GRTRK	35
BIGCH	15	IZENR	36
KLSER	16	ENERY	37
DMRGD	17	A1CAP	38
BIENY	18	EKSUN	39
FORTE	19	OFSYM	40
KAYSE	20	KZGYO	41
MEKAG	21	VRGYO	42

for mutation 0.1 and crossover 0.1

Stock ticker	Rank	Stock ticker	Rank
MACKO	1	KOPOL	22
ADGYO	2	GOKNR	23
TNZTP	3	SOKE	24
BYDNR	4	BVSAN	25
MHRGY	5	DOFER	26
EUPWR	6	EBEBK	27
ASTOR	7	PASEU	28
AKFYE	8	TATEN	29
TARKM	9	HATSN	30
CVKMD	10	TABGD	31
GIPTA	11	ATAKP	32
ASGYO	12	REEDR	33
CWENE	13	BORLS	34
FZLGY	14	GRTRK	35
BIGCH	15	IZENR	36
KLSER	16	ENERY	37
DMRGD	17	A1CAP	38
BIENY	18	EKSUN	39
FORTE	19	OFSYM	40
KAYSE	20	KZGYO	41
MEKAG	21	VRGYO	42

for mutation 0.5 and crossover 0.5

Stock ticker	Rank	Stock ticker	Rank
MACKO	1	KOPOL	22
ADGYO	2	GOKNR	23
TNZTP	3	SOKE	24
BYDNR	4	BVSAN	25
MHRGY	5	DOFER	26
EUPWR	6	EBEBK	27
ASTOR	7	PASEU	28
AKFYE	8	TATEN	29
TARKM	9	HATSN	30
CVKMD	10	TABGD	31
GIPTA	11	ATAKP	32
ASGYO	12	REEDR	33
CWENE	13	BORLS	34
FZLGY	14	GRTRK	35
BIGCH	15	IZENR	36
KLSER	16	ENERY	37
DMRGD	17	A1CAP	38
BIENY	18	EKSUN	39
FORTE	19	OFSYM	40
KAYSE	20	KZGYO	41
MEKAG	21	VRGYO	42

for mutation 0.9 and crossover 0.9

Table 4.47 : Correlation test of rankings

Coefficient(rs)	0.891
N	42
T statistic	12.441
DF	40
p value	0.0000000000002%

Table 4.46 : Ranking comparison

Stock ticker	Triangular spherical fuzzy set ranking	GA algorithm-ranked space method
SOKE	16	24
TNZTP	1	3
ASTOR	4	7
MACKO	2	1
BVSAN	17	25
GOKNR	25	23
AKFYE	12	8
EKSUN	36	39
KOPOL	15	22
CVKMD	7	10
EUPWR	5	6
GRTRK	35	35
CWENE	10	13
BIGCH	18	15
KAYSE	23	20
BIENY	26	18
PASEU	22	28
A1CAP	40	38
FORTE	14	19
ATAKP	33	32
FZLGY	30	14
KLSER	11	16
ASGYO	27	12
IZENR	32	36
OFSYM	38	40
TATEN	28	29
ENERY	37	37
BYDNR	8	4
KZGYO	41	41
EBEBK	34	27
TARKM	6	9
GIPTA	19	11
REEDR	31	33
HATSN	20	30
ADGYO	3	2
DMRGD	24	17
MEKAG	13	21
DOFER	21	26
BORLS	39	34
MHRGY	9	5
VRGYO	42	42
TABGD	29	31

4.4 Long Term Competitive Power of BIST 30 Companies

BIST 30 specifically refers to the Borsa Istanbul 30 index, comprising the largest 30 companies based on their company value, compared to the BIST 100 index with an actual floating share value of 1,540,832,967,896.64 Turkish Liras as of January 12, 2024 (Url-2). Additionally, twenty-one of these companies are part of the BIST Sustainability Index, and nine are included in the BIST Governance Index at Table 4.48. These indices encompass long-term competitive power and corporate governance indicators, which are utilized as supplementary factors for assessing long-term competitive strength in this extension (Url-3). These indicators include perspectives such as shareholder viewpoint, transparency and public relations, stakeholders' perspective, board of directors, and business and growth strategy. The financial indicators have been evaluated over 2020-2022 financial statement as last three years. Financial institutions with stock ticker AKBNK, GARAN, ISCTR and YKBNK has been exluded due to balance sheet incompitability.

Table 4.48 : BIST 30 index companies relative index ownership

#	Ticker	Company Name	BIST Sustainability Index	BIST Corporate Govarnance Index
1	AKBNK	AKBANK T.A.Ş.	YES	
2	AKSEN	AKSA ENERJİ ÜRETİM A.Ş.	YES	YES
3	ALARK	ALARKO HOLDİNG A.Ş.		YES
4	ARCLK	ARÇELİK A.Ş.	YES	YES
5	ASELS	ASELSAN ELEKTRONİK SANAYİ VE TİCARET A.Ş.	YES	YES
6	BIMAS	BİM BİRLEŞİK MAĞAZALAR A.Ş.	YES	
7	EKGYO	EMLAK KONUT GAYRİMENKUL YATIRIM ORTAKLIĞI A.Ş.		
8	ENKAI	ENKA İNŞAAT VE SANAYİ A.Ş.	YES	YES
9	EREGL	EREĞLİ DEMİR VE ÇELİK FABRİKALARI T.A.Ş.	YES	YES
10	FROTO	FORD OTOMOTİV SANAYİ A.Ş.	YES	
11	GUBRF	GÜBRE FABRİKALARI T.A.Ş.		
12	SAHOL	HACI ÖMER SABANCI HOLDİNG A.Ş.	YES	
13	HEKTS	HEKTAŞ TİCARET T.A.Ş.		
14	KRDMD	KARDEMİR KARABÜK DEMİR ÇELİK SANAYİ VE TİCARET A.Ş.	YES	
15	KCHOL	KOÇ HOLDİNG A.Ş.	YES	
16	KOZAL	KOZA ALTIN İŞLETMELERİ A.Ş.		
17	KOZAA	KOZA ANADOLU METAL MADENCİLİK İŞLETMELERİ A.Ş.		
18	ODAS	ODAŞ ELEKTRİK ÜRETİM SANAYİ TİCARET A.Ş.		
19	PGSUS	PEGASUS HAVA TAŞIMACILIĞI A.Ş.	YES	YES
20	PETKM	PETKİM PETROKİMYA HOLDİNG A.Ş.		
21	SASA	SASA POLYESTER SANAYİ A.Ş.		
22	TAVHL	TAV HAVALİMANLARI HOLDİNG A.Ş.	YES	
23	TOASO	TOFAŞ TÜRK OTOMOBİL FABRİKASI A.Ş.	YES	
24	TCELL	TURKCELL İLETİŞİM HİZMETLERİ A.Ş.	YES	
25	TUPRS	TÜPRAŞ-TÜRKİYE PETROL RAFİNERİLERİ A.Ş.	YES	
26	THYAO	TÜRK HAVA YOLLARI A.O.	YES	
27	GARAN	TÜRKİYE GARANTİ BANKASI A.Ş.	YES	YES
28	ISCTR	TÜRKİYE İŞ BANKASI A.Ş.	YES	
29	SISE	TÜRKİYE ŞİŞE VE CAM FABRİKALARI A.Ş.	YES	YES
30	YKBNK	YAPI VE KREDİ BANKASI A.Ş.	YES	
		30	21	9

4.4.1 Expert selection

Taking into consideration of finance, trading, practical experience on company valuation and fuzzy logic knowledge, three experts have been chosen as Table 4.28.

4.4.2 Indicators selection for BIST 30 companies

Six additional indicators have been incorporated alongside the generic 5 KPIs for the BIST 30 index. This decision is driven by the recognition that companies within the BIST 30 index, characterized by relatively high share values, adhere to robust corporate governance and sustainability practices. As a result, four of these indicators encompass various dimensions of corporate governance: shareholder perspective, transparency and public relations, stakeholders' perspective, and board of directors. Business and growth strategy has been incrementally introduced to evaluate the organization's capabilities in strategic planning and execution, long-term vision, and alignment with goals, as well as market expansion and diversification strategies.

The final indicator is the market/book value, serving as an initial price indicator for companies, providing insights into their undervalued or overvalued conditions relative to industry averages. Except the 5 generic KPIs and market/book value, other additional corporate indicators evaluation basis is given at Table 4.49.

4.4.3 Initial expert assessment and validation

The methodology detailed at section 4.2.4 has been applied. There is no available any discrepancy within litmus test. Expert assessment and litmus test results are given at Table 4.50, Table 4.51 respectively.

4.4.4 Expert’ s view weighting & aggregation & defuzzification process

The methodology detailed at section 4.2.5 has been applied. Expert weights are the same with previous section given in Table 4.52. The resultant aggregated values are detailed in Table 4.53.

Table 4.52 : Expert weights for BIST 30 indicator evaluation

Expert	Expert Weights
Expert 1	40%
Expert 2	30%
Expert 3	30%
Sum of Total	**100%**

4.4.5 Relative importance evaluation of indicators

The methodology detailed at section 4.2.6 has been applied. The experts furnished their evaluations utilizing a five-scale linguistic scale at Table 4.8. Subsequently, these linguistic assessments underwent defuzzification using a triangular linguistic scale provided in Table 4.53. The ultimate crisp weight scores for the KPIs were then computed, portraying their respective importance levels, as depicted in Table 4.54.

Table 4.49 : Corporate indicators evaluation criterias

Shareholder perspective	Transparency and Public Relations	Stakeholders' Perpective
Shareholder Rights and Equitable Treatment	Communication Strategies and Stakeholder Engagement	Stakeholder Engagement and Collaboration
Dividend Policies and Shareholder Returns	Disclosure Policies and Reporting Practices	Corporate Social Responsibility (CSR) Initiatives
Transparency in Financial Reporting to Shareholders	Investor Relations and Shareholder Communications	Ethical Practices and Stakeholder Rights
Governance Structure and Board Accountability	Ethics and Integrity in Public Communications	Supply Chain and Vendor Relationships
Voting Rights and Proxy Access	Crisis Management and Reputation Building	Employee Relations and Workplace Culture
Shareholder Activism and Engagement	Community Engagement and Social Responsibility	Environmental Sustainability and Impact
Conflict Resolution and Dispute Handling with Shareholders	Media Relations and Public Perception Management	Community Development and Contributions

Board of Directors	Business and Growth Strategy
Board Composition and Diversity	Strategic Planning and Execution
Leadership Structure and Independence	Long-Term Vision and Goals Alignment
Governance Oversight and Risk Management	Market Expansion and Diversification Strategies
Committees and Their Responsibilities	Innovation and Research & Development Focus
Director Qualifications and Expertise	Acquisitions and Partnerships for Growth
Board Evaluation and Performance Assessment	Performance Measurement and KPIs
Decision-Making Processes and Transparency	Risk Management in Growth Initiatives

Table 4.50 : Expert assessments for BIST 30 indicators

		Expert 1									Expert 2									Expert 3								
		μ			ν			π			μ			ν			π			μ			ν			π		
Year	Competitive Advantage KPIs	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h
2020	Gross Profit Margin	0.79	0.92	0.94	0.07	0.09	0.11	0.13	0.15	0.17	0.80	0.83	0.94	0.03	0.06	0.09	0.22	0.25	0.28	0.65	0.75	0.85	0.08	0.10	0.12	0.20	0.30	0.40
2021	Gross Profit Margin	0.80	0.93	0.95	0.08	0.10	0.12	0.13	0.15	0.17	0.80	0.83	0.95	0.03	0.06	0.09	0.22	0.25	0.28	0.65	0.75	0.85	0.08	0.10	0.12	0.20	0.30	0.40
2022	Gross Profit Margin	0.83	0.96	0.98	0.05	0.07	0.09	0.13	0.15	0.17	0.83	0.87	0.90	0.01	0.03	0.05	0.13	0.15	0.17	0.75	0.80	0.90	0.02	0.05	0.07	0.10	0.20	0.30
2020	Cash Flow from Operations / Total Liabilities	0.80	0.81	0.83	0.07	0.08	0.10	0.06	0.08	0.10	0.67	0.70	0.81	0.15	0.19	0.23	0.12	0.14	0.16	0.62	0.65	0.76	0.15	0.22	0.27	0.13	0.17	0.20
2021	Cash Flow from Operations / Total Liabilities	0.80	0.81	0.83	0.07	0.08	0.10	0.06	0.08	0.10	0.67	0.70	0.82	0.15	0.19	0.23	0.12	0.14	0.16	0.62	0.65	0.77	0.16	0.23	0.28	0.13	0.17	0.20
2022	Cash Flow from Operations / Total Liabilities	0.83	0.84	0.85	0.07	0.07	0.08	0.04	0.04	0.06	0.70	0.74	0.77	0.13	0.18	0.22	0.10	0.10	0.12	0.65	0.69	0.72	0.13	0.20	0.28	0.11	0.15	0.21
2020	Cash Flow from Operations / Total Liabilities	0.95	0.96	0.98	0.01	0.03	0.04	0.03	0.05	0.07	0.87	0.93	0.96	0.03	0.04	0.06	0.05	0.07	0.14	0.72	0.77	0.82	0.06	0.11	0.18	0.05	0.08	0.14
2021	Cash Flow from Operations / Total Liabilities	0.95	0.96	0.98	0.01	0.03	0.06	0.03	0.05	0.07	0.87	0.94	0.96	0.03	0.04	0.06	0.05	0.07	0.14	0.69	0.76	0.82	0.06	0.12	0.18	0.05	0.09	0.14
2022	Cash Flow from Operations / Total Liabilities	0.98	0.98	0.99	0.01	0.02	0.03	0.01	0.01	0.03	0.90	0.95	0.97	0.02	0.03	0.04	0.03	0.03	0.07	0.75	0.83	0.88	0.09	0.15	0.18	0.02	0.06	0.10
2020	Net Working Capital /Net Sales	0.80	0.81	0.83	0.16	0.17	0.19	0.23	0.25	0.27	0.69	0.72	0.83	0.13	0.20	0.27	0.25	0.32	0.39	0.64	0.71	0.78	0.19	0.26	0.32	0.13	0.19	0.27
2021	Net Working Capital /Net Sales	0.80	0.81	0.83	0.16	0.17	0.19	0.23	0.25	0.27	0.69	0.72	0.84	0.13	0.20	0.27	0.25	0.32	0.39	0.66	0.72	0.79	0.20	0.28	0.33	0.12	0.18	0.25
2022	Net Working Capital /Net Sales	0.83	0.84	0.85	0.16	0.16	0.17	0.21	0.21	0.23	0.72	0.76	0.79	0.14	0.19	0.29	0.26	0.31	0.41	0.70	0.76	0.82	0.18	0.24	0.26	0.05	0.12	0.16
2020	Total Liability / Shareholder Equity	0.64	0.71	0.75	0.21	0.27	0.33	0.13	0.15	0.17	0.59	0.62	0.73	0.24	0.32	0.41	0.17	0.19	0.21	0.73	0.80	0.86	0.06	0.12	0.15	0.07	0.12	0.16
2021	Total Liability / Shareholder Equity	0.64	0.71	0.75	0.21	0.27	0.34	0.13	0.15	0.17	0.59	0.62	0.74	0.24	0.30	0.41	0.17	0.19	0.21	0.72	0.82	0.86	0.06	0.11	0.15	0.07	0.13	0.16
2022	Total Liability / Shareholder Equity	0.70	0.74	0.80	0.20	0.26	0.35	0.11	0.11	0.13	0.62	0.66	0.69	0.23	0.29	0.38	0.15	0.15	0.17	0.73	0.82	0.88	0.03	0.09	0.12	0.05	0.10	0.13
-	Market Value / Book Value	0.95	0.96	0.99	0.01	0.02	0.03	0.01	0.02	0.03	0.93	0.95	0.94	0.01	0.03	0.05	0.01	0.02	0.03	0.98	0.98	0.99	0.01	0.01	0.01	0.01	0.02	0.03
-	Shareholder perspective	0.78	0.83	0.87	0.02	0.03	0.04	0.01	0.02	0.03	0.74	0.80	0.82	0.03	0.05	0.07	0.02	0.04	0.06	0.75	0.80	0.85	0.03	0.06	0.09	0.01	0.02	0.03
-	Transparency and Public Relations	0.83	0.88	0.92	0.04	0.08	0.09	0.01	0.02	0.03	0.79	0.85	0.87	0.05	0.07	0.10	0.02	0.04	0.06	0.74	0.79	0.80	0.05	0.08	0.10	0.05	0.07	0.09
-	Stakeholders' Perspective	0.65	0.72	0.75	0.10	0.15	0.20	0.06	0.10	0.14	0.60	0.65	0.70	0.06	0.10	0.14	0.05	0.10	0.15	0.56	0.62	0.66	0.12	0.16	0.19	0.07	0.10	0.13
-	Board of Directors	0.86	0.91	0.95	0.02	0.03	0.04	0.01	0.02	0.03	0.82	0.88	0.90	0.03	0.05	0.07	0.02	0.04	0.06	0.80	0.85	0.90	0.03	0.06	0.09	0.01	0.02	0.03
-	Business and Growth Strategy	0.86	0.91	0.95	0.02	0.03	0.04	0.01	0.02	0.03	0.82	0.88	0.90	0.03	0.05	0.07	0.02	0.04	0.06	0.80	0.85	0.90	0.03	0.06	0.09	0.01	0.02	0.03

Table 4.51 : Expert assessments litmus test for BIST 30 indicators

Year	Competitive Advantage Indicators	Expert 1			Expert 2			Expert 3		
		1	2	3	1	2	3	1	2	3
2020	Gross Profit Margin	0.65	0.88	0.92	0.69	0.76	0.97	0.47	0.66	0.90
2021	Gross Profit Margin	0.66	0.90	0.95	0.69	0.76	0.99	0.47	0.66	0.90
2022	Gross Profit Margin	0.71	0.95	1.00	0.71	0.78	0.84	0.57	0.68	0.90
2020	Cash Flow from Operations / Total Liabilities	0.65	0.67	0.71	0.49	0.55	0.73	0.42	0.50	0.69
2021	Cash Flow from Operations / Total Liabilities	0.65	0.67	0.71	0.49	0.55	0.75	0.43	0.50	0.71
2022	Cash Flow from Operations / Total Liabilities	0.69	0.71	0.73	0.52	0.59	0.66	0.45	0.54	0.64
2020	Cash Flow from Operations / Total Liabilities	0.90	0.93	0.97	0.76	0.87	0.94	0.52	0.61	0.72
2021	Cash Flow from Operations / Total Liabilities	0.90	0.93	0.97	0.76	0.89	0.94	0.48	0.60	0.72
2022	Cash Flow from Operations / Total Liabilities	0.96	0.96	0.98	0.81	0.90	0.95	0.57	0.72	0.82
2020	Net Working Capital /Net Sales	0.72	0.75	0.80	0.56	0.66	0.91	0.46	0.61	0.78
2021	Net Working Capital /Net Sales	0.72	0.75	0.80	0.56	0.66	0.93	0.49	0.63	0.80
2022	Net Working Capital /Net Sales	0.75	0.78	0.80	0.61	0.71	0.88	0.52	0.65	0.77
2020	Total Liability / Shareholder Equity	0.47	0.60	0.70	0.43	0.52	0.75	0.54	0.67	0.79
2021	Total Liability / Shareholder Equity	0.47	0.60	0.71	0.43	0.51	0.76	0.53	0.70	0.79
2022	Total Liability / Shareholder Equity	0.54	0.63	0.78	0.46	0.54	0.65	0.54	0.69	0.81
-	Market Value / Book Value	0.90	0.92	0.98	0.87	0.90	0.89	0.96	0.96	0.98
-	Shareholder perspective	0.61	0.69	0.76	0.55	0.64	0.68	0.56	0.64	0.73
-	Transparency and Public Relations	0.69	0.78	0.86	0.63	0.73	0.77	0.55	0.64	0.66
-	Stakeholders' Perspective	0.44	0.55	0.62	0.37	0.44	0.53	0.33	0.42	0.49
-	Board of Directors	0.74	0.83	0.91	0.67	0.78	0.82	0.64	0.73	0.82
-	Business and Growth Strategy	0.74	0.83	0.91	0.67	0.78	0.82	0.64	0.73	0.82
								Check	**0.997**	**TRUE**

Table 4.53 : Aggregated and defuzzified expert evaluations for BIST 30

			Aggregated Expert Evaluations									Expert 1									Expert 2									Expert 3								
			μ			v			π			μ			v			π			μ			v			π			μ			v			π		
Year	Competitive Advantage Indicators	Defuzzification	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h	l	m	h
2020	Gross Profit Margin	0.65	0.76	0.86	0.92	0.06	0.08	0.11	0.18	0.22	0.28	0.68	0.47	0.42	0.35	0.38	0.41	0.66	0.44	0.38	0.74	0.70	0.52	0.35	0.43	0.49	0.70	0.66	0.37	0.85	0.78	0.68	0.47	0.50	0.53	0.83	0.73	0.53
2021	Gross Profit Margin	0.66	0.76	0.87	0.93	0.06	0.09	0.11	0.18	0.22	0.28	0.66	0.45	0.39	0.36	0.40	0.43	0.65	0.42	0.34	0.74	0.70	0.50	0.35	0.43	0.49	0.70	0.66	0.31	0.85	0.78	0.68	0.47	0.50	0.53	0.83	0.73	0.53
2022	Gross Profit Margin	0.75	0.81	0.91	0.95	0.02	0.05	0.07	0.12	0.18	0.23	0.63	0.36	0.27	0.30	0.35	0.38	0.61	0.32	0.16	0.70	0.65	0.61	0.25	0.35	0.41	0.69	0.64	0.58	0.78	0.74	0.61	0.31	0.41	0.45	0.77	0.71	0.50
2020	Cash Flow from Investments / Net Sales	0.55	0.72	0.74	0.81	0.11	0.14	0.17	0.10	0.12	0.15	0.66	0.65	0.63	0.35	0.36	0.40	0.66	0.65	0.62	0.84	0.82	0.73	0.57	0.61	0.64	0.83	0.81	0.71	0.86	0.85	0.77	0.57	0.63	0.68	0.86	0.84	0.75
2021	Cash Flow from Investments / Net Sales	0.55	0.72	0.74	0.81	0.11	0.14	0.17	0.10	0.12	0.15	0.66	0.65	0.63	0.35	0.36	0.40	0.66	0.65	0.62	0.84	0.82	0.72	0.57	0.61	0.64	0.83	0.81	0.70	0.86	0.85	0.76	0.58	0.64	0.68	0.86	0.84	0.74
2022	Cash Flow from Investments / Net Sales	0.60	0.75	0.78	0.80	0.10	0.13	0.16	0.08	0.09	0.13	0.63	0.61	0.60	0.34	0.35	0.36	0.63	0.61	0.60	0.82	0.79	0.76	0.54	0.60	0.63	0.81	0.78	0.76	0.85	0.82	0.80	0.54	0.62	0.68	0.84	0.81	0.78
2020	Cash Flow from Operations / Total Liabilitie	0.84	0.89	0.92	0.95	0.02	0.05	0.07	0.04	0.07	0.12	0.39	0.36	0.27	0.16	0.25	0.28	0.39	0.36	0.26	0.65	0.55	0.47	0.35	0.38	0.43	0.65	0.54	0.43	0.80	0.76	0.72	0.43	0.52	0.60	0.80	0.76	0.70
2021	Cash Flow from Operations / Total Liabilitie	0.83	0.89	0.92	0.95	0.02	0.05	0.08	0.04	0.07	0.12	0.39	0.36	0.27	0.16	0.25	0.32	0.39	0.36	0.26	0.65	0.52	0.47	0.35	0.38	0.43	0.65	0.52	0.43	0.82	0.77	0.72	0.43	0.53	0.60	0.82	0.77	0.70
2022	Cash Flow from Operations / Total Liabilitie	0.90	0.93	0.95	0.97	0.02	0.04	0.06	0.01	0.03	0.06	0.27	0.27	0.21	0.12	0.21	0.25	0.27	0.27	0.20	0.61	0.50	0.43	0.31	0.35	0.38	0.61	0.50	0.42	0.78	0.70	0.64	0.49	0.57	0.60	0.78	0.70	0.63
2020	Net Working Capital /Net Sales	0.43	0.73	0.76	0.82	0.16	0.20	0.25	0.22	0.26	0.32	0.66	0.65	0.63	0.48	0.49	0.51	0.62	0.60	0.56	0.82	0.80	0.70	0.54	0.62	0.68	0.79	0.75	0.58	0.85	0.81	0.75	0.61	0.67	0.71	0.85	0.79	0.71
2021	Net Working Capital /Net Sales	0.43	0.73	0.76	0.82	0.16	0.21	0.25	0.22	0.26	0.32	0.66	0.65	0.63	0.48	0.49	0.51	0.62	0.60	0.56	0.82	0.80	0.69	0.54	0.62	0.68	0.79	0.75	0.56	0.84	0.80	0.75	0.62	0.68	0.72	0.84	0.79	0.71
2022	Net Working Capital /Net Sales	0.49	0.77	0.80	0.82	0.16	0.19	0.23	0.20	0.23	0.28	0.63	0.61	0.60	0.47	0.48	0.49	0.59	0.57	0.55	0.80	0.77	0.75	0.55	0.61	0.69	0.77	0.71	0.62	0.82	0.77	0.72	0.60	0.65	0.67	0.82	0.76	0.70
2020	Total Liability / Shareholder Equity	0.43	0.66	0.72	0.79	0.15	0.22	0.28	0.13	0.15	0.18	0.81	0.76	0.72	0.54	0.59	0.64	0.80	0.74	0.70	0.88	0.86	0.80	0.65	0.71	0.77	0.87	0.85	0.77	0.79	0.74	0.67	0.43	0.53	0.57	0.79	0.73	0.65
2021	Total Liability / Shareholder Equity	0.43	0.65	0.73	0.79	0.15	0.21	0.28	0.13	0.15	0.18	0.81	0.76	0.72	0.54	0.59	0.65	0.80	0.74	0.70	0.88	0.86	0.79	0.65	0.70	0.77	0.87	0.85	0.76	0.80	0.72	0.67	0.43	0.52	0.57	0.80	0.70	0.65
2022	Total Liability / Shareholder Equity	0.50	0.69	0.75	0.81	0.12	0.19	0.26	0.10	0.12	0.14	0.76	0.73	0.66	0.53	0.58	0.66	0.76	0.72	0.65	0.86	0.84	0.82	0.64	0.69	0.75	0.86	0.83	0.81	0.80	0.72	0.64	0.35	0.48	0.53	0.79	0.71	0.62
-	Market Value / Book Value	0.94	0.96	0.97	0.98	0.01	0.02	0.03	0.01	0.02	0.03	0.39	0.36	0.21	0.16	0.21	0.25	0.39	0.36	0.20	0.55	0.50	0.52	0.25	0.35	0.41	0.55	0.50	0.52	0.38	0.38	0.31	0.25	0.25	0.25	0.38	0.38	0.30
-	Shareholder perspective	0.75	0.76	0.81	0.85	0.03	0.04	0.06	0.01	0.03	0.04	0.69	0.63	0.57	0.21	0.25	0.28	0.69	0.63	0.57	0.79	0.74	0.72	0.35	0.41	0.45	0.79	0.74	0.71	0.78	0.74	0.68	0.35	0.43	0.49	0.78	0.74	0.68
-	Transparency and Public Relations	0.75	0.79	0.85	0.88	0.05	0.08	0.09	0.03	0.04	0.06	0.63	0.55	0.47	0.28	0.36	0.38	0.63	0.55	0.47	0.75	0.68	0.65	0.41	0.45	0.50	0.75	0.68	0.65	0.79	0.75	0.74	0.41	0.47	0.50	0.79	0.74	0.73
-	Stakeholders' Perspective	0.48	0.61	0.67	0.71	0.09	0.14	0.18	0.06	0.10	0.14	0.80	0.75	0.72	0.40	0.47	0.53	0.80	0.74	0.71	0.87	0.85	0.82	0.43	0.50	0.55	0.87	0.84	0.81	0.89	0.86	0.84	0.53	0.58	0.61	0.89	0.86	0.83
-	Board of Directors	0.82	0.83	0.89	0.92	0.03	0.04	0.06	0.01	0.03	0.04	0.58	0.49	0.39	0.21	0.25	0.28	0.58	0.49	0.39	0.72	0.64	0.61	0.35	0.41	0.45	0.72	0.64	0.60	0.74	0.68	0.61	0.35	0.43	0.49	0.74	0.68	0.61
-	Business and Growth Strategy	0.82	0.83	0.89	0.92	0.03	0.04	0.06	0.01	0.03	0.04	0.58	0.49	0.39	0.21	0.25	0.28	0.58	0.49	0.39	0.72	0.64	0.61	0.35	0.41	0.45	0.72	0.64	0.60	0.74	0.68	0.61	0.35	0.43	0.49	0.74	0.68	0.61

Table 4.54 : Linguistic evaluation of indicators for BIST 30

	Expert 1	Expert 2	Expert 3
Gross Profit Margin	Important	Important	Important
Cash Flow from Investments / Net Sales	Fairly important	Fairly important	Important
Cash Flow from Operations / Total Liabilities	Important	Important	Important
Net Working Capital /Net Sales	Slighly Important	Slighly Important	Fairly important
Total Liability / Shareholder Equity	Fairly important	Slighly Important	Slighly Important
Market Value / Book Value	Very Important	Very Important	Very Important
Shareholder perspective	Fairly important	Important	Important
Transparency and Public Relations	Important	Important	Fairly important
Stakeholders' Perpective	Fairly important	Fairly important	Slighly Important
Board of Directors	Important	Important	Important
Business and Growth Strategy	Very Important	Very Important	Important

4.4.6 Normalization of indicators and relative point scoring

For the normalization of first 5 KPIs, already transitioned from BIST 100 scope in the first research area, and market/book ratio have been applied in the same way detailed at section 4.2.7. For Additional indicators corporate indicators do not have any rigid value in the contrary of first five KPIs. Evaluations for these indicators are applied within more detailed linguistic variables given at Table 4.56. Later, Crips values at Table 4.57 are derived and regular max-min normalization has been applied, explained in previous scope.

Table 4.55 : Crips scores of indicators' weights for BIST 30

	Gross Profit Margin	Cash Flow from Investments / Net Sales	Cash Flow from Operations / Total Liabilities	Net Working Capital /Net Sales	Total Liability / Shareholder Equity	Market Value / Book Value	Shareholder perspect Transparency and Public	Stakeholders' Perpective		Board of Directors	Business and Growth Strategy
Expert 1	Important	Fairly important	Important	Slighly Important	Fairly important	Very Important	Fairly important	Important	Fairly important	Important	Very Important
Expert 2	Important	Fairly important	Important	Slighly Important	Slighly Important	Very Important	Important	Important	Fairly important	Important	Very Important
Expert 3	Important	Important	Important	Fairly important	Slighly Important	Very Important	Important	Fairly important	Slighly Important	Important	Important
Expert 1	(6, 8, 10)	(4, 6, 8)	(6, 8, 10)	(2, 4, 6)	(4, 6, 8)	(8, 10, 10)	(4, 6, 8)	(6, 8, 10)	(4, 6, 8)	(6, 8, 10)	(8, 10, 10)
Expert 2	(6, 8, 10)	(4, 6, 8)	(6, 8, 10)	(2, 4, 6)	(2, 4, 6)	(8, 10, 10)	(6, 8, 10)	(6, 8, 10)	(4, 6, 8)	(6, 8, 10)	(8, 10, 10)
Expert 3	(6, 8, 10)	(6, 8, 10)	(6, 8, 10)	(4, 6, 8)	(2, 4, 6)	(8, 10, 10)	(6, 8, 10)	(4, 6, 8)	(2, 4, 6)	(6, 8, 10)	(8, 8, 10)
Average Expert evauation	(6,8,10)	(4.67, 6.67, 8.67)	(6, 8, 10)	(2.67, 4.67, 6.67)	(2.67, 4.67, 6.67)	(8, 10, 10)	(5.33, 7.33, 9.33)	(5.33, 7.33, 9.33)	(3.33, 5.33, 7.33)	(6, 8, 10)	(7.33,9.33,10)
Triangular Fuzzy Crisp Formula	(l+4m+u) / 6										
Defuzzificated Crisp Value	8.00	6.67	8.00	4.67	4.67	9.67	7.33	7.33	5.33	8.00	9.11

Table 4.56 : Extended linguistic scale for additional indicators evaluations

	l	m	h
Outstanding	9	9	10
Very Good	8	8	9
Good	6	6	7
Mediocre	5	5	6
Poor	4	4	5
Very Poor	2	2	3
Disaster	0	0	1

Table 4.57 : Additional indicators - expert evaluation defuzzied crisp values

Stock Ticker	Stock Ticker Name	Shareholder perspectve	Transparency and Public Relations	Stakeholders' Perpective	Board of Directors	Business and Growth Strategy
AKSEN	AKSA ENERJİ ÜRETİM A.Ş.	4.83	4.17	5.17	6.17	4.83
ALARK	ALARKO HOLDİNG A.Ş.	6.83	5.83	6.17	6.83	5.50
ARCLK	ARÇELİK A.Ş.	6.83	6.17	6.17	7.83	7.50
ASELS	ASELSAN ELEKTRONİK SANAYİ VE TİCARET A.Ş.	6.17	5.17	6.17	6.83	7.50
BIMAS	BİM BİRLEŞİK MAĞAZALAR A.Ş.	8.83	8.17	8.17	7.83	8.83
EKGYO	EMLAK KONUT GAYRİMENKUL YATIRIM ORTAKI	5.17	5.17	4.50	4.17	4.17
ENKAI	ENKA İNŞAAT VE SANAYİ A.Ş.	5.17	5.17	5.17	6.17	3.83
EREGL	EREĞLİ DEMİR VE ÇELİK FABRİKALARI T.A.Ş.	6.17	6.17	6.17	6.83	7.50
FROTO	FORD OTOMOTİV SANAYİ A.Ş.	9.17	5.83	5.50	7.83	8.50
GUBRF	GÜBRE FABRİKALARI T.A.Ş.	6.83	5.83	6.17	6.83	9.17
SAHOL	HACI ÖMER SABANCI HOLDİNG A.Ş.	8.50	6.83	6.83	7.83	8.17
HEKTS	HEKTAŞ TİCARET T.A.Ş.	8.17	4.17	5.17	6.17	6.83
KRDMD	KARDEMİR KARABÜK DEMİR ÇELİK SANAYİ VE Tİ	8.17	5.17	8.17	2.83	4.83
KCHOL	KOÇ HOLDİNG A.Ş.	9.17	5.50	4.50	8.17	8.83
KOZAL	KOZA ALTIN İŞLETMELERİ A.Ş.	4.17	4.17	5.17	5.83	5.17
KOZAA	KOZA ANADOLU METAL MADENCİLİK İŞLETMELİ	4.17	4.17	5.17	5.83	5.17
ODAS	ODAŞ ELEKTRİK ÜRETİM SANAYİ TİCARET A.Ş.	5.50	4.83	5.17	5.83	7.50
PGSUS	PEGASUS HAVA TAŞIMACILIĞI A.Ş.	8.50	4.50	6.83	7.83	8.50
PETKM	PETKİM PETROKİMYA HOLDİNG A.Ş.	7.50	5.17	5.50	5.17	4.50
SASA	SASA POLYESTER SANAYİ A.Ş.	7.50	8.17	6.17	6.17	8.17
TAVHL	TAV HAVALİMANLARI HOLDİNG A.Ş.	7.50	6.17	5.50	6.83	5.83
TOASO	TOFAŞ TÜRK OTOMOBİL FABRİKASI A.Ş.	8.50	6.17	5.83	7.83	6.17
TCELL	TURKCELL İLETİŞİM HİZMETLERİ A.Ş.	6.17	6.17	7.50	5.17	6.17
TUPRS	TÜPRAŞ-TÜRKİYE PETROL RAFİNERİLERİ A.Ş.	8.83	8.17	8.50	7.83	8.83
THYAO	TÜRK HAVA YOLLARI A.O.	8.50	6.83	8.17	5.17	9.17
SISE	TÜRKİYE ŞİŞE VE CAM FABRİKALARI A.Ş.	7.50	5.83	6.83	7.50	8.17
	Global Max	**9.17**	**8.17**	**8.50**	**8.17**	**9.17**

4.4.7 Final scoring and list

The methodology detailed at section 4.2.8 has been applied.

Final Score of Stock = $\sum_{n=1}^{11} RP(\text{KPI}_n)$ * Relative weight of KPI_n

$\text{RP}(\text{KPI}_n)$ represents relative point of KPI with number n.

A compiled list of calculated final scores is created for each (KPIn)j for BIST 30 companies.

Table 4.58 presents the ultimate scores for all 26 stocks in a ranked sequence, reflecting their long-term competitive strength and significant potential for high valuation over time. Elevated scores indicate a higher valuation potential for the respective BIST 30 index companies.

Table 4.58 : Long-term competitive strength of BIST 30

Stock ticker	Stock	Final Score	#Ranking
KOZAA	KOZA ANADOLU METAL MADENCİLİK İŞLETMELER	43.19	1
TUPRS	TÜPRAŞ-TÜRKİYE PETROL RAFİNERİLERİ A.Ş.	42.84	2
SISE	TÜRKİYE ŞİŞE VE CAM FABRİKALARI A.Ş.	42.60	3
EREGL	EREĞLİ DEMİR VE ÇELİK FABRİKALARI T.A.Ş.	41.42	4
THYAO	TÜRK HAVA YOLLARI A.O.	39.97	5
ODAS	ODAŞ ELEKTRİK ÜRETİM SANAYİ TİCARET A.Ş.	39.81	6
ARCLK	ARÇELİK A.Ş.	39.64	7
KCHOL	KOÇ HOLDİNG A.Ş.	39.58	8
ASELS	ASELSAN ELEKTRONİK SANAYİ VE TİCARET A.Ş.	38.80	9
SAHOL	HACI ÖMER SABANCI HOLDİNG A.Ş.	38.19	10
ALARK	ALARKO HOLDİNG A.Ş.	37.80	11
TAVHL	TAV HAVALİMANLARI HOLDİNG A.Ş.	36.79	12
PGSUS	PEGASUS HAVA TAŞIMACILIĞI A.Ş.	36.28	13
ENKAI	ENKA İNŞAAT VE SANAYİ A.Ş.	35.39	14
BIMAS	BİM BİRLEŞİK MAĞAZALAR A.Ş.	34.72	15
FROTO	FORD OTOMOTİV SANAYİ A.Ş.	33.66	16
AKSEN	AKSA ENERJİ ÜRETİM A.Ş.	32.21	17
TOASO	TOFAŞ TÜRK OTOMOBİL FABRİKASI A.Ş.	28.75	18
KOZAL	KOZA ALTIN İŞLETMELERİ A.Ş.	28.43	19
SASA	SASA POLYESTER SANAYİ A.Ş.	26.64	20
TCELL	TURKCELL İLETİŞİM HİZMETLERİ A.Ş.	26.39	21
PETKM	PETKİM PETROKİMYA HOLDİNG A.Ş.	25.68	22
KRDMD	KARDEMİR KARABÜK DEMİR ÇELİK SANAYİ VE TİC.	25.34	23
EKGYO	EMLAK KONUT GAYRİMENKUL YATIRIM ORTAKLIĞ	22.10	24
GUBRF	GÜBRE FABRİKALARI T.A.Ş.	20.41	25
HEKTS	HEKTAŞ TİCARET T.A.Ş.	16.97	26

5. FINDINGS

5.1 Long Term Competitive Power of BIST 100 Companies

The findings presented in Table 4.28 underscore the machine learning model's preference for lasso regression as the most effective method in linear setting from the aspect of MSE. Vice versa, Ridge regression r-square values are higher than lasso. Upon a detailed examination of the lasso regression models and their predictor coefficients, it is evident that the intercept for all clusters is positive. This implies a positive expectation for returns from Borsa Istanbul 100 index companies, regardless of their long-term competitive power-oriented clusters.

The positive contributions to stock returns for all clusters are observed in the gross profit margin, market-to-book value, and Turkey's industrial production index. Conversely, total liability/shareholder equity has a consistently negative impact on stock returns across all clusters, aligning with expectations.

Surprisingly, both lasso and ridge regression models show a negative effect of copper price increases on stock returns across all clusters. This contradicts the initial anticipation based on the extensive use of copper in various industries during periods of heightened economic activity.

Furthermore, the relationship between cash flow from operations/total liabilities and stock returns displays a negative correlation for three clusters: red ocean, blue ocean, and extra clear blue ocean companies. Contrary to expectations, this predictor exhibits low negative values, suggesting a nuanced role within the model.

It is noteworthy that the industrial production index of Turkey is consistent across all clusters, supported by a 95% confidence level GAMs. In the linear settn, it is specifically applied to the Extra Clear Blue Ocean cluster, while in the models for the remaining three clusters, it is integrated in a nonlinear form. Industrial production index of Turkiye is

common for all clusters with 95 confidence level, in linear form for extra clear blue ocean, non linear form for residual three cluster' s model.

An in-depth analysis of cluster centers, utilizing the ward method and euclidean distance in Table 4.23, reveals significant separations in gross profit margin and cash flow from operations/total liabilities. However, indicators such as cash flow from investment/net sales and total liability/shareholder equity show minimal separation effects.

The final clusters can be described as follows:

Bloody Red Ocean Company (24 out of 70): Firms devoid of enduring competitive strengths, functioning in intensely competitive markets, characterized by meager profit margins, substantial working capital needs, and considerable capital investments, consequently resulting in restricted dividend distributions.

Red Ocean Company (27 out of 70): Businesses lacking sustained competitive advantages, functioning in markets of moderate competitiveness, marked by diminished profit margins, elevated working capital requirements, and substantial capital investments, thereby constraining their capacity to dispense dividends.

Blue Ocean Company (12 out of 70): Enterprises possessing enduring competitive strengths, operating in non-competing markets, experiencing elevated profit margins, minimal working capital demands, and nominal capital investments. They have the ability to utilize cash flows for consistent dividend disbursements.

Extra Clear Blue Ocean Company (7 out of 70): Companies listed on BIST 100 for the past five successive years, showcasing a significant degree of enduring competitive edge in markets where there is little competition. They exhibit remarkably elevated profit margins, minimal working capital requirements, and possess the capacity to issue substantial dividends derived from operational activities..

5.2 Long Term Competitive Power of 2023 Borsa Istanbul IPOs

The Spearman's Rank Correlation Test presented in Table 5.1 establishes the research findings as a highly reliable predictor for the long-term performance of IPOs, with a confidence level of 99.9%. This reliability is evident even over a period of less than one

year, considering that the IPO dates are distributed across various months, making the duration even shorter.

Table 5.1 : Spearman's rank correlation test

Spearman's Rank Correlation Test	
Coefficient(rs)	0.670
N	42
T statistic	5.709
DF	40
p value	0.0001%

Experts have pinpointed the gross profit margin, cash flow from operations/total liabilities, and business and growth strategy are critical in determining the long-term competitive advantage that propels significant potential price increases in the stock market. Analyzing the real shifts in stock prices in the post-IPO phase shows that the industry itself doesn't directly signify the performance of an IPO. Instead, it is indirectly manifested through proxies like elevated gross profit margins, favorable operating cash flow, and diminishing liabilities.

Genetic algorithm approves the robustness of methodology and resulted with very similar ranking for valuation potential of 2023 IPOs. It revealed that 89% correlation, affirming a robust monotonic relationship between these two ranking methodologies

5.3 Long Term Competitive Power of BIST 30 Companies

Experts have identified business and growth strategy, market-to-book value, gross profit margin, cash flow from operations/total liabilities, and the board of directors as pivotal indicators in determining the long-term competitive advantage that fuels significant potential price increases in the stock market. The research indicates that the sector is not a direct indicator of the long term competitivce power of BIST30 companies. Instead, it is reflected indirectly through indicators such as higher gross profit margins, positive operating cash flow, and decreasing liabilities acting as proxies.

Within the companies listed in the BIST 30 index, four company affiliated with the Koc Group attract the attention, with three of them holding positions within the top eight in

terms of the highest points. This accomplishment serves as evidence not only of their commitment to corporate governance principles but also of their stable finance execution. Among the top 10 ranked companies, all except Turkish Airlines belong to the production sector. This observation suggests a potential division between production and service companies, hinting at block availability effect that may favor production-oriented enterprises over service-based ones. Hektas, ranked as the lowest-scored company in the research, seems to validate widespread market view by appearing overvalued. Another noteworthy stock, Kardemir, holds a lower score and displays a wide dispersion of shares among various investors, to the extent that a 5% shareholder holds a board seat. This situation implies that a struggle for board seat.

6. CONCLUSION

This article explores the crucial query of what sets certain businesses apart and renders them more valuable than others over an extended period. To tackle this inquiry, an innovative methodology incorporating Triangular Spherical Fuzzy Sets was employed to scrutinize the financial records of BIST 100 firms spanning the last five years. Distinct microeconomic key performance indicators (KPIs) were chosen to assess the enduring competitive advantage of these enterprises, encompassing metrics like gross profit margin, cash flow from investments to net sales, cash flow from operations to total liabilities, net working capital to net sales, and total liability to shareholder equity. A panel of experts participated in the study, evaluating the significance of these KPIs throughout the five-year timeframe, enabling a nuanced comprehension of their importance. Expert assessments were amalgamated and clarified to derive precise values for each KPI. To further enhance the analysis, the significance of each KPI was appraised by ultimate experts via linguistic evaluation, furnishing a well-rounded perspective on the importance of these indicators. The comprehensive findings of this study categorized the 70 BIST 100 companies into four distinct groups of competitive prowess: Bloody Red Ocean Company, Red Ocean Company, Blue Ocean Company, and Extra Clear Blue Ocean Company. The validation process involved intuitionistic fuzzy sets, as well as both hierarchical and non-hierarchical clustering methodologies, ultimately favoring the hierarchical clustering approach—utilizing the ward method and euclidean distance—due to its theoretical alignment with the dataset. These classifications provide valuable insights into the competitive strengths and market standings of the respective firms. In the concluding phase, machine learning algorithms, specifically lasso and ridge regression, partial least square alongside generalized additive models, were employed to formulate models for the four distinct clusters. The direction and potency of relationships were scrutinized, and the observed outcomes were matched against the anticipated results.

The constructed framework, extending to the 2023 BIST IPOs, showcases the application of fuzzy logic in evaluating IPO valuation potential, unveiling insights into their prospects for sustained growth. This prolonged study presents a distinctive outlook on the long-term valuation potential of IPOs for investors, stakeholders, and analysts, guiding them to make informed decisions in the dynamic financial landscape. It underscores the importance of pre-IPO financial and corporate indicators as determinants of post-IPO long-term performance for investors. In contrast to the prevalent emphasis on short-term analysis by analysts, this framework proves effective in assessing actual performance within the initial year post-IPO, challenging conventional notions. Furthermore, it emphasizes the significance of corporate indicators such as management competence, business growth, and strategy in reinforcing the importance of corporate governance perspectives within valuation potential for stakeholders. All these aspects highlight the importance of comprehending the long-term competitive prowess of companies in an ever-evolving market milieu.

The most recent extended research on the BIST 30 index suggests the importance of corporate governance and sustainability perspectives in establishing long-term competitive power, substantiating it with the elevated rankings of certain conglomerate companies in the list.

6.1 Further Discussion

The undeniable truth taught by the past is that the future will always surprise us. Therefore, in this study, we will be humble about the results we present and the models we obtain so that we do not expose ourselves to excessive risk based on a potentially incorrect view of the future. This is one of the most powerful tools that keeps an investor and researcher constantly vigilant.

The model has been designed after deep literature review on long term competitive power and indicators have been selected on this literature review compatible with value investing methodology. Theoretical model may be extended into different country indexes with customization of indicators according to industry and market/competition realities. Evaluating the long-term actual performance of stocks

and comparing them with the established framework constitutes another crucial aspect of the examination. The examination could be expanded to incorporate the classical portfolio theorem. As part of this process, the leverage ratio could be assessed based on industry medians. Additionally, an expert weighting process could be applied to the fuzzy process to ensure all factors are considered in fuzzy dominance calculations.

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