ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF ARTS AND SOCIAL SCIENCES

ANALYSING THE EFFECT OF COALITION ON COST STRUCTURE FOR TURKISH LIBERAL ELECTRICITY MARKET AND ALLOCATION OF PROFIT SURPLUS WITH COOPERATIVE GAME THEORY

M.A. THESIS

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İSTANBUL TEKNİK ÜNİVERSİTESİ ★ SOSYAL BİLİMLER ENSTİTÜSÜ

Türkiye Serbest Perakende Elektirik Piyasasında Koalisyonun Maliyet Yapısına Etkisi ve Oluşan Kar Fazlalığının Dağıtımının Kooperatif Oyun Kuramı Modelleri ile İncelenmesi

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Nurtaç Karaca, a M.A. student of ITU Graduate School of Arts and Social Sciences student ID 412141013, successfully defended the thesis entitled "ANALYSING THE EFFECT OF COALITION ON COST STRUCTURE FOR TURKISH LIBERAL ELECTRICITY MARKET AND ALLOCATION OF PROFIT SURPLUS WITH COOPERATIVE GAME THEORY", which he prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures

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Date of Submission : 03 May 2019
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To my family,

FOREWORD

Retail electricity market the last link of the electrical value chain is in the liberalization process in Turkey. Liberalization also brought with investments. Changes in the market and regulations put the profitability of investments in a difficult position. These evolving dynamics compel market players to develop new business strategies. However, providing value added and get high profit margins is hard in commodity trade. Electricity is a commodity and so the suppliers do not have the power to affect the quality of electricity. Competition is mostly for the price due to the nature of electricity supply. In this regard, the question of how suppliers could create added value. The first choise to solve this problem is low cost operation. In a retail electricity market where price competition is dominant, only cost-effective suppliers remain competitive by simply reflecting their savings in prices and employing a befitting pricing policy.

Within this context, instead of competing with each other, cooperating with two or more players and acting together for retail services is became applicable and meaningful for Turkish electricity retail market. In this paper, we use three well-known two-person Nash bargaining solution, Kalai Smorodinsky bargaining solution and weighted Shapley solution to analyse a sub-coalition between retailer and power plant of electricity market based on retail part. We analyse the relation in electricity rateil market as a game in value function form, which is calculated as a net profit value. The solution of each game concepts allocates to each liberal player –Power Plant, Retailer – a share from the total profit. Additionally, we compare the three solution concepts mentioned above.

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May 2019 Nurtaç KARACA
(Management Engineer)

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ABBREVIATIONS

LRT	: Last Resort Tariff
App	: Appendix
KSBS	: Kalai Smorodinsky Bargaining Solution
TU	: Transferable Utility
NTU	: Nontransferable Utility
TEK	: Turkish Elektiricity Corporation (Türkiye Elektrik Kurumu)
TEAS	: Turkish Electricity Generation and Transmission Corporation
TEDAS	: Turkish Electricity Distribution Corporation
EMA	: Electricity Market Act
EMRA	: Electricity Market Regulatory Autority
EMRT	: Electricity Market Tariff Regulation
EUAS	: Electricity Generation Corporation
BOT	: Build Operate Transfer
BOO	: Build Operate Own
TOR	: Transfer of Operating Rights
MENR	: Ministry of Energy and Natural Resources
SPM	: System Marginal Price
NGCC	: Natural Gas Combined Cycle

SYMBOLS

PM	**:** Unit Profit Margin (TL/MWh)
SP	**:** Unit Sales Price (TL/MWh)
EC	**:** Unit Energy Cost (TL/MWh)
FiT	**:** Unit Feed in Tariff Cost (TL/MWh)
IC	**:** Unit Imbalance Cost (TL/MWh)
MOF	**:** Unit Market Operating Fee (TL/MWh)
SF	**:** Unit Spread Fund (TL/MWh)
DC	**:** Unit Doubtful Cost (TL/MWh)
FC	**:** Unit Finance Cost (TL/MWh)
OPEX	**:** Unit Operational Expence (TL/MWh)

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ANALYSING THE EFFECT OF COALITION ON COST STRUCTURE FOR TURKISH LIBERAL ELECTTRICITY MARKET AND ALLOCATION OF PROFIT SURPLUS WITH COOPERATIVE GAME THEORY

SUMMARY

In this study, retail electricity supply to the high consuming customers is analyzed using cooperative game theory to find the way of sharing the extra profit that is generated via cooperation.

The physical electricity supply chain consist of producing, transmission, distribution and retail. The retail activity includes sale of electricity to end users. The retail activities are splited in two manners, the regulated and the liberal. In the liberal supply chain, consumers are eligible customers, who are entitled to select their suppliers as their consumption amount is over the electrical power amount defined by the Energy Market Regulatory Board. There are different types of market player in liberal retail electricity, as incumbent and non-incombent retail companies, electricity wholesalers, and power producers.

Players have only retail licence and sell only retail electricity directly to the end user, operates with low levels of profit margin due to high cost and competition in the market. In commodity product market, customers prefer the cheapest product. If companies do not able to reduce their costs unfortunately have to sink or loose the market share. Thus, the ability of reducing cost is crucial and vital for getting competitive advantage. Implementing efficient operational process and finding the cheaper way to reach raw materials are main alternative for companies to reduce the costs

In this study, we suggest the cooperation of the players for retail electricity market and combine theirs strength to reduce the cost. There are two party for retail electricity sales to end user, power plants and retailers respectively. Power plants have the generation asset and the retailers have sales knowhow. If they operate separately, they get some amount of profit. When they cooperate and entegrate the market vertically they generate extra profitability, but on their own they can generate no extra profit.

It can be considered easy to calculate estimated incremental profit will be realized in case of a coalition between two parties power plant and retailer for retail electricity sales. Since rationality and intelligence are two fundamental assumptions in game theory, any cooperation between players must take into account the objective of maximizing their own individual payoffs. The problem here is how to divide the surplus profit among players.

Bargaining theories in the literature address the dividing problem mentioned above and solve the question of how to divede the surplus among the participants. In this study, we investigate the analytical way of profit sharing system and make a comparison among them. We pick Nash Bargaining, Kalai Smorodinsky Bargaining and weighted Shapley among the several bargaining solution. Because they mostly match with our specific problem with two players.

Nash Bargaining solution studies the classic two person bargaining problem and maximizes the product of surplus utilities. Kalai-Smorodinsky Bargaining solution equalizes the ratios of maximal gains. While weighted Shapley defines the weights those are proportions in which players share in unanimity game.

In this study, Nash and Kalai-Smorodinsky have shared the extra payoff by the same portion. It is also demonstrated that lack of symmetries may arise naturally when players in a game represent nonequal size constituencies. The weighted Shapley associates positive and different weights with each players. If greater effort is needed on the part of player one than on the part of player two in order for the project to succeed, the proportion of profit allocated to player one should be greater also.

While the extra profitability that will arise from the cooperation will benefit these two players in the short term, it will be transferred to the final consumer by increasing the number of bilateral cooperation in the medium or long term.

TÜRKİYE SERBEST PERAKENDE ELEKTİRİK PİYASASINDA KOALİSYONUN MALİYET YAPISINA ETKİSİ VE OLUŞAN KAR FAZLALIĞININ DAĞITIMININ KOORPERATİF OYUN KURAMI MODELLERİ İLE İNCELENMESİ

ÖZET

Fiziksel elektrik tedarik zinciri; üretim, iletim, dağıtım ve perakende iş alanlarından oluşmaktadır. Üretim tarafı kullanılan kaynaklara göre; yenilenebilir hidro, rüzgâr, güneş, jeotermal enerji santralleri ve termik doğalgaz, kömür enerji santrallerinden oluşmaktadır. Üretim tarafı ayrıca sahiplik bakımından devlete ait olan santraller, özel santraller ve belli bir kontrat doğrultusunda iş yapan Yap-İşlet, Yap-İşlet-Devret santrallerinden oluşmaktadır.

Türkiye elektirik piyasasının liberalleşmesine yönelik düzenlemeler uzun yıllardır hayata geçirilmektedir. Dolayısıyla özel santrallerin toplam üretim içindeki payı özelleştirmeler ve yeni açılan santraller ile birlikte her geçen yıl artmaktadır. İletim tarafı doğal regüle monopol iş kolu olarak tanımlanabilmektedir.

Dağıtım tarafı Türkiye'de bölgelere ayrılmış olup, faaliyetler söz konusu bölgeler bazında sürdürülmektedir. Bu kapsamda Türkiye 21 farklı bölgeye ayrılmıştır. Bu bölgelerde dağıtım şirketleri elektriğin fiziksel olarak son kullanıcıya ulaşmasını sağlayan altyapı şirketleri olarak faaliyetlerini yürütmektedir. Perakende şirketler temel olarak, görevli tedarik şirketleri veya normal tedarik şirketi bazında ayrıştırılmaktadır. Görevli tedarik şirketleri 21 bölge için son kaynak tedarikçisi olarak görev yapmaktadır.

Diğer yandan perakende satış faaliyetleri elektriğin tüketicilere satılmasını ifade etmektedir. Perakendecilik faaliyetleri, düzenlenmiş ve liberal olmak üzere iki şekilde sürdürülür. Liberal tedarik zincirinde serbest tüketicilere hizmet verilmektedir. Düzenleyici otorite tarafından belirlenen tüketim miktarının üzerinde tüketime sahip ve ikili anlaşma yoluyla elektrik tedarik eden müşteriler serbest tükeci olarak nitelendirilmektedir. Serbest perakende elektrik pazarında piyasa oyuncuları, görevli tedarik şirketleri ve görevli olmayan perakende şirketleri, toptan piyasada elektrik alım satımı yapan toptancılar ve enerji üreticileridir.

Türkiye'de elektriğin son kullanıcıya satış fiyatı iki farklı yolla belirlenmektedir. İlki düzenleyici otorite tarafından çeyreklik olarak açıklanan tarifelerdir. Bu tarifeler son kaynak tedariği almak durumunda kalan serbest olmayan müşteriler içindir. Ayrıca geçtiğimiz 2018 senesinde düzenleyici otoritenin yüksek tüketimli müşteri olarak tanımladığı müşterilere PTF ve YEKDEM bedeli üzerinden belirlediği maliyet bazlı tarife yapısı ile elektriğin fiyatı belirlenmektedir. Düzenleyici otorite söz konusu yeni tarife yapısı ile piyasayı zorunlu olarak serbestleşmeye itmekte ve aynı zamanda kendi üzerindeki yükü farklı taraflara devretmektedir. Öyle ki 2017 yılının başından itibaren geçerli tarifeler ile maliyetler toplamı arasında neredeyse hiç aralık kalmamış, bu durum düzenleyici otoritenin sırtına büyük bir yük getirmiştir. Düzenleyici otorite her

sene yüksek tüketimli müşteriler için belirlenmiş tüketim limitini aşağı çekerek kendisini biraz daha rahatlatmakta ve bu şekilde serbest piyasanın önünü açmaktadır.

Perakende elektrik pazarında doğrudan nihai müşteriye sadece satış yapan oyuncular, yüksek rekabet nedeniyle düşük karlılık seviyelerine katlanmak zorundadırlar. Emtia ürün pazarında, müşteriler en ucuz ürünü tercih ederler. Maliyetlerini düşürmeyen şirketler maalesef pazar payı kaybetmek veya faaliyetlerini sonlandırma gibi sonuçlarla karşı karşıya kalmaktadır. Dolayısıyla Türkiye perakende elektirik piyasasında operasyonel mükemmellik ile maliyetlerin düşürülmesi pazarda rekabet avantajı elde etmenin kritik faktörüdür. Maliyetleri azaltmak için şirketler verimli operasyonel süreç uygulamak ve hammaddelere ulaşmanın daha ucuz yolunu bulmak gibi yöntemlere başvurmaktadır. Türkiye ve dünyadaki perakende elektrik pazarının en temel sorunu da elektriğin bir emtia oluşudur. Öyle ki oyuncular katma değer sağlayabilmek için farklı yollar aramış ve en çok tercih edilen yöntem maliyetlerin minimize edilmesi yoluyla daha fazla karlılık sağlanması olmuştur.

Bu çalışmada, yüksek tüketimli müşterilere perakende elektrik satışında, işbirliği yoluyla elde edilen fazladan karlılığı paylaşımında kooperatif oyun teorisi kullanılarak paylaşım yöntemleri incelenmiş ve farklı çözüm yöntemleri ile elde edilen sonuçlar kıyaslanarak analiz edilmiştir.

Yapılan inceleme ve analiz sonuçlarına göre, perakende elektrik pazarındaki oyuncuların işbirliği yapmaları ve bu sayede daha etkin maliyet yapısının elde edilmesi önerilmektedir. Eletrik üretim santralleri üretim tarafında sahip oldukları varlıkları sayesinde perakende şirketlere göre daha düşük fiyatlı baz enerji maliyetine sahipken, perakende şirketleri sahip oldukları yaygın satış ağı, müşteri datasını analitik işleme kabiliyeti ve satış bilgisine sahiptir. İki tarafın yetkinliklerinin bir araya gelmesi ile sağlanacak yeni yapı pozitif sonuçlar doğuracaktır. Yapılacak işbirliği sayesinde daha etkin bir maliyet yapısı elde edilecek ve ortaya fazladan karlılık çıkacaktır.

Bu çalışmada üretim tarafından özel santrallerden yerli kömür, ithal kömür ve doğalgaz üretim santralleri ayrı ayrı olacak şekilde perakende şirketi arasındaki oyun incelenmiştir. Ayrıca yüksek tüketimli müşteriler pazardaki mevcut müşteri segmentasyonu gereği üçe ayrılmıştır. Öyleki ilk grupta 50 GWh ve üzeri, ikinci grupta 10-50 GWh arası ve üçüncü grupta 1-10 GWh arası tüketime sahip müşteriler alt hedef kitleler olarak belirlenmiştir. Müşterilerin üç gruba ayrılmasının sebebi oyuncuların iş modelleri ve kurumsal stratejileri gereği farklı maliyet ve satış fiyatının ortaya çıkmasından kaynaklanmaktadır. Üç farklı üretici tipi perakende işbirliği ve üç farklı segment için incelenmiş ve toplam dokuz farklı sonuç ortaya çıkarılmıştır.

Koalisyon sayesinde elde edilebilecek kar fazlasının her bir senaryoya göre hesaplanması çalışmanın uygulama kapsamında ilk adımını oluşturmaktadır. Burada her bir koalisyonun mevcut duruma ilaveten sağlayacağı maliyet avantajları sayesinde elde edilecek kar büyüklükleri hesaplanmıştır. Söz konusu ilave kar büyüklüğü koalisyonun gerçekleşmemesi durumunda oluşmayacaktır. Sadece koalisyon ile sağlanacak bu kar büyüklüğü oyunun başında bilinmekte ve tarafların kendilerine düşen payı kabul ettikleri durumunda koasliyon sağlanabilecektir. Bu kapsamda oyuncuların rasyonel kararlar vermesi en temel ihtiyaçtır.

Elde edilen ilave kar büyüklüğünün taraflar arasında ne şekilde pay edileceği uygulama kapsamının ikinci adımını oluşturmaktadır. Pratikte şirketlerin bu tür anlaşmalarda mutabakat sağlaması oldukça zorlu süreçlerin tamamlanmasını gerektirmektedir. Öyle ki her bir taraf kendi faydasını maksimize etmeye çalışacak ve kendi için en büyük değeri elde etmeye çalışacaktır. Bu doğrultuda uygulamanın ikinci adımı, koalisyon ile ortaya çıkabilecek ilave kar büyüklüğünün oyunular arasında nasıl paylaştırılacağı sorusunu ele almaktadır. Diğer bir deyişle bu çalışmada, kar paylaşım sisteminin analitik çözümü ve farklı çözüm yöntemleri ile elde edilen sonuçların karşılaştırılması gerçekleştirilmektedir. Bu doğrultuda uygulamada kullanılan çözüm yöntemleri; iki Oyunculu Nash Pazarlığı, Kalai Smorodinsky Pazarlığı ve Ağırlıklı Shapley'dir.

Kullanılan yöntemlerden ilki Nash Pazarlık çözümüdür. Bu çözüm yöntemi koalisyon ile elde edilen fazlalık faydayı maksimuma çıkarır ve oyuncular arasında paylaştırır.

Uygulamada kullanılan ikinci yöntem Kalai-Smorodinsky Pazarlık çözümü, maksimum kazancın oyuncular arasındaki paylaştırılmasını eşit ağırlıkta yapmaktadır, diğer bir deyişle elde edilen fazlalık faydayı iki oyuncu arasında eşit dağıtmaktadır.

Son çözüm yöntemi olarak uygulanan Ağırlıklı Shapley ise belirli bir ağırlıklandırma methodu ile oyuncular arasında fazladan faydanın dağıtım esasını ele almaktadır. Bu çözüm yöntemi oyuncuların koalisyon ile elde edilen fazladan faydayı farklılaşan oranlarda dağıtabilmeyi mümkün kılmaktadır. Pratikte de söz konusu farklılaşan oranlara ihtiyaç duyulmaktadır. Öyleki herhangi bir durumun başarılı olabilmesi için gerçekleştirilen koalisyonda taraflardan birinin ya da birkaçının daha fazla katkı sağlaması gerekmesi durumunda elde edilecek fazladan faydayı da harcanan efor üzerinden dağıtılması talep edilebilmektedir. Böyle durumlarda elde edilen fazladan faydanın oyuncular arasında eşit dağıtılmasından ziyade belirlenecek kritere göre oyuncuların alacağı ağırlıkların farklılaştırılması oyunun gerçekleştirilmesini de mümkün kılan adım olabilmektedir. Nitekim fazladan efor sarfeden oyuncunun diğer oyuncular ile eşit hakka sahip olması her durumda kabul edilebilir olmayacaktır. Bu durumda koalisyon da gerçekleşemeyecektir. Ağırlıklı Shapley bu soruna çözüm getirerek oyuncuların eforlarına göre ağırlıklı olarak faydadan pay almasını sağlamaktadır.

Koalisyon ile elde edilecek fazladan faydanın oyuncular arasında paylaşımı kapsamında uygulanan üç çözüm yöntemi sonuçları kıyaslandığında; Nash ve Kalai-Smorodinsky, fazladan karlılığı oyuna giren iki oyuncu arasında aynı miktarda paylaşıtırırken, ağırlıklı Shapley oyuncuların tek başında elde etmiş oldukları karlılık oransallığında paylaşım yapmaktadır.

Karar aşamasında üç farkı çözümden hangisinin kullanılmasının gerektiği bakış açısına göre değişebilecektir. Öyle ki söz konusu fazladan karlılığın gerçekleşebilmesi iki oyuncunun da oyuna katılması durumunda geçerlidir. Eğer bir oyuncu koalisyona katılmaz ise diğer oyuncu kendi başına elde edeceği karlılığa razı gelmek durumunda kalır ve söz konusu fazladan karlılık oluşmayacaktır. Ancak oyuncuların tek başlarına elde ettikleri karlılığa baktığımızda özellikle kömür santralleri ve perakende şirketi arasındaki oyunda büyük bir uçurum olduğu görülmektedir. Bu sebeple kömür santrali fazla karlılığın eşit paylaşımını kabul etmemeyi tercih edebilecektir ve oyun gerçekleşmeyecektir ki bu durumda da bahsi geçen fazladan karlılık da gerçek olmayacaktır. Bu durumda işbirliğinin sağlanabilmesi için ağırlıklı Shapley yöntemi uygulamak gerekebilir.

Türkiye perakende elektirik piyasası kapsamında değerlendirildiğinde işbirliği ile sağlanan ekstra karlılık kısa vadede söz konusu iki oyuncuya fayda sağlarken, orta-uzun vadede piyasada ikili işbirliği sayısının artması ile fayda nihai tüketiciye aktarılabilecektir. Tüm sektörler düşünüldüğünde ise elektriğin temel maliyet kalemi olması sebebi ile tüketim ürünleri fiyat seviyesi olumlu etkilenecektir.

1. INTRODUCTION

Turkish electricity sector is one of the fastest growing market in terms of supply and demand, globally. Turkish population is among top countries, it is now more than 80 million. And Turkish production level is significant by comparison other developing countries. Furthermore it has been in the process of liberalization of the within the context of “Energy Sector Reform” since the early 1980s. Since March 2001, the Turkish Government has embarked on a long and comprehensive process to reform and liberalize its energy market in order to attract private investments, enhance competition, increase efficiency and shift the investment burden from the state to the private sector. There are huge achivements regarding this aim.

Especially in retail electricity market, companies have difficulty competing against each other. Although there are separated parties power plants, wholesalers and retailers, as every each of them eligible to obtain retailer licence from regulators. So that they are competitors for end user side. Because of compelling regulatory conditions as having limited playing field as regulation tariff is too low to compete and economic situation for Turkish citizens, it get hard for electricity companies to carry on the retail activities. There are different regions that the electiricity distribute to end user. So we can say that the cost of distribution is very high to handle by every retailers. This is why the country split into regions.

Within this context, instead of competing with each other, cooperating with two or more players and acting together for retail services is became applicable and meaningful for Turkish electricity retail market. Because there are retailers and other companies providing electricity to end user directly. This situation makes a huge number of different parties so the competition level get high and the operational efficiency get hurt. Thanks to economy of scale, excellence in operations by building a significant coalition with two or more players among retailers, whosalers and power plants, cost saving can be obtained. With the coalition every part can put the best capability they have. So that the new coalition have margin to fall the end user price level with the same profit margin levels and increase its electricity volumes.

The mentioned above situation building a coalition game is difficult to realize. As being stand alone and seeking profit, every of each party to purpose for the objective of maximizing their own individual payoffs. In other word, rationality and intelligence are two fundamental issues in such a coalition sitiation of parties from electricity retailers. The notion of coalition which is closely tied with the notion of correlated strategies, can be developed without abandoning the individual decisions. In addition, here the main question is how the total payoff is to be divided among the players. The concept of game theory and and as solution approaches cooperative and non-cooperative games allow players in a coalition to share the payoff with an agreed point of weight. Because the share principles is the main factor for a player to accept or reject the cooperation. Of course they do not believe each other if there are no applicable mathematical model regarding profit or cost saving. But with the solution concept of game theory enablep a game to come true.

1.1 Purpose of Thesis

Our purpose is to study cooperative and non-cooperative game theory concepts for rationalization of building a electricity retailer cooperative including all parties such as retailer and power plant who have retailer licence.

Within this thesis scope, we establish a framework in which the possible sub-coalitions, positive effects for profit surplus and the comparison of game theory solution concepts have been implemented.

In this paper, we use three well-known two-person Nash bargaining solution, Kalai Smorodinsky bargaining solution and weighted Shapley solution to analyse a sub-coalition between retailer and power plant of electricity market based on retail part. We model the interdependencies in electricity rateil market as a game in value function form, which is calculated as a net profit value. The solution of each game concepts allocates to each liberal player –Power Plant, Retailer – a share from the total profit. Additionally, we compare the three solution concepts mentioned above.

The rest of the article is organized as follows. Section 2 is devoted to cooperative games. In Section 3, 4 and 5 we analyse Nash bargaining, Kalai Smorodinsky and weighted Shapley value solutions respectively. Within these sections we try to summarise the framework of mentioned solution concets. Moreover, as having its special characteristics and dynamics, in Section 6 we give crucial information about Turkish electricity market structure, supply chain and each of players from different parties.

Ultimately, in section 7, we calculate maximum profit that will earn with cooperation of retailer and power Plant. Additionally within this section, we built solution models enabling profit allocation across two players for each of every concepts -two-person Nash bargaining, Kalai Smorodinsky bargaining solution, weighted Shapley value- and compare their results.

Section 8 summarizes our conclusions and the recommendations.

1.2 Literature Review

For the literature review, we mainly use game theory, cooperative and non-cooperative games, solution concept, Nash Bargaining, Shapley value, game theory implementations on energy markets keywords in order to understand the game theory solution concepts, applications and academically aproved studies regarding cooperative games.

We may say that John von Neumann and Oskar Morgenstern laid the foundations of modern game theory with a comprehensive book named Theory of Games and Economic Behavior, published in 1944. Julia (2010) claims that, Edgeworth (1881), von Neumann (1928), Cournot (1838), Bertrand (1883), and Zermelo (1913) has also key achievements however she emphasizes that these studies are lacking a uniform theory regarding strategic behavior of interactive decisions.

There are many critical social science studies solved with game theory applications, especially in the field of economics. For complicated issues mathematical approaches of game theory can be utilised according to Von Neumann and Morgenstern (1944). Hence, they ensure an abstract mathematical formulation especially for complicated situations in social science. They basically develop a comprehansive theory including the normal or extensive games, concepts of stand alone and mixed strategies, coalitional games, and etc. Apart from these achivements, they build up the utility theory itself.

The categorization of game theory concepts is a critical milestone for development of game theory. Such that, Von Neumann and Morgenstern split the theory of games into two approaches. The first approach is considered as strategic or non-cooperative game theory, and the second approach is called coalitional or cooperative game theory. Within this concept, a noncooperative game determines all rational and possible actions of each decision maker in the game. On the other hand for cooperative games, addresses the patterns of cooperation. This type of consideration is valid until this day as cooperative and non-cooperative game theory.

There have been various study regarding game theory following von Neumann and Morgenstern. Equilibrium idea, which is corresponding well-known notion Nash equilibrium is builded up by John Nash (1950, 1951). In Nash (1953), he also studies cooperative game theory. In the scope of two-person cooperative game, he uses two different solution types. The first approach contains switching cooperative game to non-cooperative game. With the second approach, axioms are used which include preferred properties and ensure an optimal solution for players. Nash (1953) makes a definition regarding the term bargaining as a situation in which cocluding the mutually beneficial agreement is optional for the parties, and there is a conflict of interests about which agreement to conclude and the agreement may not be imposed on any player without acceptance. The affermentioned two person bargaining problem has been applied in many important contexts including management labor arbitration, duopoly market games where two big rival companies work out adjustments on their production to maximize their retuns, supply chain contracts where a buyer and a supplier work out a mutually beneficial contract. We will detailed Nash Bargaining solution concept in Section 3.

Shapley (1953) makes a huge achivements in the scope of cooperative game theory. They are considered as important basis for game theory. The concept of core is established by Gillies (1959) for cooperative n-person games. Shapley (1953) develops the term of the Shapley value as an additional solution concept as well. The core can be considered as the a set of possible allocations with specific properties, which means the set of solutions. On the other hand, the Shapley value ensures a unique allocation for players. The Shapley value solution concept is described by many economists as the main solution concept to cooperative games with transferable utility. Having fully symmetric allocation is the motivation of the Shapley value. However, for some situations being non-symmetric is the main requirement itself. For those situations classical the Shapley value model does not match for players. Exactly for that requirement, the weighted Shapley value was introduced by Shapley (1953). In this solution concept, each player has a positive weight for the allocation. These weights are the share of the allocation for the players. We will define in Section 5 the notion of the weighted Shapley value.

According to Lewontin (1961), most applications were found in economics, politics, military, and first steps in evolutionary biology during the early time of game theoretical researchs. For the economic applications, according to Shubik (1962) cost accounting problems for a company can be solved with game theory. However, critical developments regarding different solution concepts has continued until now. Each of them have their pros and cons, so we cannot say that one of them is superior. This can be define within the situation and the requirements.

According to Harsanyi (1966) a cooperative game is an situation where commitments are binding and enforceable for players which means the each article of the contract is valid during the duration of contact. Here commitments can be, agreements or promises. Infact threats also can be classified as commitment for some situations. On the other hand, there is no binding commitments in non-cooperative game. Harsanyi (1966) says that any cooperative game can switch to a non-cooperative game if required. In a situation when commitments are broken, the incorporation of the commitments into the rational strategies and the penalties into the payoff matrix have required. As the afferomentioned switch makes a huge increase in the size of the payoff matrix, Harsanyi (1966) does not propose to use with non-cooperative games alone. Additionally, in Harsanyi and Selten (1988), they have refined the definition as the players are not able to be in obligatory agreements, but there is a situation where they are able to model such commitments with game theory. In many areas of economics, those obligatory commitments are prevalent for players. In practice we can say that almost every purchasing relation is include some binding principles stated in a contract signed between two companies. Additionally budgetary penalties have been covered in these contracts that focus to deter the parties from going back on the contract articles. By this way the contract can be characterized as binding.

As we see the researches of game theory until the 1970s, these solution concepts were generally considered and used as a mathematical concepts. Later on, lots of study utilized game theory for solving economical problems. We can say thay in the situation of competition or cooperation between companies requires the decision problems, which can be solved with the game theory methods. In the practice, players can be considered as firms, parties in the supply chain, companies' business units, customers, or even employees. So, we can say that business applications are utilised in lots of sectors in very extensive application area. Within this scope Chatterjee and Samuelson (2001) develops many comprehensive studies in the field of business issues.

As a matter of course, service model of energy market includes multi players and so that the share of profit/cost in the case of any business agreement, is a critical matter for this market. Additionally, as having coalition option for service model and due to its scale with multi player structure, energy market is a well-suited study field for game theory. We have seen lots of applied study regarding profit/cost sharing model for energy market. Parsons (1989) develops an application regarding long–term gas supply contracts mainly focusing long term value of those contracts. With a more recent study, Hubert and Ikonnikova (2004) and Hubert and Suleymanova (2008) invest a quantitative case of power relations in real world supply chains using cooperative game theory. Tinç (2018) provides a most recent study regarding profit sharing model for Turkish electricity supply chain using cooperative game theory.

2. COOPERATIVE GAMES

While the Non-Cooperative Games analyses the the individuals, Cooperative games deal with the competition between coalitions of players. Allocation method of the payoff in is the main question. The allocation of the outcome of a co-working between the players is a basic assumption in cooperative game theory. Transferable utility means a commodity, which can be transferred between the players. Transferable utility assume that the numbers can express the earnings of a coalition. For instance, individual utilities can be expressed in monetary terms. The second assumption is risk-averse behavior of the players in their preferences for money. Therefore, it is possible to ignore the player's individual utility functions.

Cooperative games are defined by N = {1,2,…,|N|} is the given set of players. Players are decision makers and every subset S ⊆ N of cooperating players a coalition. Players coooerating with each other are in same coaliation. If not, they belong to another coalition. N is called the grand coalition, that is the group consisting of all players. The main purpose of cooperative game is analysing the players decisions, strategies, and solutions. Two-player-games are more manageable than the more than two players game because of complexity of the solutions. The number of coalisrions rising exponentially.

The second factor, the characteristic function c, representing the total amount of transferable utility.

$$c : 2^N \to \mathbb{R} \tag{2.1}$$

This function can be a cost or profit value to each coalition S ⊆ N which determines the best outcome for the coalition S

It is assumed that for an empty coalitions.

$$c(\emptyset) = 0. \tag{2.2}$$

If the players able to create the grand coalition and aim to share total profit among themselves, the allocation will mainly depend on the dominance structure in the grand coalition. Ability to make any sub-set of players agreeing to cooperate can be defined as a player's dominance (Myerson 1991). So, characteristic function can be considered as the summary of the dominance structure of the game. In summary, a game is defined by the pair

$$\Gamma := (N, c). \tag{2.3}$$

For the characteristic function, the term coalitional game can be used instead. Here, it is required to give the characteristic function to define a cooperative game by the reason of via the dimension of the characteristic function the players are covered entirely.

If we consider a revenue or profit situation the outcome to be preferred as higher as possible. On the contrary, for a cost situation, outcome which enables lower cost amounts will be welcomed. The symbol υ is usually used for profit functions and c for cost functions. Most of the time, profit and cost games can be handled the same way. An exception to this is the existence of restricted cooperation. It is also customary in game theory and its applications to convert a cost game into a cost savings game with

$$\upsilon\,(S) = \textstyle\sum_{i \in S} c(\{i\}) - c(S) \text{ for all } S \subseteq N \tag{2.4}$$

$$c(S) = \upsilon\,(N) - \upsilon\,(N \backslash S) \text{ for all } S \subseteq N \tag{2.5}$$

Obviously, $v(\emptyset) = c(\emptyset) = 0$ holds for both transformations.

3. NASH BARGAINING SOLUTION

Economic transactions create surplus. Bargaining theory research the question of how the surplus will be distributed among the participants. In almost all cases it is restricted to the case of two agents. Assume one agent has an object to sell, and another has the opportunity to buy it. Assume the seller values the object less than the potential buyer. The diference between the valuation of the seller and that of the buyer is the potential surplus. Because there are joint gains from trade, it is rational to assume that the transaction will occur. The objective of bargaining theory is to say something about the price at which the transaction will take place.

According to Nash (1950), bargaining means that the each of every player have rights to be involved in a game or not. This is totally upon players decision, so that the game should be mutually beneficial agreement for players. We can also say that any of agreement can not be imposed on any players if the player do not accept the game.

In the scope of this thesis we use two-person bargaining problem which may be described as: think there are two persons for a situation lets state player 1 and 2. They will decide to be included or not upon the profit/cost savings they will get in case of game realized. Here the results or outcomes are given by the utility functions u_1 and u_2, respectively. The payoff vector, $u = (u_1, u_2)$, is an element of a two dimensional payoff space, P, (i.e., $u \in$ P). The pay off space is supposed to be compact and convex. For the set of payoff vectors we use H. Here in the solution we shall use H as the upper-right boundary of pay off space P.

For the disagreement payoffs of player 1 and player 2 we use t point and $t = (t_1, t_2) \in P$ be the vector of, respectively. Here if any of player do not accept the game and so the game can not be realized, player i get t_i $(i = 1, 2)$ payoff. Let $P^* = \{ u \in P) : u_1 \geq t_1, u_2 \geq t_2\}$. So that, $P^* \subseteq P$.

Let H* denote the upper-right boundary of P*. Thus, $H^* \subseteq H$. The bargaining problem is then: Given P and t, what will be the solution, $\bar{u} = (\bar{u}_1, \bar{u}_2)$ that the bargaining parties will eventually reach, assuming all individuals act rationally?

In the scope of two-person Nash bargaining solution concept, main theory, perceiving only total utility functions. This total utility function able to contains two of rationality axioms. The first axiom which is supported by ordinal utility function is individual rationality (IR) that means players will not accept the payoff or the game itself if that player's payoff from the game to be lower than the disagreement point amounts,

$$\bar{u}_i \ \geq \ t_i \ (i = 1, 2) \ so \ that \ \bar{u}_i \in P$$

The second one is pareto optimality (PO). The PO means that the agreement will not be formed. Because if none of the players will get a better results or there are some other alternatives providing better results than the game for any of players, rational players would not involve in the game.

These two axioms limit the solution, $\bar{u}$ to H*. The negotiation set, is not a unique result or solution, $\bar{u}$. As mentioned in the literature review Nash (1950) provides a sigle solution to the game. For this unique solution three additional axioms have to be covered apart from the two axioms mentioned above. The additional three axioms are as follows symmetry, linear invariance and independence of irrelevant alternatives.

Symmetry (SYM) can be explain with the following statement. Let P* be "symmetric"; namely, if a point, (b, ɑ) ∈ P*, then the point (b, ɑ) is also in P*. Then, P* is symmetric, $(\bar{u}_1 = \bar{u}_2)$.

For explaining linear invariance (LINV), let $\bar{u}$ to be the result of the agreement (or simply game), G. Let G* be the game that results from G if one player's result from the game (or simply utility function), $\bar{u}_i$, is liable to an order-preserving linear transformation, T, making the remaning player's results, $\bar{u}_j$, the same. With this condition, the result $\bar{u}$* of the new situation, G*, is the image of $\bar{u}$ under T, i.e., $\bar{u}$* = T $\bar{u}$.

For the last one of three additional axioms the independence of irrelevant alternatives (IIA), we can refer also binary independence. This axiom means that if a game is multiplied by a positive constant the results will not be affected and to be the same actually.

With this approach including five axioms, Nash proved that under the aforementioned five axioms, $\bar{u} = (\bar{u}_1, \bar{u}_2)$ as the result of the game or lets say the utilities that the players will take, is the point satisfying

$$(\bar{u}_1 - t_1)(\bar{u}_2 - t_2) = \max_{(u \in P)} [(u_1 - t_1)(u_2 - t_2)] \tag{3.1}$$

$$u_{max}$$

such that

$$u_i \geq t_i \ (i = 1, 2)$$

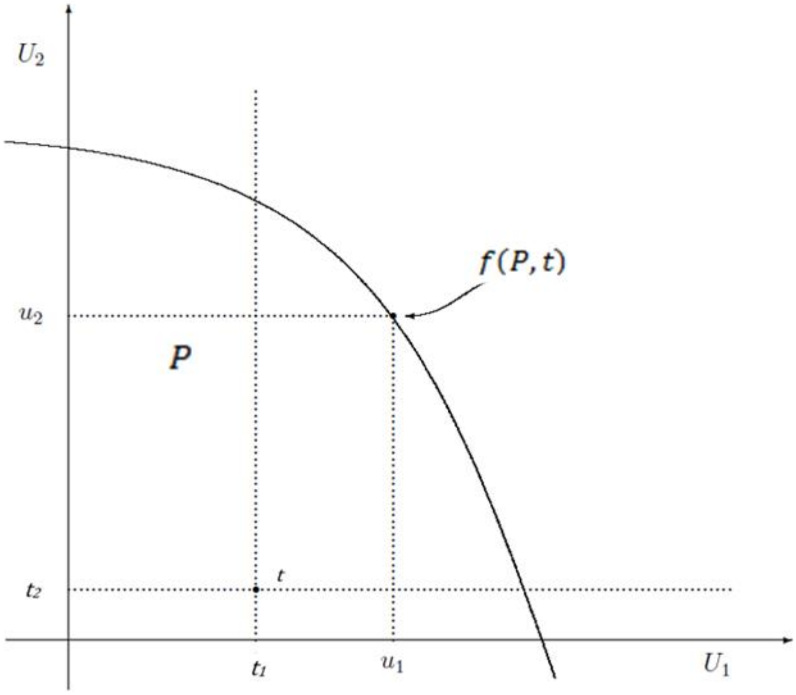

Figure 3.1 : Bargaining problem and solution function.

4. KALAI–SMORODINSKY BARGAINING SOLUTION

Within the scope of the Kalai–Smorodinsky Bargaining Solution (KSBS short), the convexity is not a property that need for the feasible set. However it is not the case for comprehensivity, the feasible set must be comprehensive.

To be clarified, a set $P \subset \mathbb{R}$n is comprehensive if, given a point $z \in \mathbb{R}$n, the relation $z \le x \le y$ with $y \in P$, implies $x \in P$.

Here again we use point t for disagreement point. In the scope of the feasible set P and the disagreement point t, this solution concept says that the solution should be covere at least following four properties. The first one is $f(P,t) \ge t$. And the second property is $y \ge f(P,t) \Rightarrow y \notin P$.

Additionally the third property can be explained as; $\tau()$, it holds that $f(\tau(P),\tau(t)) = \tau(f(P,t))$. And the last property for KSBS can be detailed as; suppose that $t \in P' \subseteq P$ and Pmax is identical for both (P,t) and (P',t). Then, if $f(P',t)$ shows Pareto–optimal situation of P, it holds that $f(P,t) = f(P',t)$.

The quantity Pmax, also we can refer as utopian point, can be define as the point that ensures the biggest possible results with involving in the agreement. This situation can be formulated as

$$P\text{max}(P,t) = \left(\max_{P_1 \in P} P_1, \max_{P_1 \in P} P_1, \ldots, \max_{P_1 \in P} P_1\right) \mathrm{T} \ge t \tag{4.1}$$

where max P_k represents the maximum possible utility for node k and shall be greater or equal to the utility at its disagreement point t_k. Usually, all nodes cannot simultaneously achieve their maximum possible utility, hence the utopian point does not belong to the feasible set.

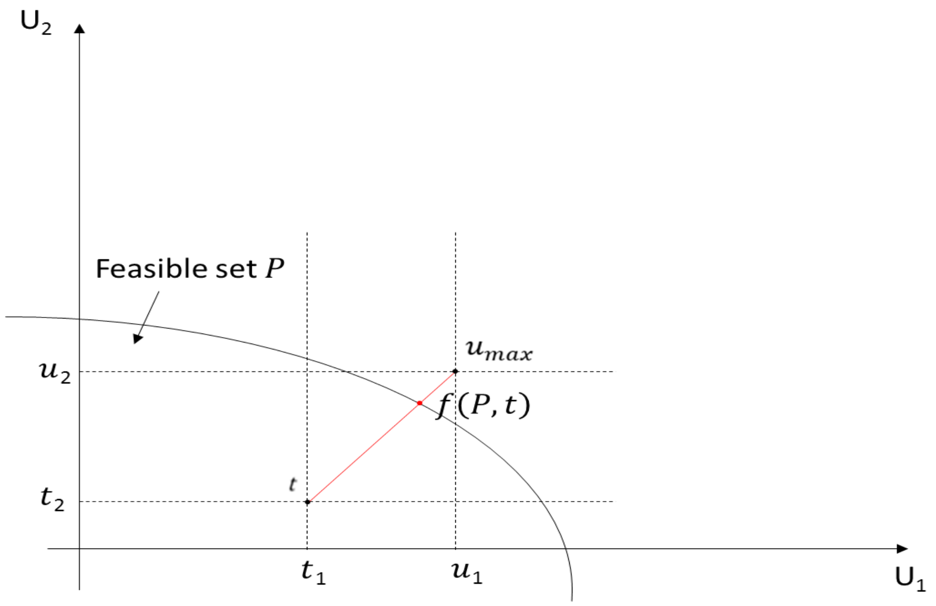

Figure 4.1 : A feasible set and KSBS.

In practice the solution may be found with the following calculation steps. First disagreement point t and the utopian point Pmax or $u_{\max}$ which gives the maximum possible level of profit. After then the space we refer as feasible set and use symbol P, should be found. And of course this space will provide all utility points from any cooperative. Finally, with simply connecting t and Pmax with a straight line, and computing the equation of the straight line, the solution can be found. This calculation steps is illustrated in figure above.

5. WEIGHTED SHAPLEY VALUE

The Shapley value is a widespread solution concept in cooperative game theory that provides a unique allocation to players in a cooperative. It is considered as the main solution concept for cooperative games with transferable utility. The Shapley value is based on a set of axioms that decide the allocation to a player based on the player's marginal contribution.

One of the main axioms that characterize the Shapley value is one of symmetry. The underlying motivation for using this axiom is the assumption that except for the parameters of the games, the players are completely symmetric. Symmetry is unrealistic itself, for some situations. If the two players cooperate, they can generate a incremental profit which is to be divided between them. If they continue to be separate, they can generate no profit. The Shapley value considers this situation as symmetric, allocates the incremental profit uniformly among the players. For some situations, one of the player's effort may be needen more than other player in order to be succeed.

For the very reason, The family of weighted Shapley values was introduced by Shapley (1953). With an other word, weighted Shapley value is an asymmetric version. Each weighted Shapley value allocates weight, which is positive, and sum of all weight must be equal to one. In this case, weights are assigned to players and the incremental profit or cost is divided according to these weights. The case where some players are assigned a zero weight is also applicable for some situations. With this perspective, we can say that the symmetric Shapley value is also considered a weighted where all the weights are the same.

Shapley (1981) proposed also a family of weighted cost allocations schemes and axiomatically characterized, for exogenously given weights, the schemes associated with these weights. This family of solutions is related to the weighted Shapley values by duality. We explore further the relationship between these two families, provide an axiomatization of the latter family (which does not use the weights explicitly in the axioms as Shapley's axioms do) and get as a result an axiomatization of the symmetric.

Let $\omega \in R^N{++}$ (that is $\omega_i > 0$ for every $i \in N$). Unanimity game $u_{S,}$ for $S \in C_O$, is defined by $u_{S,}(T) = 1 \, for \, T \supseteq S \, and \, u_S(T) = 0$ otherwise, and that the set of unanimity games, for all $S \in C_O$ is a basis for the lenear space G of games. The positively weighted value φ^ω $(which \, is \, called \, the \, \omega - value)$ is the unique linear perator satisfying

$$\varphi^\omega u_S(i) = \begin{cases} \frac{\omega_i}{\omega(s)}, \text{ for } i \in S \\ 0, \quad \text{for } i \notin S \end{cases} \tag{5.1}$$

for each unanimity games u_S. If $\omega_i = \frac{1}{n}$ for every $i \in N$, then φ^ω is the Shapley value. Owen (1972) says that positively weighted values are path values, the path α being defined by

$$\alpha_i(t) = t^{\omega_i} \text{ for every } t \in [0,1]. \tag{5.2}$$

It is important that the mapping $\omega \rightarrow \varphi^\omega$ is homogeneous of degree zero, that is $\varphi^{\lambda\omega} = \varphi^\omega$ for every $\lambda > 0$. So that we can dicrease our attention to vector ω in the relative interior of $\Delta(N)$, which is called weight vectors.

Now let turn to an axiomatic characterization of positively weighted values. A solution ψ is strictly positive if for every monotone game v without null players, $\psi v(i) > 0$ for every $i \in N$. It is easily verified that a probabilistic value ψ is strictly positive, if and only if $p^i(S) > 0$ for every i and every $S \in C^i$, where $\{p^i : i \in N\}$ is the collection of probability measures that define ψ. A coalition S is said to be a coalition of partners or a p-type coalition, in the game v, if, for every T ⊊ S and each $R \subseteq S^C, v(R \cup T) = v(R)$. A solution ψ satisfies the partnership axiom if, whenever S is a p-type coalition,

$$\psi v(i) = \psi(\psi v(S) u_S)(i) \text{ for every } i \in S. \tag{5.3}$$

6. TURKISH ELECTRICITY MARKET

The roots of the current electricity market was established by the foundation of the state-owned and vertically- integrated electricity company Turkish Electricity Authority (Türkiye Elektrik Kurumu) (“TEK”), which was controlling the entire Turkish electricity sector starting from 1970 to 1984.

Private generation and distribution modeled companies were allowed to operate in the market after 1984. In 1993, in order to start the liberalization of the market, TEK was separated into two embranchments: namely, Turkish Electricity Generation and Transmission Corporation (“TEAS”) and Turkish Electricity Distribution Corporation (“TEDAS”).

While TEAS performed the generation, transmission and wholesale activities, TEDAS performed the distribution activities. The Turkish Electricity Market Law of 2001, provided for the unbundling of state owned electricity assets, opened the market above a hurdle rate (certain level of electricity consumption), and allowed third-party companies to the system. It also mandated that all generation capacity to be sold to wholesalers, retailers, or directly to consumers, either directly or via a spot market.

In 2001, Turkish Electricity Generation and Transmission Corporation (TEAŞ) was structured as three separate public economic enterprises with the titles of Turkish Electricity Transmission Company (TEİAŞ), Electricity Generation Company (EÜAŞ) and Turkish Electricity Trade and Contracting Corporation (TETAŞ). TEDAŞ, which has been conducting electricity distribution and retailing activities since 1993, was included in the privatization scope and program in 2004 upon the decision on privatization of these services.

The regions of distribution were reidentified again and Turkey was separated into 21 distribution regions. 100% of the shares of the companies operating distribution assets owned by TEDAŞ, and the compulsory elements for the operation of these assets under the scope of operation rights were privatized through share transfer method. Their privatization started in 2008 and completed in 2013. While Electricity Distribution and

Retailing Services were being conducted via the distribution companies before, they were started to be provided by separate companies as of 2013.

The structure and development of the companies can be seen in figure below.

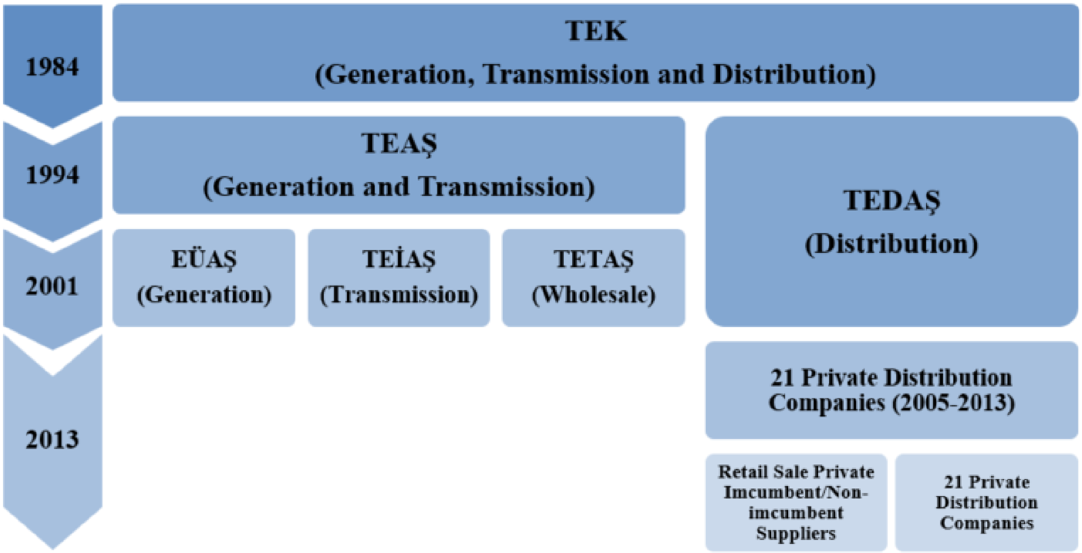

Figure 6.1 : Development of electricity companies.

6.1. EMRA's Electricity Market Tariff Regime

Companies in the electricity market are subject to be licenced by Electricity Market Regulation Authority's ("EMRA"). End user tariffs are published by EMRA's board's decision for a three-months period. According to the tariff consumers are divided into two main categories upon their connection point to the network.

First group is the consumers who have transmission system connections while they are purchasing electricity from the incumbent supply companies. The second group of consumers are the consumers whose connection to the network system is from the distribution system.

The second group is divided into five main categories. These groups are mainly categorized according to usage of electricity. These are; industry users, commercial users, households, agricultural irrigation and lighting. It should be addressed that most of the consumers in the above-mentioned groups also fit in the free consumer category.

The latest tariff which effective for first quarter of 2019 with TL/kWh unit price can be seen table below.

Table 6.1 : Electricity tariff effective for first quarter of 2019.

Connection Type	Voltage/ Term	Tariff Group	Single Time Active Energy Price	Distribution Fee	All Taxes and funds included End User Price
Transmission		Industrial	364,5	0,0	438,7
Distribution	Medium Voltage Double Term	Industrial	372,6	68,0	528,7
		Commercial	406,6	106,0	643,2
		Residential	281,5	105,0	482,6
		Agricultural Irrigation	367,8	87,3	554,4
		Illumination	372,2	101,8	594,4
	Medium Voltage Single Term	Industrial	372,6	75,1	537,2
		Commercial	410,2	132,2	678,8
		Residential	280,2	129,7	510
		Agricultural Irrigation	370,5	108,7	583
		Illumination	375,6	126,9	628,5
	Low Voltage Single Term	Industrial	380,9	116,3	595,6
		Commercial	415,0	157,6	714,8
		Residential	279,1	154,1	537,5
		Martyr Families	103,2	104,5	254,8
		Agricultural Irrigation	374,5	129,5	612,3
		Illumination	380,2	150,9	662,5

In addition to tariff categorization, EMA also categorized the electricity customers into two categories with respect to their consumption levels. Energy Market Regulatory Board is absolute authority to determine the limit in yearly basis which is called "eligible consumer limit" and for the 2019 the free consumer limit has been decided as 1600 kWh. Free consumers are the consumers whose yearly electricity consumption is over the free consumer limit or directly connected to the transmission system or organized industrial zones according EMRA. The main characteristics of the free consumers is to have the right of signing bilateral energy purchase contracts with the electricity suppliers. Those who are not eligible consumers (non-free consumers) can only supply electrical energy or capacity from the incumbent supplier company in its region while paying the regulated prices.

Additionally, EMA defines another consumer group as the "free customers" who do not actively use their right to sign bilateral energy purchase contracts, and this sale transaction of electricity is called "supply of last resort". Moreover, the Electricity Market Tariff Regulation (EMTR) defines two different group of the last resort consumers such as low-consumption level consumers and high-consumption level consumers.

6.2. New Practice For High-Consumption Level Consumers

Before the high-low consumption level practivce "supply of last resort" consumers were purchasing electricity from the incumbent supply companies, and the price of the electricity was equal to the regulated retail price. However, the last resort consumers in the electricity retail market divided into two categories according to their consumption level as low-consumption level consumers and high-consumption level consumers. The consumer limit has been determined as 50 million kWh for 2018. In other words, consumers who consume more than 50 million kWh electricity defined as high-consumption level consumers. The other side of the coin is that the consumers who consume less than 50 million kWh electricity defined as low-consumption level consumers. In January 2019, the limit leveled down to 10 million kWh and EMRA gave very clear message to electricity market that the limit will go down. We should address that there is nothing changed for the low-consumption level consumers, and they will continue to purchase electricity at the regulated retail price. Customer group according consumption level, tariff and supplier options can be seen in the figure below.

Figure 6.2 : Customers according consumption level, tariff and supplier options.

The gap between the regulated price for the low-consumption customers and the market price became smaller. In order to create a liberal market, the margin between the regulated price and the market price is essential. Then, the new tariff application is defined for high consumption customer with cost reflective calculation as (PTF+FIT)*(1.0938). Because of this tariff calculation, retail companies and other companies who has retail licence target the high consumption customers whose regulated tariff option gives margin to liberal market action. Last three years regulated active energy price level for both low and high level consumers and market price level as TL/MWh are seen in figure below.

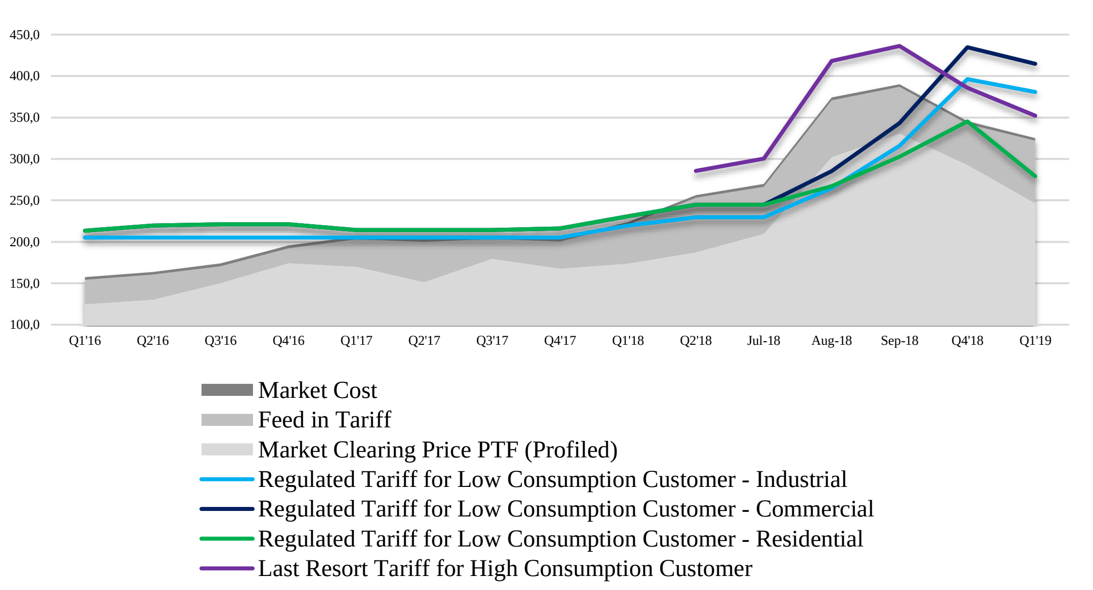

Figure 6.3 : Regulated tariff versus market price.

6.3. Market Activities

Supply chain structure of Turkish electricity market drawn as the figure below. The left side of the chain is generation companies and the right side indicates the end user of electricity. The red line shows regulated supply chain which determined by EMRA’s rules and tariff. The blue lines indicates free market activities which determined by the equilibrium of supply and the demand of the market.

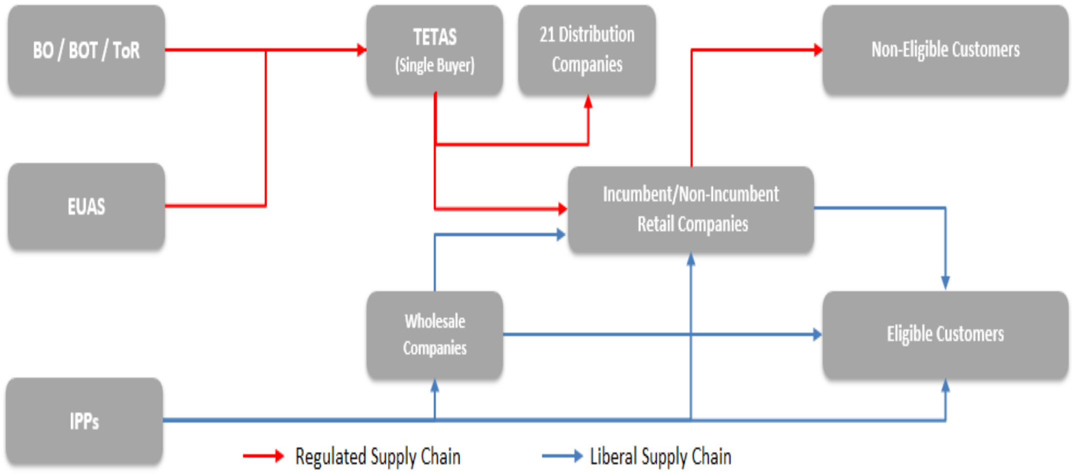

Figure 6.4 : Supply chain structure of turkish electricity market.

6.3.1. Generation

There are five types of generation players both licensed and unlicensed on Turkish electricity generation market. The first type is state-owned EUAS. Second one is build-operate-transfer (BOT), build-operate-own (BOO) companies. These companies operate under a concession (BOT) or license (BOO) agreement signed between the state and a private company. The third type is companies operating under a transfer-of-operating-rights (TOR) agreement. The generation utility is owned by the state and operated by a private entity. The forth type is independent power producers and the last type of generation player is auto producers (Benan & Tuzcu, 2014).

The distribution of licensed electricity generation and installed capacity by entities in 2018 is shown in figure below. The biggest share both in generation and installed capacity belongs to independent power producers. The distribution of licensed electricity generation and installed capacity by resources in 2018 is shown in figure below. The biggest share both in generation and installed capacity is belongs to the natural gas power plants.

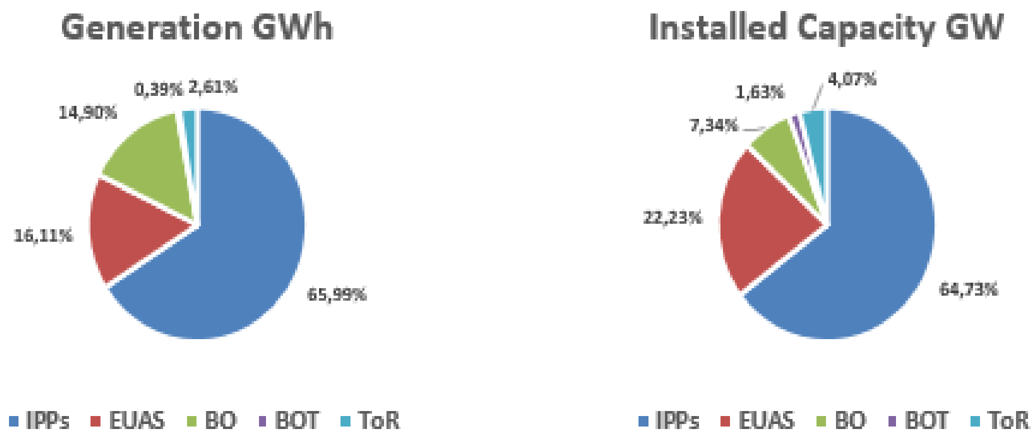

Figure 6.5 : Generation and installed capacity according to entities.

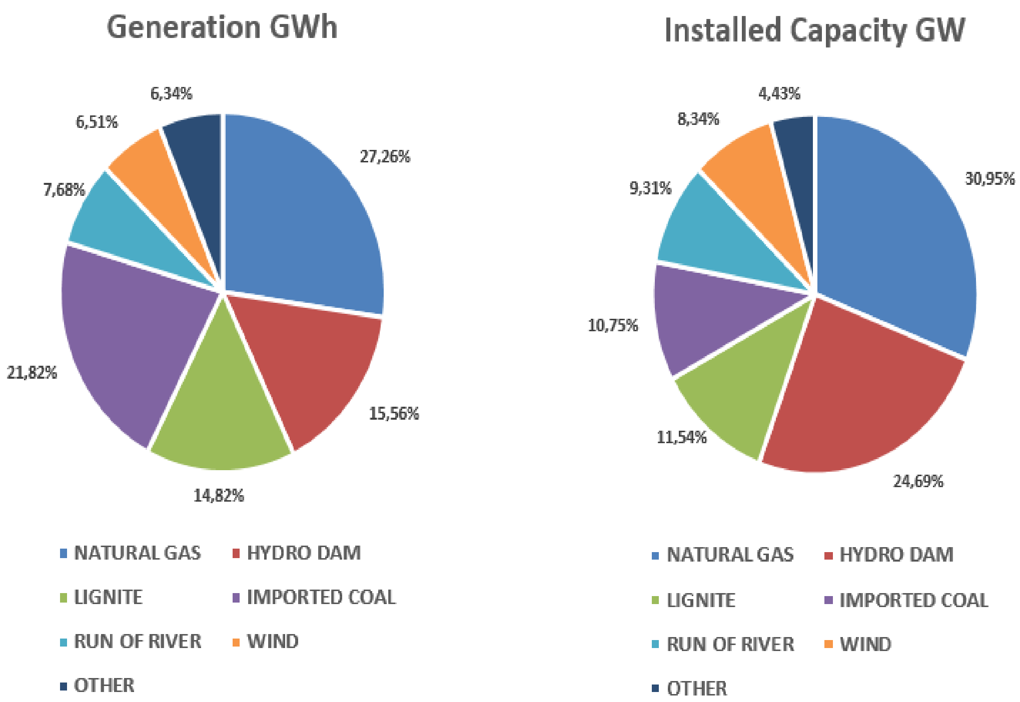

Figure 6.6 : Generation and installed capacity according to resources.

6.3.2. Transmission

Transmission activities are performed by the state-owned TEIAS, which has a complete monopoly over this segment of the electricity market due to the natural monopolistic characteristics of the transmission infrastructure.

6.3.3. Wholesale

The aim of wholesales is to bring electricity, which is a commodity not stored, in the most planned way until it is consumed. The wholesale market activities consist of bilateral agreements, day-ahead market, intra-day market and Balancing Powermarket.

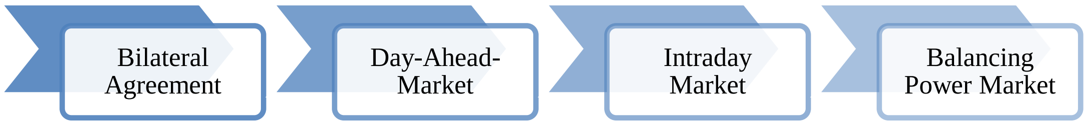

Figure 6.7 : Structure of wholesale market.

6.3.3.1.Bilateral agreements

The majority of Turkish electricity contracts take place between a generation company or a wholesale company or a retail company or an end-customer as an energy sales contract. Bilateral contracts are not standardized so that the terms of the contracts are subject to negotiations between parties.

6.3.3.2.Day-ahead market

An electricity market is a system enabling purchases, through bids to buy; sales, through offers to sell; bids and offers use supply and demand principles to set the price. Both the supply and demand sides may compete on the market, with producer on one side and wholesale and retail companies on the other. The equilibrium price which sellers want to sell and buyers want to buy is Market-Clearing Price (PTF). The price on the day-ahead market is determined at the intersection of supply and demand. For each trading hour, a supply curve is formulated from a combination of price-quantity pairs that are listed in ascending order and combined into one offer. The demand curve is formulated in the same manner, but the pairs are listed in descending order. The intersection of the supply-demand curves determines the price of the related hour.

Legal entities holding license can join Day-Ahead Market by signing Day-Ahead Market Participation Agreement which includes market participants responsibilities regarding to Day-Ahead Market. Prices and volumes applied for clearing of Day-Ahead Market at daily basis are determined for each hour.

Daily demand on the Turkish Day Ahead Market is met by a large number of electricity products based on a variety of energy sources. Every type of power plant (Natural gas, imported coal, lignite, etc.) has marginal costs in terms of usage. Marginal costs are primarily determined by the "variable cost" of fuel and operating assets - costs that are incurred when the power station is up and running and must at least be earned back. Power plant capacity is drawn upon, starting from the lowest-cost option, until the demand is met. The offer price of the last power station needed to satisfy this demand ("marginal power plant") determines the market price for all the other power stations. Power prices are thus the result of the point at which supply and demand intersect. Therefore, to cover high demand, a gas-fired power plant with relatively high marginal costs would tend to determine prices, whereas to cover low demand, a more affordable coal-fired power station would be preferable.

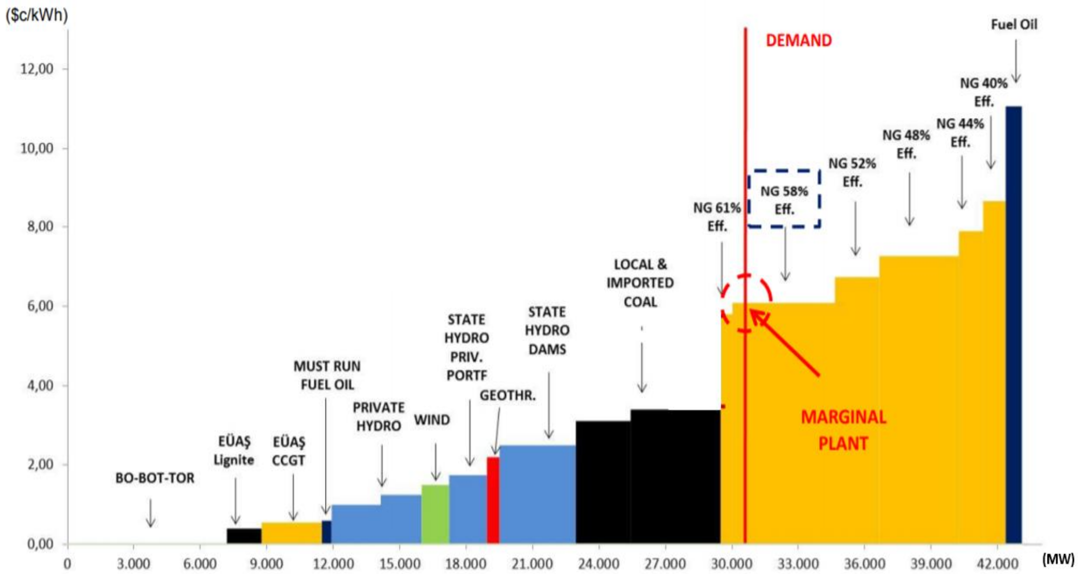

Figure 6.8 : Supplied capacity in merit order.

6.3.3.3.Intra-day market

Intraday Market operate as a connection between the Day Ahead and the Balancing Markets, together with this characteristic it primarily contribute to the balancing and the sustainability of the electricity market.

6.3.3.4.Balancing power market

The balancing market is an enabler for ensuring a physical supply and demand equilibrium. Although the system is theoretically in balance after the day ahead market is closed, there is always a possibility that market participants may produce below or above their daily accepted bids/offers, leading to imbalances in real time. However, to balance the system flexible producers can load or reload the system on short notice via submitting their bids/offers through a transparent market application, the so-called balancing market.

Having an energy deficit or energy surplus in the system is the main determinant of price for the balancing market. First, all offers/bids submitted to the balancing market are ranked according to their prices. For example, we can think about there is an energy deficit in the system, the maximum accepted hourly offer price is accepted as the system marginal price (SMP). This situation where a balancing entity sells energy to the system is called up-regulation. On the other hand, when there is a surplus, the minimum accepted bid price is accepted as the SMP. This situation where an entity buys energy from the system in order to correct an imbalance is referred to as down-regulation. This balancing model and principles have been regulated with Electricity Market Balancing and Settlement Regulation which has been published in 2009.

6.3.4. Distribution

There are 21 distribution regions each one has its own distribution company. These companies have been licensed to use TOR model. All of the production assets of every each of 21 distribution company belong to TEDAS.

6.3.5. Retail

Retail electricity is sale of electricity to consumers. Among the rings of electricity value chain, the retail electricity sector is the touch point to the end user. Competition in this sector as a result of unbundling and liberalization, and convergence with other utility sectors due to technological developments have fundamentally changed the industrial organization dynamics of the retail electricity sector. These evolving dynamics compel market players to develop new business strategies. In crafting these strategies, it is extremely important to know consumers and to analyze their behavior, to understand the structure of the new market players and their business models, how to create added value in the new market structure

In electricity retailing, electricity is a “commodity” and the relationship between supplier and consumer is a financial one. Therefore, it is extremely difficult to create added value and to obtain high profit margins in electricity –as a commodity- trade. Creating added value and obtaining high profit margins are only possible via cost-effective operations and innovative marketing methods. Cost-effective operations can be achieved via scale and scope economies whereas innovative and targeted marketing requires determining the sub-segments of the market accurately, which, in turn, necessitates the knowledge of detailed demographic and socioeconomic elements as well as consumer profiles. All these entail a thorough customer relationship management (CRM) supported by a strong information system infrastructure.

7. MODEL

7.1. Players and Markets

Commercially electricity flows through deals or bilateral agreements between players. In the following figure, you can see the flow of wholesale and retail electric market.

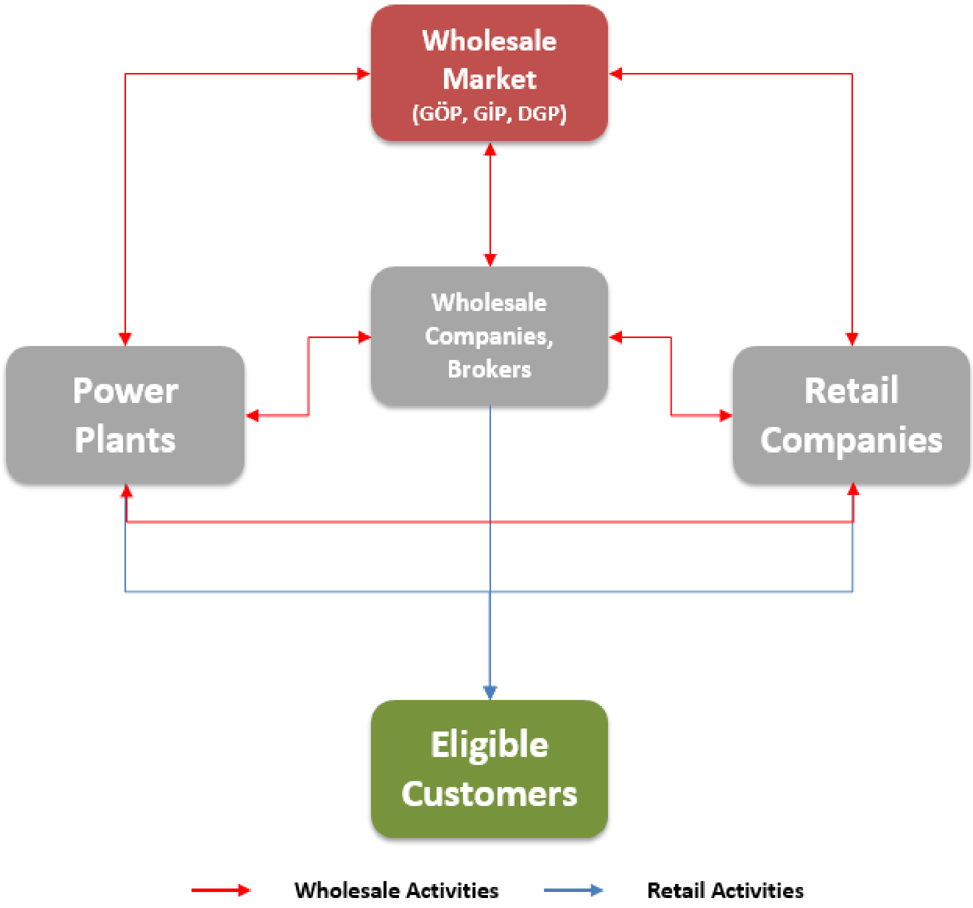

Figure 7.1 : Wholesale and retail electricity market.

In theoretical in retail market power plants, wholesale companies, and retail companies can supply electricity to the end user. However, only two players, power plants and retail companies, find it commercially reasonable to sell electricity to the end user according to their current capabilities. We can describes the strengths of the retail companies are sales organization structure are advanced customer relationship management processes while power plants have a generation asset. Incumbent retail companies have built up a relationship of fidelity with their customers. This relationship is stronger thanks to the distribution companies in the same market. They also have large portfolios and customer bases, they can spread the transactional costs to wider customer bases so as to benefit from economies of scale. Unfortunately, wholesale companies do not have a relative strong side for the retail electricity activities. Thus, we will not include it into the game.

In this study, we will divide the target customers group into three sub target segments according to players marketing and sales planning. In general, players designing their sales activities according to customers' profile and divide total customers into these three sub segments. Because of existing market and regulation conditions, high consumption customers are the target customer group for these two players. In this study, our target group is the customers who consume more than 1 Million kWh. In the near future, it is predicted that the "Last Resort Tariff" limit will be leveled down to 1 million kWh. The customers consuming 1 million kWh are generally consist of corporate customers and so the regulator will not intend to preserve from high electricity billing. For this reason, this target customer group have to find their own retail company to avoid high price of regulated electricity tariff. In addition to this, players not have enough sales force to reach large number of customer group are not tend to try selling electricity to low consumption customers.

Last year in 2018, the total invoiced consumption was approximately 234 TWh and the average electricity customer number was 43,7 million. When we separate according to consumption bands, customer over 1 GWh are nearly 0,05% of total customer. On the other hand, their consumption are 55% of the total. This imbalance caused by high average consumption of industrial customers.

Table 7.1 : Target customer subgroups.

	Sub Target Segment	**Consumption Bands**	**Number of Customer**	**%**	**Volume (TWh)**	**%**
Target Customers	1	Over 50 GWh	1.004	0,002%	62.46	26,7%
	2	10 GWh - 50 GWh	1.399	0,003%	33.42	14,3%
	3	1 GWh - 10 GWh	17.817	0,041%	32.92	14,1%
		0 GWh - 1 GWh	43.638.168	100,0%	104.75	44,9%
		Total	**43.658.388**	**100%**	**233.56**	**100%**

Each players has their own cost structure with respect to its capability. The value function captures business profitability that consist of revenues and costs of the players, differentiation between consumption segments, number of customers, consumption, etc. As mentioned in the above, we will consider different value functions to reflect three different type power plant and retailer game for the three consumption segments.

7.2. The problem of Retail Electricity Market

The main problem of the retail electricity market is that difficulty of provide added value and get high profit margins in commodity trade, including electricity. Electricity is a "commodity" and the relationship between suppliers and consumers is a financial one. Suppliers do not have the power to affect the quality of electricity and competition is mostly for the price due to the nature of electricity supply. In this regard, the question of how suppliers could create added value for consumers except for the price makes sense in terms of strategy.

The first choise to solve this problem is low cost operation. In a retail electricity market where price competition is dominant, only cost-effective suppliers remain competitive by simply reflecting their savings in prices and employing a befitting pricing policy. Cost-effective operations can be conducted via economies of scale. In economies of scale, bigger companies prove advantageous provided that they reduce their average costs by spreading the fixed costs to large consumer bases. Also, big companies which can do low pricing thanks to economies of scale might also take advantage of economies of scale by stealing the customers of other players in the market.

The second choise targeted marketing. In retail electricity sector, a successful targeted marketing requires the determination of sub-segments of the market accurately, which requires the knowledge of detailed demographic and socioeconomic elements as well as consumer profiles.

There are also possible macro risks. The most possible one is decrease in demand for electricity and, as a result, in revenues of suppliers due to low rates of economic growth contrary to expectations. If the demand decreases, most of the thermic power plant will be inactive due production cost.

7.3. The Value Function

In this section, we analyze the situation of power plants and electricity retail companies under the conditions mentioned below, and examine how they can benefit and share this benefit if they cooperate with each other.

We reflect the relation among the players by a game in value function form (N, v), where N denotes the set of players – Private Power Plant, Retailer – and the value function $v : 2^N \rightarrow \mathbb{R}$ gives the payoff, which a subset of players $S \subseteq N$ can achieve.

Value Funtion:

$$PM = [SP - (EC + FiT + IC + MOF + SF + DC + FC + OPEX)] \qquad (7.1)$$

Table 7.2 : Model parameters.

Symbol	Interpretation
PM	Unit Profit Margin (TL/MWh)
SP	Unit Sales Price (TL/MWh)
EC	Unit Energy Cost (TL/MWh)
FiT	Unit Feed in Tariff Cost (TL/MWh)
IC	Unit Imbalance Cost (TL/MWh)
MOF	Unit Market Operating Fee (TL/MWh)
SF	Unit Spread Fund (TL/MWh)
DC	Unit Doubtful Cost (TL/MWh)
FC	Unit Finance Cost (TL/MWh)
OPEX	Unit Operational Expence (TL/MWh)

7.3.1. Sales price

Sales price to the end customer is generally determined by the discount made on the ceiling price set by the Energy Market Regulatory Authority (EMRA) during the contract period. Last year, low consumption end-user sales prices were set aside from generalization, as the margin between the regulated price and energy costs narrowed. On the contrary, for the high consumption customer free market sales price lower than the regulated last resort tariff because of cost reflective tariff mechanism. Because with the monetary point of view selling to premium customer in upper consumption segment more important than the others. For this reason, the sales price for high-end customer are lower than to the others. In this study, we will use the liberal LRT segment sales prices of the player that they implement in 2018 and 2019 year to date.

We will calculate the sales price as (PTF+FiT)*(1+X%). X% will change according to customer segment that we mentioned above.

7.3.2. Energy cost

Energy cost is the essential difference for the players. There is differentiation in terms of the cost of electricityPower Plant in Turkey.Power Plant with lower production costs are more advantageous than to the others. In this study, we will examine three types of termal power plant - Natural Gas Combined Cycle (NGCC), Domestic Coal Power Plant, Imported Coal Power Plant. Renewable Power Plants will not be in the game due to feed-in-tariff mechanism in Turkey.

Power plants with highest production costs are natural gas power plants. At the lower limit of this cost, there are turbine-type combined cyclePower Plants at the upper limit and natural gas engine plants at the upper limit. Depending on the fuel type, coalPower Plants are relatively low-costPower Plants according to to natural gasPower Plant. The share of 30.95% of licensed electrical installed power is belongs to the natural gasPower Plant, 10.75% is belongs to imported coal firedPower Plant and 12.28% is belongs to domestic coal firedPower Plant at the end of December 2018.

In this study, we assume thePower Plants' enery cost as its marginal cost of generating a unit of energy. It is equal to sum of unit investment cost, unit variable cost and unit fixed cost. The first investment cost is the expenditures made for the basic elements such as machinery-equipment, building and land, in order to make the plant ready for energy production before starting operation. The finance cost of first investment is also included to first investment cost. Unit investment cost is the division of the total investment cost of installation phase to the total generation throughout life of thePower Plant. The variable operating costs are fuel used in the plant, energy, water, chemicals, catalysts, gases, lubricants, consumable materials and resources, and costs caused by waste. In this study, we will assume the unit variable cost is equal to fuel cost of generation one unit of energy. The fixed operating costs are employees' salaries and premiums,Power Plant general and administrative expenses, plant support equipment, planned maintenance. In this study, we will assume unit fixed cost as a different share of unit variable cost for the each type ofPower Plant.

Since the Retailer does not have any generation asset. They obliged to buy it from day ahead market or they can make bilateral agreement according to their risk management. In this study, their energy sourcing cost is equal to Market Clearing Price (PTF). In the certain period of the year, average PTF will be lower than the some thermalPower Plants marginal production cost due to the demand and renewable generation capacity.

7.3.3. Feed in tariff

Market operators buy energy of renewable power plants in feed-in tariff with a fixed price. The difference between Market Clearing Price and fixed price is called Feed in Tariff. In this study, it is same for the two players.

7.3.4. Imbalance cost

If a market participant is short, it has to buy the energy with the maximum of prices Market Clearing Price (PTF) or System Marginal Price (SMF). If a market participants is long, it has to sell the energy with the minimum of prices (PTF, SMF). The unit cost of the portfolio between PTF and buying-selling price is called imbalance cost. Imblance cost vary depending on demand forecasting performance of the player. In this study, we will assume that forecastion performance is same but differentiate according to the customer type. Imbalance cost for high consumption segment also smaller than to the low consumption bands due to consistent consumption forecasting capability of the premium customers.

7.3.5. Market operating fee

Costs of the market operator which comes from operating the market and investments related with market operations. In this study, we assume same for all players.

7.3.6. Spread fund

The cost of the difference between daily system sales prices and system purchase prices which occurs because of rounding numbers and block offers. In this study we assume same for all players.

7.3.7. Finance cost

The cost of interest expense on short-term borrowings of the energy procurement. Players in the market financing their cash need overnight borrowing ratio. Especially energy procurement form day ahead market cause significant finance cost because of daily payments before invoice transaction. Retailers are obliged to finance this payment. In this study, we will use The Banks Association of Turkey's overnight TRLIBOR ratio to calculate finance burden of waiting collection of the bill.

7.3.8. Doubtful cost

The provision for doubtful debts is the estimated amount of bad debt that will arise from accounts receivable that have been issued but not yet collected. Collection rate are getting increase if the average consumption getting increase due to institutional management of the companies. In this study, we will use corporate market average bad debt ratio of a sample retail and generation company in Turkey.

7.3.9. Operation expense

Operating expenses are the costs for a company to run its business operations. The operational expenses for the one specific premium customer is more than to the non-premium one. To calculate unit operation expense cost we will divide average operation expense for one customer to its yearly consumption.

We will use actualized monthly cost parameter of the leading examples of the players in Turkey in 2018 to calculate the value functions. Our players are three type of private power plants and retailer. In each game, we will match one type of power plant to the retailer. In this study, we assume the group of generation and retail companies as one sample player for the ease of calculations.

7.4. Solving The Games

A two-person bargain problem consists of a feasibility set and a disagreement point. In our study, feasibility set includes all possible payoffs of the coalition of two the players and disagreement point is the singleton payoff of the players if negotiations break down.

We first define disagreement point t and find the utopian point $P_{\max}$ that is equal to maximum level of profit that the Power Plant and Retailer cooperative can create. Then we determine the feasible set P that includes the points resulting from all different combinations of the coalition of Power Plant and Retailer.

Table 7.3 : Players options.

Type	Option A	Option B
Power Plant	$P_{\max}$ (PP)	t (PP)
Retailer	t (R)	$P_{\max}$ (R)

They can also mix these options in arbitrary fractions. E.g, they can choose option a for Option A fraction X of the time, Option B for fraction Y, such that: X + Y = 1. Hence, the set P of feasible agreements is the convex hull of A($P_{\max}$(PP), t (R)) and B(t (PP), $P_{\max}$ (R)).

For both Nash, Kalai Smorodinsky solutions, we have to normalize the agents' utilities by subtracting the disagreement values, since we are only interested in the gains that the players can receive above this disagreement point.

Table 7.4 : Players normalized options.

Type	Option A	Option B
Power Plant	$P_{\max}$ (PP) - t (PP)	0
Retailer	0	$P_{\max}$ (R) - t (R)

The Nash bargaining solution maximizes the product of normalized utilities:

Max ([$P_{\max}$ (PP) - t (PP)]*X)*([$P_{\max}$ (R) - t (R)]*Y) (7.2)

The Kalai-Smorodinsky bargaining solution equalizes the relative gains - the gain of each player relative to its maximum possible gain - and maximizes this equal value:

Max ([$P_{\max}$ (PP) - t (PP)]*X) / [$P_{\max}$ (PP) - t (PP)] = ([$P_{\max}$ (R) - t (R)]*Y) / [$P_{\max}$(R) - t (R)] (7.3)

In the following, we simply connect t and Pmax with a straight line, and compute the equation of the straight line. Having calculated the bargaining set, which consists of the union of all Pareto–optimal points, we approximate the curve. Thus, having a system of two equations (these of the straight line and curve), we solve this system and obtain the KSBS $f(P,t)$ as the intersection point. See for example Figure xx

A weighted Shapley value splits the synergy payoff in proportional to the exogenously or endogenously given weights of its members. In this study, the weights are endogenous; the singleton worths of the players.

ω (PP) = t (PP) / [t (PP) + t (R)] (7.4)

ω (R) = t (R) / [t (PP) + t (R)] (7.5)

The figures below shows the unit in TL/MWh profitability The green point represents the Nash and Kalai Smorodinsky Solution. The red point represents weighted Shapley solution. The pink line is the set P of feasible agreements. The bottom left point is disagreement point t. The up right point represent $P_{\max}$ of the players. The dashed blue line connent the disagreement point t with $P_{\max}$ of the players. Details are given in appendix.

Firsly we will examine the the game between Domestic Coal Power Plant and Retailer.

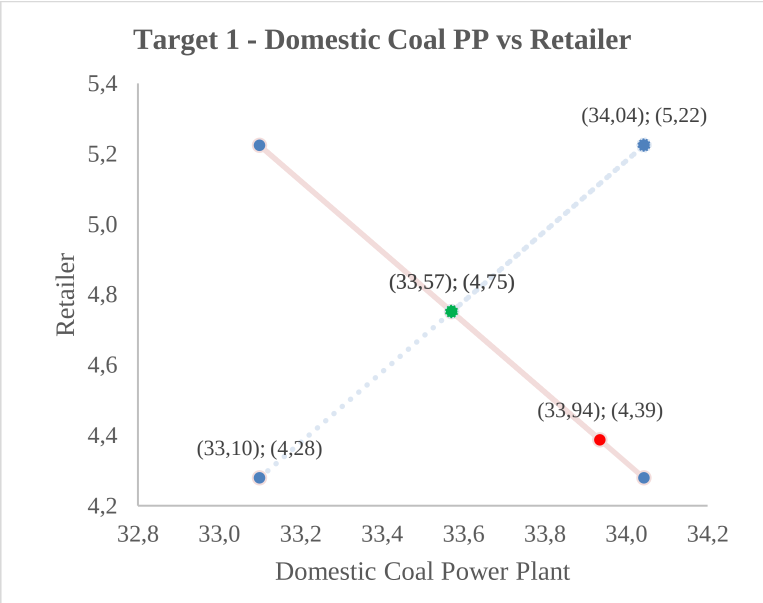

Figure 7.2 : Target group 1 - domestic coal power plant and retailer solution.

The disaggreement points are 33.10 TL/MWh for the power plant and 4.28 TL/MWh for the retailer. The best points are 34.04 TL/MWh for the power plant and 5.22 TL/MWh for the retailer. Nash and Kalai-Smorodinsky Solution distribute the total unit payoff of 38.32 TL/MWh with the share of 87.6% to power plant and 12.4% to retailer. Weighting the total payoff according to players singleton value distribute the total payoff share 88.6% to power plant and 11.4% to retailer.

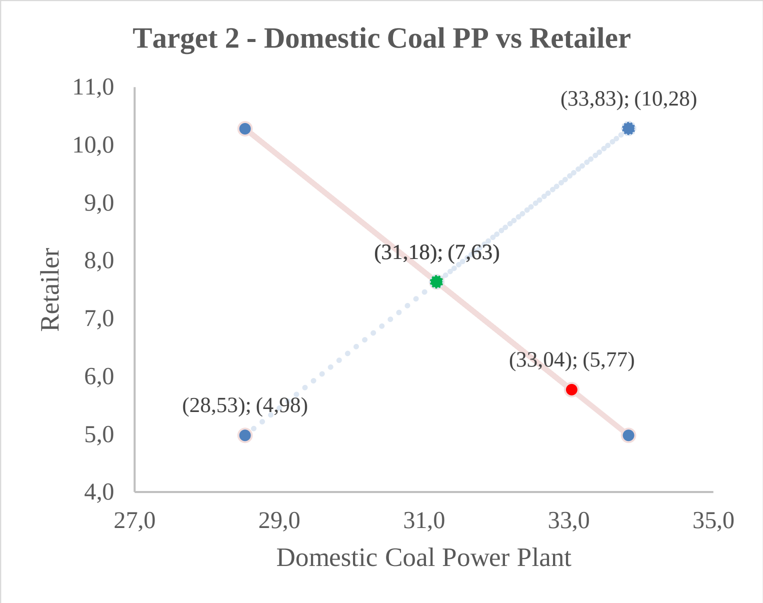

Figure 7.3 : Target group 2 - domestic coal power plant and retailer solution.

The disaggrement points are 28.53 TL/MWh for the power plant and 4.98 TL/MWh for the retailer. The best points are 33.83 TL/MWh for the power plant and 10.28 TL/MWh for the retailer. Nash and Kalai-Smorodinsky Solution distribute the total unit payoff of 38.81 TL/MWh with the share of 80.3% to power plant and 19.7% to retailer. Weighting the total payoff according to players singleton value distribute the total payoff share 85.1% to power plant and 14.9% to retailer.

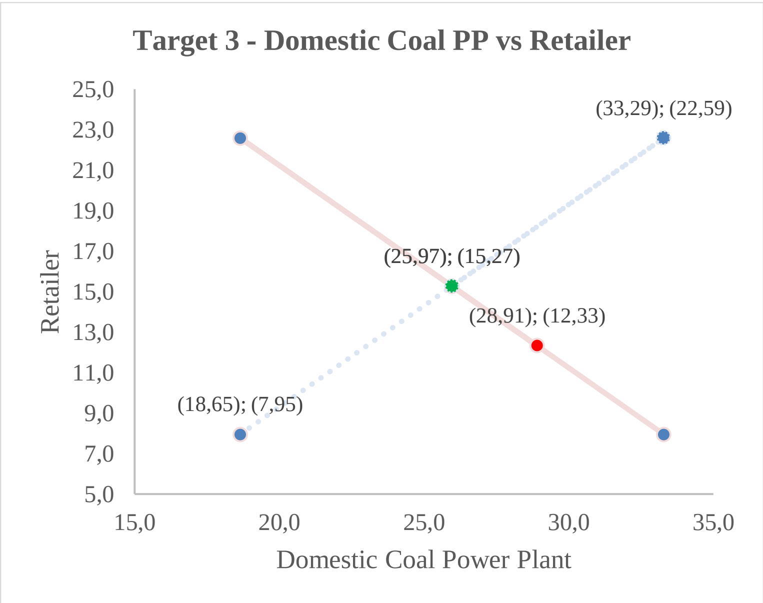

Figure 7.4 : Target group 3 - domestic coal power plant and retailer solution.

The disaggrement points are 18.65 TL/MWh for the power plant and 7.95 TL/MWh for the retailer. The best points are 33.29 TL/MWh for the power plant and 22.59

TL/MWh for the retailer. Nash and Kalai-Smorodinsky Solution distribute the total unit payoff of 41.24 TL/MWh with the share of 63.0% to power plant and 37.0% to retailer. Weighting the total payoff according to players singleton value distribute the total payoff share 70.1% to power plant and 29.9% to retailer.

Secondly we will examine the the game between Imported Coal Power Plant and Retailer.

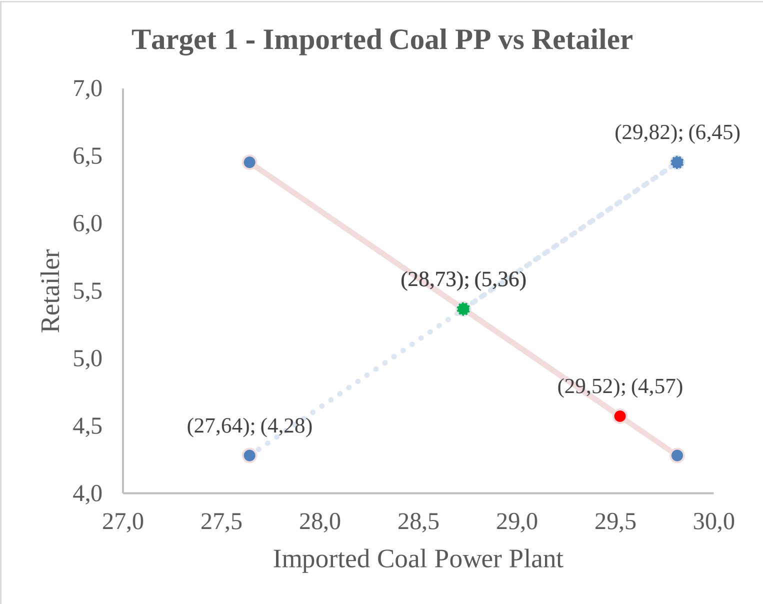

Figure 7.5 : Target group 1 - imported coal power plant and retailer solution.

The disaggrement points are 27.64 TL/MWh for the power plant and 4,28 TL/MWh for the retailer. The best points are 29.82 TL/MWh for the power plant and 6.45 TL/MWh for the retailer. Nash and Kalai-Smorodinsky Solution distribute the total unit payoff of 34.09 TL/MWh with the share of 84.3% to power plant and 15.7% to retailer. Weighting the total payoff according to players singleton value distribute the total payoff share 86.6% to power plant and 13.4% to retailer.

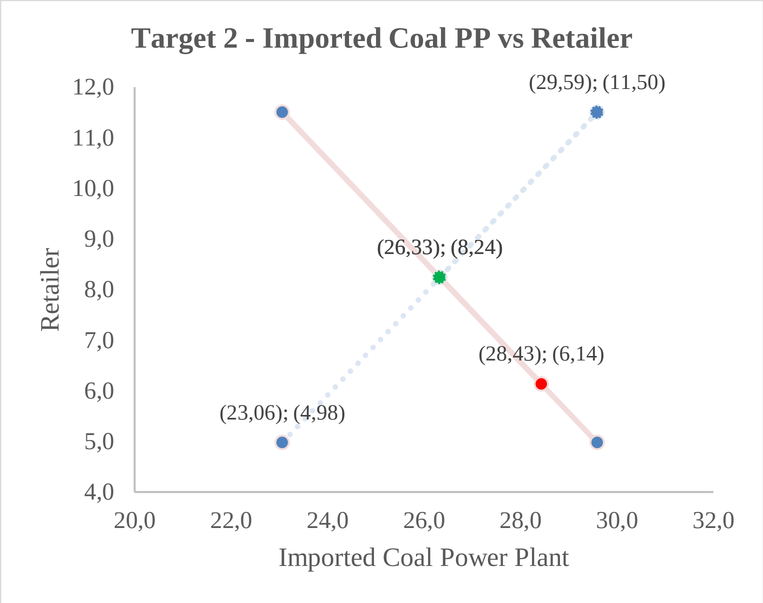

Figure 7.6 : Target group 2 - imported coal power plant and retailer solution.

The disaggrement points are 23.06 TL/MWh for the power plant and 4,98 TL/MWh for the retailer. The best points are 29.59 TL/MWh for the power plant and 11.50 TL/MWh for the retailer. Nash and Kalai-Smorodinsky Solution distribute the total unit payoff of 34.57 TL/MWh with the share of 76.2% to power plant and 23.8% to retailer. Weighting the total payoff according to players singleton value distribute the total payoff share 82.2% to power plant and 17.8% to retailer.

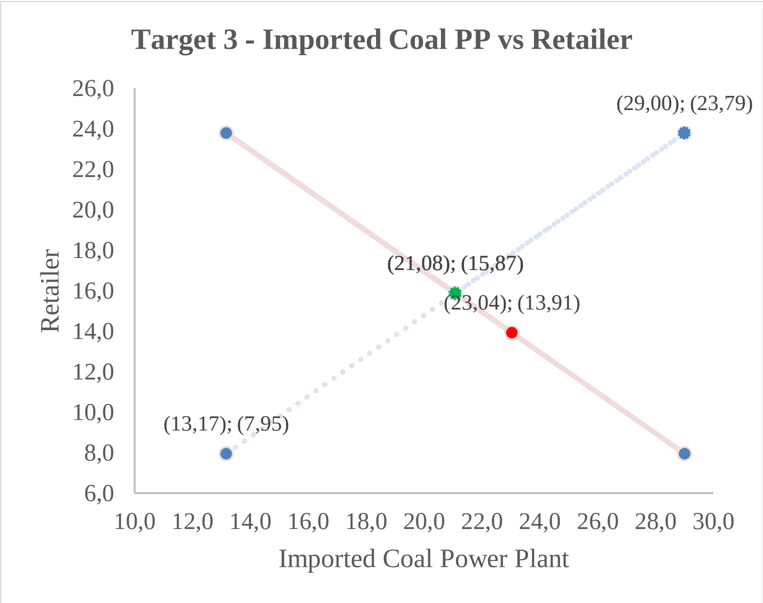

Figure 7.7 : Target group 3 - imported coal power plant and retailer solution.

The disaggrement points are 13.17 TL/MWh for the power plant and 7.95 TL/MWh for the retailer. The best points are 29.00 TL/MWh for the power plant and 23.79

TL/MWh for the retailer. Nash and Kalai-Smorodinsky Solution distribute the total unit payoff of 36.95 TL/MWh with the share of 57.1% to power plant and 42.9% to retailer. Weighting the total payoff according to players singleton value distribute the total payoff share 62.3% to power plant and 37.7% to retailer.

Thirdly we will examine the the game between Natural Gas Combined CyclePower Plant and Retailer.

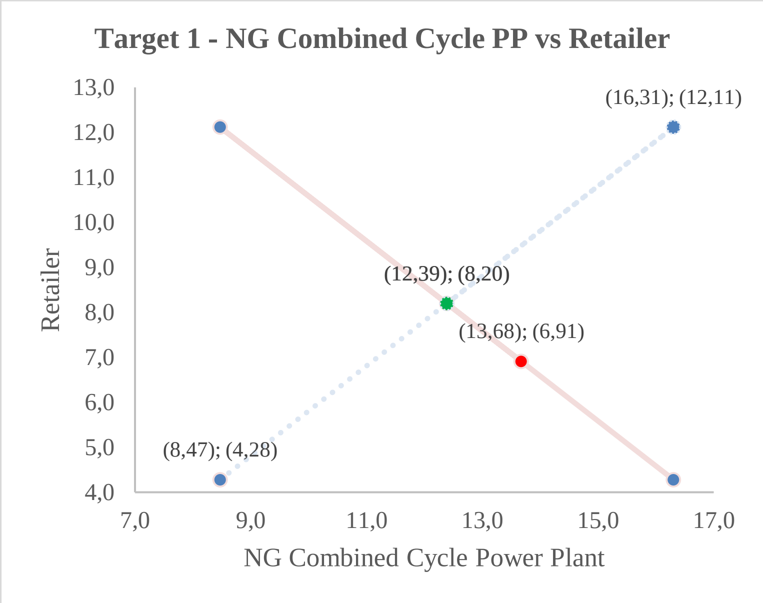

Figure 7.8 : Target group 1 – NGCC power plant and retailer solution.

The disaggrement points are 8.47 TL/MWh for the power plant and 4.28 TL/MWh for the retailer. The best points are 16.31 TL/MWh for the power plant and 12.11 TL/MWh for the retailer. Nash and Kalai-Smorodinsky Solution distribute the total unit payoff of 20.58 TL/MWh with the share of 60.2% to power plant and 39.8% to retailer. Weighting the total payoff according to players singleton value distribute the total payoff share 66.4% to power plant and 33.6% to retailer.

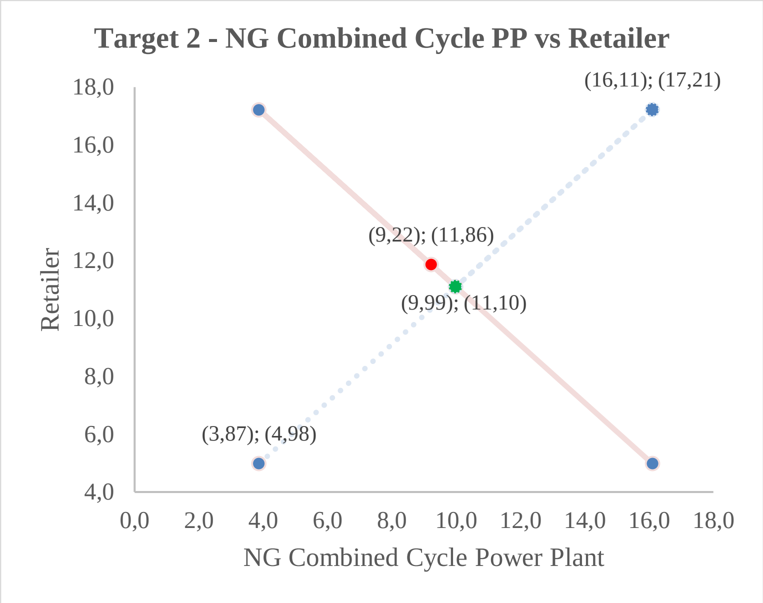

Figure 7.9 : Target group 2 – NGCC power plant and retailer solution.

The disaggrement points are 3.87 TL/MWh for the power plant and 4.98 TL/MWh for the retailer. The best points are 16.11 TL/MWh for the power plant and 17.21 TL/MWh for the retailer. Nash and Kalai-Smorodinsky Solution distribute the total unit payoff of 22.08 TL/MWh with the share of 47.4% to power plant and 52.6% to retailer. Weighting the total payoff according to players singleton value distribute the total payoff share 43.7% to power plant and 56.3% to retailer.

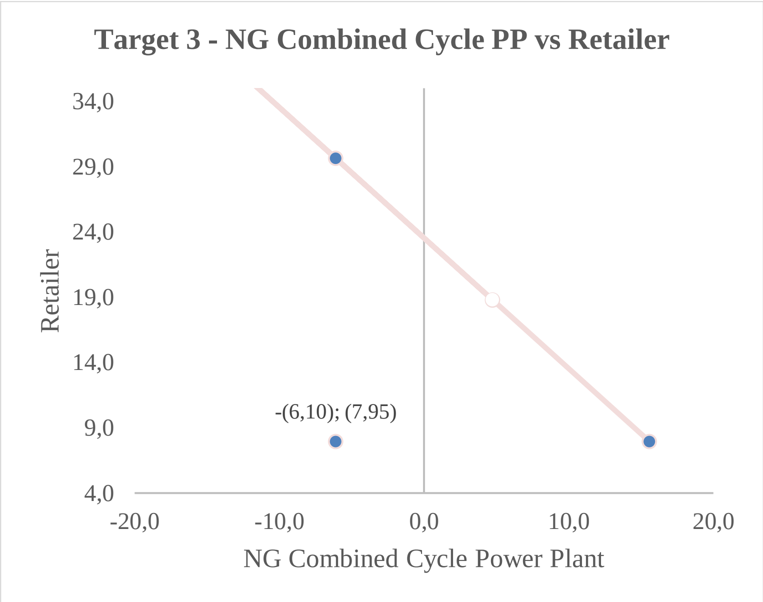

Figure 7.10 : Target group 3 – NGCC power plant and retailer solution.

The singleton value of the Natural Gas Cycle Power Plant is negative for the third target customer group. For this reason, there will be unreasonable to cooperate with power plant for the retailer.

Nash and Kalai-Smorodinsky gives the same solution for all games. Thus the utopian point Pmax, the disagreement point t are the diagonal point of a square. However, the weighted Shapley differentiated from these two solution with a different point of view.

As a result of all nine games, three different subsegment and three different power plant, we can easily say that retailers are generally have less singleton profitability according to the power plants. Furthermore, the retailers profitability is increasing when we go down to the bottom consumption subsegment. Nash and Kalai-Smorodinsky gives more payoff to the retailers according to the weighted Shapley.

8. CONCLUSIONS AND RECOMMENDATIONS

In this thesis, we analyzed how to increase the profitability of the electricity service delivered to the end user by using cooperative game theory and how to share the extra profit arising from the cooperation between the players.

Firt of all, we made some research on the the concepts of cooperation game theory and well-known applications - Nash bargaining solution, Kalai Smorodinsky bargaining solution and weighted Shapley solution. After then, we have analyzed the development of Turkish Retail Electricty Market. Thus EMRA's electricity market tariff regime for the high consumption costomer started a mandatory liberalization process, it is the essential part of retail electricity development. Then we have identified the problem of the retail electricity market as a commodity business. For solution of this problem, we sugget the cost efficient way of coaliation of the player in which both players do what they do best. We consider different value functions to reflect three different type power plant and retailer game for the three consumption segments. We see extra profit to be shared between the players. To analyse a sub-coalition between retailer and power plant of electricity market based on retail part, we apply three well-known solution concepts; two-person Nash bargaining solution, Kalai Smorodinsky bargaining solution and weighted Shapley solution respectively. While Nash and Kalai-Smorodinsky share the extra payoff by the same portion, the weighted Shapley allocates the surplus nonsymmetricly among two players upon their contribution for the coalition. These two different approaches –symmetric or nonsymmetric– can be the way of cooperation for two different point of views. If we think that the player cannot bring extra profitability alone without other, we should share it equally. However, the size of singleton value is also important. Regardless of the method of sharing, both players will earn more money compared to their initial profitability.

8.1. Practical Application of This Study

In terms of functionality, retail sale of electricity is a financial activity. Electricity is commodity and supplier and customer deals on a financial agreement. The quality of the power is same in wires that reach to the customer meters. Suppliers have no chance to improve the quality of the power. Thus, low cost operation and targeted maekting is the only way to improve the market share and the profitability. Cost effective energy sale organisations competitive by as they reflect the saving from cost to price. Cost effective operations in retail electricity market can be managed and succeed by cooperation of the players complementing each other.

In this study, the retailers are step forward by their effective low cost sales operation and customer relationship management. On the other side, the power plants have the strength power cost management. The supplementary features of the players generate extra surplus. In theoretically, bargaining solutions divide the payoffs. We have to keep in mind that, the process of coalition will not be easy for the players. To sustain the cooperation, principle of transparency should be the main shared value for the players.

The applications of the cooperative game theory models in the retail electricity market will provide solutions to the companies subject to regulated tariff regime and market risk as well as the thermal power plants that will have difficulty in the market with the new establishment of renewable power plants and nuclear power plants. While the extra profitability that will arise from the cooperation will benefit these two players in the short term, it will be transferred to the final consumer by increasing the number of bilateral cooperation in the medium-long term.

The decrease in demand for electricity is the most possible macro risk for both the retailers and power plants. Especially, it the threat for the most of the thermic power plant, which will inactive due production cost. If we consider this threat, coalition is the only way for the survival of power plants. In Turkey, most of the power plants are under the credit burden. Therefore, the uninterrupted and profitable production is essential for the power plants future financials.

In later studies, the effect of the benefits arising from bilateral cooperation on the end consumer prices can be examined. This study can also be enriched by including electricity wholesalers and natural gas and coal suppliers.

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APPENDICES

APPENDIX A:

Table A.1 : Details of graphes in Section 7.

	1. Target Customer Group (Over 50 GWh)		2. Target Customer Group (10 GWh - 50 GWh)		3. Target Customer Group (1 GWh - 10 GWh)	
	Payoff (TL/MWh)		Payoff (TL/MWh)		Payoff (TL/MWh)	
	Domestic Coal Power Plant	Retailer	Domestic Coal Power Plant	Retailer	Domestic Coal Power Plant	Retailer
Disagreement Payoffs	33,10	4,28	28,53	4,98	18,65	7,95
Best Payoffs	34,04	5,22	33,83	10,28	33,29	22,59
Nash Bargaining Solution	33,57	4,75	31,18	7,63	25,97	15,27
Kalai-Smorodinsky Solution	33,57	4,75	31,18	7,63	25,97	15,27
Weighted Shapley Solution	33,94	4,39	33,04	5,77	28,91	12,33

	1. Target Customer Group (Over 50 GWh)		2. Target Customer Group (10 GWh - 50 GWh)		3. Target Customer Group (1 GWh - 10 GWh)	
	Payoff (TL/MWh)		Payoff (TL/MWh)		Payoff (TL/MWh)	
	Imported Coal Power Plant	Retailer	Imported Coal Power Plant	Retailer	Imported Coal Power Plant	Retailer
Disagreement Payoffs	27,64	4,28	23,06	4,98	13,17	7,95
Best Payoffs	29,82	6,45	29,59	11,50	29,00	23,79
Nash Bargaining Solution	28,73	5,36	26,33	8,24	21,08	15,87
Kalai-Smorodinsky Solution	28,73	5,36	26,33	8,24	21,08	15,87
Weighted Shapley Solution	29,52	4,57	28,43	6,14	23,04	13,91

	1. Target Customer Group (Over 50 GWh)		2. Target Customer Group (10 GWh - 50 GWh)		3. Target Customer Group (1 GWh - 10 GWh)	
	Payoff (TL/MWh)		Payoff (TL/MWh)		Payoff (TL/MWh)	
	Natural Gas Combined Cycle	Retailer	Natural Gas Combined Cycle	Retailer	Natural Gas Combined Cycle	Retailer
Disagreement Payoffs	8,47	4,28	3,87	4,98	-6,10	7,95
Best Payoffs	16,31	12,11	16,11	17,21	15,58	29,63
Nash Bargaining Solution	12,39	8,20	9,99	11,10	4,74	18,79
Kalai-Smorodinsky Solution	12,39	8,20	9,99	11,10	4,74	18,79
Weighted Shapley Solution	13,68	6,91	9,22	11,86	-77,49	101,02

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