ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

A COMPARATIVE EVALUATION STUDY ON INTELLECTUAL PROPERTY VALUATION METHODS

M.Sc. THESIS

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Department of Management Engineering

Management Engineering Programme

APRIL 2018

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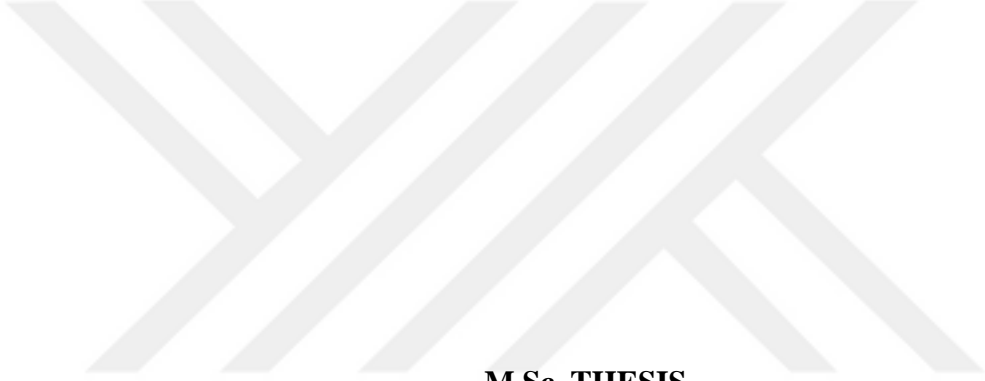**M.Sc. THESIS**

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Aysun Beyazkılıç Koç, a M.Sc. student of ITU Graduate School of Science Engineering and Technology student ID 507121003, successfully defended the thesis entitled "A COMPARATIVE EVALUATION STUDY ON INTELLECTUAL PROPERTY VALUATION METHODS", which she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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FOREWORD

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Aysun Beyazkılıç Koç
Mathematics Engineer
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ABBREVIATIONS

ASTP-Proton	**:**	Association of European Science and Technology Transfer Proffesionals
ATTP	**:**	Aliance of Technology Transfer Proffesionals
CapEX	**:**	Capital expenditure
CAPM	**:**	Capital Asset Pricing Model
CLP	**:**	Certified Licensing Proffesionals
CPC	**:**	Cooperative Patent Classification
DCF	**:**	Discounted Cash Flow
EBIT	**:**	Earnings Before Interest and Taxes
EBITDA	**:**	Earnings Before Interest, Taxes, Depreciation and Amortization
EC	**:**	European Commision
EPC	**:**	European Patent Convention
EPO	**:**	European Patent Office
IA	**:**	Intangible Asset
INV	**:**	Investment
IP	**:**	Intellectual Property
IPC	**:**	International Patent
IPR	**:**	Intellectual Property Right
IT	**:**	Information Technologies
LES	**:**	Licensing Executives Society
LP	**:**	License Price
MAP	**:**	Maximum Achievable Profit
NCF	**:**	Net Cash Flow
NOPAT	**:**	Net Operating Profit After Tax
NPV	**:**	Net Present Value
OpEX	**:**	Operational Expenditures
PATLIB	**:**	Patent Information Centres
PMV	**:**	Patent Monetary Value
PV	**:**	Present Value
R & D	**:**	Research and Development
RaNPV	**:**	Risk Adjusted Net Present Value
RFR	**:**	Relief From Royalty
RTTP	**:**	Registered Technology Transfer Proffesionals
STI	**:**	Science and Technology Istatistic
TP	**:**	TURKPATENT
TURKPATENT	**:**	Turkish Patent and Trademark Office
TRL	**:**	Technology Readiness Level
TTO	**:**	Technology Transfer Office
TUBITAK	**:**	Scientific And Technological Research Council Of Turkey
USIMP	**:**	University-Industry Collaboration Platform
VAL	**:**	Valuation

VC	**:**	Venture Capital
WACC	**:**	Weighted average Cost of Capital
WIPO	**:**	World Intellectual Property Organization
PMP	**:**	Project Management Proffesionals

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A COMPARATIVE EVALUATION STUDY ON INTELLECTUAL PROPERTY VALUATION METHODS

SUMMARY

Intellectual property valuation is a major topic that have significant effect on technology development, innovativeness, R&D, and manufacture based R&D, return on investment/income and completion performance in technology development and innovation ecosystems. Therefore, the awareness about IP and IP valuation is essential for growth and competitiveness of companies, universities, public institutions and government agencies. According to Triple Helix technology development ecosystem approach, The Universities have a pioneering role for value adding R&D activities. Therefore, R&D management and intellectual propery management are key roles of University Technology Transfer Offices (TTOs). The activities of TTOs in Turkey and all over the world underlined and proved the importance of the commercialization of IPRs in deployment and diffusion of technologies and innovations. The intellectual properties may be valued for various purposes such as making strategic decisions, merger and acquisition processes of companies including joint venture, negotiations and transactions to sell or license intellectual properties, court proceedings, taxation purposes etc. As can be seen from the Science and Technology Indicators (STI) statistics, in recent decades there is a significantly increasing trend in the number of global patent applications and registrations/grants which proved the fact that IP awareness has reached a certain level. This increase in patenting and IP awareness also had been evident for Turkey. As perceptions and initiatives regarding the registration of technology, invention, intellectual property rights show a rapid rise in Turkey in recent years. Therefore, intellectual property issues were addressed within the scope of several state policies for Universities and Industries to support technology oriented growth. To know the value of an owned IP portfolio is strategically important for owners and inventors whether they are legal entitities or natural persons. At this point, the purpose of the valuation and the preference of the appropriate valuation method gains importance and worths being searched about as they affect both the effectiveness of applications and business results.

There are many methods which are based on quantititative or qualititative analyses to value an IP. There exist a large variety of sources ont the definition or application process of the IP Valuation methods in literature, but there is still room for research for applications, related cases and preference criteria of each method as the theoretical and practical publications are very limited. Application of some methods requires high level expertise and know how about IP valuation. Before starting the IP valuation process there are some fundamental prerequisite steps such as setting the purpose of valuation, acquiring deep knowledge about the IP technology being valued, definition of the type of the process of patent application, defining TRL of IP, identifying the available data and etc. All fundamentals affect the preference for the valuation methods. Even if the valuers meet almost all requirements of a valuation method, they

may still not be able to use the method effectively because of its difficulties/challenges. As well, the opposite condition can also may apply. Moreover, in literature, there are limited studies about patent valuation practices in developing country contexts. Similarly limited number of studies are available for the patent valuation in Turkey. Besides this, IP valuation experience and knowledge of experts are insufficient in Turkey. All types of quantitative methods were not explored by comparing all methods relatively with each other and also the experience and competency of experts in all of the IP valuation methods were not searched as a whole. In general, the comparisons of IP valuation methods were made and main evaluation approaches were exemplified in categories of cost approach, market approach, income approach and sometime advanced method. Therefore, a study based on experiences and knowledge of experts is essential because of the fact that the preference of the appropriate valuation method is highly important for all actors in technology transfer ecosystems.

To fulfill the gap of knowledge, the main goal of this thesis study is to explore the practices of patent valuation methods and determine the applicability and preferences of the quantitative IP valuation methods in different contexts and in various cases of IP ecosystems of technology transfer. based on the experiences and knowledge of experts in this field.

For this aim, within a qualitative research methodology which utilized the experiences of the IP valuation experts and professionals in technology transfer ecosystem in Turkey, USA and Europe, data were collected about level of expert knowledge, level of usage for different quantitative IP valuation methods, the purpose of using different IP valuation methods, challenges or benefits of applying the methods in patent valuation, the appropriate sectors to apply the different patent valuation methods, the combined application of the valuation methods.

For verifying the research, I counducted structured in-depth interviews with IP valuation experts from Universities, TTOs, Patent Offices or Intellectual Capital Firms and national or international patent organizations at various meetings and conferences. As well, a two-round Delphi survey was made for gaining more insights on the experts' perceptions about the IP valuation methods by taking the literature review and expert opinions into account. Survey questionnaire was designed by the dimensions and concepts that were derived from theoretical background/literature. The Delphi survey consists of 18 questions which are focusing on 18 quantitative valuation methods, namely Reproduction method, Replacement method, Sales comparison method, Comparable Profit Margin Method, Discounted Cash Flow Method, Incremental Income Method, Profit Split Method, Maximum Achievable Method, Technology Factor, Return on Investment Ratio, Relief from Royalty Method, Rules of Thumb, the 5% of Sales Method, Profit Differential Method, Risk Adjusted NPV Method, Probability Tree Analysis, Monte Carlo Method and Real Option Pricing Method. Total of 15 experts participated to the Delphi survey.

Findings reveal that replacement cost, reproduction cost, sales comparison, DCF, the 25 percent rule, comparable profit margin and RFR methods are widely preferred and known IP valuation methods which are priorly expressed by the respondent experts of this study. Advanced valuation methods are much rarely known and used when compared to previously stated methods. According to our participant experts' opinions, Cost methods, "the 5% of sale" method and "Rules of Thumb: 25% percent rule" method are easy to apply. Survey and interviews showed that "Patent pending technologies" or "nonproprietary technologies" can also be valued by replacement method, reproduction method and sales comparison method (which are mostly referred

methods for this kind of valuations). In order to make effective and well-supported estimates of an IP value, more than one valuation method which can be selected according to the objectives and different situations and qualitative parameters should be considered because of their indirect effect to the valuation.

For Universities' IP valuation processes, the replacement cost, the 25% percent rule, the 5% of sales, reproduction cost, sales comparison and RFR method were commonly indicated by the respondent experts and occurred as widely preferred methods. DCF method was found to be a preferred method to value start-up's patents. On the other hand, the technologies at 6th or higher Technology Readiness Levels are generally stated as most suitable for valuation. However, suitable TRLs are changing for each valuation method and requires further elaboration.

Keywords: Intellectual Property Rights, IP Valuation Methods, Delphi Method

FİKRİ SINAİ MÜLKİYET HAKLARI DEĞERLEME YÖNTEMLERİNİN KARŞILAŞTIRMALI DEĞERLENDİRİLMESİ ÜZERİNE BİR ÇALIŞMA

ÖZET

Günümüzde, fikri ve sınai mülkiyet haklarına ilişkin değerleme çalışmaları, teknoloji geliştirme, inovasyon, Ar-Ge ve üretim temelli Ar-Ge, yatırımın geri dönüşü, teknoloji geliştirme ve inovasyon ekosistemlerinde performansı üzerinde önemli etkiye sahip bir konudur. Bu nedenle, fikri sınai mülkiyet hakları ve sahip olunan hakların değerini bilmesi; şirketlerin, üniversitelerin, araştırma merkezlerinin ve kamu kurumlarının gelişmesi ve buna bağlı olarak rekabet edebilirlik düzeylerinin artması için gerekli ve oldukça önemlidir. Triple Helix teknoloji geliştirme ekosistemi yaklaşımına göre, üniversiteler ulusal ve uluslararası kapsamda katma değerli Ar-Ge faaliyetleri gerçekleştirilmesi konusunda öncü bir role sahiptir. Bu sebeple, Ar-Ge yönetimi ve fikri sınai mülkiyet hakları süreç yönetimi, Üniversite Teknoloji Transfer Ofisleri (TTO)'nin ana faaliyetleri arasındadır. Türkiye'de ve dünya genelinde TTO'ların faaliyetleri teknoloji transferi için sınai mülkiyet haklarının ticarileşmesinin önemini vurgular ve kanıtlar niteliktedir. Patentler ve diğer sınai haklar stratejik kararlar vermek, ilgili hakların satışı veya lisanlanması, şirket birleşmeleri, ayrılmaları veya devralınmaları, hak ihlalelerine bağlı dava işlemleri, vergilendirme gibi çeşitli amaçlarla değerlenebilir.. Bilim ve Teknoloji Göstergeleri istatistiklerine göre son on yılda artan ulusal ve uluslararası patent başvuru ve tescil sayıları, FSMH bilincinin de belirli bir seviyeye ulaştığını göstermektedir. Türkiye'de de patent farkındalığında ve buna bağlı patent başvurularında artış gözlemlenmektedir. Gelişen algı ile, girişimcilik, buluş, FSMH, ticarileştirme gibi konular çok konuşulur ve üzerinde çalışmalar yapılır hale gelmiştir. Hatta fikri sınai mülkiyet konuları, teknoloji odaklı büyümeyi desteklemek için üniversiteler ve sanayi firmaları için çeşitli devlet politikaları kapsamında da ele alınmıştır. Hem tüzel hem de gerçek kişilerin sahip olunan bir FSMH portföyünün değerini bilmesi stratejik olarak önemlidir. Bu değerin belirlenmesi için değerlendirmenin amacı ve uygun değerleme yönteminin seçilmesi, hem seçilen yönteme bağlı uygulamayı hem de değerleme sonucunu etkilediğinden oldukça kritik bir konudur.

Fikri sınai mülkiyet haklarının değerlemesi için nicel veya nitel analizlere dayanan birçok yöntem vardır. Literatürde bu değerleme yöntemlerinin tanımlarına ya da uygulama süreçlerine ilişkin pek çok kaynak bulunmaktadır, ancak uygulamada her bir yönteme ilişkin örnek vaka içeren çalışmalar ve değerlenecek teknolojiye, farklı senaryolara göre en uygun değerleme yöntemini belirlemeye yönelik kriterlere ilişkin çalışmalar oldukça sınırlıdır.Bazı yöntemlerin uygulanması, önemli ölçüde bilgi ve uzmanlık gerektirir. Değerleme sürecinde değeri belirlenecek buluş hakkında derin bilgiye sahip olunması, değerleme amacının belirlenmesi, patent başvurusu varsa tescil edilip edilmediği, henüz tescil edilmedi ise başvurunun hangi aşamada olduğu bilinmeli ve teknolojinin olgunluk seviyesinin belirlenmesi gibi öncelikle bilinmesi/belirlenmesi gereken hususlar vardır. Temelde bilinmesi gereken bilgiler toplandığı takdirde değerleme süreci daha güvenilir olacak ve bu durum patentin

değerindeki sapmaları minimize edecektir. Temelde bilinmesi gereken bilgiler değerleme yönteminin seçimini etkiler. Ancak ilgili değerleme yöntemlerinin tüm gereklilikleri sağlansa bile, bazen uygulamaya yönelik zorluklarla karşılaşılmaktadır ve bazı zorluklar nedeniyle yöntemler bazen etkin bir şekilde kullanılamazlar. Bazı durumlarda aksi de geçerli olabilir, avantajları sebebi ile herhangi bir yöntem eldeki veri kısıtına rağmen tercih edilebilmektedir. Patent değerleme uygulamalarına yönelik çalışmalar Türkiye'de ve dünyada sınırlı sayıdadır. Bunun yanı sıra, Türkiye'de Patent değerleme deneyimi ve uzman bilgisi yeterli değildir. Tüm nicel değerleme metotlarını birbirleriyle göreceli olarak karşılaştırma çalışmasına ve bu yöntemlerin ticarileştirme ve değerleme uzmanlarının deneyimlerini araştıran bir çalışmaya rastlanılmamıştır. Genelde karşılaştırma çalışmalarında nicel yöntemler, ana yöntemler olan maliyet yöntemi, pazar yöntemi ve gelir yöntemine ve bazen de gelişmiş yöntemlere göre yapılmış olup bu yöntemlere bağlı tüm alt yöntemleri ele alan bir karşılaştırma çalışması yapılmamıştır. Uygun değerleme yöntemini kullanmak, teknoloji transferi ekosistemlerindeki tüm aktörler için son derece önemli olduğundan, teorik bilgi ile birlikte, değerleme uzmanlarının bilgi ve deneyimlerine dayanan bir çalışma gerekliliği ortaya çıkmıştır.

Bu çerçevede, bu tez çalışmasının amacı, patent değerleme uygulamalarını araştırmak ve farklı teknolojilere ve durumlara göre nicel değerleme yöntemlerinin uygulanabilirliğini ve seçilme kriterlerini FSMH değerleme uzmanlarının deneyimlerine ve bilgilerine dayanarak belirlemektir.

Bu amaçla, Türkiye'de, Avrupa'da ve Amerika'da teknoloji transferi alanında çalışan FSMH değerleme uzmanlarının ve profesyonellerinin deneyimlerinden ve bilgilerinden faydalanan nitel bir araştırma yapılmıştır. Uzmanların farklı nicel değerleme yöntemleri hakkında bilgi sahibi olma durumu, farklı nicel değerleme yöntemlerini kullanım durumu, bu yöntemleri kullanma amacı, yöntemlerin zorlukları ve avantajları, sektörlere ya da teknolojilerin olgunluk seviyelerine göre uygun yöntemler hakkında bilgiler toplanmıştır.

Araştırma kapsamında, üniversiteler, TTO'lar, patent ofisleri veya teknoloji yatırım odaklı şirketlerinde çalışan patent değerleme uzmanları ile çeşitli toplantılarda ve konferanslarda, ulusal veya uluslararası patent seminerlerinde konu ile ilgili derinlemesine görüşmeler yapılmıştır. Literatürden derlenen bilgiler ve konu ile ilgili görüşülen uzmanlardan alınan görüş ve öneriler ışığında, uzmanların IP değerleme yöntemlerine ilişkin algılarını daha iyi anlamak ve deneyimlerine göre uygun değerleme yöntemlerini belirlemek için iki tur Delphi anketi yapılmıştır. Anket soru formu, literatürden elde edilen teorik bilgi, ölçek ve kavramlara uygun olarak hazırlanmıştır. Delphi anketinde on sekiz kantitatif değerleme yöntemine odaklanılmıştır. Bu yöntemler; Yeniden Üretme Metodu, Yerine Koyma Metodu, Satış Karşılaştırma Metodu, Karşılaştırmalı Gelir Farkı Metodu, İndirgenmiş Nakit Akışı Metodu, Gelir Artış Metodu, Kar Dağıtım Metodu, Ulaşılabilir Maksimum Kar Metodu, Teknoloji Faktörü, Yatırımın Geri Dönüş Analizi, Teliften Kurtulma Metodu, %25 Kuralı, Satışın % 5'i Kuralı, Karşılaştırmalı Kuvvetli Yanlar Analizi, Risk Ayarlamalı İndirgenmiş Nakit Akışı Metodu, Olasılık Ağacı Analizi, Monte Carlo Metodu ve Reel Opsiyon Fiyatlandırma Metodu. Delphi anketine toplam 15 uzman katılım sağlamıştır.

Edinilen bu bulgular, ankete katılan uzmanlara göre Yeniden Üretme Metodu, Yerine Koyma Metodu, Satış Karşılaştırma Metodu, İndirgenmiş Nakit Akışı Metodu, %25 Kuralı, Karşılaştırmalı Gelir Farkı Metodu ve Teliften Kurtulma Metodu yöntemlerinin yaygın olarak tercih edildiğini ve bilindiğini ortaya çıkarmıştır.

Gelişmiş değerleme yöntemleri olan Risk Ayarlamalı İndirgenmiş Nakit Akışı, Olasılık Ağacı Analizi, Monte Carlo Metodu ve Reel Opsiyon Fiyatlandırma metotlarının diğer belirtilen yöntemlerle karşılaştırıldığında daha az bilindiği ve paralel olarak daha az olarak kullanıldığı görülmüştür. Ayrıca, maliyet yöntemleri, Satışın %5'i Kuralı ve %25 Kuralı uygulaması kolay olan yöntemlerdir. Henüz tescil edilmemiş ama başvuru süreci devam eden patentlere veya patentle korunmayan/ korunması tercih edilmeyen teknolojiler için ise Yeniden Üretme Metodu, Yerine Koyma Metodu ve Satış Karşılaştırma Metodunun uygun olduğu belirlenmiştir.

Patentin değerini belirlerken iyi bir tahmin yapmak için, değerleme amacına ve farklı durumlara göre birden fazla yöntemin kullanılması ve nitel faktörler de dikkate alınmalıdır.

Üniversitelerdeki patent değerleme süreçlerinde, Yeniden Üretme Metodu, % 25 Kuralı, Satışların % 5'i, Yerine Koyma Metodu, Satış Karşılaştırma Metodu ve Teliften Kurtulma Metodu ankete katılan uzmanlar tarafından en çok seçilen yöntemlerdir. Filiz şirketlerinin patentlerini değerlemek için en uygun yöntemin ise İndirgenmiş Nakit Akışı Metodu olduğu görülmüştür. Teknoloji olgunluk seviyesi 6 ve 6'dan yüksek olan teknolojilerin değerlemeye daha uygun olduğu ortaya çıkmıştır. Ancak her bir değerleme yöntemi için uygun teknoloji olgunluk seviyelerinin değişmekte olduğu görülmüş olup daha derin ve kapsamlı bir çalışma gerekmektedir.

Anahtar Kelimeler: Fikri Sınai Mülkiyet Hakları, Patent Değerleme Yöntemleri, Delphi Metodu

1. INTRODUCTION

In global R&D and innovation ecosystem, intellectual property has become most important right to protect the owned competitive technology. The development of technology is a critical competency for achieving competitive advantage and sustainability; however, integrating it into the economy and commercializing it plays the major role in deploying the value of the developed technologies. In the era of rapid technology development and innovation which results in enormous increase in number of patents issued, the effectively determining the value of owned rights has become a necessity for all stakeholders in patenting and licensing value chain. Due to the fact that even technology giant companies face the threat of being convicted for billions of dollars by being accused of damaging free trade and violating their competitor's rights, there had been a rise in the awareness about the importance of intellectual property rights. Aligned with these global trends, in recent years, perception and initiatives regarding the registration of technology, invention, intellectual property rights showed a rapid rise in Turkey as well. Therefore, intellectual property issues were addressed within the scope of several state policies to support technology-oriented growth of Turkish economy. According to Corporate Tax Law (dated 13/06/2006 numbered 5520), 50% of the profits of companies and universities that were obtained from the activities of the Patent and Utility Model Documents issued by the Turkish Patent Institute has been exempted since 2014. According to the regulation of the Council of Ministers on the second article of Technology Development Zones Law numbered 4691, it is necessary to obtain a patent or equivalent certificate such as utility model, design, copy right and etc. for companies which operate in Technoparks so that they can be exempted from corporate taxation of income from the sale of their intangible assets. Since 2014, TUBITAK has issued various incentives for patent applications, in order to increase the number of national and international patent applications and to encourage natural or legal entity to file patent applications in Turkey.

Besides all these, the activities of University TTOs in Turkey and all over the world underlined and proved the importance of the commercialization of IPRs. Many

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universities have established Technology Transfer Offices which act as the major actor of technology transfer in Universities and in Triple Helix Model of innovation. TTOs are usually responsible for transferring the university's intellectual property to the industry or government institutions in an appropriate and cost-effective manner and they should be knowing the value of their patent portfolio for strategic purpose or a commercial transaction. The intellectual properties may be valued for various purposes such as making strategic decisions, merger and acquisition processes of companies including joint venture, negotiations and transactions to sell or license intellectual properties, court proceedings, taxation purposes etc. At this point, the purpose of the valuation and the preference of the appropriate valuation method affect both the effectiveness of applications and business results. Additionally, the University Rankings for Innovativeness and Entrepreneurship performances are published every year in Turkey and in all over the World such as "Times Higher Education Ranking" organized by Times Higher Education platform and Ranking of the Entrepreneurial and Innovative University Index organized by Council of Higher Education. These rankings provide the definite list of best local universities or world's best universities through evaluation of teaching, research, international outlook, R& D income, and knowledge transfer or technology transfer income. These rankings are also an indicator that emphasize the importance of technology transfer/knowledge transfer, and accordingly the value of IPs.

However, despite the high need for research on IP evaluation methods, there are limited studies about patent valuation practices in developing contexts, similarly limited number of studies are available for the patent valuation in Turkey in the literature. In these studies, the indicators which affect the value of an IP asset, patent valuation methods, strengths and weaknesses of the patent valuation methods are explored and defined. In some of the studies only some of the practices in different valuation methods are included. Qualitative methods, quantitative methods and their sub-criteria or methods were explicated. For quantitative methods, the discussions or comparisons are about the main quantitative approaches such as cost approach, market approach and income approach in general. Actually, there are many methods under the main quantitative methods and advanced methods in the literature. At this point, the preference of the appropriate valuation method is highly important for all actors in technology transfer ecosystems.

Considering this gap in research and practice factors, this thesis study aims to explore the applicability of and preferences on the quantitative IP valuation methods in different contexts and cases of IP ecosystems of technology transfer. After identifying the classifications and dimensions of IP valuation method selection by literature research and content analysis, Data is collected through a two-round Delphi survey and structured in-depth interviews with IP valuation experts from Universities, TTOs, Patent Offices or Intellectual Capital Firms and national or international patent organizations. Based on the information that was provided from the knowledgeable experts of IP valuation, we determined the level and patterns for and the usage of quantitative IP valuation methods, the challenges or benefits of applying the methods in patent valuation, the appropriate sectors to apply the different patent valuation methods, the combined application of the valuation methods and etc.

This thesis study consists of three parts. In the first part, literature review regarding definitions of intellectual property rights, the viewpoint on IPR in Turkey and the World, the definitions and discussions of the value, valuation and IP valuation methods have been presented. Second part is the methodology section where the definitions and discussions of the research methods and techniques used in this thesis study are explained. Third part presents the process and findings of the Delphi survey and interviews. Finally, we elaborated the summary of findings, discussions, conclusions, limitations of this thesis study and the recommendations for future research.

2. LITERATURE REVIEW

An extensive literature review on intellectual property rights, the statistic of IPR registration and application all over the World, the history of IPR in Turkey and in the World, value and valuation, IP valuation process, reasons of IP valuation, different patent valuation methods. The remainder of this section is structured as follows: Section 2.1 outlines the main intellectual property rights. The statistic of intellectual property rights in Turkey and all over the World is presented in Section 2.2. and 2.3. An extensive literature review on value and valuation, IP valuation process, reasons of IP valuation, different patent valuation methods and is presented in Section 2.4.

2.1 Description of Intellectual Property Rights

Intellectual property rights allow their owners to make use of their patents, industrial design, copyright for their investment and work in a creation, therefore, IPR are similar to other proprietary rights.

The significance of intellectual property was first acknowledged in the Paris Convention for the Protection of Industrial Property (1883) and the Berne Convention for the Protection of Literary and Artistic Works (1886). These two treaties are administered by the WIPO (WIPO). The types of intellectual property rights are expressed in the next sections.

2.1.1 Patent

"A patent can be described as an exclusive right of limited duration over a new, non-obvious invention capable of industrial application where the right - to sue others for infringement, is granted in return for publication of the invention" (Pitkethly, 1997). According to the WIPO, "a patent is an exclusive right granted for an invention to a product or a process that generally provides a new way of doing something or offers a new technical solution to a problem. To get a patent, technical information about the invention must be disclosed to the public in a patent application".

Patents bring their owners an advantage as a temporary monopoly on the exploitation of the new technology that can turn into innovation. Innovations and patents make important contributions towards economic growth (Rosenberg, 2004). According to EPO, the invention protected by patent can be commercially produced, used, distributed, imported or sold by others only depend on the permission of the patent owner. Without any permission of the owner the 3th parties cannot use or commercial the patent. The exclusive rights generally can be used to the country or territory in which the patent filed or granted, according to the laws of region. The protection is granted for usually 20 years after the application date.

According to the European Patent Convention (EPC), patents are granted only for inventions which are new, have an inventive step and can be industrially manufactured. If an invention was not known to the public in any form, is not obvious to a person skilled in the art, and can be manufactured or used industrially, it is meet the requirements of patent granting.

In addition, as patent information is published by patent offices, the technical knowledge of the world is also enriched (EPO).

However, patenting in some cases is not covered by the invention, so it cannot be patented in these matters. According to Turkish Law of Intellectual Property Rights (22/12/2016 dated 6769 numbered) on the Protection of Patent Rights, Article 82 sets forth the issues that cannot be patented;

1. Discoveries, scientific theories, methods of mathematics;

2. Plans, procedures and rules for mind, trade and gaming activities;

3. Literature and art works, science works, creatures with aesthetic qualities, computer software;

4. Procedures for which there is no technical direction concerning the compilation, arrangement, submission and transmission of information;

5. Surgical and therapeutic procedures applicable to the human or animal body and diagnostic procedures relating to the human and animal body.

Moreover, even if they are inventions, no patent is granted in these matters;

1. Inventions that are contrary to public order or general morality.

2. Plant or animal species or plant or animal breeding methods based on substantial biological principles.

2.1.2 Utility model

"Generally speaking, utility models protect technical innovations which might not qualify for a patent and can be protected in some countries through registration" (EPO).

A utility model is similar to patents. There is no difference with the description of the invention in the patent document and the definition of the invention in the application of the utility model. For a utility model granted, the requirement of "novelty" is always to be met, but "inventive step" or "non-obviousness" may be much lower or absent altogether (Tüzüner, 2011, p. 47)

In general, utility models applications are often preferred for innovations that may not have the patentability criteria.

The differences between utility models and patents are stated in below (WIPO):

- The term of protection for utility models depends on the countries and it is usually between 7 and 10 years.

- In most countries where utility model protection exists, patent offices do not review applications based on pre-registration requirement. This means that registration is easier and faster and it takes usually six months.

- Utility models costs are less than patent costs

- In some countries, useful model protection can only be obtained for only for product (not for process) which can be obtained specific technologies.

With the According to Law No. 6769 in Turkey, it becomes a requirement that patent offices do examine applications. The differences between utility model and patent are the following Table 2.1.

Table 2.1 : The differences between utility model and patent (TURKPATENT).

	Patent	Utility Model
Novelty	Yes	Yes
Inventive Step	Yes	No
Industrial applicability	Yes	Yes
Methods protection	Yes	No
Chemicals protection	Yes	No
Research report	Yes	Yes
Examination report	Yes	No
Publishing	Yes	Yes
Protection period	20 Years	10 Years

2.1.3 Industrial design

According to the Turkish Law of Intellectual Property Rights (22/12/2016 dated 6769 numbered), a design is a view resulting from features such as shape, line, color, material, form or surface texture of all or a part of the product or of the ornament on it. The product refers to any combination of industrial objects or any hand-produced object, as well as a compound product or parts thereof, packaging, objects, multi-object perceptions, graphical symbols and typographic characters, except for computer programs. A combined product consists of parts that can be replaced or renewed. Design, registered in accordance with the provisions of this Law, the registered design shall be protected as unregistered design if it is presented to the public in Turkey for the first time. Presenting to the public; exhibition, sales, such as ways to drive the market, use, description, publication, promotion or similar purposes. The disclosure of the design to a third person on the condition of confidentiality does not mean presenting to the public. The duration of protection for registered designs is five years from the date of application. This period can be extended up to a total of twenty-five years by renewing it for periods of five years. The duration of protection for unregistered designs is three years from the date on which the design requested for protection is first offered to the public (22/12/2016 dated 6769 numbered Turkish Law of Intellectual Property Rights). In principle, the registered industrial design may not be sold, imported as a products bearing a design or a copy of the protected design by third parties when these activities are for commercial purposes. "In some countries, industrial designs are protected under patent law as design patents. Industrial design laws in some countries grant without registration time and scope limited protection to so-called unregistered industrial design" (WIPO).

2.1.4 Copy right

Copyright is a legal term used to denote the rights of the authors' works on their works and protects the rights of the authors against unauthorized use by others. Many artistic and mental products such as books, computer programs, musical works, technical drawings, choreographers, advertisements, pictures, photographs, sculptures, films, databases, maps and architectural works are protected under copyright. Copyright is the natural right of every work. In other words, there is no need to apply for copyright protection of the work. However, copyright protection begins with the recognition of the work. The duration of protection of a work in our country by copyright is 70 years from the death of the owner (5/12/1951 dated and 5856 numbered Law on Intellectual and Artistic Works). For the countries that have signed the Bern Convention, this work is at least 50 years from the death of the owner of the work (2/10/2015 dated Bern Convention). For the European Union countries this number is 70 years from the death of the owner (29/10/1993 dated Council Directive 98/93/EEC).

2.1.5 Trademark

"A trademark is a sign capable of distinguishing the goods or services of one enterprise from those of other enterprises. Trademarks are protected by intellectual property rights" WIPO.

A word or a form of words, letters, shapes, numbers, voices, goods and packages can constitute a trademark. The registration of trademarks is not compulsory but it is the most important means of proving the rights on the trademark and preventing trademark infringement (TURKPATENT,2017).

The protection period of a registered trademark has 10 years. This period will be renewed for ten years. The brand does not become free after a certain period of time. A registered trademark may be transferred to someone else. It may be transferred by inheritance, may be usage, licensed and hypothecate (Tekinalp, 2012, p. 22).

2.1.6 Geographical indications

According to the definition of TURKPATENT, the geographical indications refer mainly to the name of a local product. In this sense, geographical indications, is a sign indicating a product identified with a distinctive character, reputation or origin, area, region or country. The geographical indications are divided into two as the origin name

and the merchandise mark. Origin names are produced only in the geographical region where they belong. Because the product can be won only if its qualities are produced in the region where it belongs. For example, Finike Orange and Malatya Apricot can be mentioned. At least one of the characteristics of the product with the merchandise mark belongs to that locality. But it is also possible to produce products outside the region. The connection of the product with the region can only be the reputation. For example, Antep Baklava and Hereke Silk Carpet. The aim of the geographical indication and the traditional product is to ensure the protection of the products which have a certain reputation due to the properties related to some general qualities of product (TURKPATENT).

Geographical indication and traditional product names do not protect the rights of a single manufacturer but protect the rights of all those producing and marketing in accordance with the terms of the registration certificate. Because the registration has regional, regional and country-wide generality, the rights cannot be linked to a certain person or some persons (Tekinalp, 2012, p.23).

2.2 Intellectual Property Rights in Turkey

Legal arrangements regarding the industrial property in Turkey date back to the 1870s. 1871 dated " Eşya-i Ticariyeye Mahsus Alamet-i Farikalara Dair Nizamname " and 1879 "İhtira Beratı Kanunu " constitute the basis of legal protection in Turkey. With these arrangements, Turkey is among the first countries to provide protection for industrial property rights. In the first years of the Republic of Turkey, the IP protection was considered important and Paris Convention on the Establishment of an International Union for the Protection of Industrial Property was attended in 1925. The entry into force of the "Brand Law" numbered 551 in 1965 and participation to "World Intellectual Property Organization (WIPO) Establishment Agreement" in 1976 were among the important steps in the industrial property rights protection in Turkey. The establishment of the Turkish Patent Institute with the Decree Law No. 544 on June 24, 1994 has been a milestone in the field of industrial property rights. With the Industrial Property Law No. 6769 dated December 22, 2016, the name of the Corporation has been changed to "Turkish Patent and Trademark Authority" and its short name is "TURKPATENT". On 10 January 2017, according to the Industrial Property Law No. 6769, decree laws which are separately prepared for trademark, patent, design and

geographical indications are collected under one law. Since, TURKPATENT were a party to thirteen international agreements. With training and promotional activities, important studies have been carried out to raise awareness of the public. In this scope, as of the end of 2016, 100 TURKPATENT Information and Documentation Units have been established, including many universities and industry and trade chambers (TURKPATENT).

According to Cetin (2017), In the recent years, there has been a rapid rise in the field of technology, inventions and the registration of intellectual property rights in Turkey. Especially during the last 10 years, incentive regulations for R & D investments in Turkey have been made and great support has been given to researches of brands, patents, utility models which are an output of these investments. For this reason, the issue of intellectual property has been addressed within the scope of state policy and with an arrangement made in the Corporate Tax Law (dated 13/06/2006 numbered 5520) to support a technology-oriented growth and 50% of the profits obtained from the activities of the Patent and Utility Model Documents issued by the Turkish Patent Institute has been exempted in 2014 (Official Gazette, 2014). The amount to be applied for the exemption shall be determined by the valuation report prepared by the Ministry of Finance for the determination of the value of the invention in the event of transfer or sale, taking into consideration the value added (Cetin, 2017). According to the Law numbered 6728 which is announced in the official gazette dated 9th August 2016, the provision that the Ministry of Finance should issue a valuation report has been abolished.

As indicated in the Table 2.2 and 2.3, the number of patent application to TP and registrations given by TP to both domestic firms, organizations and individuals has increased rapidly in recent years. The domestic part indicates the data of applicants who are citizen of the Republic of Turkey or companies located in Turkey. As it is known, the applicant has either applied directly to TURKPATENT or has passed the national stage from the PCT application or has taken the European patent and has validated it in our institution. Foreign part shows that the data of applicants who are citizen of a foreign country or a company that is based in a foreign country.

As can be seen in the Table 2.2 and 2.3, in 2016, the number of domestic patent applications to TP increased roughly 5 times and the number of the domestic registered patent by TP increased 13,7 times compared to 10 years ago. This situation shows that

technological development and innovation in Turkey are increasing rapidly. On the other hand, some market actors state that these numbers are not enough and that we are behind the international scene, and that many patents there are not much chance of commercialization. TURKPATENT became a member of the European Patent Office in 2000. Until then the applications made by foreign applicants were made either directly to TURKPATENT or as application to the national phase from PCT. As can be seen in the Table 2.2 and 2.3, there is an increase in the number of patent applications made directly to TURKPATENT or PCT by foreign applicants and the registration number in TP system and PCT up to 2000. Since this date, the application to EPC and the registration by EPC was increased while the number of application and registration in TP and PCT system.

Table 2.2 : The Number of Patent Application to TURKPATENT (TURKPATENT).

Year	Domestic				Foreign				TOTAL
	TURKPATENT	PCT	EPC	Total	TURKPATENT	PCT	EPC	Total	
1995	170	0	0	**170**	1520	0	0	**1520**	**1690**
1996	189	0	0	**189**	687	26	0	**713**	**902**
1997	202	1	0	**203**	598	730	0	**1328**	**1531**
1998	201	6	0	**207**	596	1680	0	**2276**	**2483**
1999	265	11	0	**276**	524	2220	0	**2744**	**3020**
2000	258	19	0	**277**	442	2714	0	**3156**	**3433**
2001	298	39	0	**337**	119	2756	2	**2877**	**3214**
2002	387	27	0	**414**	88	1335	37	**1460**	**1874**
2003	454	35	1	**490**	43	305	314	**662**	**1152**
2004	633	49	3	**685**	68	167	1342	**1577**	**2262**
2005	895	33	7	**935**	75	143	2308	**2526**	**3461**
2006	979	93	18	**1090**	71	89	3915	**4075**	**5165**
2007	1747	60	31	**1838**	71	139	4141	**4351**	**6189**
2008	2159	69	40	**2268**	68	107	4694	**4869**	**7137**
2009	2473	74	41	**2588**	69	105	4479	**4653**	**7241**
2010	3120	60	70	**3250**	77	100	4916	**5093**	**8343**
2011	3962	43	82	**4087**	120	100	5934	**6154**	**10241**
2012	4360	74	109	**4543**	78	154	6824	**7056**	**11599**
2013	4345	54	129	**4528**	95	175	7257	**7527**	**12055**
2014	4654	112	95	**4861**	149	183	7182	**7514**	**12375**
2015	5302	50	160	**5512**	251	238	7957	**8446**	**13958**
2016	6153	88	204	**6445**	407	211	9715	**10333**	**16778**

Table 2.3 : The Numbers of Patent Registration issued by TURKPATENT (TURKPATENT).

Year	Domestic				Foreign				TOTAL
	TURKPATENT	PCT	EPC	Total	TURKPATENT	PCT	EPC	Total	
1995	58	0	0	**58**	705	0	0	**705**	**763**
1996	47	0	0	**47**	554	0	0	**554**	**601**
1997	7	0	0	**7**	443	0	0	**443**	**450**
1998	31	0	0	**31**	340	403	0	**743**	**774**
1999	23	5	0	**28**	301	796	0	**1097**	**1125**
2000	17	6	0	**23**	267	846	0	**1113**	**1136**
2001	41	17	0	**58**	237	1814	0	**2051**	**2109**
2002	44	28	1	**73**	349	1351	11	**1711**	**1784**
2003	74	18	1	**93**	226	685	176	**1087**	**1180**
2004	52	16	0	**68**	225	686	957	**1868**	**1936**
2005	59	29	7	**95**	210	525	2342	**3077**	**3172**
2006	89	18	15	**122**	142	410	3631	**4183**	**4305**
2007	183	114	21	**318**	130	202	4140	**4472**	**4790**
2008	253	48	37	**338**	96	154	4281	**4531**	**4869**
2009	341	68	47	**456**	93	149	4912	**5154**	**5610**
2010	507	66	69	**642**	83	110	4675	**4868**	**5510**
2011	714	59	74	**847**	56	67	5569	**5692**	**6539**
2012	879	44	102	**1025**	28	53	6710	**6791**	**7816**
2013	1068	33	143	**1244**	43	68	7570	**7681**	**8925**
2014	1141	34	76	**1251**	40	66	7173	**7279**	**8530**
2015	1471	96	163	**1730**	33	123	8214	**8370**	**10100**
2016	1563	48	183	**1794**	64	91	9125	**9280**	**11074**

Table 2.4 shows that the number of utility model application to TP are similar to the number of patent application in domestic area between 2009 and 2016. In Turkey, there was also another type of patent called patent without examination. This type of patent provides 7 years of protection. Application can be made after the completion of search report without any patent examination (24/06/1995 dated 551 numbered Turkish Secondary Law of Intellectual Property Rights). According to the changes in Turkish Intellectual Property Law, for example abolishment of patent without examination, cause to increase the number of utility model in the future.

Table 2.4 : The Numbers of Utility Model Application and Registration given by TURKPATENT (TURKPATENT).

YEAR	UTILITY MODEL APPLICATION			UTILITY MODEL REGISTRATION		
	Domestic	Foreign	Total	Domestic	Foreign	Total
2009	2842	0	2842	2148	3	2151
2010	2992	2	2994	2021	1	2022
2011	3174	1	3175	1946	2	1948
2012	3722	4	3726	2241	4	2245

YEAR	UTILITY MODEL APPLICATION			UTILITY MODEL REGISTRATION		
	Domestic	Foreign	Total	Domestic	Foreign	Total
2013	3465	3	3468	1993	4	1997
2014	3476	1	3477	2472	2	2474
2015	3449	2	3451	2680	1	2681
2016	3454	3	3457	2345	2	2347

Table 2.5 shows that the data of the Industrial design application and registration.

Table 2.5 : The Numbers of Industrial Design Application and Registration given by TURKPATENT (TURKPATENT).

YEAR	INDUSTRIAL DESIGN APPLICATION			INDUSTRIAL DESIGN REGISTRATION		
	Domestic	Foreign	Total	Domestic	Foreign	Total
2009	26312	847	27159	23765	1191	24956
2010	29467	974	30441	28623	1061	29684
2011	35451	1127	36578	31782	1028	32810
2012	39890	1330	41220	35954	1182	37136
2013	43626	1465	45091	40678	1388	42066
2014	41183	1661	42844	40018	1717	41735
2015	38665	1541	42066	40859	1583	42442
2016	39294	1069	41735	41391	1355	42746

In Turkey, there is no established market structure or mechanism functioning on technology transfer to industry. The Ministry of Science, Industry and Technology announced on 28 July 20016 that a Stock Exchange of Intellectual Property will be established within the Istanbul Stock Exchange (MSI, 2016). In addition, there are 34 Technology Transfer Offices established in Turkey for the transfer of technological inventions to companies and generally located in the Universities and Universities' Technoparks. Technology Transfer Offices (TTO); In order to commercialize the knowledge and technology produced in the universities and to commercialize them and to obtain economic/ social/ cultural value as a result of this process, to establish the cooperation between the universities and private sector institutions and to produce the knowledge and technology that the industry needs and as a result of these collaborations, contribute to the transfer of information and technology between universities and industry and the development of concrete outputs. TUBITAK has been tasked with the support of Technology Transfer Offices with the decision of High Council of Science Technology (TUBITAK).

2.3 Intellectual Property Rights in the World

"Intellectual property rights are a cornerstone of the global knowledge economy. Today patents are an important and commonly accepted indicator for innovativeness while a patent defines new technologies that can be credited for and given ownership for (Tonisson & Maicher, 2012)." In history, there was two key turning points in European and global patent-system integration: the 1883 Paris Convention, and the implementation in 1978 of the Patent Cooperation Treaty (PCT) which was global and the European Patent Convention (EPC). (Kranakis, 2007).

> The Patent Cooperation Treaty system (PCT) is an international cooperation agreement that patent applicants use when they seek patent protection internationally. It came into force in 1978. By 2010, the System had 142 members that together accounted for more than 98 percent of national and regional patent filings worldwide. In a nutshell, by filing a patent application under the PCT, applicants can delay the decision in which countries they would like to pursue exclusive rights for their inventions. In addition, the patent receives a first evaluation report, which similarly helps applicants in their subsequent patent filing decisions. (Bergquist et al., 2017)

Ozbek (2005) stated that, the World Intellectual Property Organization (WIPO) was established in 1967 to provide the protection of intellectual property rights and the interest for these rights by creating a global cooperative atmosphere. Although it seems to be a non-historical entity, the World Intellectual Property Organization dates back to 1883. The Paris Convention for the Protection of Industrial Property, signed in 1883, and the Bern Convention for the Protection of Literary and Artistic Works, signed in 1886, are two international conventions accepted as the cornerstone of the World Intellectual Property Organization (Ozbek, 2005). WIPO is a self-funding agency of the United Nations, with 191 member states.Turkey joined WIPO in 1976 and is member of 21 treaties of WIPO convention (WIPO).

According to Kranakis (2007), both the PCT and EPC affected the continued growth of industrial-property rights. Between 1884 and 1914 the number of patent applications worldwide increased from approximately 50,000 annually to around 200,000. The period between World War I and the end of World War II, there was no new net growth of patenting; in 1945, the number of patent applications worldwide was no greater than in 1914. The years from 1946 to 1973, however, it was seen strong growth in patenting, with applications worldwide increasing more than fourfold, from approximately 200,000 annually to well over 800,000. There was a significant increase in the

percentage of foreign applications to EPO. In France, the percentage of patents granted to foreigners increased from 31 percent in 1951 to 70 percent in 1977; during the same period, for the United Kingdom, the number of patent applications by foreigners climbed from 41 to 61 percent; for Italy, from 41 to 75 percent; and for Germany, from 16 to 50 percent. For smaller countries, where over 50 percent of patent applications already came from foreigners in 1951, the percentages increased higher still-to 91 percent for Belgium, and 87 percent for the Netherlands (Kranakis, 2007). The global number of patent filings has been rising from 800,000 applications in the early 1980s to 2.9 million in 2016 (WIPO).

Table 2.6 and Table 2.7 shows that the PCT application from Turkey and other countries. But the difference between these two table that Table 2.6 indicates the data of corporate applicant with more than 10 PCT application in Turkey and other countries. The ratio of PCT application by Turkish firms in total increased 2 times in 2016 compared to ten years ago.

Table 2.6 : The number of PCT application by corporate applicants which has more than 10 PCT application (WIPO).

| Year | PCT Applications[1] | | |
	Turkey	Other Countries	Total
2005	71	68.690	68.761
2006	96	78.045	78.141
2007	143	85.781	85.924
2008	161	92.989	93.150
2009	157	91.028	91.185
2010	152	88.340	88.492
2011	142	97.069	97.211
2012	133	109.988	110.121
2013	200	121.840	122.040
2014	269	133.384	133.653
2015	343	126.267	126.610
2016	395	132.224	132.619

Table 2.7 shows that the total number of PCT applicant (corporate and individual) in Turkey and other countries. The similar statistic can be seen in this table, the number

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[1] Counts are based on corporate applicants only (excluding natural person) and

of PCT application all over the World increased more than 100% in 2016 compared year of 2000.

Table 2.7 : The number of all PCT application all over the World (WIPO).

Year	PCT Applications		
	Turkey	Other Countries	Total
2000	71	93.167	93.238
2001	76	108.153	108.229
2002	85	110.311	110.396
2003	111	115.096	115.207
2004	115	122.526	122.641
2005	174	136.577	136.751
2006	269	149.378	149.647
2007	359	159.576	159.935
2008	392	162.850	163.242
2009	388	155.020	155.408
2010	479	163.875	164.354
2011	539	181.903	182.442
2012	536	194.809	195.345
2013	805	204.500	205.305
2014	853	213.478	214.331
2015	1.010	216.223	217.233
2016	1.065	231.840	232.905

As can be seen in Table 2.8, the application of EPO and EPC was increased in last ten years. The number of EPO and EPC application and registration. European patent filings analysis based on Direct European filings under the EPC and international filings under the PCT. European patent applications means direct European applications and International PCT applications entering the European phase. The number of European patent granted patents published. The number of granted patent in EPC increased roughly 100% compared to ten years ago.

Table 2.8 : The number of EPO and EPC application and patent registration (EPO).

Year	European patent filings	European patent applications	European patent granted
2007	222.574	141.231	54.700
2008	225.979	146.244	59.800
2009	211.355	134.511	51.952
2010	235.731	151.015	58.117
2011	244.995	142.822	62.108
2012	258.500	148.562	65.655
2013	265.918	148.027	66.707
2014	274.367	152.703	64.613
2015	279.002	160.004	68.419
2016	296.227	159.353	95.940

2.4 Intellectual Property Valuation

2.4.1 Value and Valuation

The value is the current price of the economic benefit to be obtained in the future depending on the use of an asset. In other words, value is the expression of the future benefits of having an asset in a single payment. The valuation is the process of determining the monetary value of an asset and also identifying and measuring benefit and risk from an intangible asset. The valuation was first started to be use for real estate. Over time, it has been applied for machine equipment, precious stones, art works and finally intangible assets (Sozer, 2008; WIPO, 2012). Economic benefits of an IP can be classified as direct or indirect. It should be direct economic benefit that patent rights can create a direct cash flow stream for the owner that could not be earned without this IP. Saving money depend on reducing cost or eliminating negative costs and indirectly help to generate cash flow are defined as indirect economic benefits. Patent have also noneconomic value such as the prestige, personal achievement and feeling of accomplishment. The noneconomic value of patents may show why so many patents are applied and sustained each year (Murphy et al., 2012, pp. 5-6). In order to value an IP, it must first be an identifiable entity (technology), a legal title of the entity (being a proprietor and transferable), and making revenue on its own (Taplin, 2004, p.8). When a patent value is expressed, it should be indicated when the valuation is made. Because the value of an entity changes over time, depending on the increase or decrease of the benefit that it will bring in the future. Hence, every value expresses a meaning for a certain time (today and future). If a patent has not been used today, which makes it profitable in the past, the value is zero. At this point it is important to note that although they are sometimes equal and can be used interchangeably, cost, price and value are related but different concepts (Smith & Parr, 2000, p.152). Reilly (1999) refers that the price, which always refers to the past, requires a certain market and operation. In order for price to be an indicator of value, at least five factors need to be considered:

- Market conditions (such as whether the price reflects the price at the time of the transaction, whether the price reflects the value at the time the valuation is made, etc.)

- Market place (where the price of the transaction is realized when there is an effective market, whether the buyer is the buyer or the seller, whether there is a competitive price offer, how many days / months)
- Buyers 'and sellers' motive (whether or not each party is willing to act, etc.)
- Method of payment (such as whether the payment is made in cash or otherwise, the payment is made during or after the transaction, etc.)
- The elements of the transaction (whether the transaction is for only patent only or for other assets with the patent, whether the contracts other than the transaction, such as warranty, development, use, etc. are signed)

The value does not come out spontaneously. Regarding the future use, the value of the patent shows different results according to the purpose of the valuation. The following are the kinds of patent values that emerged according to different valuation purposes (Sozer, 2008):

Fair Market Value: This is the value that the entrepreneurs agreed, which is reasonably well informed about the asset and which is not under any influence (such as bankruptcy, legal sanction). It is assumed that a hypothetical transaction has occurred at this value. The most commonly used value is the value.

Fair Value: It is worth that the willing parties who are reasonably knowledgeable about the asset and are not under any pressure agreed. This value does not have to reflect the price of a possible market operation. It is used more often in court cases where there is no market knowledge.

Market Value: In a competitive open market, it is the most likely value that an entity will acquire when both parties are informed and the price is not affected by unfavorable factors. Market value does not have to be about relevance, as fair value does not always have to be relevant to the market. While market value is not always fair for all parties, it is generally the best estimate of value for the asset being traded.

Historical Value: This value, which is used in some special cases related to infringement and tax, is the value of an asset at a certain place and time.

Acquisition Value: This value is the payment of this buyer is the expected amount, in case of all of the unique benefits of the asset will pass to a specific buyer.

Use Value: It is the usage value of an asset in a certain zone or sector

Investment Value: It is the value of an asset under a particular investment criterion. This value type is not necessary for the realization of an asset sale transaction. Investment value relates to the answer of the question "What would be the value if the asset will remain in business use for the next 5 years?".

Owner Value: This is the value under owner's resources and the ability to commercialize the asset. For this value, the asset does not have to be subject to the sales process. For example, the answer to this question is "what is the value of existence under the existing capabilities of the rights holder, capital resources and commercialization plan".

Insurable Value: It is the amount of insurance required to replace the asset with an asset that has similar usefulness, functionality, and revenue-generating characteristics. For this value, the asset does not have to be the subject of sales.

Assurance Value: The amount of debt that a supporter who accepts assets as an assurance agrees to give. This value is usually a percentage of the fair market value or just market value alone.

Ad Valorem Tax Value: It is the value of an asset for tax purpose. This value is sometimes a function of fair market value.

2.4.2 Why Patents Should be Valued?

There are many reasons for valuing intellectual property. For example, making strategic decision within a company, purposes of merger of a company, acquisition, joint venture, or bankruptcy, negotiations and transactions to sell or license intellectual property, court proceedings or alternative dispute resolution mechanisms, decision of venture capital, accounting and taxation purposes and country selection for the registration of intellectual property (Speier & Gupta, 2015).

Many reason can be mentioned for the necessity of IP valuation. Widely referred valuation purposes in the literature are given in the Table 2.9 below. The application possibilities in Turkey are also added to the Table 2.9 (Sozer, 2008.; EC,2013).

Table 2.9 : Valuation Purposes (Sozer, 2008.; EC,2013).

	Valuation Purposes	Applicable in Turkey?
1.	Licensing	Yes
2.	Insurance- patent insurance against infringements as risk management	No
3.	Financial Reporting for Intangible Asset in financial statements	Partially
4.	Tax	Yes (Since 2015)
5.	Financing (patents as collateral for bank loan, Sale and Leaseback as financial funding)	No
6.	Mergers and Acquisitions- Transaction	Not found.
7.	Legal (Court decision)	Yes.
8.	Patent Donations (Tax deduction by making patent donations to non-profit organizations)	No
9.	Management decisions (Internal)	Yes

In Turkey, patent valuation cases are increasing depends on R&D and innovation activities as part of the strategy to support research. The state opens the way by arranging various laws, although it is not as fast as in other countries. According to current the General Communiqué on the Amendment of the Corporate Tax (Official Gazette, 2014); the scope of earnings and revenues acquired from IPR has been

revised. With this updating; tax exception, regulation of patent valuation report, valuation and related processes are legislated. A tax exception of up to 50% of the price stated in the valuation report has been introduced. The number patent valuation activities in Turkey is expected to increase based on the legal development.

2.4.3 Patent Valuation Process

Patent valuation process is required an interdisciplinary study. This study must include economics, law, finance, accounting and investment decision making expertise. Therefore, it is not easy to determine where to start patent valuation. Since the requirements of valuation needs or perspectives vary for institutions and individuals and there is no generally accepted patent valuation process in the literature.

Hadzima (2013) mentions that coming up with IP valuation is complicated. Companies must follow three steps to valuate an IP. The quality of the invention, well-constructed patent and way to extract value from the patent.

In literature, several valuation process are suggested. Some of them has distinctive perspectives, like Chiu and Chen (2007). A patent valuation system from the perspective of licensor using Analytic Hierarchy Process by Chiu and Chen (2007) with the aim of determination of the importance of patent valuation indicators. They performed a case study on Taiwanese Company with a scoring system which utilizes below given hierarchy structure in Figure 2.1.
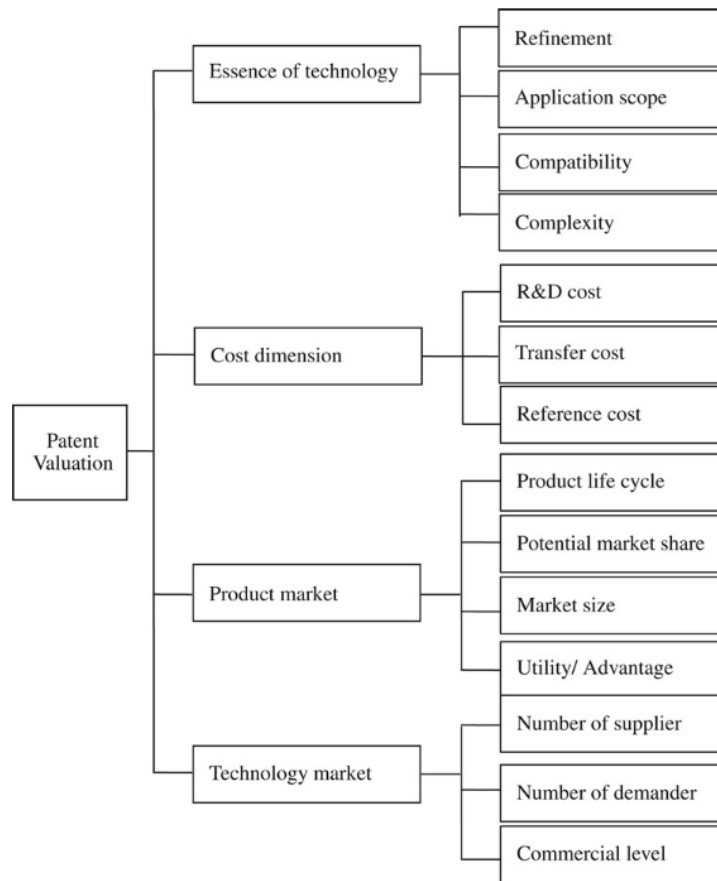
Figure 2.1 Patent valuation hierarchy structure (Chiu & Chen, 2007)

Flignor and Orozco (2006) create a valuation context in their study that a game plan for valuation and build a valuation pyramid which is shown Figure 2.2. The study would cover the all segments that might need valuation such as licensee, licensor, investor, management etc. The foundation level of the pyramid includes steps of purpose, description, premise and standard of IP valuation. "Why are you valuing the asset?", "What is the asset?", "How will the asset be used?" and "Who is the assumed buyer of the asset?" questions are answered. Legal, financial and business/strategic characteristics of the assets are determined. At this level, most of the difficult work and creative energy of valuation analysis occurs. The extensive knowledge of data is important to IP valuation method selection. The final level of the valuation process is to express the solution of a business problem and recommendation. In summary, they offer where and how to start valuation.
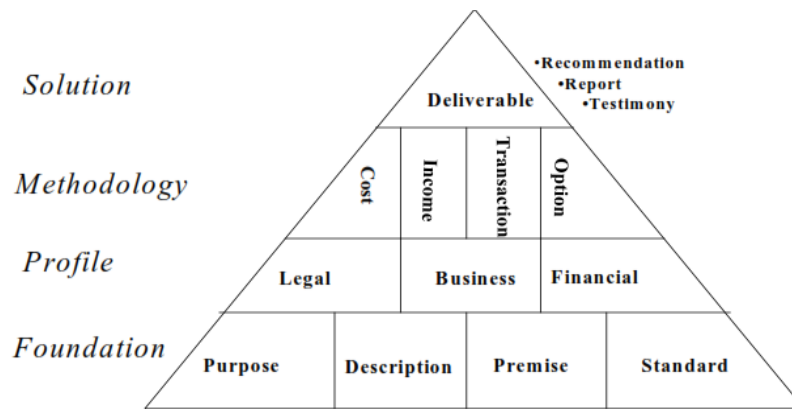
Figure 2.2 Valuation Pyramid (Flignor & Orozco, 2006)

Cromley (2004) determined following 20 steps to value American Patents:

1- Check whether the patent is valid

2- Determine the context

3- Data gathering (such as patent applications, economic data, relevant business plan, marketing study)

4- Assemble a valuation team who have expertise in monopolies, patent law, business valuation, skills and a background in the technology

5- Read the patent (scope of invention, claims, detailed description

6- Investigate the patent's scope (the claim section is the most important basis to understand patent's scope and how its claims relate to the market)

7- Talk with a patent attorney

8- Check about the patent's validity (a patent should be invalid according to court decision)

9- Check into blocking patents (If your patent infringes someone else's patent, you cannot use the patent in practice.)

10- Conceive synergies among patents (A portfolio of related patents may be more valuable than the single patent, since it can prevent patents from being blocked.

11- Investigate foreign patent protection (A valid patent registered in multinational systems will have a larger market and will have more value.)

12- Conceive the remaining life of the patent

13- Investigate any prior royalties paid for the patent

14- Investigate any actual litigation involving the patent (If a patent has been litigated, it has been affects its value.)

15- Determine the next-best alternative technologies (Analyzing competing technologies)

16- Estimate a demand curve for the patented item (Market research in the related sector, questionnaire, etc. Demand curve forecasting (calculation of expected income for different prices))

17- Specify the patented product's point of profit maximization

18- Conceive the applicability of traditional valuation approaches (Cost, market and income approach to valuate a patent. Income approach is most preferable according to many valuators)

19- Do a valuation with income methods on (Royalty-based methods, profit-contribution methods, sales projections and discount rate)

20- Prepare the patent valuation report (Valuation report should include patents value, limitations of the analysis assumptions and applied procedures)

2.4.4 Intellectual Property Valuation Methods

The most commonly and frequently used IP valuation methods in the literature have been investigate and it was seen that they were divided two main groups which are qualitative approach and quantitative approach. IP valuation methods according to the literature search is given under these two headings.

2.4.4.1 Qualitative approaches

Qualitative approach can be used for measurement of the strength of the patent, rankings and scoring methodologies. These methods do not calculate the patent's monetary value but an IP can be valuated with the accepted qualitative parameters of the patent's strength and future potential. In patent scoring, generally accepted indicators in the literature are represented below. Hamamcıoğlu and Kahraman (2015), Chiu and Chen (2007), Speier and Gupta (2015) and many more mentioned that these indicators express patent's strength.

1) Number of patents

The number of patents in the field of technology of someone's invention has an effect on the value of the patent. If the number of patents in the same technology field is too high, it means that the patent is inadequate and the number of patents affects the value inversely. However, according to a study by Lanjouw and Schankerman (2003), the increase in the number of patents in the same technology area will increase the number of citations, so the value of the patent will rise.

2) Number of patent claims (also length, type, scope of claims)

A large number of claims provide a wide scope for patent protection. To invalidate the claims is a difficult process, and this is a deterrent effect on those who try to invalidate a patent has many claims. For these reasons, the higher number of claims is regarded as an indicator of the value of the patent (Hamacıoğlu and Kahraman, 2015).

3) Number of 3rd party objections of the patent

This indicator was first introduced by van der Drift in 1989. The higher number of objections of the patent effects the value of patent. In practice, the number of appeals is not very high (van der Drift 1989). In a study conducted by Harhoff in 2003, only 8% of European Patent Office (EPO) patents are objected (Harhoff and Scherer et al., 2003).

4) Number of citations (both patents and scientific papers)

A reference to a patent has the effect of enhancing the value of this patent. Narin and Noma (1987) have developed an idea that references made to a patent may be an indication of the patent value. This idea was also examined by Trajtenberg in 1990. Trajtenberg's research showed that the accuracy of this approach. Along with the increase in the number of citations, the value of the patent has also increased. Citation indicator is the most commonly used indicator for patent value (Trajtenberg, 1990).

5) Geographical area covered by patent

A patent family represents the number of countries in which a patent is registered or a registration application is filed. Putnam (1996) revealed that the patent family is an indicator for value. The width of the patent family refers the more valuable patent. This also indicates that the patent applicant paid application and renewal fees in more than one country. For this reason, the value of the patent may be considered to be high.

6) Width of the related technical field (Cooperative Patent Classification, CPC)

The Cooperative Patent Classification (CPC) is patent classification system of the IPC and is managed by US Patent and Trademark Office and EPO. CPC include nine sections, A-H and Y, which in turn are sub-divided into classes, sub-classes, groups and sub-groups. CPC system has roughly 250 000 classification entries (EPO). The CPC code assigned to a patent during a patent application constitutes a determining factor for the scope of protection of the patent and therefore its power (Hamacıoğlu and Kahraman, 2015).

7) Infringement detection method

Another important aspect of the patent valuation process is the ability to determine whether the patent is being used by competitors. It is predicted that patent infringements that can be easily identified are more valuable than patents where detection is more difficult (Hamacıoğlu and Kahraman, 2015).

8) Patents legal life

The patent value will decrease as the patent protection period decreases over time. Patents legal life is maximum 20 years; therefore, patents have 20-year potential monopoly position. Patents that have just begun to live and have a longer time to maintain their potential monopoly position will be more valuable. Mostly, economic life is shorter than legal life. (WIPO).

9) Duration of patent application (Length of time for registration)

The long record for registration can be regarded as a sign of the technical field where competitors are active, considering that they have encountered negative references during the examination phase. The duration of the correspondence between the patent expert working in the official patent office of the relevant country and the applicant may give an idea of the value of the patent (Hamacıoğlu and Kahraman, 2015).

10) Patent registration fee (renewal fee)

The renewal fees paid for the continuation of patent protection are an indicator of the value of the patent. It was first proposed by Schankerman and Pakes that the renewal fee is an indicator of the patent value. If an inventor pays a patent renewal fee, he thinks that he will earn income from this patent. For this reason, the renewal fee is a factor affecting the value of the patent. It was revealed that more than half of the patents were canceled within the first 8 years, while only 25% had been renewed in

the 12th year. Few of the patents are protected until the 20th century (Schankerman and Pakes, 1986). Renewal decisions are assumed to be based on economic criteria, so agents will renew their patents only if the value of holding them over an additional year exceeds the cost of such renewal (Griliches, 1998, p. 310).

According to the Marr et al (2003), there are three patent-related measures are predictive of subsequent stock returns and market to book values of public companies which are compatible above listed indicators, they are;

+ Number of patents granted to the firms in a year,

+ Intensity of citation to a firm's patent portfolio by subsequent patents,

+ Number of citations of a firm's patents to scientific papers.

Hamacıoğlu and Kahraman (2015) investigated Arcelik's patent scoring methodology and they create a patent score according to eight indicators. It is assumed that similar patented inventions have approximate monetary value. Therefore, patents in the same patent portfolio are ranked by the Arcelik's patent scoring and their monetary values are calculated by using this score for the market value for the specific sector with below given equitation 2.1.

$$PMV = \frac{[patent\ score \times (sector\ max.\ LP - Sector\ min.\ LP)]}{100} + Sector\ \min LP \qquad (2.1)$$

where:

- PMV: Patent Monetary Value
- LP: License Price

In order to calculate monetary value, upper and lower limits of license price, sector average should be known. This information is not always available for unique sectors and technologies. However, Arcelik's method can be used internally by companies within their patent portfolio.

2.4.4.2 Quantitative Approaches

The value of a patent or company is obtained from the advantage which it provides its owner (Smith & Parr, 2005, pp. 148-154). At the earliest stages, the valuations based on generally qualitative information because of the very little quantitative information availability. While the technology is developed, more technical and market aspect will

become easily accessible and valuations will become increasingly quantitative (Stevens, 2016). The three-different traditional valuation approach provide to measure of this benefit. These three basic concepts are Income, Market and Cost methods (Goddar & Moser, 2011, pp. 109-110). In addition to the traditional valuation methods, a few advanced valuation methods are used for value an IP. The reason why they are called advanced methods is that they contain more complex mathematical calculations than the NPV method. Risk Adjusted NPV Method, Probability Tree Analysis, Monte Carlo Method and Real Option Pricing Method are most known of advanced methods (Sozer, 2008).

2.4.4.3 Cost-Based Methods

Cost-based methods are divided two types which are historical cost or reproduction cost and replacement cost. With both methods, the total costs incurred in developing the IP are calculated. Replacement cost quantifies the estimated cost of replacing the IP or creating an equivalent asset, whereas historical cost measures the actual cost incurred in creating the IP. (EC, 2013). With both methods, the current price is taken into account (Speier & Gupta, 2015). Hard costs (materials and acquisition of assets), soft costs (engineering time, design time, and overhead and market costs, costs of advertising etc.) for the IP must be examined (Anson et al.,2014).

Murphy et al. (2012, pp. 224-225) explained the cost of development an IP and cost of reasonable alternatives. These two cost methods do not show the future net economic benefits of IP. Research costs, development costs, legal expenses and filling fees, costs to maintain or defend the developed patent should be taken into account. A patent value should be accounted at least the amount of its development cost and maintain cost. It should be expressed as formula 2.2:

$$\text{Minimum value of patent right} = \text{Cost of developing the technology} + \text{Patenting and maintenance costs} \qquad (2.2)$$

If a party use the cost of development method to transfer a patent right, a reasonable profit margin should be added to minimum value of patent right.

The replacement cost method use the cost of a non-patented technology similar to the patented technology. Therefore, patenting and maintenance cost are not considered in formula 2.2 to calculate the value of non-patented technology (Sozer, 2008).

The patent does not prevent competitors from using alternative products or technologies. Determination of the cost of alternative products for an IP can contribute to determine the underlying value of the IP. Purchaser or licensor should pay maximum cost of obtaining reasonable technology alternative for patent right of income producing asset. In some cases, alternative technology can be less preferable than the IP being valued. At that case, value of reduced productivity or product attributes that comes from using the inferior technology alternative can be add to cost of obtaining reasonable technology alternative (Murphy et al.,2012, pp. 228-229).

Cost method is commonly used in situation where there is no market revenue data, accounting and tax purpose and in early stage technology valuation (Speier & Gupta, 2015).

2.4.4.4 Market Based Methods

The existing literature of patent valuation with market approach typically refer that the main purpose of market methods is determination of the value of IPs by studying the prices of comparable assets which have been transferred between third parties at arm's length in an active market for commercial purpose (Pitkethly, 1997; Goddar & Moser, 2011, p. 112; Murphy et al., 2012, pp. 189-190). Hence the name of method, if an active market and transactions can be found, the market approach to valuation an IP is more feasible (Anson et al.,2014).

The market methods represent a value that has already accepted in the market, therefore it is considered that these methods give the most objective result. However, similar asset is not always available in the market because of unique characteristic of the patents and also such agreements can be confidential and are not shared with the public. For example, according to Reilly (1998), the below steps should be followed in the market method:

- Identification of similar or identical technologies subject to transfer or license (Similar technology type, use of technology, sector, transaction date, etc.),

- Check whether the transaction information to be compared reflects the reality and market conditions (If the process to be compared is not in the market conditions, some adjustments may need to be made to the relevant information),

- The determination of the relevant unit (price per unit, etc.) of the comparison and the development of comparative analysis,

Reilly (2016) groups market-based methods in three; sales comparison method, relief from royalty and comparable profit margin. All three market approach methods are based on empirical data and a measure of comparability. The sales comparison method is based on actual and comparable sales. The relief from royalty method is based on actual and comparable licenses. The comparable profit margin method is based on actual and comparable companies. The sales comparison method is most applicable when the similar type of asset being valued sell independently in the market. The comparability criteria should be identified to search for sale data for example, type of intangible asset, industry in which the intangible asset is used, size of industry, how the intangible asset is operated by its owner, size the owner, buyer or seller, growth rate of industry, profitability of industry. Then the similar intangible asset sales are searched that the meet comparability criteria. The comparable profit margin method is applicable when the company has some ordinary intangible assets and one extraordinary intangible asset, which stands out as the reason for the owner/operator's success and excess profitability. That intangible asset can be a patent, copyright, trademark, product design or formula, distribution method, or trade secret. In this analyze, the competitors can be selected as a benchmark group. The owner's higher profit margin than the benchmark group is identified. The analyst makes sense of the excess profit margin with the intangible asset. Then, the excess profits are used to obtain the indicated value of the subject intangible asset. The relief from royalty method is applicable to estimate is intercompany transfer price, a third-party license royalty rate, or a reasonable royalty rate damages measure, licensed between a licensor and a licensee, including patents, proprietary technology, trademarks and tradenames, copyrights, franchises, licenses, permits, product designs, and chemical formulas. The relief from royalty method is the value of the royalty payments the company will receive due to its ownership of the asset. RoyaltyStat and RoyaltySource are commonly used databases for getting information details of related patent licenses and transactions (Holt et al.,2015).

Although some analysts consider the relief from royalty method is subgroup of income method or cost approach, Reilly (2016) referred this method as a market approach because the method relies on market-derived, empirical data. According to Anson

(2014), the relief from royalty rate method is a combination of the market method and the income method.

Sozer (2008) differently from Reilly (2016), mentioned two other methods: market replacement cost method and comparative income differential method. The market-based replacement cost method is a method of estimating the replacement cost of an associated patent in an open market. Unlike the substitution method discussed in the cost method, the information of an external observer who is knowledgeable about the sector and related patents, rather than internal information, is used for estimation. Market-focused reliable metric, where unbiased estimates of market conditions are obtained. This method also requires a follow-up of the procedure in the cost method. In the comparative income differentiation method, which can be applied in the same area where two similar activities are carried out with patented and other non-patented technologies, the difference between the incomes of both activities is determined and multiplied by an appropriate market-based activation rate (Sozer, 2008).

Some difficulties related to applicability of market method are mentioned in literature. Market based method is suitable for real estate, machinery and equipment, tools, computer software and hardware, franchises, stocks and other securities and company valuations and is often used by tax authorities and other third parties. In the case of patent valuation, it is not suitable for use as a stand-alone patent value and is mostly used for cross-checking the results of other theoretical methods (Sozer 2008). The market approach is required that comparable intellectual property necessarily exists. Because of patents are unique, two patents are rarely comparable. Estimating the value of a patent relying on value of another patent cannot lead to precise results (Speier & Gupta, 2015). According to Anson et al. (2014), the market approach to appraisal has traditionally been used in fields such as equipment, raw materials and real estate with material assets that have been active for decades. However, most intangible assets have not been bought and sold in large quantities, at least until recently, to create a value based on direct marketplace comparisons; for this reason, analysis and tuning are almost always necessary. Therefore, it is often difficult to obtain sufficient detail to ensure that all value elements that are to be used in a market approach for something comparable, in each of the similar or comparable transactions, are appropriately valued (Anson et al.,2014).

2.4.4.5 Income based methods

Income based methods are the most popular and generally used methods for IP valuation, although the methods often involve using assumptions about the future use of the IP. Input data must be accessible and certain for the valuation result to be correct (EC, 2013). There are many methods based on income approach have been found in the literature and these methods are given below under the main headings (Sozer, 2008; Goddar & Moser, 2011, pp. 125-134).

1. Discounted Cash Flow Method

2. Incremental Income Method

3. Profit Split Method

4. Relief form Royalty Method

5. Maximum Achievable Profit Method

Discounted Cash Flow (DCF) Method:

The income method is a metric based on Discounted Cash Flows (accounting for time and uncertainty). Discounted cash flows are the expression of the net present value (NPV) of the asset that is expected to be achieved throughout the economic life. Net Present Value (NPV) of the asset is calculated through the following formula 2.3 (Goddar & Moser, 2011, p. 126):

$$NPV = \sum_{t=0}^{n} \frac{Ft}{(1+r)n} \tag{2.3}$$

where n is economic life of the asset, F_t is the incremental free cash flow or net cash flow related in year t and r is the discount or risk rate. The three basic estimation components of the income methods are future income stream, time period of income stream, risk or discount rate (Anson et al., 2014).

- Time Period Estimation

Time estimation is a requirement to determine that the patent revenue will be available for which period of time. The economic life of the technology underlying the patent as well as the patent protection period can be used for this period (Sozer, 2008). In

general, the economic life is bounded by the legal life of the asset, but is often much shorter (Flignor & Orozco, 2006).

- Free Cash Flow Estimation

In determining the income, all costs directly or indirectly related to the patent must be included in the account. The free cash flow (F_t) generated by a patent or other asset is calculated by formula in following Table 2.10 (Goddar & Moser, 2011, pp. 126-127):

Table 2.10 : Free cash flow table (Goddar & Moser, 2011, pp. 126-127).

+	Revenues
-	Cost of sales
=	**Gross profit**
-	General, administrative and commercial cost (OpEX)
=	**Earnings Before Interest, Taxes, Depreciation and Amortization (EBITDA)**
-	Depreciation and Amortization
=	**Earnings Before Interest and Taxes (EBIT)**
-	Taxes
=	**Net Operating Profit after Taxes (NOPAT)**
+	Depreciation
-	Capital expenditure (CapEx)
-	Increase in Net Working Capital
=	**Free Cash Flow**

According to Parr (2016) report, Net Cash Flow is calculated through the following formula in Table 2.11.

Table 2.11 : Net cash flow (Parr, 2016).

+	Net Sales
-	Manufacturing Cost
=	Gross Profits
-	Marketing Expenses
-	General Overhead Expenses
-	Selling Expenses
=	Operating Profits
-	Income Taxes
=	Net Income
+	Depreciation
=	Gross Cash Flow
-	Additions To Working Capital
-	Additions To Fixed Plant Investment
=	Net Cash Flow

Parr (2016) explained that sales are the revenue collected by the company or owners from providing products or services to customers. Net sales are defined the amount of

revenues that remain after discounts, returns and refunds. Manufacturing cost represent the primary costs related with manufacturing or providing the product or service. In this expense category include expenses associated with labor, raw materials, manufacturing plant costs and all other expenses directly associated to turning into raw materials into finished goods. The difference between net sales and manufacturing costs show the Gross Profit. The gross profit level reflects production efficiencies and overall product profitability. However, it does not reflect the final commercial success of a product or service. Many other costs that are important to business success are not accounted for at gross profit. Other costs contributing to the successful commercialization of a product include research, Marketing, General overhead and selling expenses. R&D costs related with developing new products and improving old ones. The cost for motivating buyers to purchase the products or service expressed the marketing costs. General overhead costs include the cost related commercialization activities and basic corporate support. Commissions, salaries and other activities to move into the product to the hands of customers are selling costs. Operating profits is the difference between gross profit and other cost explained above. Income tax is the cost of doing business and must be calculated for to evaluate any business venture. Depreciation is accounted according to the remaining useful life of the equipment purchased for commercial purposes. Non-cash expenditure that allocates the original amount invested in fixed assets to annual activities. Depreciation is calculated to account for the deterioration of fixed assets as they are used to generate, sell, market, present and manage the sales generation process. Depreciation accounts for the use of assets. It is called a non-cash cost because the cash related with the expense was disbursed long ago at the time that fixed assets were purchased and installed. The depreciation expense is deducted before reaching operating profit, so income taxes will reflect the depreciation as an expense of doing business. Gross cash flow is accounted by adding the depreciation deducted from the previously calculated operating income to the after-tax income of the company. The gross cash flow is the total amount of cash that the company generates each year. Additions to the working capital and the additions to fixed plant investment are business investments needed to increase ongoing production capacity. Net cash flow is everything that remains from gross cash flow following the calculation of reinvestment in the business for fixed plant and additions to working capital. The value of a product, an asset or a patent is derived

from net cash flows by transforming the expected amounts into a present value using discount rates that reflect the investment risk and the time value of money (Parr, 2016).

- Discount Rate Estimation

When valuing any type of investment, the rate of return is a critical element for converting expected streams of income and cash flow into a present value. Investment rates of return are also often referred to as the cost of capital or a discount rate used to convert expected (Smith & Parr, 2005, p. 757). The value of discount rate has a major impact on future values. Therefore, it is important that the use of an appropriate discount rate to NPV calculations (Stevens, 2016). Discount rates are usually slightly higher than the cost of a company's capital and should be considered with a discount rate of 20% to 50% per year, similar to investment capital types (Flignor & Orozco, 2006). The discount rate refers to the rate at which the appraiser decides and there is no specific standard value. Calculation methods such as Capital Asset Pricing Model, Weighted Average Cost of Capital, Gordon Growth Model, Venture Capital and Build-Up method can be used in determining the appropriate discount rate (Smith & Parr, 2005, p. 760). Smith and Parr (2005) outline these four approaches to determine the discount rate as below:

- Gordon Growth Model:

Equation 2.4 is a simple illustration of this model for determining the discount rate.

$$k = (\frac{NCFo \, * \, (1 + g)}{PV} + g) \tag{2.4}$$

where:

- PV: The present value of an investment

- NCFo: Net cash flow in period 0, period immediately before valuation date

- k: Discount rate

- g: Expected long-term growth rate in net cash flow to the investor

The inputs PV, NCFo and g for this equation must be determined from similar IP being valued that can be found in the investment market.

- Build-Up Method:

The method lists the risk components and brings a return to compensate for each risk component. The calculation of required return for a specific investment is given in equation 2.5.

$$R_i = R_f + R_{mp} + R_u + R_o \qquad (2.5)$$

where:

R_i = Required return for a specific investment

R_f = Risk free rate of return

R_{mp} = The risk premium associated with the investment market that combines maturity and systemic risk premiums

R_u = Risk premium for unsystematic risk associated with a specific industry or company

R_o = Risk premium for other specific risks associated with a particular technology, such as risks of development failures

- Capital Asset Pricing Model (CAPM):

The capital asset pricing model states that the expected risk premium on each investment is proportional to a factor. This factor is the volatility of investment returns relative to the investment returns that can be achieved by a broad market portfolio (Smith & Parr, 2005).

The equation of CAPM is given in equation 2.6:

$$R_e = R_f + B(R_m - R_f) \qquad (2.6)$$

where:

R_e = The equity rate of return

R_f = The risk-free rate of return

R_m = The rate of return provided by the overall market portfolio of investments

B = Beta, a measure of the volatility that indicates a company's susceptibility to changing conditions.

- Venture Capital

The venture capitalists provide increasingly the seed money for risky investment. Sometimes venture means vulture because of the apparently extraordinary rate of returns that these investors require. When considered that the high potential in these cases for the total loss of millions of dollars of seed money, the required investment returns aren't unacceptable. The required rates are changed at various stages of company by the venture capital. Following Table 2.12 gives an estimate of the amount of return required at different stages of development:

Table 2.12 : Venture Capital Rates of Return (Smith & Parr; 2005).

Venture Capital Rates of Return	
Stage of Developments	Required Rate of Return
Start-Up	50%
First Stage	40%
Second Stage	30%
Third Stage	25%

- Weighted Average Cost of Capıtal (WACC)

Weighted average cost of capital is the average after-tax cost of a company's various capital sources (equity and debt). WACC is calculated as below equation 2.7:

$$\text{r}_{\text{WACC}} = r_{\text{e}} \frac{E}{(E+D)} + r_{\text{d}} \frac{D}{(E+D)} (1-t) \tag{2.7}$$

where:

r_{e} = cost of equity

r_{d} = cost of debt

E = market value of the firm's equity

D = market value of the firm's debt

t= corporate tax rate

Ferguson (2016) refers that the importance of technology risk (TR) as well as discount rate. According to him, value of an IP is multiplication risk adjusted NPV and technology risk. For example, the technology risk of developing of a device is 50%.

The value of this technology should be the half of its NPV Additionally, he points out commonly used discount rates for valuing by the NPV method as in the Table 2.13.

Table 2.13 : Discount rates commonly used in NPV method Ferguson (2016).

Inflation Rate	3%
Cash Instruments	5%
Long Term T Bill	7%
Corporate Bonds	12%-18%
Average Cost of Capital	15%
Corporate Investment	30%
VC Investment	50%

Incremental Income Method:

The value of the patented technology taking into account, is the present value of the differential future free cash flows. Changes in the free cash flows can be directly attributed to the patented technology. Incremental income method is direct technique because of providing a direct measure of the economic benefit by patented technology. This valuation approach is often use to value of identifiable cost-saving technologies (Goddar & Moser, 2011, p. 128; Park et al.,2012).

Monetary growth, increase in selling price per unit, increase in market share and increase in the number of customers can be taken as basis to determine the income increase in the method. In the same way with cost reduction, decrease in cost of goods sold, decrease in material cost, increase in production level, decline in management expenditures and decline in total cost of capital can be taken as basis (Sozer, 2008).

This approach need to isolate the incremental income attributable to the technology, therefore it is often difficult to apply. Income growth can be attributed by contributing assets, such as a trademark or a pooled labor force. In general, it is not possible to measure the effect of a technology being valued on volumes and sales prices; For this reason, patented technologies are not often valued using this techniques (Goddar & Moser, 2011, p. 129).

Profit Split Method:

There is an income from having a patent within the total income of companies or a unit of companies. Profit split method relates income depending the patent to total income. In general, the method by which income criteria such as operating cash flow, operating income or net cash flow is used begins with the division of the total income to distribute it to all the assets that constitute the company's income (Sozer,2008).

Biotechnology companies of late stage products to pharmaceutical companies are often used profit split method in licenses. If the licensee sells relatively few products, the cost distributions are quite clear and transparent. In this case, profit sharing decision are the best result. This is why the method works good in the pharmaceutical industry. The cost of a company has to collect for different products, therefore, profit sharing license arrangements should include a fairly detailed set of financial provisions to determine which charges will be allowed, thus the licensee will eventually check the payments he will receive (Stevens, 2016).

Maximum Achievable Profit Method:

The maximum achievable profit method (MAP) reduces problems related with the discounted cash flows method. The maximum incremental profit based on commercialization of a patent is identified in this method. The present value of this profit express the highest valuation of patent. All factors which affect the value of a patent are rated to give a score. The MAP method starts with the determination of market size, achievable market shares and profits per unit of patented product. During these determinations, the most optimistic values are used, such as the maximum market size, the maximum market share a company can reach, and the maximum profit that can be earned from patented product. MAP is calculated with these values. All factors affecting the value of the patent are identified and classified into categories, subcategories, and stand-alone. Example: The "patent" category has the "request width" subcategory, and this subcategory has the "total number of requests" factor. Then, if sufficient information is available, all factors which affect the value are systematically graded. The discount rate in the DCF method is considered in this rating process in the MAP method. The rating is based on measuring the risk effect of each factor and determining an arbitrary risk premium. These ratings are multiplied by the weight coefficient given to the same factor, yielding a weighted grade. The ratings of some factors affecting patent value are given in Table 2.14.

Table 2.14 : Grading of some exemplary factors that affect patent value (Carte, 2005)

Category: Sub- category factor	Instructions for grading	Grade	Weight	Weighted grade
Patent:	Does the patent provide a competitive advantage? Scores range from – 1000 to + 1000. Negative scores indicate that patent may help competitors.		0.400	
Term	+5 for each year remaining. Max = +100	85	0.100	8.5
Alternative products	Do alternate products exist? Many = -100. None = 0.	0	0.100	0
Design around	How easy are the claims to design around? Very = -100. Impossible = 0	0	0.090	0
Breadth claims:	How broad are the claims		0.030	
No. of total claims	1 point for each claim. Max = 30.	30	0.010	0.3
No. of independent claims	10 point for each claim. Max. = 50.	50	0.010	0.5
No. of device claims	1 point for each claim. Max. = 10.	15	0.005	0.075
No. of method claims	1 point for each claim. Max. = 10.	15	0.005	0.075
Continuation pending	+ 100 points if continuation pending.	0	0.020	0
Quality of specification	Scores range from -300 to + 300	100	0.020	2
Enabling	Lack of enablement = -100 Complete enablement = + 100		0.008	
Best mode disclosed	Lack of best mode = -100 Disclosure of best mode = + 100		0.008	
Supports favorable claim construction	No = -100. Yes =+ 100		0.004	
Enforceability:	Scores range from -300 to +300	175	0.040	7
Previously litigated (but not invalidated)	Unfavorable outcome = -300 Favorable outcome = +300		0.010	
Invalidating prior art	Potentially invalidating prior art = -100. None = +100		0.010	
All prior art cited	Uncertain = -100. All known material prior art cited = +100		0.010	
Infringement	Patented product likely to infringe the patent of another = -100. Not likely = +100		0.010	

To determine the value, the present value of the maximum achievable incremental profit, an investment amount and the score, are used as following formula 2.8 (Carte, 2005):

$$VAL = (MAP + INV) \ e^{-(\frac{Score-100}{40})^2} - INV \qquad (2.8)$$

where:

VAL = the valuation;

MAP = the maximum achievable profit;

INV = the investment;

Score = the percentage score.

Although it is argued that more reliable results can be obtained by not using the discount rate in the DCF method, the MAP method also has arbitrariness during the rating (measuring the risk effect of each factor and determining an arbitrary risk premium) (Sozer, 2008).

Technology Factor Method:

Andriessen (2004) refers that the technology factor became known thanks to Khoury, who is senior intangible asset appraiser at DOW Chemical Company. Dow's responsibility is to improve existing technology competencies and maximize their value through their intellectual assets. To make decisions on technology exploitation, determination of the value of technology at each phase of its development is necessity. Thus, the technology factor method was designed. It is also useful in purchase/ license infringement, litigation, sell/ out license and decision making. This method is used to determine the fair market value of a specific technology. The methodology includes two parts: determining the NPV of the technology and prediction of a technology factor between 0 to 100%. The multidisciplinary team of experts looks qualitative assessment such utility issues and competitive advantage issues. The utility issues can be usefulness of the technology to company or others, capital and required to implementation, useful life of technology. The competitive issues emphasis competitive differentiation of technology, alternative technologies, legal strengths and anticipated competitive response. This method is not so applicable for early stage technology.

Technology factor method involves determining the cost structure, the future cash flow, the required capital expenditures, the discount rate, etc. When a patented technology is used for a product, this method is to convert future economic value into

the present value depends on the potential to provide economic benefit. Estimation start to determine all the business value based on the technology being valued, and then multiply this total value by technology's contribution factor. With this method, different valuation results can be obtained based on the estimation of several valuation variables (Park et al.,2012).

A technology factor (ratio) that is low for low technology sectors and high for sectors that require high technology is defined, which expresses the maximum contribution the technology uses to the value of the company. This ratio is reduced to a narrower range by using competitive features such as the stage in which the technology is now, the capital required to make the technology marketable, the availability characteristics of alternative technologies such as market size, the likelihood of alternative technologies, the demoded, competitive positions of competitors and technologies. It is determined which of these features are to be used and each one is scored by giving weights (Sozer,2008).

Relief from Royalty Method:

The relief from royalty method is indirect technique. This is based on the concept that a firm which owns an asset or patented technology does not need to license or purchase it from another party. Therefore, the technology owner is "relieved" from paying a royalty. The royalty payments saved by patent owner for having the ownership of the patented technology are attributed as income to the patented technology. The value is the present value of royalty payments, taking taxes into account, over the remaining useful life (Anson & Suchy, 2005; Goddar & Moser, 2011, pp. 130-131; Park et al., 2012). This method is most applicable technology, brand and know- how valuation, when the comparable transactions exist in the market. The technology value is calculated with this method as follows (OECD, 2011; Hadjiloucas; 2014):

1. Revenue forecast with the asset being valued

2. Expected life of intangible

3. Determine appropriate royalty rate

4. Multiplication with matching valuation base

5. Deduction of tax expenses

6. Calculation the present value of royalty savings

The license and licensor may use comparable transaction in the industry to determine appropriate royalty rate. Industry royalty rates are used from more common royalty rate sources: Intellectual Property Research Associates, RoyaltySource.com, the Association of University Technology Managers and the Licensing Executive Society (Murphy et al., 2011, p. 253). Licensing is a common method to reach a technology. Using an intellectual property through licensing includes a royalty payment. Royalty payments are based on sales, units or sometimes a one-time lump sum is made with no additional obligations to the licensor. Profit expectations are fundamental for setting a royalty rate because of a royalty is basically based on the sharing of profits between the licensee and the licensor. In most negotiations, the licensee pays a share of their sales as a royalty. A license agreement can cover a running royalty rate that is based on per unit of output from using the licensed technology. Another license agreement can include a one-time lump sum patent. It is a one-and-done payment scheme. After making a lump-sum payment, the licensee is free to use the licensed intellectual property into eternity (Parr, 2016).

There are various methods under the Relief Form Royalty Method to determine the royalty rates. Each method can be considered as a patent valuation method on its own. In practice, the 25% rule has been used especially in mergers and acquisitions for over 40 years (Sozer, 2008). The methods under relief from royalty method are explained below.

- Rules of Thumb: the 25 percent rule

In the late 1950s, when Robert Goldscheider was examining commercial licenses, they found that 18 companies, Swiss subsidiary in Switzerland of a large American company licensed, made about 20% profit on their sales and that they paid royalties on 5% of these sales, so that the amount of royalties (5%) was 25% of the profit (20%). Thus, the royalty rates were found to be 25% of the licensee's profits on products embodying the patented technology. This method underline that the licensor and licensee should share the profit from the patented products. The licensee should retain 75% of the profits because it has assumed operational and commercialization risks, substantial development, contributed other technology/intellectual property, and/or brought to bear its own development, operational, and commercialization contributions. According to this rule, the royalty rate must be applied to the operating profit in the multiple profit statements (operating profit, total profit, net income, pre-

tax income) in the income statement. This method has been employed as follows (Smith & Parr; 2005, pp.410-418):

1. Determine the remaining economic life of the asset being valued,
2. The operating profit rate expected during each year in economic life of patent is projected, and 25% is performed to each of the annual figures.
3. A DCF analysis is applied, using a convenient discount rate to translate future flows into a current year lump-sum amount.

For the empirical test of the rule, the average royalty rates in 15 sectors getting from RoyaltySource.com was compared with the average profits of ratios in the same sectors getting from The Bloomberg database. The results (royalties to equity ratio) close to the 25 percent are confirmed by the rule (Razgaıtıs, 2009, p. 229).

- The 5% of Sales Method

The 5 % as a royalty rate in license agreements across all industries across all industries is most popular. Sales of patented product multiplied by 0.05 equals the royalty payment. It is related with mature trademarks and embryonic technology. It has been found in many core industries such as industrial equipment, food, construction, electronics and medical device. Although many factors such as operating expenses, profits, earnings growth, investment risk, capital investment and even development costs were not taken into account, 5% of sales method most frequently used (Sozer, 2008; Parr, 2016).

- Profit Differential Method

The profit differential method was firstly mentioned in a patent infringement court decision. This method is used for obtaining reasonable royalty rate. The royalty rate models which are used in legal proceedings can be examined for an independent license negotiation of any legal actions with regard to determination of license royalty rate. According to this analytical approach, a reasonable royalty is identified as calculation of the profit differentials obtained when the profits from the use of the infringing technology are deducted from the expected profits in a normal industry without reach to technology. The result is indicated to the infringing technology and it is seen by some as an indicator of a royalty. The analysis can be expressed by the following equation 2.9:

$$Royalty\ Rate = \text{Expected Profit Margin from the Licensed IP} - \text{Normal Profit Margin} \qquad 2.9$$

Finding normal profit margin can be accomplished by considering the profit margins of other companies that in the same industry but without access to the technology to be licensed. The average of the profit margin of selected companies is used as normal profit margin (Smith & Parr, 2005).

- Return on Investment Method

The lack complementary assets to account in the profit differential method can be eliminated by return on investment ratio. The fundamental of this method is define the total profits of a business and distributing the profits among the different classes of assets of the business. For this, the income from many assets of the company, including patented technology, is calculated. Then, total income is distributed according to different asset categories, amount of assets in each category and comparative investment risks of each asset category. Then, fair rate of return is determined for all assets. These rates for each asset represent the comparative risks of these assets. Table 2.15 shows the distribution of the weighted average of capital costs to the assets of a sample company. Weighted Required Return (%) values are obtained by multiplying the Percent (%) and Required Return (%). The allocated weighted return (%) values are calculated with the ratios within these values. The allocated weighted return in the rightmost column of the Table 2.15 represent the royalty rates of the related assets.

Table 2.15 : Required return on intangible assets & intellectual property (Smith & Parr, 2005, p. 361).

Asset Category	Amount	Percent%	Required Return%	Weighted Required Return%	Allocated Weighted Return%
Net Working Capital	10,000	10	2.00	0.20	1.6
Fixed Assets	20,000	20	7.00	1.40	11.1
IA & IP	70,000	70	1571	11.00	87.3
INVESTED CAPITAL	100,000	100		12.60	100.0

As can be seen in the Table 3.7, the royalty rate for intangible assets is 87.3%. This means that 87% of the profits are due to intangible assets. For example, in a company with an operating profit of 20%, 17% of this profit comes from intangible assets. The

final job to do in this analysis is to decide how much of this (17%) is due to patented technology. For this, the same analysis as above will be made for this company by finding a company with similar intangible assets but not patented technology. The royalty rate of patented technology is determined to be 7% by subtracting the allocated weighted return (for example 10%) for intangible assets of this company from the weighted profit distribution (17%) of intangible assets of the company with patented technology (Smith & Parr, 2005, pp. 359-363).

2.4.4.6 Other valuation approaches

In addition to the traditional valuation methods, a few advanced valuation methods are used for value an IP. The reason why they are called advanced methods is that they contain more complex mathematical calculations than the NPV method. Risk Adjusted NPV Method, Probability Tree Analysis, Monte Carlo Method and Real Option Pricing Method are most prominent methods of advanced methods. They require expertise in practice. (Sozer, 2008). These methods depend on decision tree models where the conditional events required for the IP to generate value is modeled explicitly. The application of the methods has two steps. First step is computation the probability of the positive event occurring which will make the IP valuable, and second step is computation the earnings if the positive event occurs (Flignor & Orozco, 2006).

Risk Adjusted NPV Method:

When the costs are significant and early, and the project returns are far into the future for long lived projects, the use of single discount rate lead to make projects look economically unattractive because of heavy discounting that is a step in DCF equation. For pharmaceutical technologies, where the first income may not occur for seven or even ten years after a technology license, applying high values of discount rate make it difficult justify investing in any project (Razgaitis, 2009, pp.338-339).

In standard NPV method, the risk is explained in the discount rate. Higher discount rate means higher risk. Risk is not constant during the project's lifetime. Risk is occurred technical and market risk that is decreased in progress during the project, but the NPV method use the same discount rate, which is defined in the beginning of the project, during the project's lifetime. that was appropriate in the earliest, highest risk phases of the project The major difference between the discount rate in NPV method and the raNPV method is that risk is determined clearly in the raNPV method, and the

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discount rate used in NPV approach does not a risk based discount rate, it is only a cost of money discount rate (Stevens, 2016).

Probability Tree Analysis:

Decision trees (also referred to as probability trees) can be used for patent valuation analysis and patent decision making and help to show the best choice among possible alternatives. Decision trees are schematics of future events in which each node represents a decision point with which a probability can be associated. To construct a decision tree, five steps are followed: identifying the constituent parts of the decision or valuation exercise, specifying the subsequent decision and uncertainties that flow from the initial decision, determining the probabilities for each future uncertainty, predicting the value for each alternative decision and outcome path and performing the necessary rollback calculations to reassemble the constituent elements back to a value result (Murphy et al., 2012, pp. 69-70). According to Parr (2005), decision tree approach can be useful even if it does not directly value a patent, because it forces one to logically examine the probabilities.

The most important problem encountered in the valuation with probability trees is how to determine the probability of realization of each scenario. Some suggest using similar information from similar projects in the past to solve this problem. However, even assuming that such portfolios exist for patented technologies, the unique features of each patent make it debatable for the patent to have the likelihood of success / failure for other patents in the past. In this regard, it would be a more reasonable solution to consider the possibilities of realization to be determined by those with very large experience in the relevant area (Sozer, 2008).

Monte Carlo Method:

Monte Carlo method is the most sophisticated analyses for multiple scenario techniques. Monte Carlo calculation does not produce a single value answer. Because of their complexity and multiplicity, these calculations are computer-based. Crystal Ball and @Risk are two commercially available Monte Carlo simulation software which work with Microsoft Excel. (Smith & Parr, 2005, p.251; Razgaitis, 2009, p.345). NPV and risk adjusted NVP method require some assumption of an analyst. The Analyst make assumptions about all parameters of the asset being valued or project. Such as costs, revenues, risk of project etc. Then a single value is generated as the

estimate best of the present value of project. On the contrary, Monte Carlo approach the analyst to set ranges round the various parameters; this implies the possibility that cost overruns during development and sales may be lower than expected. Then the NPV is accounted for each combination of the estimated parameters, and the results are presented as a distribution of the probability of the NPV. The benefit of using this method is to give much more complicated analysis of risk than NPV and raNPV. Besides the benefit, there is limitations to apply Monte Carlo method. For early stage technologies the data may not be available (Stevens, 2016).

In using Monte Carlo analysis, hundreds or thousands of DCF calculation are performed. The Monte Carlo system provides with the distribution of the results. The distribution, standard deviation, mean, median and average in graphic form for each one of the results can be observed (Smith & Parr, 2005, p.251)

Real Option Pricing Method

A real option is a right to make or abandon a capital investment or business decision. The owner of the option has not an obligation to use this option. There are two types of options which are called call option and put option. A call option gives the option holder the right to buy a property or financial asset at a specified price for a specified time. A put option gives the option holder to sell a property or financial asset at a specified price for a specified time. In addition to financial asset, investment projects, manufacturing plans, business opportunities, R&D projects and patent can be a subject for option. The principal processor of the real option method is that the value of underlying asset is very uncertain, but the option holder has some degree of flexibility regarding its execution. (Oriani & Sereno, 2011, pp.142-143). Real option methods have been most useful for pharmaceutical and oil exploration sectors because of these sectors require large capital investments with a highly uncertain and far away payoff (Flignor & Orozco, 2006)

Fischer Black and Myron Scholes developed Black-Scholes option pricing model to value financial option contracts in 1773. Black-Scholes model specifies the value of an option as a function of the following variables in equation 2.10 (Murphy et al., 2012, pp. 166-170):

$$C = S\,N(\mathrm{d_1}) - K\,e^{-rT}\,N(\mathrm{d_2}) \qquad\qquad 2.10$$

$$d_1 = (\ln (S/K) \; + \; (r \; + \; v2/2) \; T)/ \; v\sqrt{T}$$

$$d_2 = d_1 - v\sqrt{T}$$

C: price of call option

S: current price of underlying stock

K: exercise price or strike price of option

T: time to option expiry

r: risk free interest rate

v: volatility of the stock price

If the Black-Scholes model is adapted to the patent, the variables will be expressed in the following:

S: NPV of the cash flow that will result from the future decision

K: Capital investment required the future decision

T: Length of time the future decision will expire (patent life)

v: volatility of the cash flow that will result from the future decision

According to Oriani and Senero (2011, pp. 149-152), patent return in the pharmaceutical firms are very uncertain. The real option method is an alternative for patents in pharmaceutical industry. New drugs are required many test and evaluations in order to determine their safety and effectiveness before releasing to the market. New drug development process is approximately 10-12 years. At every stage of new drug development, United States Food and Drug Administration and other regulatory agencies scrutinize the process. Pre-clinical and clinical trials and meeting government regulatory requirements take time significantly. There is an empirical evidence that the government agency will approved only 21.5 percent of drugs entering clinical development. Depending on the test results, firms can be abandon the development of the drug. Firms have an option to abandon the drug development project at each development phase. or to proceed the following step to development. Under the uncertainty, patent can offer various flexibility to different real option.

There are four main real option for patent valuation: Option to wait, option to abandon, option to expand and option to sue. The option to wait means that the patent holder can defer launching the new product protected by patent. In other words, decision-maker can wait for a specific period of time to see the profitability of an investment. In this case the patent can be considered as a call option, where the present value of

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the expected cash flow of patent (V) and the strike price is investment (I) needed. At the time to option expiry, the worth of option to wait is max (V-I, 0). The option to abandon exists when the patent holder can be abandon the patent with or without limited cost. The patent holder can avoid further fee for renewal of patent. The option to abandon can be viewed as a put option. Abandonment may provide some salvage value (S) by selling the patent right and saves on renewal fees. At the term of option, the worth of this option is max (S-V, 0). The option to expand refers to expand the geographic protection of patent. This requires additional fees (F) for each country. If the present value of the cash flows from the patent in the new countries is over than the additional fees to apply a new country, patent protection can be expanded in some countries. This option can be considered as a call option. The value of this option at the maturity is max (V-F, 0). Option to sue exist when a potential litigation event occurs. When a patent right is infringed, the patent holder can use the legal system to block the infringing activity and sue for damages. The patent holder has a right on the present value of the cash flows from the patent exploitation (V). If damage (D) becomes very high due to expected cash flow from the patent (V), then the patent holder may invest in litigation in order to stop the infringement. This option can be considered as a put option which gives the right to sell the present value of expected cash flows from the patent (V) instead of a certain damage (D) accounted by a court. The value of the option to sue at the maturity is equal to max (D-V,0).

3. METHODOLOGY

The aim of the study is to explore the current practices, applicability of and preferences on the quantitative IP valuation methods in different contexts and cases of IP ecosystems of technology transfer. In R&D and innovation ecosystem all over the world, intellectual property has become most important right to protect the owned competitive technology. There are many reasons to value the intellectual properties such as making strategic decisions, purposes of merger of a company, acquisition, joint venture, negotiations and transactions to sell or license intellectual property, court proceedings, taxation purposes and etc. In this point, the preference of the appropriate quantitative valuation method significantly affects the application process and achieved results. In this context, the main research questions of the study are designed as follows:

- What is the level of expert knowledge and level of usage for different patent valuation methods?

- Why and how are different valuation methods used? The aim of using different valuation method

- What are the advantages or difficulties of patent valuation methods?

- What are the appropriate sectors for applying different patent valuation methods? What is the relationship between industry type and valuation method preference?

- How and why is combined application of the valuation methods used?

The motivation of this study is also inspired by the fact that I work as a technology transfer professional and expert in ITUNOVA Technology Transfer Office that is TTO of Istanbul Technical University. Intellectual property valuation is a critical part of my job. My colleagues and I know that IP valuation is a necessity at the right time for commercialization. It requires multidisciplinary studies and applying right strategies During the valuation process, we deal with many uncertainties. I experienced that the different valuation technique gives different results. The listed valuation method in

section 2 can be learned theoretically but its application knowledge requires a different kind of expertise. Before starting this research, I've consulted the General Manager of ITUNOVA Technology Transfer Office and we've discussed the need of a research regarding IP valuation especially for University based technologies. Then I decided to make a research based on IP valuation expert opinions and experiences.

3.1 The Research Methodology

This study aims to focus on exploring and understanding the patterns, characteristics and challenges of patent valuation practices which utilize quantitative valuation methods. To begin with the literature, we searched about the theoretical and regulative frameworks of intellectual property, patent valuation method and research methods. Science direct, Google scholar, ITU Library have been used as acquisition of literature resources.

Data Collection:

In this study we used both primary and secondary data to be used in analysis. For primary data, we conducted Delphi survey, structured in-depth interviews, observations and self-history.

As stated by Kothari (2004, p. 95), the primary data are those which are collected a fresh and for the first time, and thus happen to be original in character. The secondary data, on the other hand, are those which have already been collected by someone else and which have already been passed through the statistical process. There are several methods of gathering primary data, particularly in in surveys and descriptive researches. The main methods are observation method, interview method, through questionnaires and through schedules.

Each method is briefly explained below (Kothari, 2004, p. 95):

- **Observation Method**

This method is generally used in studies relating to behavioral sciences. When observation carry out a formulated research purpose, is systematically planned and recorded and is subjected to checks and controls on validity and reliability, it becomes a scientific tool and the method of data collection for the researcher. Under the observation method, the information is gotten through observer's own direct observation without asking from the respondent.

- **Structured Interview Method**

This method of gathering data is oral-verbal communication where interviewer ask questions to the responder. Two types of interviews are personal interview and telephone interview. Personal interview method requires an interviewer asking questions in a face to face to responder. Telephone interview method requires contacting on the telephone. These two type interviews can be structured or unstructured. In a structured interview follows a rigid procedure pre-determined, asking questions in a form and order prescribed. In an unstructured interview, interviewer do not follow a system of pre-determined. The interview can be in depth. Depth interviews are applied to discover underlying motives and desires and are often used in motivational research. Such interviews are held to explore needs, desires and feelings of respondents. Indirect question or projective techniques are used to know behavior of the respondent.

- **Through Questionnaires**

Questionnaires are very popular tool for data collection. A questionnaire consists of a number of questions and it is mailed to respondents who are expected to read and understand the questions and reply it. The respondents have to answer the questions on their own.

- **Through Schedules**

In through schedules method, the data is collect through questionnaire but the questionnaire is filled by enumerators. Enumerators are assigned for filling questionnaire and they explain the aim of the study and fill the answers in provided space.

Beside the methods mentioned above, Focus group study or Delphi technique for the different purpose may be used for data collection in a research.

- **Focus Group**

Focus group study is a way to interview in-depth with a small group. This group being focused on a given topic. A moderator who a well-trained professional who works from a predetermined set of discussion topics guides the group interview while participants discus the topics. The essential data in focus groups are the participants' opinion and discussion. in the group say during their discussions are. Generally, there

are six to eight participants who have similar backgrounds (Morgan, 1997, p. 1). According to Guest et al. (2017), the focus groups range in size can be 6 to 12 participants. The number of participants for focus group suggested as being manageable. The large number of participants provide variety perspectives and small group is enough not to disorganized and disjoined. The lack of self-confidence and self-esteem of participants can hinder their participating in a group discussion. Therefore, some participants of focus groups may not be active participant. For this reason, it is advisable to provide 10-25% of the participants (Rabiee, 2004).

- **Delphi Technique**

The history of Delphi Technique is based on the study concerning the use of expert opinion of Air Force-sponsored RAND Corporation in early 1950's. They had begun investigating the scientific use of expert opinion and published several studies that group judges were superior to individual judges. The Delphi study was applied here for the first time as part of a defense project with all its features (Dalkey & Helmer, 1963, p.458). The Delphi approach, a quantitative research method, is the most appropriate method that can be used when expert opinions are sought, evidence is low or not significant. The advantage is that it exposes the experts as an individual (Okoli and Pawlovski, 2004). In general, the characteristics of the Delphi study are anonymity, repetition, controlled feedback and statistical group response (Rowe & Wright, 1999). Delphi is defined as structuring a group communication process. The process referred as "structural" is defined as the reorganization of the system by taking returns, the evaluation of group opinions, and the option of re-evaluating opinions of individuals (Linstone & Turoff, 2002, p.3). In the literature, the Delphi method can be used for situation detection and estimation (Brancheau et al., 1996; Hayne & Pollard, 2000). Akins et al. (2005) mention that Delphi technique has numerous advantages:

- The ability to conduct a study in geographically different locations without physically bringing the experts with no prior history of communication with one another together;
- Sufficient time to give opinion;
- Time and cost efficiency;
- Respondents can respond at their convenience;
- The anonymity of participants;
- The effective proof of the method in a variety of fields, problems, and situations

Since there are not too many experts on patent valuation in Turkey, it was necessary to reach the experts abroad. It was not possible to bring together all the target participants and make a focus group meeting or personal interview. This is particularly useful when there are only a limited number of experts in a field of interest (Culley, 2011). Therefore, in this study, Delphi survey method were chosen to gain more insight into the experts' perceptions about the IP valuation methods. This is essential because of the fact that there is not many IP valuation experience in Turkey. So this research had to design all questions about the experience of experts. During this process, expertise and knowledge of patent valuation professionals as experts were highly needed and their contribution and participation were critically guiding.

3.2 Data Collection Process of the Study

3.2.1 Pre Survey Interviews

For verifying the research, structured interview method on the IP valuation methods is used and we made interviews with some experts at various meetings and conferences.

With some experts from EPO and Deutsches Patent- und Markenamt, Technisches Informations Zentrum Berlin, we discussed the aim of planned research at PATLIB2017 conference which was organized by EPO as a learning event dated on 3th and 4th May 2017. Every year, the member of Patent Information Centres (PATLIB centres) in Europe attend this event. The experts interviewed have given some opinions, advices and IP valuation expert recommendation for study planning process and said that they can contribute at the data gathering process. Announcement of a survey about patent valuation in PATLIB network was required from EPO expert. But it is mutually convinced that the number of expert of PATLIB who has full knowledge of IP valuation is not much in all members of PATLIB centres. However, they recommended some expert who have experienced about IP valuation from EPO or different companies/institutions.

In this study, I also used my own knowledge as an expert contribution with my 5 years' career as a technology transfer professional. I know that IP valuation is a necessity at the right time for commercialization. During the valuation process, I witness many uncertainties. Before starting this research, I've also consulted the General Manager of ITUNOVA Technology Transfer Office as an expert.

The aim and necessity of this study have been explained to some TTO experts and technology investors from two other investment fund management company in Turkey and their opinions have received. The focus of interviews was IP valuation methods used more often and its application conditions while a patented technology. For further study for data collection from expert, valuable information was gained to ask IP valuation experts.

In September 2017, I attended to IP.CAMP (https://www.ipcamp.org/) training event. IP.CAMP is the training event in the field of Intellectual Property Management and Licensing that is organized by Sabanci University Industry Collaboration and Technology Licensing Office (ILO), EBILTEM Technology Transfer Office and LES Turkey and supported by USIMP. Every year, professionals who are active in IP management and licensing field attend to this event. This year the main topic of the trainings was patent valuation and licensing. This was a chance for this research. There were the trainers who have many experience in IP valuation and participant be interested in this topic. Some IP valuation technique in income method was explained in detail. Pre-interviews were done the trainers and some participant. In the case of a questionnaire, some interviewer said that they may contribute to this research with their opinions.

Pre-interviews were utilized in designing the finalized Delphi survey questionnaire and also the interviewees were asked to provide the information about potential participant experts for the survey. Based on the interviewees' references, Delphi survey participant invitation was designed.

3.2.2 Delphi Survey

Survey has been prepared based on literature review and the opinion of experts that were interviewed as explained in the 4.2.1 section. In follows it is explained in detail.

3.2.2.1 Structure of the Delphi Survey

The survey consists of 18 questions oriented 18 quantitative valuation method which are:

- Reproduction method,
- Replacement method,
- Sales comparison method,

- Comparable Profit Margin Method,

- Discounted Cash Flow Method,

- Incremental Income Method,

- Profit Split Method,

- Maximum Achievable Method,

- Technology Factor,

- Return on Investment Ratio,

- Relief from Royalty Method,

- Rules of Thumb, the 5% of Sales Method,

- Profit Differential Method,

- Risk Adjusted NPV Method,

- Probability Tree Analysis,

- Monte Carlo Method

- Real Option Pricing Method.

In the beginning of survey, there is a personal information about the participant including their name, company and position. Totally 11 multiple choice questions regarding the recognition level of each method, utilization of each method, purpose and reason of selection of each method, using of each method in different sector's patent valuation and convenience of each method for University's IP, Start-up's IP, software technology and nonproprietary technology were asked to participants. These questions are asked as a matrix. 5-Likert Scale where 5 implies "very high" and 1 implies "very low" and yes/no options were used for some questions. 6 open ended questions regarding necessities, difficulties and advantages in applying each method and combining of methods were asked to participants. After the questions regarding the recognition of each method and usage of each method, the answers were expected according to the valuation method participants know and/or used before.

After preparing the survey, a pilot study was conducted with some experts. There are some feedbacks which given from some experts from UK and Turkey before the survey was shared with targeted participants.

- Scales were edited.

- Options added yes/no questions as "some".

- Some new options were added to few questions.

- Type of two questions were changed.

- The definition of TRL were added.

- Some typos and ambiguities were corrected.

- A summary info of valuation methods mentioned in questionnaire was prepared to share with participant.

Table 3.1 illustrates of questions, scale of questions and sources. The questions were derived from related literature, the pre interviews and the self-experience. Survey can be founded in Appendix A.

Table 3.1 : Question table of survey.

Question	Scale	Question Number	Source
Please introduce yourself	Nominal	1	X
Do you have any information about these methods?	Interval	2	X
Have you ever used these methods to value an IP before?	Nominal	3	Expert in pre-survey interviews
When do you use these methods to value an IP, what is the commercial or strategic purpose?	Nominal	4	Lagrost et al., 2010, Speier & Gupta, 2015
When/Why do you use this method?	Nominal	5	Speier & Gupta, 2015
In which sector's patents are these methods often used?	Nominal Method by industries matrix	6	Grube, 2009
Evaluate this method for being preferable for the University's Intellectual Property valuation in general?	Ordinal 1-5 Likert Scale	7	Wang (2016), Expert in pre-survey interviews
Evaluate this method for being preferable for the Start-Up's Intellectual Property valuation in general?	Ordinal 1-5 Likert Scale	8	Dubiansky (2006), Pöltner et al. (2011), Expert in pre-survey interviews
Are these methods useful for patent pending technology or nonproprietary technology valuation?	Ordinal 1-3 Likert Scale	9	Expert in pre-survey interviews
Which methods are used for IT/ Software product pricing ?	Listed Nominal	10	Smith & Parr, 2005
Which TRLs (Technology Readiness Level)* (1 to 9) are more suitable to apply this method?	Interval	11	Expert in pre-survey interviews
What are the necessities or inputs of the application of this method?	Nominal	12	Smith & Parr, 2005, Hagelin, 2002
What are the difficulties in applying this method?	Nominal	13	Speier & Gupta, 2015

Table 3.1 (Continued): Question table of survey.

Question	Scale	Question Number	Source
What are the advantages of this method?	Nominal	14	Speier & Gupta, 2015
Do you consider the qualitative approaches for future potential of the technology being valued?	Nominal	15	Chiu and Chen (2007), Lagrost et al., 2010,
In which step do you use qualitative indicators and what is the effect to monetary value of technology?	Nominal	16	Lagrost et al., 2010, Expert in pre-survey interviews
Do you apply more than one method to value an IP?	Nominal	17	Grube, 2009
Which methods do you use simultaneously to value an IP?	Nominal	18	Expert in pre-survey interviews

3.2.2.2 Conducting Survey

The primary consideration in this study is exploring the conditions of use of IP valuation method according to the experience of experts. In this context, a Delphi survey was conducted to collect information and opinions in the patent valuation methods. The survey was conducted in a closed manner and based on the invitation of the participant list that represented the experts regarding IP valuation. The participant list that represented the experts in IP valuation. Survey was prepared on SurveyMonkey. Afterwards survey links and summary info of valuation methods was sent via customized e-mail and LinkedIn message to target participant list. The survey was sent to the experts, colleague in TTOs, instructors, speakers regarding IP and valuation who have been met before in national and international conference, training, meeting and etc. When the survey was sent via email, new expert recommendation was asked to participant (to utilize snowball effect). In order to contact with new people, the IP experts were searched on LinkedIn and various website. From Technology Transfer Office's website, patent valuation and investment companies' website and some IP network such as USIMP, LES, ATTP, ASTP-Proton, some contact addresses were reached and survey was sent them via e mail. The individuals who will be invited to the survey have the following characteristics:

- Professionals working on Intellectual Property management and technology investment

- Researchers studying on Intellectual Property, business valuation, IP valuation and evaluation,

- Experts working at TTOs, Patent Offices or Intellectual Capital Firms, national or international patent organizations.

In the first round, the Delphi survey was sent to totally 87 experts from Turkey, UK, USA, Germany, Hungary, Austria, Luxembourg and Holland. Experts who did not respond within 10 days of the posting were sent an e-mail reminding them. Participants had the option of leaving the survey uncompleted and then completing it at a later time. 15 experts from different countries out of the 87, responded to the survey. The response rate is approximately %17. Some participants who cannot participate to the survey have informed that they are not convenient participants because of their limited experience even they are working on or interested in intellectual property.

The Delphi surveys results were reviewed for their face validity. There were some irrelevant answers for two open ended questions showing that these questions were misunderstood by the respondent. Therefore, teleconference was made with the responder. Two questions and the answers were discussed. After then the respondent corrected some answers.

The results of Delphi survey obtained from SurveyMonkey. The results of multiple choice questions were shown in the percentage graph or the table creating the number of respondent. When the findings analyzed, the scale of two questions which have 5-Likert scale where 5 implies "very high" and 1 implies "very low" was used was converted 3-Likert scale where 3 implies "high" and 1 implies "low" to make the result clearer. Due to the number of respondents we use normalization. The result of open-ended questions, the responses classified according to similar opinions and the frequency of all responses is indicated in the report of outputs of the first round responses.

In the second round of Delphi survey, the outputs of the first round responses as report were shared with all participant to receive their final consensus and opinion about the results. Totally 11 participants participated in second round. With two of them have made face to face interview with regard to all questions and answers. Each of the second of Delphi survey respondents generally confirmed the findings.

The reliability and validity should be considered in any research study. Reliability is the rate at which a procedure produces similar results under constant conditions under all conditions. In two or more panels which are given the same information, same

results don't be obtained. Therefore, there is no evidence of the reliability of the Delphi method. It is unlikely that a few people will reach a wrong decision than one person. It can be said that Delphi method is based on the assumption of safety in numbers. The decisions are then strengthened by logical arguments that are challenged by the assumptions, thus helping to increase their validity. Besides, the participation of individuals who have knowledge and are interested in the topic can help to increase the content validity of Delphi and help increase the validity of the use of consecutive rounds of the survey (Hasson et al., 2000).

No reliability and validity studies were conducted for Delphi surveys because the number of respondents participating in the survey is very small. There is no opinion on sample size for Delphi researches, nor any suggestions or precise definitions of "small" or "large" examples. In literatures, 10 to 1685 participants were utilized in Delphi studies (Akins et al., 2005). Reliability test cannot be conducted – cronbach alpha test cannot be applied with such low sample size. It is hard to say the minimum level of sample. Yurdugul (2008) referred very fruitful literature overview about minimum necessary sample size for cronbach alpha test. The minimum sample size for coefficient alpha is commonly recommended as 200, 300 or 500. In his study minimum sample size for Cronbach alpha test was tried to estimate. The sample sizes were used as 30, 100, 300, 500. Baskale (2016) mentioned that some researchers have emphasized that the number of samples for qualitative studies cannot be calculated, that the purpose of qualitative research is not to generalize the outcomes of the whole universe, and that one or two cases are sufficient. Some researchers have stated that the power of qualitative research can be evaluated in different ways. Qualitative power analysis is demonstrated by its effectiveness with adequate sampling. Qualitative studies should be assessed according to how well they meet the relevant objectives and the suitability of the units in the sample. These units can be people, words, observations, events, activities, social process or anything in the work.

4. FINDINGS

This section presents the finding of first round and second round of Delphi Survey.

4.1 Delphi Survey Findings

Taking into account the findings of the first round of Delphi survey, a report of findings given in Appendix B was created. The report was sent to the all participant of first Delphi survey. The adverse opinion, consensus or new opinion regarding the findings and questions were asked to them. Totally 11 participants participated in second round. The all findings were examined with two experts participated first Delphi survey in face to face meeting. Each of the second Delphi respondents generally confirmed the findings. Just one respondents have been face to face interviewed gave points to a comment indicated for Question 6 regarding sectors. It was mentioned in first Delphi survey that using the valuation methods do not depend on the technology. From one respondents give adverse opinion about this comment in second round of Delphi. He indicated that some methods are often used in some specific sector, it can be seen even in literature.

The findings of first round of Delphi survey is stated in 4.1.1 and 4.1.2 sections.

4.1.1 Identification of Participant

In the survey, personal information such as name, family name, the organization where they work and their professions were asked to participants firstly. 15 experts participated to the Delphi survey. While the survey report was shared, consent have been received from participants in order to indicate the names and experience year of participant in this section. The information of the participants is given in the Table 4.1. The experiences of all include at least one valuation of a technology or business. 9 of the listed participant have experience in TTOs. There are 5 participants from IP firms and one participant from IP Merchant Bank. Totally 7 participants have international certificate related licensing, commercialization or technology/knowledge transfer. 5 of the participants have CLP certificate, 4 of them have RTTP certificate and 2 of them

have EuKTS certificate. Participants also include patent attorneys, lawyers, investors and lecturers.

Table 4.1 : Qualifications of participant.

#	Name/Family Name	Experience Year	Organization	Profession
1	Aykut Gulalanlar	11	Techin2b	Founder
2	Christopher Noble	40+	Confidential	Commercialization professional
3	Iclal Arguc	7	Telos.IP	Senior Partner
4	Confidential	Confidential	Ocean Tomo	CEO
5	Johannes Schaaf	NA	EPO	Patent Information Specialist
6	Confidential	Confidential	Finnegan	Lawyer
7	Karin Hofmann	19	TU Wien	Technology Transfer Manager
8	Kazim Yalcinoglu	30+	SmartsUnited	Founder/ Technology Investor
9	Dr. Malte Koellner	20+	Dennemeyer	Patent Attorney
10	Mehmet Alpatlı	26	Istanbul Şehir University Incubation Centre	Finance & Tech Transfer Professional
11	Mustafa Cakır	8	Sabancı University TTO	Patent Attorney
12	Confidential	Confidential	University of Liverpool	Senior Lecturer
13	Omer Hiziroglu	15	Telos.IP	Founder
14	Confidential	Confidential	Confidential	Consultant
15	Confidential	Confidential	National Institutes of Health Technology Transfer Office	Deputy Director, Licensing and Entrepreneurship

4.1.2 Assessments According to The Valuation Methods

Second question and after were related with the valuation methods. According to responses regarding 18 valuation method taken from participants, rules of Thumb method is the most known technique at a rate of 73,3% and reproduction method is commonly used technique at a rate of 93,3%. As can be seen in the Figure 5.1, all participants have information about rules of thumb, reproduction and DCF method. Replacement method, sales comparison and incremental income method are also among most well-known methods. More than 60% of participants have used reproduction method, replacement method, sales comparison, discounted cash flow method, rules of thumb, comparable profit margin, relief from royalty method, risk adjusted NPV method before. When viewed from experiences and knowledge of participants, advanced valuation methods are known less than the other method and in parallel with this result they are not used by most participants. It can be seen in the Figure 4.1 and Figure 4.2.
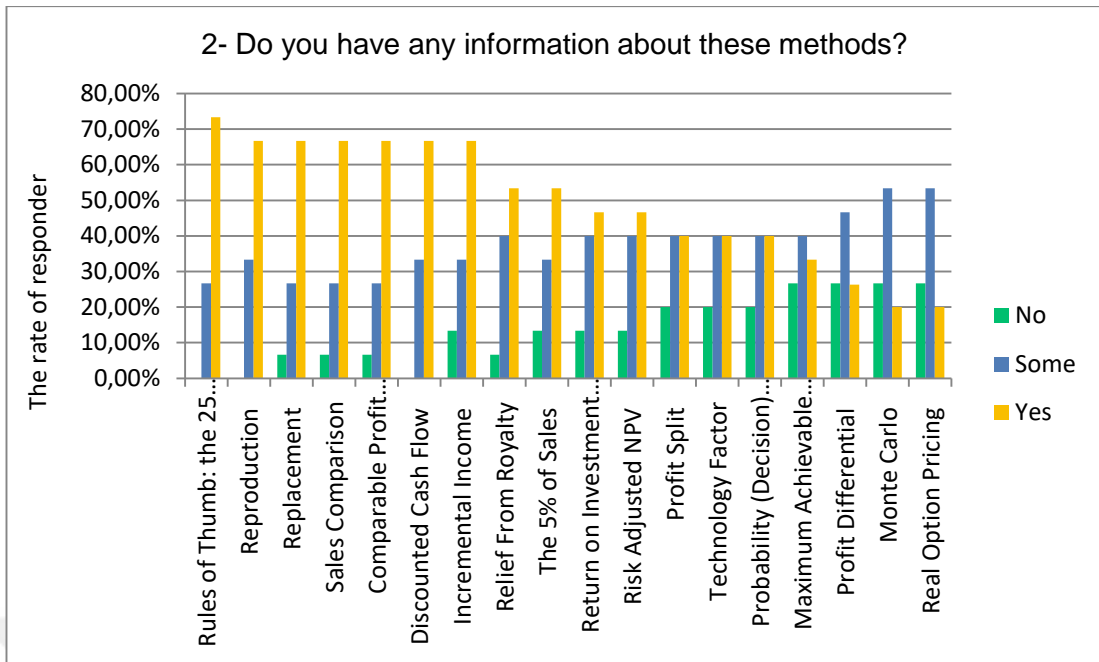
Figure 4.1 Level of Awareness about IP valuation methods
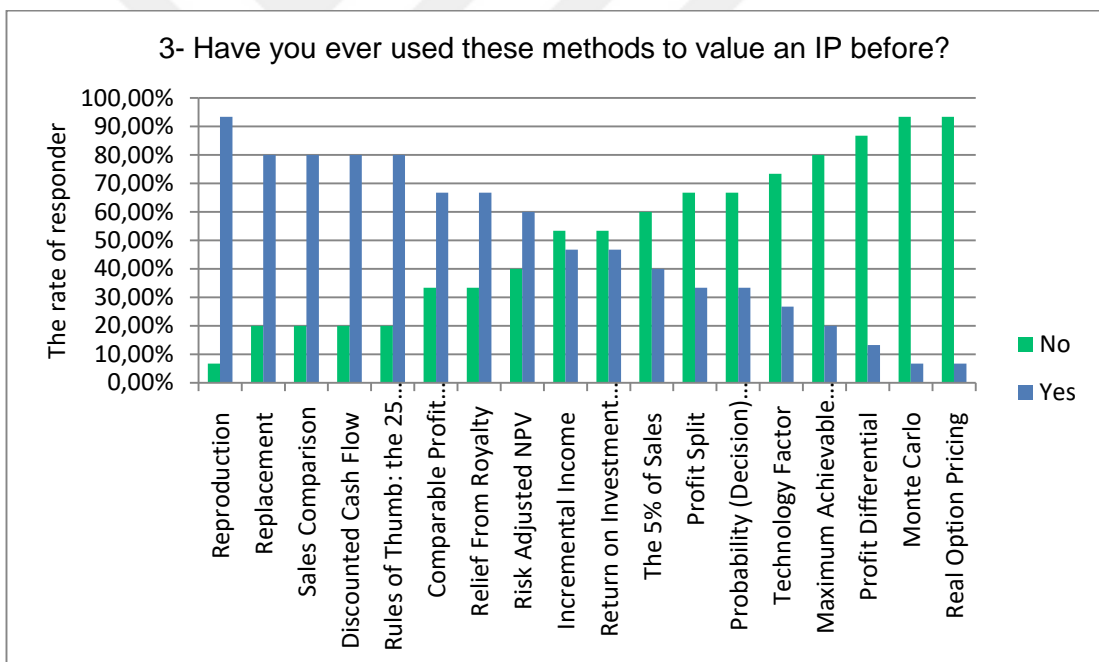
Figure 4.2 Application Rate of the IP valuation methods

As of the question 4, the answers were expected according to the valuation method participants know and/or used before and reply was not compulsory. Therefore, a different number of participants responded to each method. Table 4.2 shows the result of question 4 regarding the IP valuation purpose of using these methods and Table 4.3 show the data of question 5 about when participants use these methods. The numbers in the tables represent the number of responder.

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<p style="text-align:center">Table 4.2 : IP valuation methods by their purpose of usage.</p>

Methods/ Answer Choices	In-licensing	Out-licensing	Sale	R & D	Portfolio Analysis	Merger & Acquisition	Tax	Other	Total Preference
Discounted Cash Flow	4	7	7	1	8	3	2	2	34
Rules of Thumb: the 25 percent rule	2	7	5	3	5	2	4	1	29
Replacement	4	7	4	2	3	2	2	4	28
Sales Comparison	2	9	5	1	6	1	0	0	24
Relief From Royalty	2	5	5	1	3	2	3	2	23
Incremental Income	2	5	4	2	3	2	2	2	22
Reproduction	3	5	4	1	3	1	2	2	21
Profit Split	3	5	5	1	2	1	1	2	20
Comparable Profit Margin	2	6	3	1	4	0	2	1	19
Risk Adjusted NPV	1	4	4	0	3	2	1	0	15
Probability (Decision) Tree Analysis	2	3	3	1	1	1	0	2	13
Return on Investment Ratio	2	2	3	0	1	2	1	1	12
The 5% of Sales	0	3	4	1	2	1	1	0	12
Technology Factor	1	3	2	2	2	1	0	0	11
Profit Differential	1	3	2	0	1	0	1	2	10
Maximum Achievable Profit	1	2	2	0	1	0	0	0	6
Monte Carlo	1	1	2	0	1	0	0	1	6
Real Option Pricing	0	0	2	0	2	0	0	1	5
Total Preference	33	**77**	**66**	17	**51**	21	22	23	310

<p style="text-align:center">Table 4.3 : The method applied in different usage.</p>

Methods/ Answer Choices	Early Stage Technology Valuation	Business Valuation	In Litigation Situation	Current Portfolio Analysis	In sectors of high uncertainty and risk	Other	Total Preference
Rules of Thumb: the 25 percent rule	**10**	4	3	**6**	**7**	1	31
Discounted Cash Flow	7	**8**	3	**6**	3	1	28
Replacement	**9**	4	**5**	3	2	1	24
Sales Comparison	7	6	2	**5**	2	0	22
Relief From Royalty	7	3	**4**	4	2	2	22
Comparable Profit Margin	6	**7**	2	4	2	0	21
Reproduction	**9**	3	3	3	1	1	20
Incremental Income	5	5	3	3	2	1	19
Profit Split	4	3	3	5	2	2	19
Risk Adjusted NPV	6	5	1	3	2	0	17
The 5% of Sales	4	3	1	3	**4**	0	15
Probability (Decision) Tree Analysis	5	3	1	1	3	0	13
Return on Investment Ratio	2	3	0	1	2	0	8
Technology Factor	2	2	0	2	1	0	7

Table 4.3 (Continued): The method applied in different usage.

Methods/ Answer Choices	Early Stage Technology Valuation	Business Valuation	In Litigation Situation	Current Portfolio Analysis	In sectors of high uncertainty and risk	Other	**Total Preference**
Maximum Achievable Profit	1	1	1	2	0	0	5
Profit Differential	1	2	1	1	0	0	5
Monte Carlo	2	2	0	0	1	0	5
Real Option Pricing	2	1	0	1	1	0	5
Total Preference	**89**	**65**	33	53	37	9	286

In question 4, purpose options were chosen totally 310 times by the all respondents. The first three most frequently chosen purpose for each method are as follows: Out-licensing, sale and portfolio analyze. The most preferred methods are also seen as DCF method, the 25 percent rule and replacement cost method. According to the opinion of respondents, cost based methods are less preferable for R&D and merger & acquisition purpose. In addition to R&D and merger & acquisition purpose, in taxation issue comparing to other purposes, market based methods are less used. When the purposes for income method was examined, these methods are the least preferred in R & D purpose. The purpose are not also R&D and Tax advantage purpose when advanced methods are used as in market based method. When considering the methods that can be used according to purpose, it can be seen in Table 4.2 which methods are more applicable for in which IP valuation purpose. While the real option pricing and the 5% of sales method was not chosen for in-licensing purpose, most of responder chose the replacement cost method and DCF method. For out-licensing purpose, most preferable method is sales comparison method and followings are replacement cost method, DCF method and rules of thumb method. DCF method is commonly used for valuation in sale, portfolio analysis and merger & acquisition purpose. If the valuation need for R&D and Tax advantage, Rules of Thumb 25% rule method is the most applicable method. According to opinion of some participant for "other" option, in case of investment in a patent, return on investment method can be used.

In different valuation situation such as early stage technology valuation, business valuation, valuation in litigation situation, portfolio analysis and sectors under the high uncertainty and risk, different valuation method can be used as can be seen in the Table 4.3. The experiences of respondents say that 25% percent rule, reproduction cost method and replacement cost method are commonly used for early stage technology

valuation. For business valuation, comparable profit margin and DCF method are mostly preferred. In litigation situation, an infringed IP right is valued in general by replacement cost and relief from royalty method. Besides that, technology factor, return on investment ratio, Monte Carlo and real option pricing method are never used according to the respondents. When current portfolio would be analyzed, DCF method, the 25 percent rule and sales comparison method are the mostly used methods. This result is similar to output of Question 4. If the uncertainty and risk are high in a technology sector, the 25 percent rule and the sale of 5% is seen the most applied methods to value an IP in this sector. Similar to previous result in Table 4.2, for the general total of usage, the 25 percent rule method, DCF and replacement cost method distinguish from other methods.

The sixth question was related with the patent in different sectors. Participants considered the methods according to the sector. When the Table 4.4 is examined generally, as can be seen that the most valuation is made in the manufacturing sector. Material, automotive and medicine sectors are following the manufacturing sector. According to the opinion of responder, maximum achievable method is not used to value an IP in listed sector. There is one "other" option for this method but its name was not provided by the respondent. While risk adjustment NPV and RFR method is most preferable techniques for valuing an IP in IT technology, DCF method is most preferable method for telecom and energy sector. In mining and constructions sector, the choices are similar and close values for each method, but DCF method is seen the most preferable method for valuing an IP regarding construction. Cost based methods, market based methods and RFR method are commonly preferred for technology valuation in manufacturing sector. For textile, automotive, material and medicine sector, findings revealed that the replacement cost method is more usable. The total number of preferences of respondents on the methods and sectors in the survey refers to the most patent valuing sectors and the methods that they mostly used for valuing IP. Also for the general total of all sectors, replacement cost method, DCF method and RFR method distinguish from other methods. There is a general comment about this questions that the methods are not depend on the technology. It maybe stated that using these method is not dependent on the sector.

Table 4.4 : The method applied in different sector.

Methods/ Answer Choices	Information Technologies	Telecom	Mining	Energy	Constructions	Manufacturing	Textiles	Medicine	Automotive	Material	Other	Total Preference
Replacement	2	3	2	2	2	**7**	**3**	**5**	**5**	**6**	2	39
Discounted Cash Flow	2	**4**	2	**5**	**3**	3	2	3	3	4	1	32
Relief From Royalty	**3**	3	2	**4**	2	5	2	3	3	2	3	32
Risk Adjusted NPV	**3**	2	1	3	2	2	2	3	3	2	1	24
Reproduction	1	1	1	1	1	**6**	1	2	3	4	1	22
Rules of Thumb: the 25 percent rule	2	2	1	2	2	3	1	1	2	3	2	21
Comparable Profit Margin	2	1	2	2	0	4	1	2	2	2	0	18
Probability (Decision) Tree Analysis	2	2	1	2	1	1	1	2	2	2	1	17
Profit Split	2	2	1	2	1	1	2	1	1	1	2	16
Sales Comparison	1	2	1	0	1	4	2	3	1	0	0	15
Incremental Income	2	1	2	1	1	1	1	1	2	1	2	15
Monte Carlo	1	2	1	2	1	1	1	1	1	1	2	14
Real Option Pricing	1	2	1	1	1	2	1	1	1	1	2	14
Profit Differential	1	1	1	1	1	1	1	1	1	1	1	11
Technology Factor	1	2	0	1	0	0	0	1	1	1	0	7
Return on Investment Ratio	1	1	1	1	0	0	0	1	1	1	0	7
The 5% of Sales	0	0	0	1	0	0	0	1	1	2	0	5
Maximum Achievable Profit	0	0	0	0	0	0	0	0	0	0	1	1
Total Choice	27	31	20	31	19	**41**	21	**32**	**33**	**34**	21	310

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The usage of methods was considered for IP developed in University or Start-up companies. For question 7 and question 8, 5-Likert Scale where 5 implies "very high" and 1 implies "very low" was used, but when the findings analyzed, the scale was converted 3-Likert scale where 3 implies "high" and 1 implies "low" to make the result clearer. Figure 4.3 and Figure 4.4 show that commonly preferred valuation methods for the University's IP and start-up's IP. For University's IP, comparable profit method, profit split, maximum achievable profit, Monte Carlo, real option pricing, return on investment and profit differential method were less preferable. The rate of responder for the "low" option is greater than and equal to 50% for these methods. The methods with high preference level for valuing University's IP are replacement cost, the 25% percent rule, the 5% of sales, reproduction cost, sales comparison and RFR method. Income methods are also preferable reasonably.
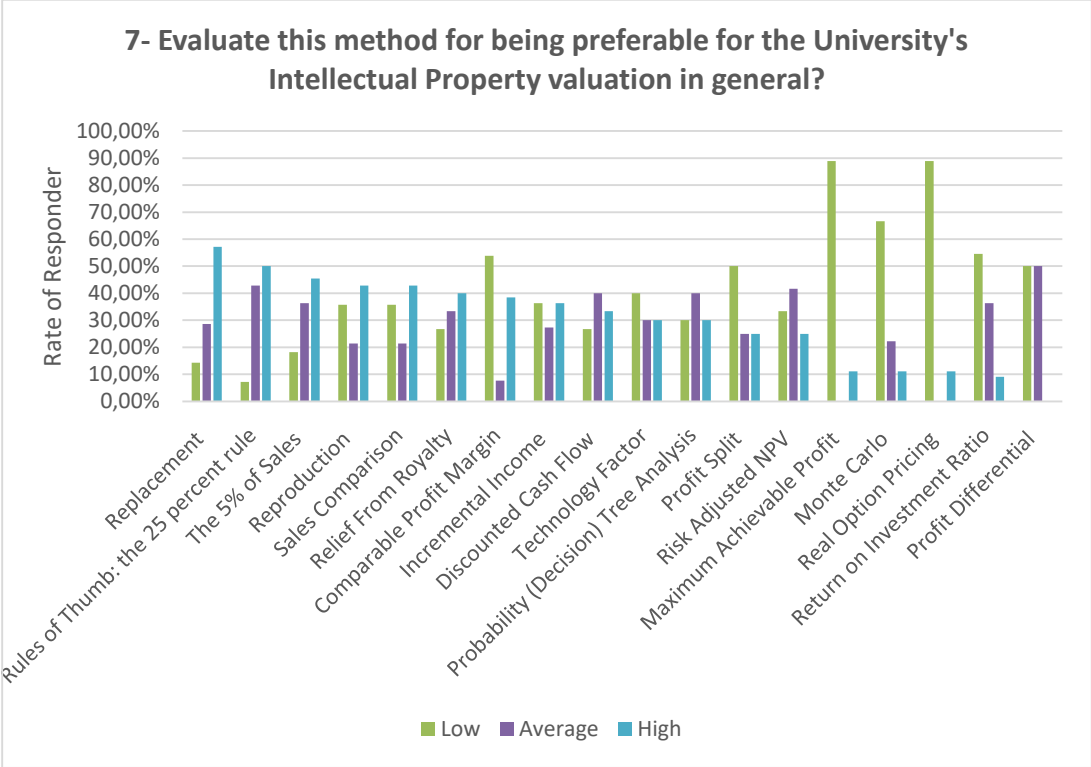
Figure 4.3 Preferable Methods for University's IP Valuation

As can be seen in the Figure 4.4, reproduction, replacement, real option pricing and Monte Carlo methods are not so preferable for the start-up companies. DCF method is the most appropriate method to value a start-up's IP, additionally profit split method, incremental income, comparable profit margin, maximum achievable method, sales

comparison, RFR, the 25 percent rule, the 5% of sale and technology factor method can be highly preferable.
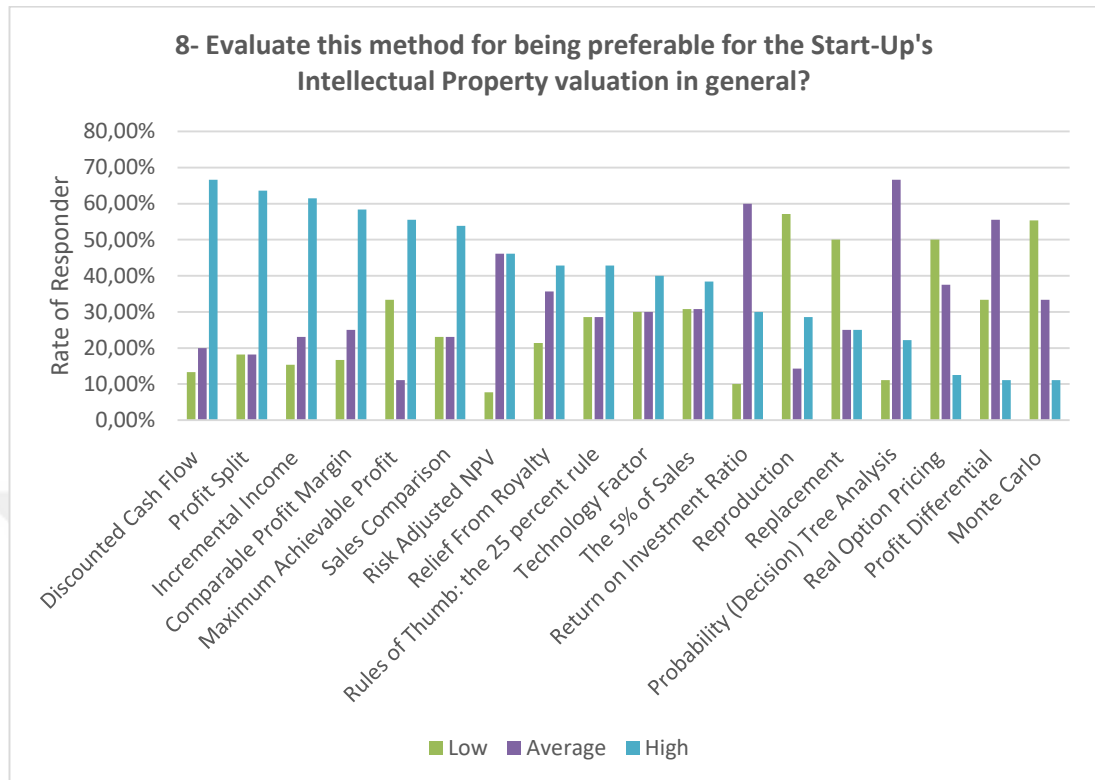
Figure 4.4 Preferable Methods for Start-Up's IP Valuation

Useful valuation method for non-patented or patent pending technologies were asked to participants in Question 9. In Figure 4.5, replacement method, reproduction method and sales comparison method are seen useful certainly. While real option method is not very useful for patent pending technology or nonproprietary technology, for the other methods somehow option was chosen in large measure.
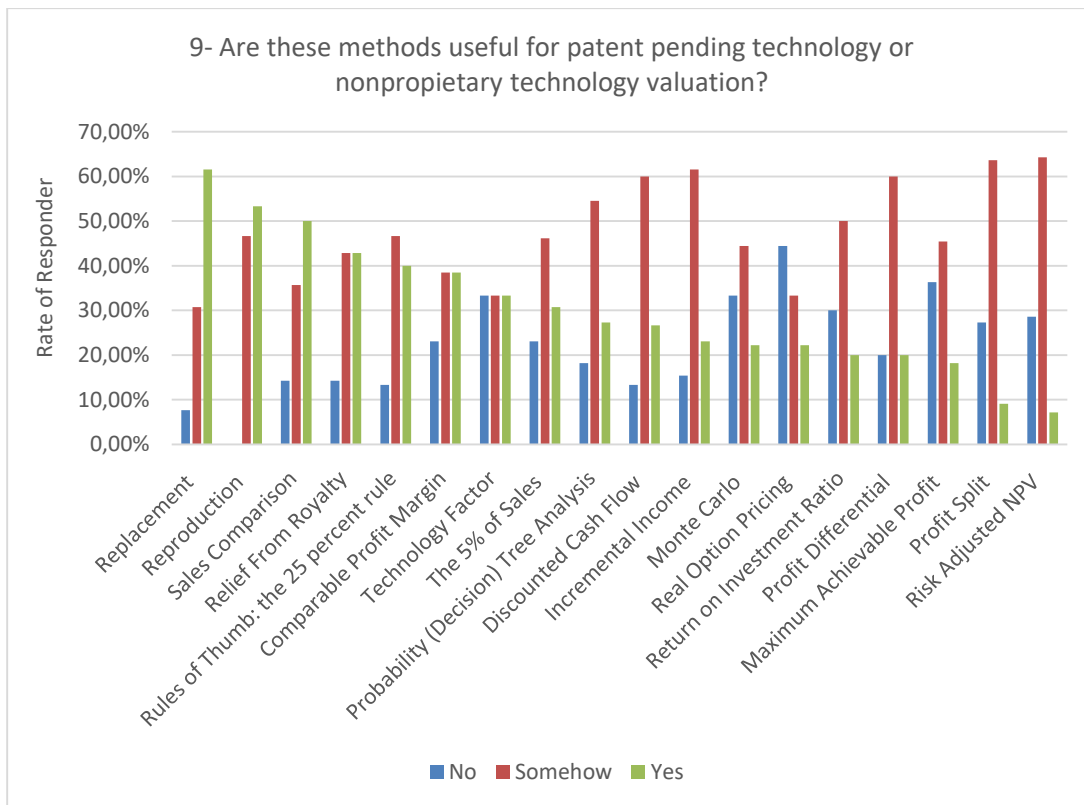
Figure 4.5 Useful Methods for Patent Pending Technology or Nonproprietary Technology Valuation

Question 10 regarding IT/ Software product valuation were asked to participant. The responses given by the respondents are shown in the Figure 4.6. According to the responses, replacement method, sales comparison method, reproduction method and DCF method are found the most appropriate for IT/ Software product pricing.
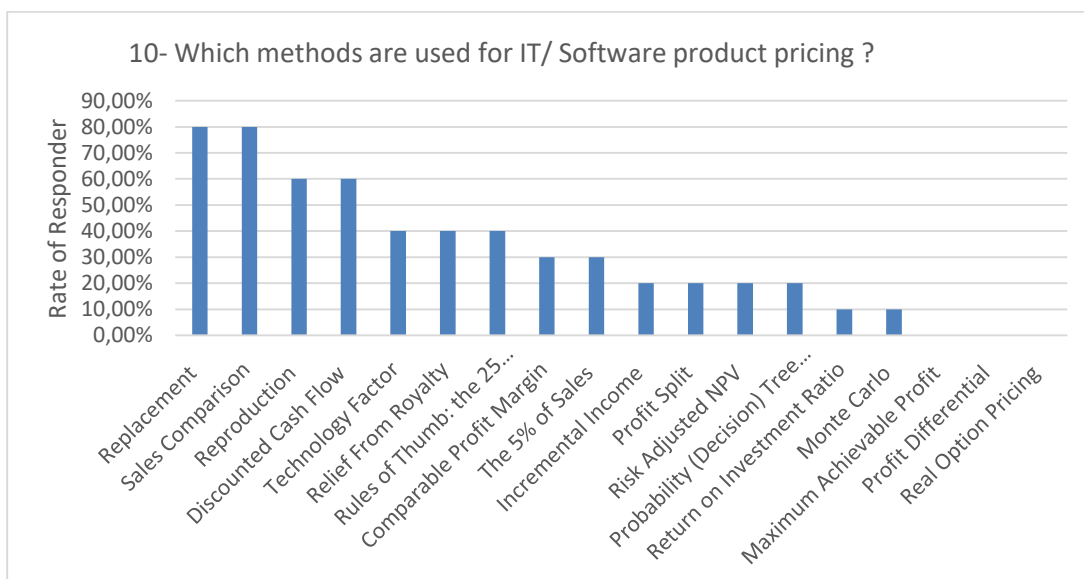
Figure 4.6 IP valuation methods used for it/ software product pricing

Suitable technology readiness levels to apply each method are shown in Table 4.5. The numbers in the tables represent the number of respondent. According to the responses taken from participants, the technologies at TRL 3 to 5 is more suitable to apply cost based methods. Market based methods can be used for technologies at all TRL, but TRL 9 was chosen highest comparing to other TRLs. When income methods are examined, the results refer to different TRL ranges. Income based methods are almost applied to technologies at all TRL, but responses are concentrated at TRL 5 and after for rules of thumb method, at TRL 6 and after for DCF, profit split method and the 5% of sale method, at TRL 7 and after for maximum achievable method, technology factor and RFR, at TRL 9 for incremental income method, return on investment ratio and profit differential method. All advanced methods except risk adjusted NPV method are required technology being valued at minimum TRL 7. Risk adjusted NPV method is suitable for valuation of the technologies at TRL 9. As can be seen in general total of preference, the technology at TRL 6 and after is most suitable for valuing.

Table 4.5 : Suitable TRL to apply the methods.

Methods/ TRLs	TRL 1	TRL 2	TRL 3	TRL 4	TRL 5	TRL 6	TRL 7	TRL 8	TRL 9
Reproduction Method	1	1	**4**	3	**4**	1	1	-	-
Replacement Method	1	1	**3**	2	3	-	1	-	1
Sales Comparison	1	2	2	2	2	1	1	2	**4**
Comparable Profit Margin	1	1	1	1	2	2	2	2	**3**
Discounted Cash Flow Method	-	-	1	2	2	**4**	3	2	**5**
Incremental Income Method	-	-	-	-	-	2	3	2	**4**
Profit Split Method	-	1	-	-	-	**4**	2	2	3
Maximum Achievable Profit Method	1	-	-	-	2	1	**3**	2	2
Technology Factor	1	-	2	1	2	2	**3**	**3**	**3**
Return on Investment Ratio	-	1	2	1	1	2	1	2	**3**
Relief From Royalty Method	1	1	2	3	3	3	**4**	**4**	3
Rules of Thumb: the 25 percent rule	1	1	3	3	**4**	**4**	**4**	3	**4**
The 5% of Sales Method	1	1	1	1	3	**4**	3	**4**	3
Profit Differential Method	-	-	-	-	-	2	2	2	**3**
Risk Adjusted NPV Method	-	-	-	2	-	2	1	2	**4**
Probability (Decision) Tree Analysis	-	-	1	1	1	1	**4**	2	3
Monte Carlo Method	-	-	-	-	-	1	**2**	**2**	**2**
Real Option Pricing Method	-	-	-	-	-	1	**2**	1	**2**
Total Preference	9	10	22	22	29	37	42	37	52

In Question 12, the necessities and inputs of application of the methods were asked to the participants. All methods except profit differential method, probability decision

tree method, Monte Carlo method and real option pricing method were responded with minimum one necessity or input. The responses classified according to similar opinions. According to the responses taken from participants, requirements that are need to be known for the responded method are shown in Table 4.6.

Table 4.6 : The necessities and inputs of application of the methods.

Methods	The Necessities/ Inputs
Reproduction	Previous R & D / Development Cost, Patent Cost
Replacement	Previous R & D/ Development Cost, Cost of replacing IP
Sales Comparison	Market base data, Comparable Info/Deals, Adjustment for differences in deal factors
Comparable Profit Margin	Market base data, Comparable Info/Deals
Discounted Cash Flow	Discount Rate, Risk Factor, Future Income, Savings, Investment Cost, Time, Amount
Incremental Income	Turnover of products with IP
Profit Split	Turnover of products with IP
Technology Factor	Need to know TRL
Return on Investment Ratio	Risk factor, time, amount, making a good projection
Relief From Royalty	Market base data, Discount Rate, Risk Factor, Savings, Investment Cost, Amount, Turnover of products with IP, Royalty Rate
Rules of Thumb: the 25 percent rule	Future Income, Profit Margin, Financials of products with IP
Risk Adjusted NPV	Risk factor, Time, Amount

The difficulties in applying the methods and advantages of the methods were asked to the participants. Mostly, different answers were given by the respondents. But there are some responds come to the forefront as a difficulty or advantages. Early stage technology is seen difficulty for using the comparable profit margin, DCF method, incremental income method and risk adjusted NPV method because these technologies have no income. Ease of apply was indicated an advantage reproduction method, replacement method, the 25 percent rule and the 5% of sale method. The all advantages and difficulties taken by the respondents is stated the Table 4.7. The numbers in parenthetic represent the number of respondents.

Table 4.7 : The difficulties and advantages of the methods.

Methods	Challenges/Difficulties	Advantages/ Benefits
Reproduction	• To determine the past cost (2) • No relation to future income (1) • Past cost may be high if costumer needs do not be satisfied (1) • Lack of data and information (1) • Most early stage biomedical technology difficult to assess using analytical methods (1) • ignoring the unique and novel characteristics of IP (1)	• Suitable for early stage technologies (2) • Suitable if there is no direct cash flow being generated from use of the subject IP assets (1) • Costs are defined in the projects (1) • Easy to apply/calculate (1)
Replacement	• Past cost may be high if costumer needs do not be satisfied (1) • To find comparable IP/ market case (1) • Ignoring risk factor and uncertainty (1)	• Suitable for early stage technologies (2) • Suitable if there is no direct cash flow being generated from use of the subject IP assets (1) • Costs are defined in the projects (1) • Easy to apply/calculate (1) • No need business plan (1)
Sales Comparison	• To find comparable IP/ market case (3) • Regions (3)	• Very useful and good indicator if exact comparable are available (2) • Seeing the real numbers (1)
Comparable Profit Margin	• To find comparable IP/ market case (1) • Early stage technologies have no income (1)	• Very useful and good indicator if exact comparable are available (1) • You value others (1)
Discounted Cash Flow	• Early stage technologies have no income (1) • To predict the future for early stage technology and others (2) • To discount uncertainties (1)	• valuation is comparable to other investment decisions, discounting and time value of money is standard in other valuations (1) • good to determine the influence of risk and time and to get numbers for selling the technology (1) • easiest way to use whose cash flows are currently positive and can be forecasted with some reliability (1)
Incremental Income	• Early stage technologies have no income (1)	NA
Technology Factor	• To have good knowledge about the technology (1)	• automatically compare with the technology level (1)

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Table 4.7 (Continued): The difficulties and advantages of the methods.

Methods	Challenges/Difficulties	Advantages/ Benefits
Relief From Royalty	• To predict the future for early stage technology and others (1) • Assumptions on potential licenses (1)	NA
Rules of Thumb: the 25 percent rule	• profit based methods can be manipulated (attributable costs etc.) (1) • to determine the calculation base (which part of the profit is based on the invention) (1)	• easy to apply/calculate (1) • Need less time and effort than other methods(1)
The 5% of Sales	NA	• Easy to apply/calculate (2)
Risk Adjusted NPV	• Early stage technologies have no income (1) • To assess the risk reliably (1)	NA
Real option pricing	NA	• More than one scenario considered (1)

Separately from the question regarding the quantitative methods, considering qualitative methods, its effect to the value of technology and the steps they used the qualitative indicators were asked to the participant. 14 participants responded this question. 86 % of respondents given answer as "yes" and 14% of the respondents given and answer as "no". Some respondents have similar opinion about the effect and phase of considering qualitative methods. They think that the qualitative approach is useful for assessing the IP. One responder indicate that he/she use the qualitative approach throughout the valuation. Some other comments of experts about the usefulness are below:

> "Qualitative factors are used to assess the strategic importance and key questions regarding the technology, marketing etc. The goal of this is to get a holistic picture and explore alternative scenarios etc. not just relying on simple financial assumptions."
>
> "to evaluate an overall supremacy of the IP you need qualitative indicators as well."
>
> "For each method used for valuation, the respective parameters are selected based on the qualitative assessment of the technology."

Its contribution to determine discount rate, technology risk and risk of IP are indicated by 3 respondents. According to the other answers, qualitative indicators can be used for IP valuation in case of licensing, startup book value, opportunities determination, sales comparison, validation and comparing the portfolio. Regarding usefulness on licensing case, there is a remark from a respondent:

> "Before to determine the monetary value of IP during the licensing agreement negotiations it will be useful for comparing, categorizing and ranking IP within a portfolio or competitors' IP."

The last two questions were about usage of more than one method in a IP valuation case. All participants responded these two questions. One responder indicated that he/she does not apply more than one method. 14 respondents of all indicated that they apply more than one method to value an IP. Their opinions were received on which methods they applied together. Depending on objectives and situation was remarked by 5 respondents. Besides, the different combinations of the methods were suggested by the respondents. These suggestions are listed in below:

- NPV and Qualitative Methods
- DCF and Market Method
- Reproduction, Market, RFR, 25% Rules

- Cost Methods and Market Methods

- Reproduction and Replacement Method

- DCF and another one

- Rule of Thumb, Replacement Method, Sales Comparison Method

- Technology Factor, Sales Comparison and Replacement

- Replacement, Reproduction, Sales Comparison, Comparable Profit Margin, DCF

- At least two approaches from the methods such as Reproduction, Replacement, Sales Comparison, the 25 percent rule, the 5% of Sales, DCF, return on Investment Ratio, Probability Tree Analysis

5. SUMMARY OF FINDINGS AND DISCUSSION

Intellectual properties are increasingly becoming the core of many organizations, universities, research institutes and business transactions. Therefore, the valuation of IP is an important necessity for its owner. As can be seen in the literature, there are many reason for valuing IP and many methods in order to quantify the value of the intellectual property. Choosing the most appropriate method to carry out an IP valuation is a complex process. An evaluator has to take into account several parameters and factors. It is difficult to choose a specific valuation method for all IP valuation situations.

By taking all these situations into consideration, in this thesis study, the selection of appropriate valuation method has been researched according to experiences of valuation experts. All findings of this thesis study are discussed in this section as a summary and given in Table 5.1.

Table 5.1 Summary and Discussion of Findings.

Dimension/Question	Major Finding	Notes	Reference for discussion	Discussion result
Recognition and usage of the methods	Advanced valuation methods are less known; hence less used.	Mostly used: Cost methods, market methods and some of income methods	Taplin (2004)	Cost method as a most used method is not aligned with Taplin (2004)
Purpose of using valuation methods	• Sales comparison method is the best suitable method for licensing purpose. • For IP sale, DCF method is found to be the most appropriate method. • IP valuation is made least for merger & acquisition (M&A) and R&D purpose. • In taxation issue, the Rules of Thumb: 25 percent rule method and RFR method are more suitable for IP valuation. • For purpose of IP portfolio analyze, sales comparison method, comparable profit margin, the 25 percent rule and DCF method are shown as mostly used.	• The other methods mostly used for licensing purpose: Replacement cost method, DCF methods, Rules of Thumb: 25 percent rule • The other suitable methods for IP sale purpose: Sales comparison method, profit split method, RFR method and Rules of Thumb: 25 percent rule. • For merger & acquisition (M&A) and R&D purpose, there is no consensus found. The findings are so close but DCF can be seen is most appropriate method for M&A purpose, and Rules of Thumb: 25 percent rule is most suitable for R&D purpose, since these methods are mostly chosen • Most preferred methods in total of all purposes: DCF method, the 25% rule	Smith & Parr (2005), Lagrost et al. (2010)	Most preferred methods (DCF method, the 25% rule) aligned with Smith & Parr (2005); The suitable methods for each purpose are in line with Lagrost et al. (2010).

Table 5.1 (Continued) Summary and Discussion of Findings.

Dimension/Question	Major Finding	Notes	Reference for discussion	Discussion result
Using the valuation methods in different situation	• Cost methods, DCF method, the 25 percent rule, sales comparison method and RFR method were indicated as suitable for early stage technologies.	• Mostly used in litigation situation: Replacement cost method and RFR method • Mostly used for business valuation: Market methods and DCF method	Smith & Parr (2005), Stevens (2016), Lagrost et al. (2010)	• DCF and Cost methods as suitable for early stage technologies re aligned with Smith & Parr (2005) and Stevens (2016). The 25 percent rule, sales comparison method and RFR method were revealed among the appropriate methods for early stage in our new findings. • For other usage area of the methods are in line with the study of Lagrost et al. (2010)
The IP valuation method applied in different sectors	The most patent valuation is made in the manufacturing sector.	• <u>Most preferred method in manufacturing sector:</u> Cost methods, Market Methods and RFR Method • IP in material, automotive and medicine sectors are also valued mostly.	Lagrost et al. (2010), Stevens (2016), Razgaitis (2009), Sozer (2008)	Almost all findings of Delphi Survey are new, because there is no direct information regarding appropriate valuation method for different sectors' IP in the study of Lagrost et al. (2010), Stevens (2016), Razgaitis (2009), Sozer (2008).
The IP valuation method applied for University's IP	The most preferred methods for University's IP valuation are similar to the suitable for early stage technology valuation.	Most preferred: The replacement cost, the 25% percent rule, the 5% of sales, reproduction cost, sales comparison and RFR method.	Wang (2016)	The most preferred method for this question are in line with study of Wang (2006).
The IP valuation method applied for Start-up's IP	DCF method is the most suggested method to value start-up's patents.	The other useful methods: RFR method, market methods and some income methods such as profit split method, incremental income and maximum achievable method.	Dubiansky (2006), Pöltner et al. (2011)	The DCF and RFR method as suitable methods are aligned with Dubiansky (2006) and Pöltner et al. (2011)

Table 5.1 (Continued) Summary and Discussion of Findings.

Dimension/Question	Major Finding	Notes	Reference for discussion	Discussion result
Useful Methods for Patent Pending Technology or Nonproprietary Technology Valuation	The replacement method, reproduction method and sales comparison method are useful.	Real option method is seen not very useful.	IPEG	Even IPEG mentioned that the patent pending technologies can be licensed (IPEG), there is no information useful valuation method for these technology. The findings of Delphi survey can be considered as new findings.
IP valuation methods used for IT/ software product pricing	Cost methods, sales comparison and DCF methods are founded suitable for IT/Software product valuation.	The other suitable methods according to the other question regarding IP in IT sector: risk adjustment NPV and RFR method is most preferable techniques	Smith and Parr (2005)	Depending on the type of software, some of the cost method, income methods and market methods may be used for valuing an IT/ Software product.
Suitable TRL to apply the methods	In general, the technology at TRL 6 and after is most suitable for valuation.	• Most suitable TRL for Cost Methods: TRL 3 to 5, • Most suitable TRL for Market Methods: TRL9 • Most suitable TRL for Income Methods: TRL5 and above • Most suitable TRL for other advanced method: minimum TRL 7 • Most suitable TRL for raNPV: TRL 9	-	-

Table 5.1 (Continued) Summary and Discussion of Findings.

Dimension/Question	Major Finding	Notes	Reference for discussion	Discussion result
The necessities and inputs of application of the methods	• <u>The inputs of applying cost methods:</u> previous R & D / development cost, patent cost and cost of replacing IP • <u>The inputs of applying market methods:</u> Market base data, comparable Info/Deals, adjustment for differences in deal factors		Murphy et al. (2012 pp. 225- 228), Reilly (1999); Anson et al. (2014), Goddar & Moser (2011, pp. 126-127), Parr (2016), Andriessen (2004)	The all indicated necessities to apply mentioned method are aligned with the mentioned studies in the literature.
The difficulties and advantages of the methods	The lack of data or data existing can be defined as an advantages or difficulty to apply a valuation method.	• Easy to use: the reproduction, replacement, 5% of sale and, 25 percent rule methods • Comparable profit margin method, DCF method, Incremental Income method and risk adjusted NPV methods are not easy.	Grube (2009), Stevens (2016), Smith & Parr (2005), Taplin (2004)	
The effect of qualitative approach	The qualitative approaches should be considered when a technology is valued for assessing IP.	It is a necessity to evaluate the overall picture and to determine some required parameters for valuation.	Pöltner et al. (2011,- Hamamcıoğlu and Kahraman (2015)	The qualitative factor is used for different purpose at different time. The results are similar with the study of Pöltner et al. (2011) and Hamamcıoğlu and Kahraman (2015) with regard to determination of some parameters and the effect of qualitative approach.
Usage of more than one method in an IP valuation case	• An IP should be valued with more than one valuation method which can be selected according to the objectives and different situations.	DCF method is stated in most of suggested different valuation method groups.	Grube, 2009	The results regarding usage of more than one valuation method is aligned with Grube (2009).

- **Recognition and usage of the methods**

In literature, there is not enough information about ranking of quantitative valuation methods according to the recognition or usage of method. Just Taplin (2004) is argued that the cost method is less used since there isn't a direct relation between past cost and future benefits. Before replying the questions depend on the methods, all participants were responded whether they knew and use the methods or not.

- More than 50% of our sample expert group know and use the replacement cost, reproduction cost, sales comparison, DCF, the 25 percent rule, comparable profit margin and RFR methods.
- In despite of incremental income methods and the 5% of sales method are known by more than 50% of participants, they are not often used.
- The other methods of which the usage rate is less than 50% are return on investment method, profit split, probability decision tree method, technology factor, maximum achievable, profit differential method, Monte Carlo method and real option pricing method.

To summarize, advanced valuation methods are known less than the other method and in parallel with this result they are not used by most participants. Cost methods, market methods and some of income methods are known much better and are mostly used. The mostly usage can be explained with the findings of other questions. For example, as can be seen in following discussion about the advantages of the valuation method, the reproduction, replacement, 5% of sale and, 25 percent rule methods are indicated as easy to apply.

- **Purpose of using valuation methods**

The IP valuation purposes can differ. In-licensing, out-licensing, sale, R & D, portfolio analysis, merge & acquisition, tax and etc. can be reason for valuing an IP. It was researched which method is more appropriate for which purpose. Lagrost et al. (2010) mentioned that relationship between the valuation purpose and approach to use. According to the result of their study, income based methods and market based methods were the best suitable methods for purpose of company valuation, IP sale and IP license, but they indicated that cost based methods can be used to some extent for IP license and sale. For internal management and strategy, income based methods,

market based methods and qualitative approach were suitable. For taxation planning, cost based and market based method were indicated as mostly used method.

The recommended answer choices in Question 4 in Delphi survey were more detailed than the method groups in the study of Lagrost et al. (2010).

- The licensing was considered as in-licensing and out-licensing.
- According to the findings of Delphi survey, for out- licensing purpose, sales comparison method is seen the best suitable method.
- Also, replacement cost method, DCF methods, Rules of Thumb can be listed in suitable methods for this purpose. DCF method and replacement method is also suitable for in-licensing purpose.
- When the purpose is IP sale, DCF method is the most appropriate method and following suitable methods are sales comparison method, profit split method, RFR method and Rules of Thumb.
- Even though the most appropriate method for R & D purpose is seen Rules of Thumb, the results for this option very similar.
- For portfolio analysis, sales comparison method, DCF and Rules of Thumb: 25 percent rule are mostly chosen. R & D, portfolio analysis, M&A can be purpose of internal management and strategy.
- Similar to result of R&D purpose, the results of merger & acquisition purpose are close, but DCF method is mostly chosen.
- The Rules of Thumb method and RFR method are come to the forefront for taxation issue.

In general, results of this question are in line with study of Lagrost et al. (2010). The total number of preferences of respondents on the methods in the survey refers to the methods that they mostly used for valuing IP. Also for the general total of all purposes, the most preferred method is seen as DCF method and the 25 percent rule method is ranked at second. Smith & Parr (2005) classified the valuation methods as primary methods which are expected to provide the most credible results for an asset, secondary methods which may work well but probably have deficiencies and may be useful for testing and supporting indications of value obtained from using the primary method and weak methods which would be expected to give the least credible indications of value for assets if there is not special circumstances for various asset. For patents and technology valuation, primary methods were indicated as income method, secondary

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methods were indicated as marked methods and weak methods were indicated as cost methods. They also mentioned that situations may be exist contrary to this approach. Our result on the most preferred methods which are DCF method and the 25 percent rule is overlap with the approach of Smith & Parr (2005).

- **Using the valuation methods in different situation**

In different valuation situation such as early stage valuation, business valuation, valuation in litigation situation, portfolio analysis and sectors under the high uncertainty and risk, different valuation method can be used.

- In our Delphi survey result, the 25 percent rule, reproduction cost method and replacement cost method are seen as commonly used method for early stage technology valuation.
- Following methods are sales comparison, DCF and RFR method. It is not a surprising result because of the different opinions in literature.

Smith & Parr (2005) argued that the cost and market approaches are uncommonly suitable for early-stage technology. Cost and market methods cannot capture the unique characteristic of early stage intellectual property. Just like with matured technology, the cost methods have limitations. The earning power of the new technology or the final market share which may be obtained don't be reflected by cost methods. To find similar transactions involving early-stage technology for the value of the early-stage technology with market methods is difficult. Rarely, third-party exchanges involving similar early-stage technology can be found. The DCF methodology is the preferred method. The DCF method captures the present value of the future economic benefits of IP and is therefore the preferred method for calculating present value for all types of intellectual property rights, financial assets and tangible assets. But they also indicated that DCF model should be modified to demonstrate the additional input for the valuation of early-stage technology and that the arithmetic of DCF method is easy, its inputs are difficult. The first three methods which are mostly recommended in our result don't overlap the opinion of Smith & Parr (2005) but DCF is also stated among recommended method. On the contrary, Stevens (2016) mentioned that the cost method is only suitable method for early stage technology of the method despite some limitations if there are no comparable transactions can be found. For NPV based valuation method, key data may not be accessible for

technologies at a very early stage. Our result with regard to cost method is in line with this study. The difference between our result and the findings of mentioned studies is that DCF method, RFR method, sales comparison method and the 25 percent rule can be use early stage technology. As it is mentioned before, Lagrost et al. (2010) indicated that income based method and market based method are suitable for company valuation and internal management and strategy. In infringement/ litigation situations, they suggested that income based method is mostly used and cost based method and marked base method are used to some extent.

- Our result regarding business valuation also shows usually market methods and DCF were chosen.
- Regarding current portfolio analyze the findings shows that sales comparison method, DCF, profit split and the 25 percent rule are more suitable than the other method.

In litigation situation, an infringed IP right is valued in general by replacement cost and relief from royalty method. The suitable methods for portfolio analyze was asked both Question 4 and 5 in the Delphi survey. The results of these two questions are similar. The differences of the responses in these two questions are the number of preference of sales comparison method and profit split method in Question 3. The findings of these question can be considered together and the DCF method is the shown the most preferred method according to the findings of Question 4 and Question 5. The result with regard to company valuation, portfolio analyze and litigation are in line with the study of Lagrost et al. (2010). The result of the question of using the IP valuation methods in different situation also refers to the mostly used method as DCF method and the 25 percent rule method similar to result of Question 2.

- **The IP valuation method applied in different sectors**

The preference of the methods according to the sector were asked to the participants. When the findings in Table 4.4 is examined generally, the total number of preferences of respondents on the methods and sectors in the survey refers to the most patent valuing sectors and the methods that they mostly used for valuing IP.

- For the general total of all sectors, replacement cost method, DCF method and RFR method distinguish from other methods.

- All methods except maximum achievable method were preferred at least for one sector.
- The most patent valuation is made in the manufacturing sector.
- Material, automotive and medicine sectors are following the manufacturing sector.
- Cost based methods, market based methods and RFR method are commonly preferred for technology/patent valuation in manufacturing sector.
- While risk adjustment NPV and RFR method is most preferable techniques for valuing an IP in IT technology, DCF method is most preferable method for telecom and energy sector.
- In mining and constructions sector, the choices are similar and close values for each method, but DCF method is seen the most preferable method for valuing an IP regarding construction. For textile, automotive, material and medicine sector, findings revealed that the replacement cost method is more usable.

In literature, the specific study about the valuation method according the different sector doesn't exist. But there was restrictive information about the pharmaceutical or biotechnology sector, food, industrial equipment, electronics, construction, and medical device sector. Lagrost et al. (2010) indicated that the decision tree analysis method, often used in the pharmaceutical or biotechnology sector, since this method is based on the creation of a diagram illustrating different possible event outcomes. According to the Stevens (2016), profit split method is often used in licenses by biotechnology companies of late stage products to pharmaceutical companies. Profit sharing arrangements are the best result if the licensee sells relatively few products, so that the cost distributions are quite clear and transparent. This is a reason why the method works well in the pharmaceutical industry. Razgaitis (2009, pp. 338-339) was also mentioned about pharmaceutical technologies. For pharmaceutical technologies, where the first income may not occur for seven or even ten years after a technology license, applying high values of discount rate make it difficult justify investing in any project. Thus the risk adjusted NPV method is more suitable than the standard NPV method. The sale of 5% method has been used in many core technologies such as food,

industrial equipment, electronics, construction and medical device industries (Sozer, 2008).

When the findings are compared with the mentioned studies, actually the similarities are not seen. For example, the findings show that the replacement cost method is first preference with ratio of the 15% for the medicine sector which includes biotechnology, pharmaceutical, medical device and etc. The risk adjusted NPV method was preferred by 9% of respondents who answered for the medicine sector, profit split method was chosen by 6% of respondents, decision tree analysis and the 5% of sale method were preferred by 3% of respondents. Maybe the reason of differences depends on the technologies, product or method in medicine sector. Different technologic output in a sector may be valued with different method. The 5% sale method is one of the less preferred method for each sector in general in the Delphi survey result. The finding about this method is also different from the Sozer's (2008) study.

- **The IP valuation method applied for University's IP**
    - It is found that the most preferred IP valuation methods for valuing University's IP are replacement cost, the 25% percent rule, the 5% of sales, reproduction cost, sales comparison and RFR method.
    - The other income methods are also preferable reasonably. Comparable profit margin method, profit split, maximum achievable profit, Monte Carlo, real option pricing, return on investment and profit differential method were less preferable.

Wang (2016) focused on the valuation methods and applications for academic technologies in Taiwan and for this purpose managers and staffs of five TTOs in Taiwan were interviewed. The cost approach is used mostly extensively among all the valuation method. Market approach, income method and auction to determine the value of the technology in some cases according the result of this study. To determine the value of IP using cost method, the total cost of IP was adjusted according to the industry trend and market opportunity or the total cost can be increased by 30% to 50%. Even applying the income method is difficult because of the embryonic nature of academic technologies, TTOs should investigate the industry context for technology to achieve future potential revenue for technology. They should look for answers about some question such as, how much process cost can be saved for the industry, what products can be derived from the material, what changes will happen to the market, or

what business opportunities will be created? It was mentioned that the option-pricing and Monte Carlo model were not used by the universities. She argued that it is not easy to put valuation methods into practice. The results of this question are in line with study of Wang (2006). The number of respondent from TTOs mentioned in section 4. More than half of participant have been working in a TTO. This may be an effect why the results are similar.

When we compared the findings of this question and using the methods for early stage technologies of in question 4, the similar results were found. It was mentioned that the 25 percent rule, reproduction cost method and replacement cost method are seen as commonly used method and sales comparison, DCF and RFR method are also used for early stage technology valuation.

- **The IP valuation method applied for Start-up's IP**

According to the findings of question 8;

- DCF method is the most appropriate method to value a start-up's IP.
- Additionally, profit split method, incremental income, comparable profit margin, maximum achievable method, sales comparison, RFR, the 25 percent rule, the 5% of sale and technology factor method can be highly preferable.
- On the contrary, cost methods, real option pricing and Monte Carlo methods are not so preferable for the start-up companies.

Dubiansky (2006) and Pöltner et al. (2011) indicated that RFR method is more useful for startup company. Dubiansky (2006) argued that the relief from royalty method approaches the retail value of the patent therefore it is the more suitable method for a startup firm, when the startup firm license the patent right to another company. The startup firm can make and sell the patented inventions itself. In this case, the value of patent can be accounted by the analytical methods, which looks at the financial performance of manufacturer of similar products. Pöltner et al. (2011) referred that the factual value of a patent is generally accounted by future cash flow and the rate of return on investments. They presented a new model included combination of the relief from royalty method. In this model, qualitative parameters are affected the royalty rate.

DCF is mostly preferred by the respondents of Delphi survey and it is stated among the methods which are indicated as future cash flow and the analytical methods, which

looks at the financial performance of manufacturer of similar products in mentioned studies. This means that our findings are not so different than the mentioned studies. The RFR method is also seen suitable according to the result of Delphi survey, but it is not first preference. Another specific differences are profit split method, incremental income, comparable profit margin, maximum achievable method, sales comparison, the 25 percent rule, the 5% of sale and technology factor method can be found highly preferable in our study. The 25 percent rule and the 5% of sale method are a kind of relief from royalty method. Therefore, this result can be considered similar to the literature. Different from the mentioned studies, the respondents of Delphi survey indicated that the market methods and some income methods such as profit split method, incremental income and maximum achievable method can be also used highly to value for startup's patents. Some differences between the result of Delphi survey and mentioned studies can be explained with the different measure depend on making and selling of invention by startup firms or licensing.

- **Useful Methods for Patent Pending Technology or Nonproprietary Technology Valuation**

A registration period of a patent from filling its application can last about 3 to 4 year. To commercialize an IP, it is not always necessary to wait registration of patent, if the favorable conditions are met for commercialization. Therefore, the valuation of patent pending technologies or nonproprietary technologies such as technologies protected as trade secret is also important. For such situations, the useful valuation methods are asked to the participants.

- The responses given by the respondents shows that the replacement method, reproduction method and sales comparison method are useful for valuing patent pending technologies or nonproprietary technologies.
- While real option method is seen not very useful, for the other methods somehow option was chosen in large measure.

When a pending patent application is licensed, a royalty may be gotten in some situations. For example, the licensee is a paying a royalty fee for the ability to obtain confidential information, if the patent application has not yet been published. The licensee may also pay a royalty for useful know-how of patent owner that is not included in the patent application. It is also a license to use secret know how (IPEG).

But there is no information about determining the royalty rates for patent pending license it this article. Any information about the useful valuation method specially for patent pending technologies or non-patented technologies was not encountered in the literature. Patent protection and its process is important for qualitative consideration but it may not affect the applying process of many quantitative methods.

- **IP valuation methods used for IT/ software product pricing**

According to the responses about most applicable valuation methods in different sector's IP taken from participant;

- Risk adjustment NPV and RFR method is most preferable techniques for valuing an IP in IT technology.

In this questions;

- The replacement method, sales comparison method, reproduction method and DCF method are found the most appropriate for IT/ Software product pricing.

The responses for these two question not so similar. But as we mentioned before, the mostly preferred valuation method according to some sectors' IP is not clear, because of the distribution of the responses.

Some authors indicated the valuation of two type of software which are management information software and product software.

> Management information software is the systems that control and operate a business. Typically, it includes software that processes inventory control, payroll, accounting, pension benefits, accounts payable, accounts receivable, debt payments, fixed asset records, and other operating systems. Company personnel use these systems to control information and make decisions. Product software is a significant component of a company product that it sells to customers for a price. (Smith & Parr, 2005, p.263)

According to Smith and Parr (2005), The cost approach usually is useful for valuing management information software, but if market transactions is available for this type of software market methods also can be favorable to some extent. The income method is used if specific economic benefits depend on directly to specific product software being valued. To value the product software, the income method is generally used considering the commercial profits. As it is mentioned before they classified the valuation methods as primary, secondary, weak methods for valuation of different type

of asset. For management information software, primary methods were indicated as cost method, secondary methods were indicated as marked methods and weak methods were indicated as cost methods. On the contrary to management information software, primary preference for product software is income method, secondary preference is market method and weak preference is cost method. Depending on the type of software, the cost method, income methods and market methods which are indicated in our findings may be used for valuing an IT/ Software product.

- **Suitable TRL to apply the methods**

As we mentioned before, there are some information about early stage technology valuation and the suitable valuation method, but any information about the preference of IP valuation method depending on TRLs was not found. The aim of this question was to determine the optimal minimum TRL of technology being valued for each valuation method. As can be seen in the findings;

- Market based methods can be used for technologies at all TRL, but TRL 9 was chosen highest comparing to other TRLs.

This result can be explained with requirements of using market based method and being at TRL 9. TRL 9 refers successful deployment. It means that the application of a technology, in its final form, in real life condition. Marked based methods based on actual and comparable sales or companies. Therefore, the readiness level of technology being valued is close to the technology in the market to compare realistically.

- For valuation with cost based methods, the technologies at TRL 3 to 5 is more suitable.

It doesn't mean that cost methods cannot be used for after the technologies TRL 6-9. It can be used but there is more suitable alternative method to value an IP has TRL 6 and after. TRL 4 means the integration and testing of basic components in a laboratory environment and refers the early stage prototype development Shepherd, 2017. We mentioned that before the cost methods are commonly used method for early stage technologies. We've got compliant answers on cost methods.

- Income based methods are almost applied to technologies at all TRL.
- Responses are concentrated at TRL 5 and after for rules of thumb method, at TRL 6 and after for DCF, profit split method and the 5% of sale method, at TRL 7 and after for maximum achievable method, technology factor and

RFR, at TRL 9 for incremental income method, return on investment ratio and profit differential method.

It is indicated that RFR method can be commonly used for University's IP and early stage technology. It is found in this question that the optimal suitable TRL is TRL 7 for RFR. According to the responses taken from participants, the findings don't show precise result for some valuation method. RFR method is one of them. While three respondents preferred TRL 4-6, TRL 7-8 is preferred by four respondents. Actually the preferences are close. We don't say that RFR cannot be suitable for early stage and University's IP used in overall.

- All advanced methods except risk adjusted NPV method are required technology being valued at minimum TRL 7.
- Risk adjusted NPV method is suitable for valuation of the technologies at TRL 9.

We also mentioned before some advanced method is not used for early stage technologies. Advanced methods contain more complex mathematical calculations than the NPV method and required. That is why advanced methods is used the technologies which are the close to the market.

As can be seen in general total of preference, the technology at TRL 6 and after is most suitable for valuing. If the uncertainty on the technology is less, its value would be so close to realistic value.

- **The necessities and inputs of application of the methods**

In section 2.2, all IP valuation methods were explained in detail. The inputs of applying cost methods according to the responses taken from the respondents are in line with the study of Murphy et al. (2012, pp. 225- 228).

- The required inputs to apply cost methods are previous R & D / development cost, patent cost and cost of replacing IP.

Reilly (1999) indicated the steps should be followed in the market method. These steps required identification of similar or identical technologies subject to transfer or license, some adjustments if the process to be compared is not in the market conditions and the determination of the relevant unit (price per unit, etc.).

- For market methods, respondents are also indicated market base data, comparable info/deals and adjustment for differences in deal factors as inputs.
- The necessities for application of DCF methods are discount rate/risk factor, future income, savings, investment cost, time and amount.

Anson et al. (2014) mentioned that three basic estimation components of the income methods are future income stream, time period of income stream, risk or discount rate. Goddar & Moser (2011, pp. 126-127) and Parr (2016) was referred the process of free cash flow accounting to determine the income. Investment cost and amount of patented product were also input of the process.

- The respondents stated the turnover of products with IP as an input.

It can be depended on the Incremental income method and profit split method based on the cost savings or income growth attributed to the patented technology.

- One finding is regarding with TRL for technology factor.

The TRL of technology being valued should be known for technology factor method. Andriessen (2004) mentioned that the methodology includes two parts: determining the NPV of the technology and estimation of a technology factor between 0 to 100%. Since the TRL affects the score of technology factor, the findings are in line with the study of Andriessen (2004).

- Risk factor, time, amount and making a good projection are stated as necessity for return on investment ratio method by the respondents.

Smith & Parr (2005) specified that the amount of the returns, timing of the returns, trend expected in the amount of returns, duration of the economic returns, risk of receiving the return should be considered to determine the economic returns from an investment.

- For RFR method, respondents mentioned the market base data, discount rate/ risk factor, savings, investment cost, amount, turnover of products with IP, royalty rate as inputs.

Since the RFR method is based on NPV of the royalty savings, the inputs are similar with the DCF method. Additionally, suitable royalty rate should be determined, when the market transaction exist. The 25 percent rule is a kind of RFR method with 25%

royalty rate. Except royalty rate other inputs for RFR method should be exist for the 25% percent rule. But the respondents mentioned only future income, profit margin and financials of products with IP.

- According to the responses from the participants, risk adjusted NPV method required risk factor, time and amount as inputs.

Risk adjusted NPV method is the NPV based advanced method in which risk is adjusted with discount rate since risk is not constant during the project's lifetime (Stevens, 2016).

- **The difficulties and advantages of the methods**

The strengths and weaknesses or benefits and limitation of the valuation methods were mentioned some books and articles. Smith and Parr (2005) referred the cost approach is not as extensive as the market approach and income approach. Many important factors such as demand of IP product, profits, the economic remaining life, the risk associated with receiving the expected economic benefits are ignored into the cost approach. Grube (2009), reported the individual strengths and weaknesses for the cost approach, market approach and income approach to value.

The difficulties/ challenges and benefits/advantages of applying the valuation methods were asked to the participants.

- The outstanding benefit is ease of applying for four methods which are reproduction, replacement, 5% of sale and, 25 percent rule methods.

Grube (2009) and Stevens (2016) was indicated the ease of use as a benefit of cost approach. The 5% of sale method and rules of Thumb: 25% percent rule are qualified as easy to apply according to the Delphi survey result.

- Cost methods are also found as suitable for early stage technologies.

As we discussed in the part of "Using the valuation methods in different situation" of this section, the 25 percent rule, reproduction cost method and replacement cost method are seen as commonly used method for early stage technology valuation. The results of the question regarding the benefits of the valuation methods are similar with the previous opinion of respondents in terms of cost methods. The response of a respondent indicates that applying comparable profit margin method, DCF method, Incremental Income method and risk adjusted NPV methods are not easy, since the

early stage technologies have no income stream. Two other respondents also argued that prediction of future for early stage technology and other parameters is difficult while DCF method or RFR method is applied.

- One respondent mentioned specifically that valuing most early stage biomedical technology is difficult for all analytical methods.

As we mentioned before, the responses regarding early stage technologies also did not show these methods except DCF method suitable for early stage technologies. As the Smith & Parr (2005) argued the DCF method can be used for IP valuation since the DCF method captures the present value of the future economic benefits of IP. It depends on the inputs of methodology. There is no information about usage of comparable profit margin method, Incremental Income method and risk adjusted NPV method for early stage technologies.

- The other challenges of the cost methods are to determine the past costs, no relation to future income, being high past cost if costumer needs do not be satisfied, lack of data and information, ignoring the unique and novel characteristics of IP and to find comparable IP/ market case.

Grube (2009) mentioned that the cost method focuses on past, not on future benefits, there is no consideration of risk and direct correlation between cost, price and value. Taplin (2004) is also argued that the cost method is less used since there isn't a direct relation between past cost and future benefits. The opinion of respondents on challenges of valuation methods are similar the mention studies in literature.

- Determination of the past cost of IP is indicated both challenge and benefit.
- One respondent argued that the costs are defined in the projects, therefore determining the past cost is advantage in cost based methods.
- It can be challenge or benefit changes according to accessibility of the costs of IP. The other advantages distinct from ease of usage and being suitable for early stage technologies, the respondents indicate that the business plan is not necessary to value an IP and the cost methods is suitable if there is no direct cash flow being generated from use of the subject IP.

It can be a reason for valuing an IP using DCF method or other income method based DCF method. If there is direct cash flow being generated from use of the subject IP, DCF method can be used.

- According to the respondents, finding a comparable IP cannot be always possible. It is a challenge for applying market methods. But if exact comparable products are available, market methods are very useful and good indicator.
- It is a benefit to see the real numbers and value other in the market.
- To compare the sales of an IP product in different regions can be also difficult. Therefore, regions are indicated a challenge for market methods.

While Grube (2009) indicated that the market methods increased objectivity if comparable IP transaction or product is available and have reliable information, he also mentioned that the access to open market for IPs is a limitation to find comparable transactions for application of market method. But it can be expensive to access to comparable data (Stevens, 2016).

Speier & Gupta (2015) indicated the advantages and disadvantages of valuation method. For income method, being analytic was seen as an advantage, using in high-risk sector and probability of subjective assumptions were seen as disadvantages in their study. When the difficulties and advantages about income methods are examined, the different responses can be seen.

- The responses taken from the participant show that determining the discount rate can be referred a challenge for DCF method.
- Assumptions on potential licenses is not easy when RFR method would be applied.
- The 25 percent rule can be manipulated since it is profit based method or for this method it is difficult to determine the profit which is based on the invention.
- To assess the risk reliably is a challenge for risk adjusted NPV method.
- Having good knowledge about the technology using technology factor method is indicated a difficulty for using technology factor.

- **The effect of qualitative approach**

According to Pöltner et al. (2011), the patent value is accounted using future cash flow and the rate of return method realistically. They argued that the additional qualitative parameters are required to estimate the realistic potential and risks of a specific patent.

To determine the royalty rate, they use a new model which called Arbeitskreis Patentbewertung Universität Düsseldorf- APUD model. The royalties will be qualitatively determined with the APUD model. The model accounts a percent value according to several qualitative parameters. Then this value is used to determine the royalty rate. Hamacıoğlu and Kahraman (2015) examines Arcelik's patent scoring methodology and according to 8 (eight) qualitative indicators, they set a patent score. This score is an input to determine the monetary values of Arcelik's patent.

The usage qualitative methods, its effect to the value of technology and the steps they used the qualitative indicators were asked to the participant.

14 participants responded this question. 86 % of respondents given answer as "yes" and 14% of the respondents given and answer as "no".

- In general, the respondents think that the qualitative approach is useful for assessing the IP.
- According to comments received, it is understood that the qualitative factor is used for different purpose at different time.
- Qualitative factors are used to determine the parameters which is required for each quantitative method for valuing an IP such as discount rate, technology life circle, risk and etc.
- It is indicated that the overall picture of the IP should be seen, while an IP is valued.
- Only financial assumption is not enough. To evaluate the overall picture, qualitative indicators should be considered.
- Qualitative factors are also important for licensing negotiation and assessing the strategic importance and key questions regarding the technology, marketing. They are used for comparing, categorizing and ranking IP within a portfolio or competitors' IP.

In the literature, there are some studies regarding the usage of qualitative methods to value an IP. There are similarities the purpose of usage of qualitative factors such as determination of the parameters and the effect of overall picture of IP.

- **Usage of more than one method in an IP valuation case**

Grube (2009) stated the valuation process. He indicated that the three direct approaches to value can be used in order to arrive at a well-supported estimate for a

patent's value. These direct approaches were cost approach, market approach and income approach. When it was asked to participants, 93% of all respondents indicated that more than one valuation method should be used for valuing an IP. There is not only one specific suggestion about which valuation methods are used together. The valuation methods are used simultaneously to value an IP was asked to the participant. 5 respondents indicated that it depends on objectives and different situations. According to the other responses taken from participants, there is no outstanding valuation group, the different combinations of the methods were suggested by the respondents, but DCF method is stated in most of suggested valuation method groups.

6. CONCLUSION

Intellectual property valuation is a major topic which is expected to affect innovation, R&D, technology development, manufacture based R&D, income and completion in ecosystem. Therefore, the awareness of IP and IP valuation is essential for Triple Helix actors which include companies, universities, institutions, government agencies. As understood from the application or registrations statistics in the World, IP awareness has reached a certain level and the number of patents continues to increase. However, the theoretical background and researches are still very limited for understanding the practices of and comparing/locating the applicability and appropriateness of IP Valuation Methods for different needs and conditions. There are many methods based on quantitative and qualitative approaches to value an IP. Even if the valuers have almost all requirements of a valuation method, they may not use the method because of its difficulties/challenges. Based on these reasons and occurring needs, this thesis study explored the patent valuation methods and the opinion about appropriate IP valuation method for different cases of the IP valuation expert who have experienced IP valuation. Findings provided the comparisons of IP valuation methods According to the findings that were derived from the analysis of data and information taken from the experts who participated in in-depth structured interviews and in the two-round Delphi survey, we provided the following results and suggestions for the preference of IP valuation methods.

- Widely known and preferred IP valuation methods are replacement cost, reproduction cost, sales comparison, DCF, the 25 percent rule, comparable profit margin and RFR methods. On the other hand, the findings of some other questions regarding purpose of valuation method and different situations of IP valuation and sectors inform about the preference of all IP valuation method indirectly. Replacement cost method, DCF method, the 25 percent rule and RFR method are also found as commonly used or known methods.

- Advanced valuation methods are not that much known and used as other methods.

- Sales comparison method occurred as the mostly agreed suitable method for licensing purpose. Replacement cost method, DCF methods, Rules of Thumb: 25 percent rule are also seen as more suitable than the other methods for licensing purpose. The results regarding the valuation purpose are aligned with the previous literature, in general.

- When the valuation purpose is IP sale, DCF method is preferred as the appropriate method and the following suitable methods are stated as sales comparison method, profit split method, RFR method and Rules of Thumb: 25 percent rule.

- For merger & acquisition (M&A) and R&D purpose, no consensus could be reached among respondent experts. All methods were seen in similar degree of applicability, while DCF is somehow perceived as a more appropriate method for M&A purpose. Rules of Thumb: 25 percent rule was agreed to be more suitable for R&D purpose, Furthermore, the findings show that the IP valuation is made least for these purposes.

- The Rules of Thumb: 25 percent rule method and RFR method are more suitable for IP valuation in taxation issue.

- Sales comparison method, profit split method, the 25 percent rule and DCF method are shown as mostly used for purpose of IP portfolio analyze. This finding also supports the previous literature (Lagrost et al., 2010).

- In litigation situation, replacement cost method and RFR method are generally used. This result is coherent with literature (Lagrost et al., 2010).

- Cost methods and DCF methods were indicated as suitable for early stage technologies in some mentioned studies which were not in consensus. Differing from literature, in addition to cost methods, the 25 percent rule, sales comparison method and RFR method were revealed among the appropriate methods for early stages in this study.

- The Delphi survey results for University's IP valuation are similar to the results for early stage technology valuation. The replacement cost, the 25% percent rule, the 5% of sales, reproduction cost, sales comparison and RFR method are preferred methods to value of University's IP. This result supports the findings of a study which is performed among five TTO's in Taiwan (Wang, 2016).

- In this study, DCF method was suggested appropriate to value start-up's patents. Besides, RFR method, market methods and some income methods such as profit

split method, incremental income and maximum achievable method is also useful to value startup's patents. For startup's IP valuation, DCF and RFR method were mentioned in the literature (Dubiansky, 2006; Pöltner et al., 2011), but the other listed methods are new findings.

- Regarding to the valuation of IPRs in different sectors, almost all findings for each method are new suggestions which our study presents. In literature, there is limited study about IP valuation method based on the different sectors. Therefore, the researches which explore IP valuation case in each sector separately are needed, even though the replacement cost method, DCF method and RFR method are seen more suitable than the others for listed sectors.

- For valuing patent pending technologies or nonproprietary technologies replacement method, reproduction method and sales comparison method are found to be useful. This is a new finding that will contribute to literature and practitioners as well

- Cost methods, sales comparison, DCF and RFR methods were found to be suitable for IT/Software product valuation.

- The preference of IP valuation method depending on TRLs is also explored. Although the results are very close to each other, some TRLs became prominent for each method. For the technologies at TRL 3 to 5, it is more suitable to make IP valuation by cost based methods. The technologies at TRL9 are suitable for valuation with market based method. In general, TRL 5 and above are more convenient for IP valuation with income based methods. Advanced methods are required for valuing technologies at lower levels than TRL 7.

- The findings of this study show the whole necessities/inputs to apply valuation method in line with the literature.

- According to the literature, cost methods are known as easily applicable methods. The Delphi survey results show that the 5% of sale method and Rules of Thumb: 25% percent rule method are perceived as easy to apply in addition to cost methods. On the other hand, the application comparable profit margin method, DCF method, Incremental Income method and risk adjusted NPV methods are thought not to be easy.

- While a parameter is indicated as advantage for applying a method according to one opinion, it is seen that the same parameter can cause difficulties for applying

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same method for others. This situation can be explained with the lack of data needed to apply the method. If the information which is fundamental for applying the valuation method is accessible, this information can be indicated as a benefit for valuation process.

- When an IP is valued, qualitative parameters should be considered because of their indirect affect to the valuation.

- More than one valuation method should be used to make well-supported estimates for a patent's value. According to the suggestions of participant experts of our study, different combinations can be used based on cases, but DCF method is mostly suggested in valuation method groups.

Consequently, it is seen that many supporting conclusions to literature and new findings about IP valuation methods were obtained in this thesis study. Organizations, companies, individuals, Universities and TTOs which produce IP product or know how are in need of learning value of their asset and using IP valuation technique. It can be said that the Delphi method is good for this study to learn the IP experts' approach. This study differs from other IP valuation studies which is very limited since it shows an objective perspective based on IP valuation experts from different organizations and it investigated whole qualitative methods theoretically and based on Delphi method. The author's professional experience helped to find the right Delphi survey participants and exchange opinion about the IP valuation. The characteristics and comparison of all valuation methods, opinion based on experiences of the IP valuation experts and the findings of Delphi survey that are presented in this study are expected to help valuers that are in need of choosing most suitable valuation method for their IPs. In spite of the fact that some findings could not reach a consensus, this study allows experts to determine a road map for IP valuation process.

7. LIMITATION AND RECOMMENDATION

This thesis study is expected to be one of the limited available studies about IP valuation in Turkey as a case that can represent developing or fastly developing country contexts. As stated in the results, there are not many practices and experts about IP valuation in Turkey. Therefore, we faced some challenges in reaching experts and knowledge during the research, which forced us to put some limitations for the study. First of all, IP valuation is still taken as an expertise rather than a specific profession. Professionals for various educational or professional backgrounds can work on IP valuation, whether they have IP and IP valuation knowledge and expertise or not. Therefore, IP valuation experts are not available via some channels like patent attorney, PMP or RTTP. This situation has limited the number of target participants of our Delphi survey. Secondly, an expert panel could not be organized since Delphi group have been selected from different countries and any funding for organizing such a meeting were not available for our research. Thirdly, the quantitative valuation methods were divided into three groups as cost methods, market method and income method in many researches. There was not a comparative study about all methods that were presented in this study. For discussing the findings, a comparable study could not be found for each response or method.

Moreover, we had faced the challenge of limited and immature theoretical frameworks, while designing the research model of this study. There had been muchly conceptual papers available to us from major literature on IP valuation, for example one of the most cited articles in the field is the one that belongs to Lagrost et al. (2010) and it is as well conceptual paper. On the other hand, Wang (2016) is a similar study to ours and it includes sampling of five TTO in Taiwan for data collection, while in our studied we interviewed 15 experts from different institutions, hence we can easily underline that our study is a step forward to provide perspective, deeper insight for own IP valuation study. That's why we believed both the theory and the practice with this characteristic.

In the light of these analyses and findings, researcher should have courage to practice in IP valuation for themselves and future generations. In this thesis, all IP valuation methods have been researched and only quantitative valuation methods at great length has been used for Delphi method. But for further research, the framework should be narrowly scoped by focusing on the methods which are priorly needed in the practice field. For example, further studies can be regarding some related specific methods or specific sectors/ R&D centers by performing business cases. The different IP valuation studies can be examined for different target groups such as experts in TTOs or different sectors and actors in triple helix. Hence, the results will be more accurate and customized for the circumstances of these actors and institutions.

Moreover, in this study, the findings regarding the effect of TRL and sector on IP valuation method are not explained in details and sub dimensions. Dependencies and interrelations between IP valuation methods and technology readiness levels according to the specific sectors can be searched by difference tests if the appropriate data can be collected from wider samples.

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APPENDICES

APPENDIX A: Delphi Survey Questionaire

APPENDIX B: Delphi Survey Findings Report

APPENDIX A

EXPLANATION

To whom it may concern,

Welcome to our questionnaire.

We are doing this research for academic purposes within the scope of a Master's thesis conducted at Istanbul Technical University to learn which IP valuation method is more feasible in different conditions. In this study, the Cost Method, Market Method, Income Method, Advanced Methods and their sub-methods are examined.

The answers and your name will be kept strictly confidential. The results will be shared with the participants. Since this is a Delphi method-based questionnaire, the answers in the first round will be presented anonymously. You will be asked to reconcile or revise. The results will be reported to your contact information.

The survey consists of 18 questions.

Thank you for your support and contribution.

Aysun Beyazkilic Koc- ITU Graduate School of Science Engineering and Technology Management Engineering Master Student

Assoc. Prof. Nihan Yildirim- ITU Department of Management Engineering Lect. Dr.

SURVEY

1- Please introduce yourself
Name :
Family Name :
Company/ Institution Name :
Your Profession :

2- Do you have any information about these methods?

Methods/ Answers	No	Some	Yes
Reproduction Method (Cost)	( )	( )	( )
Replacement Method (Cost)	( )	( )	( )
Sales Comparison (Market)	( )	( )	( )
Comparable Profit Margin (Market)	( )	( )	( )
Discounted Cash Flow Method (Income)	( )	( )	( )
Incremental Income Method (Income)	( )	( )	( )
Profit Split Method (Income)	( )	( )	( )
Maximum Achievable Profit Method (Income)	( )	( )	( )
Technology Factor (Income)	( )	( )	( )
Return on Investment Ratio (Income)	( )	( )	( )
Relief From Royalty Method	( )	( )	( )
Rules of Thumb: the 25 percent rule (Income)	( )	( )	( )
The 5% of Sales Method (Income)	( )	( )	( )
Profit Differential Method (Income)	( )	( )	( )
Risk Adjusted NPV Method (Advanced)	( )	( )	( )
Probability (Decision) Tree Analysis (Advanced)	( )	( )	( )
Monte Carlo Method (Advanced)	( )	( )	( )
Real Option Pricing Method (Advanced)	( )	( )	( )

3- Have you ever used these methods to value an IP before?

Methods/ Answers	No	Yes
Reproduction Method (Cost)	( )	( )
Replacement Method (Cost)	( )	( )
Sales Comparison (Market)	( )	( )
Comparable Profit Margin (Market)	( )	( )
Discounted Cash Flow Method (Income)	( )	( )
Incremental Income Method (Income)	( )	( )
Profit Split Method (Income)	( )	( )
Maximum Achievable Profit Method (Income)	( )	( )
Technology Factor (Income)	( )	( )
Return on Investment Ratio (Income)	( )	( )
Relief From Royalty Method	( )	( )
Rules of Thumb: the 25 percent rule (Income)	( )	( )
The 5% of Sales Method (Income)	( )	( )
Profit Differential Method (Income)	( )	( )
Risk Adjusted NPV Method (Advanced)	( )	( )
Probability (Decision) Tree Analysis (Advanced)	( )	( )
Monte Carlo Method (Advanced)	( )	( )
Real Option Pricing Method (Advanced)	( )	( )

4- When do you use these methods to value an IP, what is the commercial or strategic purpose? (You can choose more than one purpose)

Methods/ Answers	In-licensing	Out-licensing	Sale	R&D	Portfolio Analyse	M&A	Tax	Other
Reproduction Method (Cost)	( )	( )	( )	( )	( )	( )	( )	( )
Replacement Method (Cost)	( )	( )	( )	( )	( )	( )	( )	( )
Sales Comparison (Market)	( )	( )	( )	( )	( )	( )	( )	( )
Comparable Profit Margin (Market)	( )	( )	( )	( )	( )	( )	( )	( )
Discounted Cash Flow Method (Income)	( )	( )	( )	( )	( )	( )	( )	( )
Incremental Income Method (Income)	( )	( )	( )	( )	( )	( )	( )	( )
Profit Split Method (Income)	( )	( )	( )	( )	( )	( )	( )	( )
Maximum Achievable Profit Method (Income)	( )	( )	( )	( )	( )	( )	( )	( )
Technology Factor (Income)	( )	( )	( )	( )	( )	( )	( )	( )
Return on Investment Ratio (Income)	( )	( )	( )	( )	( )	( )	( )	( )
Relief From Royalty Method	( )	( )	( )	( )	( )	( )	( )	( )
Rules of Thumb: the 25 percent rule (Income)	( )	( )	( )	( )	( )	( )	( )	( )
The 5% of Sales Method (Income)	( )	( )	( )	( )	( )	( )	( )	( )
Profit Differential Method (Income)	( )	( )	( )	( )	( )	( )	( )	( )
Risk Adjusted NPV Method (Advanced)	( )	( )	( )	( )	( )	( )	( )	( )
Probability (Decision) Tree Analysis (Advanced)	( )	( )	( )	( )	( )	( )	( )	( )
Monte Carlo Method (Advanced)	( )	( )	( )	( )	( )	( )	( )	( )
Real Option Pricing Method (Advanced)	( )	( )	( )	( )	( )	( )	( )	( )

5- When/ Why do you use these methods? (You can choose more than one purpose)

Methods/ Answers	Early Stage Technology Valuation	Business Valuation	In Litigation Situation	Current Portfolio Analysis	In sectors of high uncertainty and risk	Other
Reproduction Method (Cost)	( )	( )	( )	( )	( )	( )
Replacement Method (Cost)	( )	( )	( )	( )	( )	( )
Sales Comparison (Market)	( )	( )	( )	( )	( )	( )
Comparable Profit Margin (Market)	( )	( )	( )	( )	( )	( )
Discounted Cash Flow Method (Income)	( )	( )	( )	( )	( )	( )
Incremental Income Method (Income)	( )	( )	( )	( )	( )	( )
Profit Split Method (Income)	( )	( )	( )	( )	( )	( )
Maximum Achievable Profit Method (Income)	( )	( )	( )	( )	( )	( )
Technology Factor (Income)	( )	( )	( )	( )	( )	( )
Return on Investment Ratio (Income)	( )	( )	( )	( )	( )	( )
Relief From Royalty Method	( )	( )	( )	( )	( )	( )
Rules of Thumb: the 25 percent rule (Income)	( )	( )	( )	( )	( )	( )
The 5% of Sales Method (Income)	( )	( )	( )	( )	( )	( )
Profit Differential Method (Income)	( )	( )	( )	( )	( )	( )
Risk Adjusted NPV Method (Advanced)	( )	( )	( )	( )	( )	( )
Probability (Decision) Tree Analysis (Advanced)	( )	( )	( )	( )	( )	( )
Monte Carlo Method (Advanced)	( )	( )	( )	( )	( )	( )
Real Option Pricing Method (Advanced)	( )	( )	( )	( )	( )	( )

6- In which sector's patents are these methods often used? (You can choose more than one purpose)

Methods/ Answers	Informatio	Telecom	Mining	Energy	Constructi	Manufactu...	Textiles	Medicine	Automotiv	Material	Other
Reproduction Method (Cost)	()	()	()	()	()	()	()	()	()	()	()
Replacement Method (Cost)	()	()	()	()	()	()	()	()	()	()	()
Sales Comparison (Market)	()	()	()	()	()	()	()	()	()	()	()
Comparable Profit Margin (Market)	()	()	()	()	()	()	()	()	()	()	()
Discounted Cash Flow Method (Income)	()	()	()	()	()	()	()	()	()	()	()
Incremental Income Method (Income)	()	()	()	()	()	()	()	()	()	()	()
Profit Split Method (Income)	()	()	()	()	()	()	()	()	()	()	()
Maximum Achievable Profit Method (Income)	()	()	()	()	()	()	()	()	()	()	()
Technology Factor (Income)	()	()	()	()	()	()	()	()	()	()	()
Return on Investment Ratio (Income)	()	()	()	()	()	()	()	()	()	()	()
Relief From Royalty Method	()	()	()	()	()	()	()	()	()	()	()
Rules of Thumb: the 25 percent rule (Income)	()	()	()	()	()	()	()	()	()	()	()
The 5% of Sales Method (Income)	()	()	()	()	()	()	()	()	()	()	()
Profit Differential Method (Income)	()	()	()	()	()	()	()	()	()	()	()
Risk Adjusted NPV Method (Advanced)	()	()	()	()	()	()	()	()	()	()	()
Probability (Decision) Tree Analysis (Advanced)	()	()	()	()	()	()	()	()	()	()	()
Monte Carlo Method (Advanced)	()	()	()	()	()	()	()	()	()	()	()
Real Option Pricing Method (Advanced)	()	()	()	()	()	()	()	()	()	()	()

7- Evaluate this method for being preferable for the University's Intellectual Property valuation in general?

Methods/ Answers	Very Low	Low	Average	High	Very High
Reproduction Method (Cost)	()	()	()	()	()
Replacement Method (Cost)	()	()	()	()	()
Sales Comparison (Market)	()	()	()	()	()
Comparable Profit Margin (Market)	()	()	()	()	()
Discounted Cash Flow Method (Income)	()	()	()	()	()
Incremental Income Method (Income)	()	()	()	()	()
Profit Split Method (Income)	()	()	()	()	()
Maximum Achievable Profit Method (Income)	()	()	()	()	()
Technology Factor (Income)	()	()	()	()	()
Return on Investment Ratio (Income)	()	()	()	()	()
Relief From Royalty Method	()	()	()	()	()
Rules of Thumb: the 25 percent rule (Income)	()	()	()	()	()
The 5% of Sales Method (Income)	()	()	()	()	()
Profit Differential Method (Income)	()	()	()	()	()
Risk Adjusted NPV Method (Advanced)	()	()	()	()	()
Probability (Decision) Tree Analysis (Advanced)	()	()	()	()	()
Monte Carlo Method (Advanced)	()	()	()	()	()
Real Option Pricing Method (Advanced)	()	()	()	()	()

8- Evaluate this method for being preferable for the Start-Up's Intellectual Property valuation in general?

Methods/ Answers	Very Low	Low	Average	High	Very High
Reproduction Method (Cost)	( )	( )	( )	( )	( )
Replacement Method (Cost)	( )	( )	( )	( )	( )
Sales Comparison (Market)	( )	( )	( )	( )	( )
Comparable Profit Margin (Market)	( )	( )	( )	( )	( )
Discounted Cash Flow Method (Income)	( )	( )	( )	( )	( )
Incremental Income Method (Income)	( )	( )	( )	( )	( )
Profit Split Method (Income)	( )	( )	( )	( )	( )
Maximum Achievable Profit Method (Income)	( )	( )	( )	( )	( )
Technology Factor (Income)	( )	( )	( )	( )	( )
Return on Investment Ratio (Income)	( )	( )	( )	( )	( )
Relief From Royalty Method	( )	( )	( )	( )	( )
Rules of Thumb: the 25 percent rule (Income)	( )	( )	( )	( )	( )
The 5% of Sales Method (Income)	( )	( )	( )	( )	( )
Profit Differential Method (Income)	( )	( )	( )	( )	( )
Risk Adjusted NPV Method (Advanced)	( )	( )	( )	( )	( )
Probability (Decision) Tree Analysis (Advanced)	( )	( )	( )	( )	( )
Monte Carlo Method (Advanced)	( )	( )	( )	( )	( )
Real Option Pricing Method (Advanced)	( )	( )	( )	( )	( )

9- Are these methods useful for patent pending technology or nonpropietary technology valuation?

Methods/ Answers	No	Somehow	Yes
Reproduction Method (Cost)	( )	( )	( )
Replacement Method (Cost)	( )	( )	( )
Sales Comparison (Market)	( )	( )	( )
Comparable Profit Margin (Market)	( )	( )	( )
Discounted Cash Flow Method (Income)	( )	( )	( )
Incremental Income Method (Income)	( )	( )	( )
Profit Split Method (Income)	( )	( )	( )
Maximum Achievable Profit Method (Income)	( )	( )	( )
Technology Factor (Income)	( )	( )	( )
Return on Investment Ratio (Income)	( )	( )	( )
Relief From Royalty Method	( )	( )	( )
Rules of Thumb: the 25 percent rule (Income)	( )	( )	( )
The 5% of Sales Method (Income)	( )	( )	( )
Profit Differential Method (Income)	( )	( )	( )
Risk Adjusted NPV Method (Advanced)	( )	( )	( )
Probability (Decision) Tree Analysis (Advanced)	( )	( )	( )
Monte Carlo Method (Advanced)	( )	( )	( )
Real Option Pricing Method (Advanced)	( )	( )	( )

10- Which methods are used for IT/ Software product pricing ?

Methods/ Answers	
Reproduction Method (Cost)	( )
Replacement Method (Cost)	( )
Sales Comparison (Market)	( )
Comparable Profit Margin (Market)	( )
Discounted Cash Flow Method (Income)	( )
Incremental Income Method (Income)	( )
Profit Split Method (Income)	( )
Maximum Achievable Profit Method (Income)	( )
Technology Factor (Income)	( )
Return on Investment Ratio (Income)	( )
Relief From Royalty Method	( )
Rules of Thumb: the 25 percent rule (Income)	( )
The 5% of Sales Method (Income)	( )
Profit Differential Method (Income)	( )
Risk Adjusted NPV Method (Advanced)	( )
Probability (Decision) Tree Analysis (Advanced)	( )
Monte Carlo Method (Advanced)	( )
Real Option Pricing Method (Advanced)	( )

11- Which TRLs (Technology Readiness Level)* (1 to 9) are more suitable to apply this method? (* The information about TRL is stated below the question. You can write a spesific number 1 to 9 or the range in between.)

Methods	Answers
Reproduction Method (Cost)	
Replacement Method (Cost)	
Sales Comparison (Market)	
Comparable Profit Margin (Market)	
Discounted Cash Flow Method (Income)	
Incremental Income Method (Income)	
Profit Split Method (Income)	
Maximum Achievable Profit Method (Income)	
Technology Factor (Income)	
Return on Investment Ratio (Income)	
Relief From Royalty Method	
Rules of Thumb: the 25 percent rule (Income)	
The 5% of Sales Method (Income)	
Profit Differential Method (Income)	
Risk Adjusted NPV Method (Advanced)	
Probability (Decision) Tree Analysis (Advanced)	
Monte Carlo Method (Advanced)	
Real Option Pricing Method (Advanced)	

Technology Readiness Levels (TRL) are a type of measurement system used to assess the maturity level of a particular technology. Each technology project is evaluated against the parameters for each technology level and is then assigned a TRL rating based on the projects progress. There are nine technology readiness levels. TRL 1 is the lowest and TRL 9 is the highest.

TRL 1: Basic principles observed and reported

TRL 2: Technology concept and/or application formulated

TRL 3: Analytical and experimental critical function and/or characteristic proof-of-concept

TRL 4: Component and/or breadboard validation in laboratory environment

TRL 5: Component and/or breadboard validation in relevant environment

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TRL 6: System/subsystem model or prototype demonstration in a relevant environment

TRL 7: System prototype demonstration in a real environment

TRL 8: Actual System completed, test and demonstration

TRL 9: Actual System proven through successful mission operations.

(for more detail:
https://www.nasa.gov/directorates/heo/scan/engineering/technology/txt_accordion1.html)

12- What are the necessities or inputs of the application of this method?

Methods	Answers
Reproduction Method (Cost)	
Replacement Method (Cost)	
Sales Comparison (Market)	
Comparable Profit Margin (Market)	
Discounted Cash Flow Method (Income)	
Incremental Income Method (Income)	
Profit Split Method (Income)	
Maximum Achievable Profit Method (Income)	
Technology Factor (Income)	
Return on Investment Ratio (Income)	
Relief From Royalty Method	
Rules of Thumb: the 25 percent rule (Income)	
The 5% of Sales Method (Income)	
Profit Differential Method (Income)	
Risk Adjusted NPV Method (Advanced)	
Probability (Decision) Tree Analysis (Advanced)	
Monte Carlo Method (Advanced)	
Real Option Pricing Method (Advanced)	

13- What are the difficulties in applying this method?

Methods	Answers
Reproduction Method (Cost)	
Replacement Method (Cost)	
Sales Comparison (Market)	
Comparable Profit Margin (Market)	
Discounted Cash Flow Method (Income)	
Incremental Income Method (Income)	
Profit Split Method (Income)	
Maximum Achievable Profit Method (Income)	
Technology Factor (Income)	
Return on Investment Ratio (Income)	
Relief From Royalty Method	
Rules of Thumb: the 25 percent rule (Income)	
The 5% of Sales Method (Income)	
Profit Differential Method (Income)	
Risk Adjusted NPV Method (Advanced)	
Probability (Decision) Tree Analysis (Advanced)	
Monte Carlo Method (Advanced)	
Real Option Pricing Method (Advanced)	

14- What are the advantages of this method?

Methods	Answers
Reproduction Method (Cost)	
Replacement Method (Cost)	
Sales Comparison (Market)	
Comparable Profit Margin (Market)	
Discounted Cash Flow Method (Income)	
Incremental Income Method (Income)	
Profit Split Method (Income)	
Maximum Achievable Profit Method (Income)	
Technology Factor (Income)	
Return on Investment Ratio (Income)	
Relief From Royalty Method	
Rules of Thumb: the 25 percent rule (Income)	
The 5% of Sales Method (Income)	
Profit Differential Method (Income)	
Risk Adjusted NPV Method (Advanced)	
Probability (Decision) Tree Analysis (Advanced)	
Monte Carlo Method (Advanced)	
Real Option Pricing Method (Advanced)	

15- Do you consider the qualitative approaches for future potential of the technology being valued ?

No   ( )

Yes   ( )

16- In which step do you use qualitative indicators and what is the effect to monetary value of technology?

17- Do you apply more than one method to value an IP?

18- Which methods do you use simultaneously to value an IP?

APPENDIX B

EXPLANATION

In this research, it is expected that the Delphi survey conducted in order to collect information and opinions in the patent valuation methods. The survey was not a public survey therefore target participant list represents the experts regarding IP valuation. First of all, thank you for your contribution.

The focus group survey was sent to totally 87 experts from Turkey, UK, USA, Germany, Hungary, Austria, Luxembourg and Holland. 15 experts from different countries out of the 87, responded to the survey. This report included the results of the survey is shared with you for your information, second opinion or approval. Please provide opinion regarding the answers (especially open ended questions) if you have opposing view or additional information.

Please do not share the report with anyone.

Thank you for your contributions.

<div align="right">Aysun Beyazkılıç Koç</div>

FINDINGS

1- The Number of participant: 15

2- Do you have any information about these methods?

3- Have you ever used these methods to value an IP before?

4**-** When do you use these methods to value an IP, what is the commercial or strategic purpose?

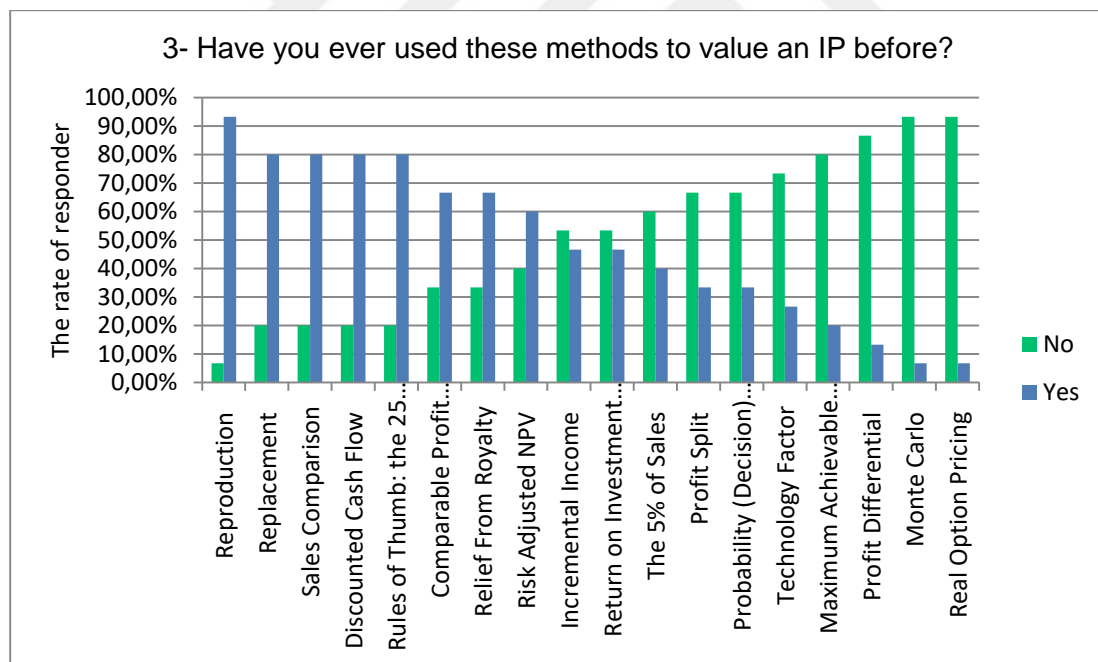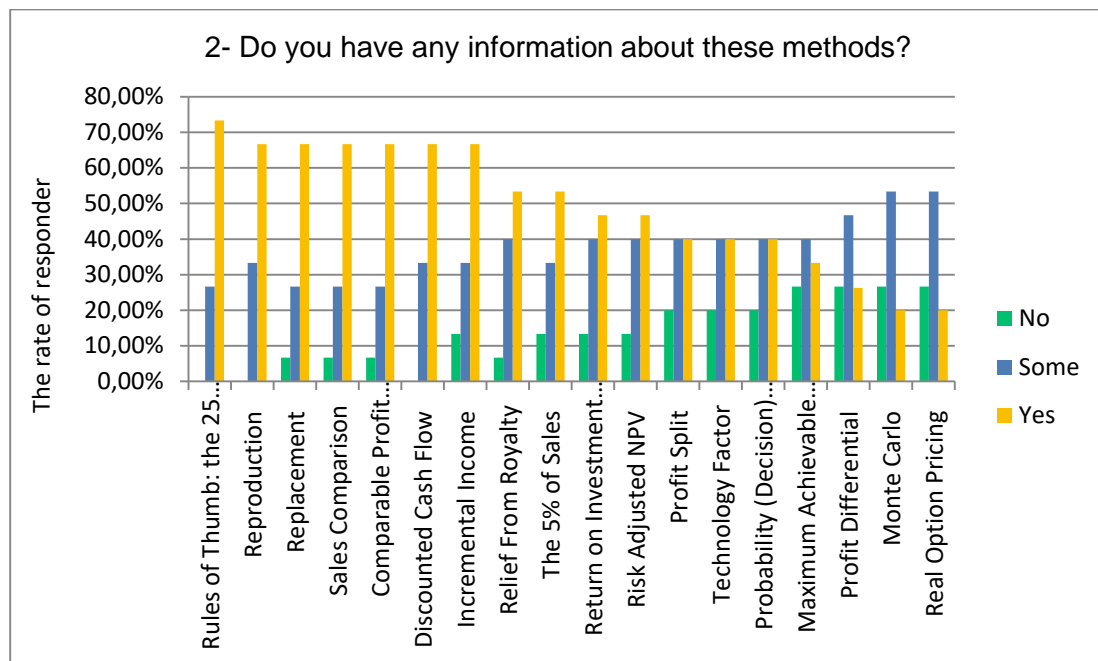| Methods/ Answer Choices	In-licensing	Out-licensing	Sale	R & D	Portfolio Analysis	Merger & Acquisitio	Tax	Other	Total Preferenc
Discounted Cash Flow	4	7	7	1	8	3	2	2	34
Rules of Thumb: the 25 percent rule	2	7	5	3	5	2	4	1	29
Replacement	4	7	4	2	3	2	2	4	28
Sales Comparison	2	9	5	1	6	1	0	0	24
Relief From Royalty	2	5	5	1	3	2	3	2	23
Incremental Income	2	5	4	2	3	2	2	2	22
Reproduction	3	5	4	1	3	1	2	2	21
Profit Split	3	5	5	1	2	1	1	2	20
Comparable Profit Margin	2	6	3	1	4	0	2	1	19
Risk Adjusted NPV	1	4	4	0	3	2	1	0	15
Probability (Decision) Tree Analysis	2	3	3	1	1	1	0	2	13
Return on Investment Ratio	2	2	3	0	1	2	1	1	12
The 5% of Sales	0	3	4	1	2	1	1	0	12
Technology Factor	1	3	2	2	2	1	0	0	11
Profit Differential	1	3	2	0	1	0	1	2	10
Maximum Achievable Profit	1	2	2	0	1	0	0	0	6
Monte Carlo	1	1	2	0	1	0	0	1	6
Real Option Pricing	0	0	2	0	2	0	0	1	5
Total Preference	33	**77**	**66**	17	**51**	21	22	23	310

5- When/Why do you use this method?

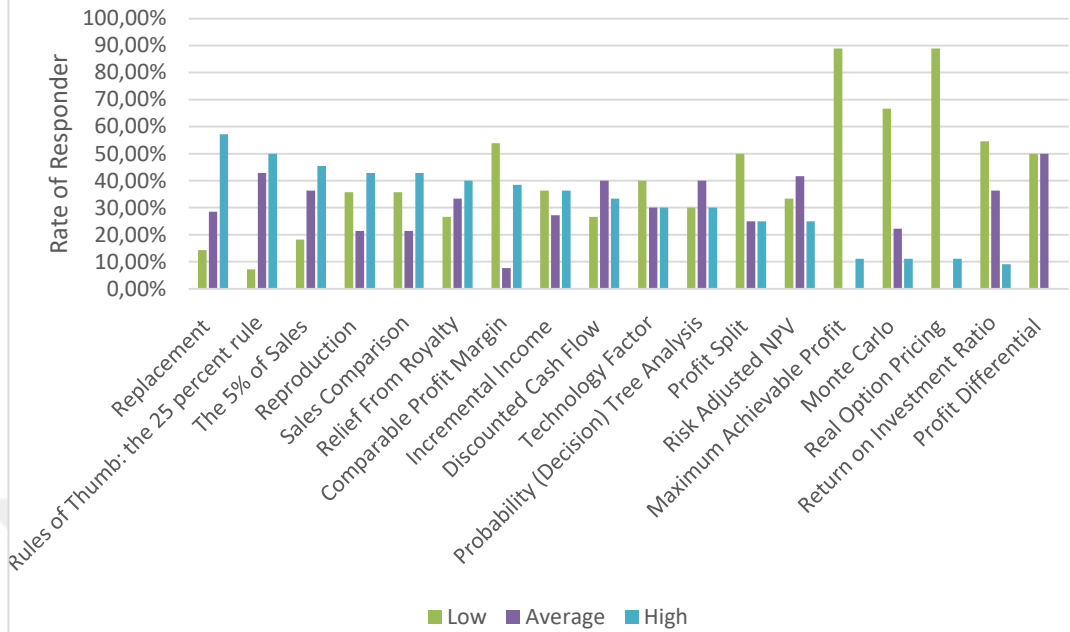| Methods/ Answer Choices	Early Stage Technology Valuation	Business Valuation	In Litigation Situation	Current Portfolio Analysis	In sectors of high uncertainty and risk	Other	Total Preference
Rules of Thumb: the 25 percent rule	**10**	4	3	**6**	**7**	1	31
Discounted Cash Flow	7	**8**	3	**6**	3	1	28
Replacement	**9**	4	**5**	3	2	1	24
Sales Comparison	7	6	2	**5**	2	0	22
Relief From Royalty	7	3	**4**	4	2	2	22
Comparable Profit Margin	6	**7**	2	4	2	0	21
Reproduction	**9**	3	3	3	1	1	20
Incremental Income	5	5	3	3	2	1	19
Profit Split	4	3	3	5	2	2	19
Risk Adjusted NPV	6	5	1	3	2	0	17
The 5% of Sales	4	3	1	3	**4**	0	15
Probability (Decision) Tree Analysis	5	3	1	1	3	0	13
Return on Investment Ratio	2	3	0	1	2	0	8

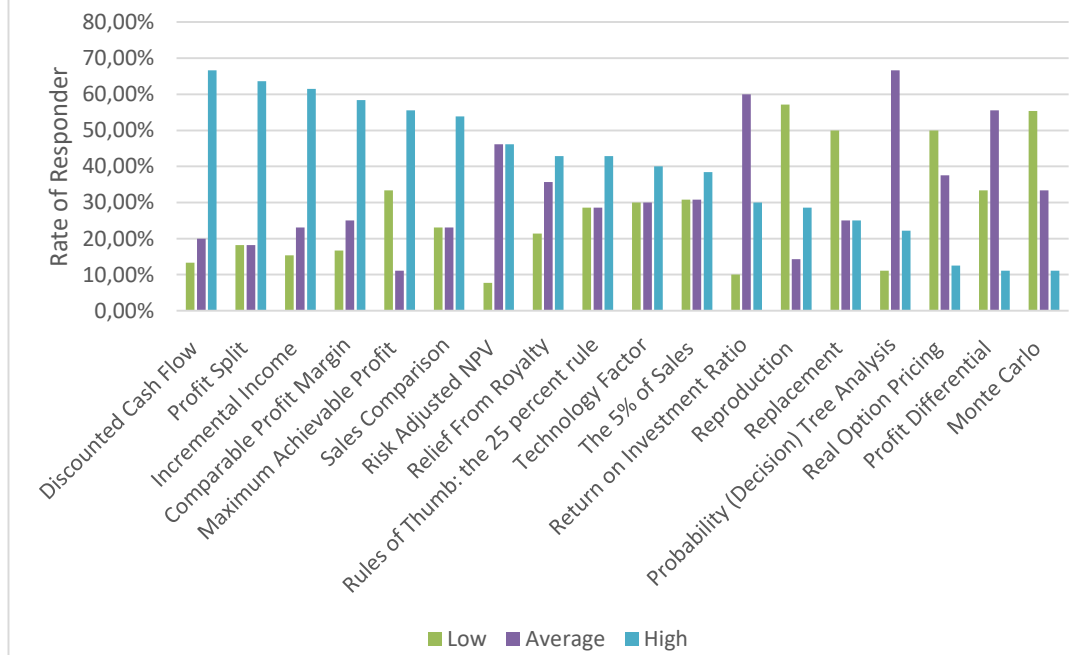| Methods/ Answer Choices	Early Stage Technology Valuation	Business Valuation	In Litigation Situation	Current Portfolio Analysis	In sectors of high uncertainty and risk	Other	Total Preference
Technology Factor	2	2	0	2	1	0	7
Maximum Achievable Profit	1	1	1	2	0	0	5
Profit Differential	1	2	1	1	0	0	5
Monte Carlo	2	2	0	0	1	0	5
Real Option Pricing	2	1	0	1	1	0	5
Total Preference	**89**	**65**	33	53	37	9	286

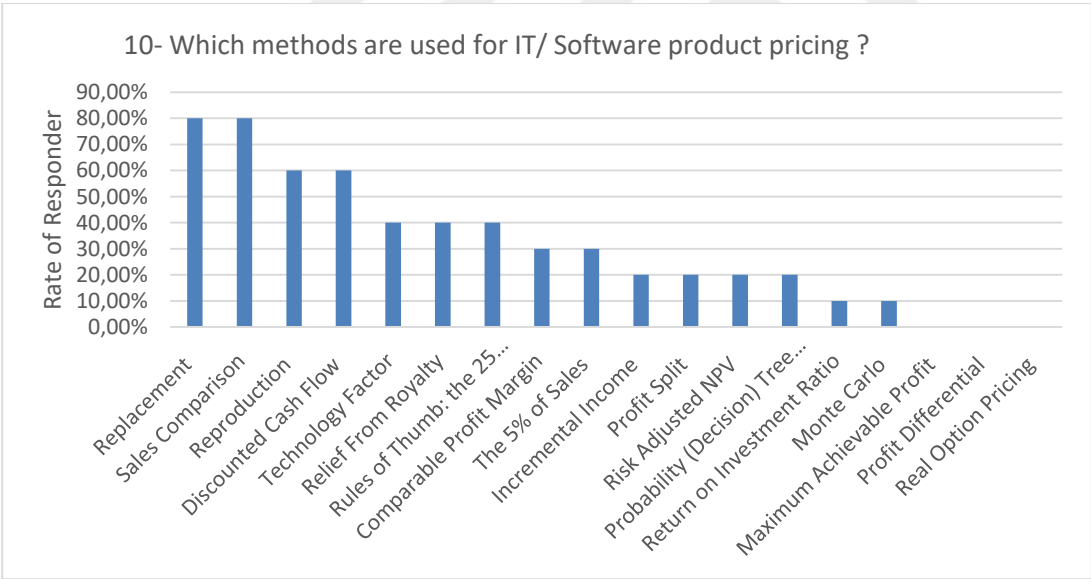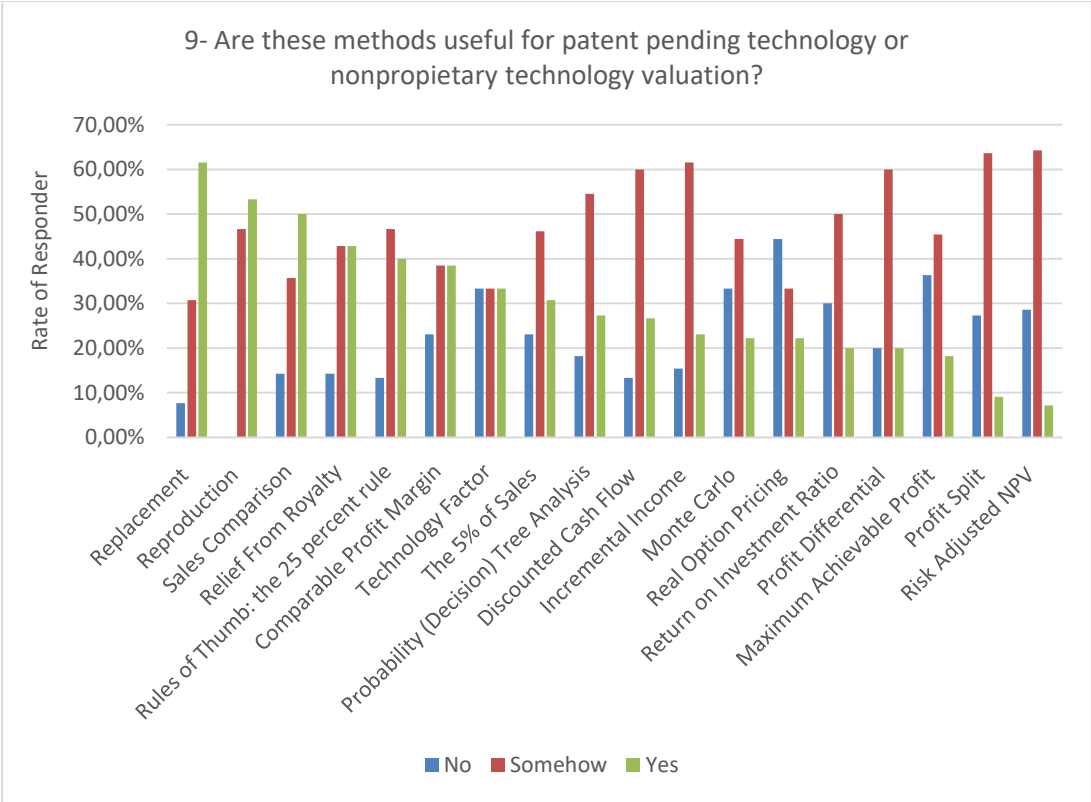6- In which sector's patents are these methods often used?

Methods/ Answer Choices	Information Technologies	Telecom	Mining	Energy	Constructions	Manufacturing	Textiles	Medicine	Automotive	Material	Other	Total Preference
Replacement	2	3	2	2	2	**7**	**3**	**5**	5	**6**	2	39
Discounted Cash Flow	2	**4**	2	**5**	**3**	3	2	3	3	4	1	32
Relief From Royalty	**3**	3	2	**4**	2	5	2	3	3	2	3	32
Risk Adjusted NPV	**3**	2	1	3	2	2	2	3	3	2	1	24
Reproduction	1	1	1	1	1	**6**	1	2	3	4	1	22
Rules of Thumb: the 25 percent rule	2	2	1	2	2	3	1	1	2	3	2	21
Comparable Profit Margin	2	1	2	2	0	4	1	2	2	2	0	18
Probability (Decision) Tree Analysis	2	2	1	2	1	1	1	2	2	2	1	17
Profit Split	2	2	1	2	1	1	2	1	1	1	2	16
Sales Comparison	1	2	1	0	1	4	2	3	1	0	0	15
Incremental Income	2	1	2	1	1	1	1	1	2	1	2	15
Monte Carlo	1	2	1	2	1	1	1	1	1	1	2	14
Real Option Pricing	1	2	1	1	1	2	1	1	1	1	2	14
Profit Differential	1	1	1	1	1	1	1	1	1	1	1	11
Technology Factor	1	2	0	1	0	0	0	1	1	1	0	7
Return on Investment Ratio	1	1	1	1	0	0	0	1	1	1	0	7
The 5% of Sales	0	0	0	1	0	0	0	1	1	2	0	5
Maximum Achievable Profit	0	0	0	0	0	0	0	0	0	0	1	1
Total Choice	27	31	20	31	19	**41**	21	**32**	**33**	**34**	21	310

7- Evaluate this method for being preferable for the University's Intellectual Property valuation in general?

8- Evaluate this method for being preferable for the Start-Up's Intellectual Property valuation in general?

9- Are these methods useful for patent pending technology or nonpropietary technology valuation?

Legend: No, Somehow, Yes

10- Which methods are used for IT/ Software product pricing ?

11- Which TRLs (Technology Readiness Level) (1 to 9) are more suitable to apply this method?

Methods/ TRLs	TRL 1	TRL 2	TRL 3	TRL 4	TRL 5	TRL 6	TRL 7	TRL 8	TRL 9
Reproduction Method	1	1	**4**	**3**	**4**	1	1	-	-
Replacement Method	1	1	**3**	**2**	**3**	-	1	-	1
Sales Comparison	1	2	2	2	2	1	1	2	**4**
Comparable Profit Margin	1	1	1	1	2	2	2	2	**3**
Discounted Cash Flow Method	-	-	1	2	2	**4**	3	2	**5**
Incremental Income Method	-	-	-	-	-	2	3	2	**4**
Profit Split Method	-	1	-	-	-	**4**	2	2	3
Maximum Achievable Profit Method	1	-	-	-	2	1	**3**	2	2
Technology Factor	1	-	2	1	2	2	**3**	**3**	**3**
Return on Investment Ratio	-	1	2	1	1	2	1	2	**3**
Relief From Royalty Method	1	1	2	3	3	3	**4**	**4**	3
Rules of Thumb: the 25 percent rule	1	1	3	3	**4**	**4**	**4**	3	**4**
The 5% of Sales Method	1	1	1	1	3	**4**	3	**4**	3
Profit Differential Method	-	-	-	-	-	2	2	2	**3**
Risk Adjusted NPV Method	-	-	-	2	-	2	1	2	**4**
Probability (Decision) Tree Analysis	-	-	1	1	1	1	**4**	2	3
Monte Carlo Method	-	-	-	-	-	1	**2**	**2**	**2**
Real Option Pricing Method	-	-	-	-	-	1	**2**	1	**2**
Total Preference	9	10	22	22	29	37	42	37	52

12- What are the necessities or inputs of the application of this method?

Methods	**The Necessities/ Inputs**
Reproduction	Previous R & D / Development Cost, Patent Cost
Replacement	Previous R & D/ Development Cost, Cost of replacing IP
Sales Comparison	Market base data, Comparable Info/Deals, Adjustment for differences in deal factors

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| Comparable Profit Margin	Market base data, Comparable Info/Deals
Discounted Cash Flow	Discount Rate, Risk Factor, Future Income, Savings, Investment Cost, Time, Amount
Incremental Income	Turnover of products with IP
Profit Split	Turnover of products with IP
Technology Factor	Need to know TRL
Return on Investment Ratio	Risk factor, time, amount, making a good projection
Relief From Royalty	Market base data, Discount Rate, Risk Factor, Savings, Investment Cost, Amount, Turnover of products with IP, Royalty Rate
Rules of Thumb: the 25 percent rule	Future Income, Profit Margin, Financials of products with IP
Risk Adjusted NPV	Risk factor, Time, Amount

13- What are the difficulties in applying this method?
14- What are the advantages of this method?

| Methods	Challenges/Difficulties	Advantages/ Benefits
Reproduction	• To determine the past cost (2) • No relation to future income (1) • Past cost may be high if costumer needs do not be satisfied (1) • Lack of data and information (1) • Most early stage biomedical technology difficult to assess using analytical methods (1) • ignoring the unique and novel characteristics of IP (1)	• Suitable for early stage technologies (2) • Suitable if there is no direct cash flow being generated from use of the subject IP assets (1) • Costs are defined in the projects (1) • Easy to apply/calculate (1)
Replacement	• Past cost may be high if costumer needs do not be satisfied (1) • To find comparable IP/ market case (1) • Ignoring risk factor and uncertainty (1)	• Suitable for early stage technologies (2) • Suitable if there is no direct cash flow being generated from use of the subject IP assets (1) • Costs are defined in the projects (1) • Easy to apply/calculate (1) • No need business plan (1)
Sales Comparison	• To find comparable IP/ market case (3) • Regions (3)	• Very useful and good indicator if exact comparable are available (2) • Seeing the real numbers (1)
Comparable Profit Margin	• To find comparable IP/ market case (1) • Early stage technologies have no income (1)	• Very useful and good indicator if exact comparable are available (1) • You value others (1)
Discounted Cash Flow	• Early stage technologies have no income (1) • To predict the future for early stage technology and others (2) • To discount uncertainties (1)	• valuation is comparable to other investment decisions, discounting and time value of money is standard in other valuations (1) • good to determine the influence of risk and time and to get numbers for selling the technology (1) • easiest way to use whose cash flows are currently positive and can be forecasted with some reliability (1)
Incremental Income	• Early stage technologies have no income (1)	NA
Technology Factor	• To have good knowledge about the technology (1)	• automatically compare with the technology level (1)

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Methods	Challenges/Difficulties	Advantages/ Benefits
Relief From Royalty	• To predict the future for early stage technology and others (1) • Assumptions on potential licenses (1)	NA
Rules of Thumb: the 25 percent rule	• profit based methods can be manipulated (attributable costs etc.) (1) • to determine the calculation base (which part of the profit is based on the invention) (1)	• easy to apply/calculate (1) • Need less time and effort than other methods(1)
The 5% of Sales	NA	• Easy to apply/calculate (2)
Risk Adjusted NPV	• Early stage technologies have no income (1) • To assess the risk reliably (1)	NA
Real option pricing	NA	• More than one scenario considered (1)

15- Do you consider the qualitative approaches for future potential of the technology being valued ?
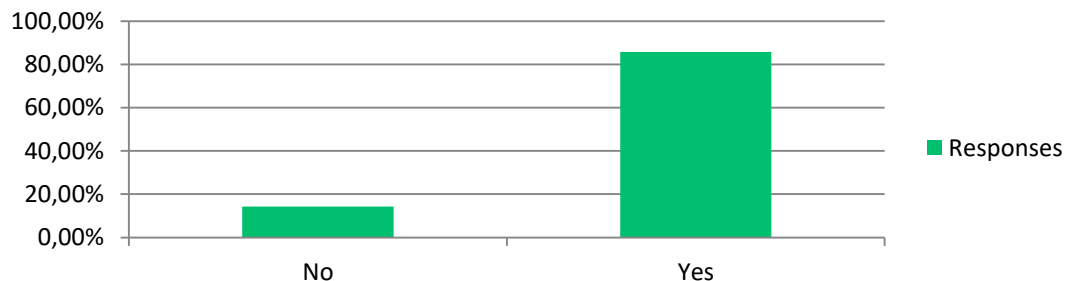
16- In which step do you use qualitative indicators and what is the effect to monetary value of technology?

Responses
1- In general, it is a separate method. Qualitative indicators could potentially be used in discount rate determination.
2- Qualitative factors are used to assess the strategic importance and key questions regarding the technology, marketing etc. The goal of this is to get a holistic picture and explore alternative scenarios etc. not just relying on simple financial assumptions.
3- at decisions (if the university should claim the invention, make a PCT application,...) to compare portfolio
4- to evaluate an overall supremacy of the IP you need qualitative indicators as well. It is useful for assessing the risks and opportunities of IP. Before to determine the monetary value of IP during the licensing agreement negotiations it will be useful for comparing, categorizing and ranking IP within a portfolio or competitors' IP.
5- Throughout
6- stage of pre-clinical or clinical development
7- Licensing or startup book value
8- TRL6
9- at sales comparison since it gives an indication on monetary value of technology
10- For each method used for valuation, the respective parameters are selected based on the qualitative assessment of the technology.
11- Technology risk factor, validation

17- Do you apply more than one method to value an IP?
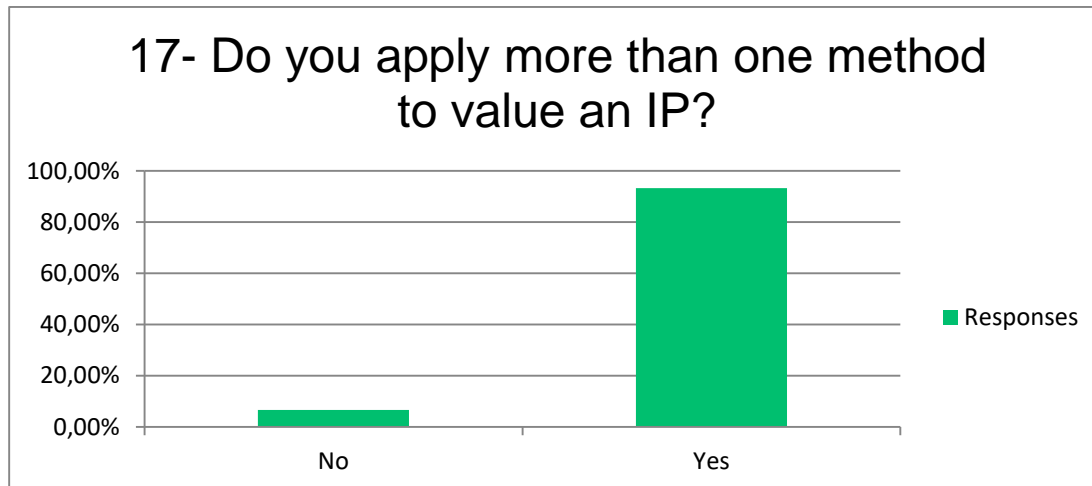
18- Which methods do you use simultaneously to value an IP?

Responses
1. Depends on objectives, situations (5 responders)
2. NPV and Qualitative Methods
3. DCF and Market Method
4. Reproduction, Market, RFR, 25% Rules
5. Cost Methods and Market Methods
6. Reproduction and Replacement Method
7. DCF and another one
8. Rule of Thumb, Replacement method, Sales comparison
9. Technology Factor , sales comparison and replacement
10. Replacement, Reproduction, Sales Comparison, Comparable Profit Margin, DCF
11. At least two approaches listed can be considered depending on the case. Reproduction, Replacement, Sales Comparison, the 25 percent rule, the 5% of Sales, DCF, Return on Investment Ratio, Probability Tree Analysis

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