Value Creation through
Intellectual Property and Innovation:

The Case of the Turkish Manufacturing Industry

Dissertation submitted to the

Graduate Institute of Social Sciences

in partial fulfilment of the requirements for the degree of

Doctor of Philosophy

In

Management

By

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Boğaziçi University

2005

ACKNOWLEDGEMENTS

I take this opportunity to express my deepest feelings of gratitude to Distinguished Prof. Dr. Özer Ertuna, who has been my teacher eversince my MBA days. With his endless knowledge and experience, he has given much, throughout my studies. His continued guidance, comments and assistance have been a source of inspiration and a valuable support during my research and the realization of this thesis.

Also, I would like to extend my sincere appreciation and gratitude to Prof. Dr. Mine Uğurlu, Assoc. Prof. Dr. Metin Ercan , Prof. Dr. Cudi Tuncer Gürsoy and Asst.Prof. Dr. Ulaş Akküçük for their contributions to my research by helpful comments and suggestions.

Here, I wish to thank also the officials at "Türk Patent Enstitüsü" in Ankara, "Istanbul Sanayi Odası" , "Istanbul Menkul Kıymetler Borsası" and all the Company Managers involved, for their positive welcome and assistance in gathering the data.

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ABSTRACT

Value Creation through Intellectual Property and Innovation:
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by

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The purpose of this thesis is to examine the importance of welfare increasing factors in the Turkish manufacturing sector. The global political and economic system in the 21st century favours those that can innovate and create value. The importance of physical labor as a factor of production is being replaced by human talent that can innovate and create knowledge. These welfare increasing factors are collectively called intellectual property and they are strictly protected in the new economic environment. Innovation is defined as any activity that "adds value" and welfare is obtained by value creation.

This thesis looks at the effect of various value adding activities like Research and Development, advertising, patents and trademarks on value creation which is operationalized in two dimensions. One is the total market value of the firms after taking into account their physical assets and the other is the value added (output or production) after controlling for traditional labor and capital. Based on the market value regressions an innovation index is constructed that can be used to rank firms with respect to their innovative activity. This index is later used in the Cobb-Douglas production function to estimate its contribution to value added of the companies that are listed in the Istanbul Stock Exchange.

The results indicate that investing in intellectual property increases the market values of the companies six times more than investing in physical assets and they have a small but significant effect on value added. However, the value adding potential of the companies seems to have been declining which necessitates future work. Finally a questionnaire for obtaining expert opinion is discussed which sheds light on best practices and difficulties.

This study is an important first step but it also has some limitations. Better measures of innovation and better models can be developed to obtain more comprehensive results. Similarly, the sample selection process and sample size can be improved to obtain more assuring results. Whatever the results, one thing is certain however. The advancement of the humanity as a whole has always depended highly on value adding activities and that will be more important than ever in the new century.

Keywords: Innovation, Intellectual Property, Research and Development, Market Value, Value added, Productivity.

ÖZET

Türk Üretim Sektöründe Entellektüel Sermaye ve Yeniliğin Katma
Değer Yaratmadaki Önemi

Ari D. Turman

Bu tezin amacı Türk üretim sektöründeki şirketlerin katma değer artırıcı faaliyetlerinin önemini araştırmaktır. 21. Yüzyılda değişen politik ve ekonomik şartlar, yeniliğe önem veren ve artı katma değer yaratabilen şirketlere başarı şansı tanımaktadır. Ekonomik fonksiyonlarda sıkça tanımlanan fiziki emek kavramı değişmekte ve yerini yenilik yapan ve bilgi yaratan beşeri sermayeye bırakmaktadır. Bu refah artırıcı faktörler yeni dünya düzeninde fikir mülkiyeti hakları adı altında sıkı bir korumaya alınmıştır. Yenilik, artı katma değer yaratan ve refahı artıran her türlü faaliyet anlamında kullanılmaktadır.

Bu çalışmada, Araştırma ve geliştirme, patentler ve markalar gibi faktörlerin katma değer yaratmadaki etkisi araştırılmaktadır. Yaratılan bu değer iki şekilde ölçülmektedir. Birincisi şirketlerin geleneksel varlıklarını dikkate aldıktan sonra yaratılan toplam piyasa değeri ve ikincisi de üretim fonksiyonlarında emek ve sermayeyi hesaba kattıktan sonra yaratılan katma değerdir (üretimin değeri). Piyasa değeri regresyonları sonucunda bir yenilik endeksi oluşturulmakta ve bu şekilde şirketleri sıralamaya sokmak mümkün olmaktadır. Bu endeks daha sonra Cobb-Douglas üretim fonksiyonunda kullanılarak borsada işlem gören şirketlerin yenilik faaliyetleri sonucunda katma değere yaptıkları etki ölçülmektedir.

Sonuçlar, yenilik çabalarının şirketlerin piyasa değerini fiziki varlık yatırımlarından altı kat fazla artırdığını ve yaratılan katma değer üzerinde küçük ama anlamlı bir etkisi olduğunu göstermektedir. Ancak şirketlerin katma değer yaratma gücünün giderek azalması düşündürücü olup ilerki bir çalışmanın konusu olabilir. Son olarak uzman bilgisi almak için yapılan bir anket, yenilik yaratmadaki uygulamalara ve sorunlara ışık tutmaktadır.

Bu çalışma önemli bir ilk adım olmasına rağmen eksiklikleri bulunmaktadır. Daha iyi ölçüm şekilleri ve modeller geliştirilmek suretiyle daha kapsamlı ve ayrıntılı sonuçlar elde edilebilir. Aynı şekilde gözlem sayısının ve kalitesinin artırılması da elde edilen sonuçların güvenilirliğini artıracaktır. Ancak ölçüm yöntemleri ve sonuçlar ne olursa olsun önemli olan tek bir şey vardır. Yenilikler ve katma değer yaratmak insanlığın tarih boyunca ilerlemesinin en önemli nedenidir ve yeni yüzyılda bunun önemi her zamankinden fazla olacaktır.

Anahtar Kelimeler: Yenilik, Fikir Mülkiyeti Hakları, Araştırma ve Geliştirme, Piyasa Değeri, Katma Değer, Verimlilik.

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1. INTRODUCTION

21st century is prone to many new developments and advances in technology that may change our world in unpredictable ways. Throughout history, society has derived great benefit from the advances in technological innovation. New products, processes and services, along with the industries that have developed around them, have steadily increased average real incomes and dramatically improved the quality of life. The current economic system however, is in many ways insufficient and incapable in coping with the requirements and aspirations of humanity.

An excellent review of the current economic system (or capitalism) and its shortcomings can be found in Mr Ertuna's book[1]. One of the major shortcomings of the current system is its treatment of "humans" or labor in economic terms. We are all taught in economics courses that labor and capital are the major factors of production in the economy. Companies try to maximize their profits by allocating labor and capital, taking into account their marginal cost and revenue. Labor, like capital is seen as a cost, and the aim is to minimise this cost until its marginal revenues and costs are equal. This might be an effective strategy in the industrial age where labor was mostly employed in physical works.

The 21st century however, needs a total redefinition of the term labor. There are basically two kinds of workers. One is the physical worker who is employed in the production of goods and services. A second kind of worker however, works in developing "intellectual property" which is the main source of new technology that is

[1] Özer Ertuna, *Kapitalizmin Son direnişi* Alfa Yayınları, 2005.

used in many different ways to create or add value to products beyond their physical value or production cost. These "knowledge" workers are better seen as a value increasing stock or asset rather than expired labor cost. Investments in increasing the skill and knowledge of the modern workers are vital for today's economic environment as I will try to explain below.

A simple but imperfect example is that of mobile phones. The older definition of labor are those who assemble the various components of plastic, metal and silicon chips, package the final product and make it ready for sale. The second type of worker, which can be defined as the knowledge worker, however, works in developing the integrated electronic circuits that gives the real value to the phone. Today, those plastic and metal boxes can take pictures, record videos, help find your position on the world and finally make phone calls.

This simple example can be generalised to the whole economies or countries where these two kinds of workers are in conflict. This conflict is actually created by the recent developments in the world economy that started with the fall of socialism and USSR in the early 1990s. The famous GATT (General Agreement on Trade and Tariffs) agreement and its watchdog the WTO (World Trade Organisation) laid the foundations of a new world order. This new framework strongly supports the development of free world trade where all goods and raw materials are allowed to move around country borders with little or no restrictions at all. The aim is to increase the total revenue available to nations. This is in fact desirable because it is well established that trade increases the total revenue by means of comparative advantages in production in various economies. The actual problem is the sharing of that created revenue. Labor on the other hand is strongly restricted in its movement across borders helping keep labor market and wage differences across countries.

One other important development is the protection of intellectual property rights which are best defined by WIPO (2003) in the following way: “Intellectual property (IP) is the term that describes the ideas, inventions, technologies, artworks, music and literature, that are intangible when first created, but become valuable in tangible form as products. Some classic forms of IP are – patents, copyright, trademarks, and other evolving forms.“[2] The protection of intellectual property rights together with the free movement of goods and production around the world actually defines the two kind of labor just discussed above in our mobile phone example. Since intellectual property is strictly protected by the GATT and TRIPS[3] agreements, those countries that can produce these intellectual capital can sell their products anywhere they like with high profit margins since these are the most important component of a product’s value in today’s world[4].

Continuing our analogy of the mobile phones, these developments imply that, the production and assembly of mobile phone parts like plastics and metal, can be produced anywhere in the world where physical labor is cheapest. The final product can also be sold anywhere on earth for higher prices since the intellectual value added to the phone (in this case the integrated electronic circuits, design etc.) is protected. One day robots may take up the whole production and assembly process. The most important factor that will still need to be produced by humans is the “technology” or “innovation” that goes into the product which are strictly protected by intellectual property rights. The “knowledge workers” behind these have actually become a factor

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[2] World Intellectual Property Organisation. 2003 “Intellectual Property–A Power Tool for Economic Growth”

[3] Trade Related Intellectual Property Rights.

[4] “Private ownership” of intellectual capital is the key word here.

of production. The physical product "the phone" is more or less the same in physical appearance, but the actual value creation comes with the development of technology, design, image etc. There are limitless "values" that can be added to a phone. At first, they were only simple devices to make phone calls. Now, they can take pictures and videos, store your agenda, and manage your emails. Tomorrow, they may monitor your health, control your home remotely, or be a source of energy in itself using fuel cells.

Today's economic and political environment as defined by the above developments may be far from optimal solutions in addressing the requirements of the 21st century. Many argue that a better world is possible since the current system actually makes the rich richer and the poor poorer. One of the main reasons of this can be easily understood by the above mobile phone example. Put any product in the place of the phone, and it will be evident that the real value creation occurs by adding what is called "intellectual property" to the physical product[5]. Other examples are Nike shoes which are sold at least three times their cost thanks to the image created by Michael Jordan ads[6]. Similarly, cars fitted with ESP[7] drastically increase the safety of the cars which adds value to the physical product, the car. The physical production can take place anywhere on earth where labor is cheapest, but the actual value added to the product will sell for higher and higher prices with the advancement of new technology. The main problem in this scenario is that "intellectual capital" and the "physical product" can be produced at different places by different inputs.

It should be evident now, that the starting point of this thesis is the duality mentioned above. Companies or economies that want to take the lion's share should concentrate

[5] The notion that products comprise of hard and soft sides is best described by Prof. Ertuna in his various books.
[6] Walter LaFeber, *Michael Jordan ve Yeni Küresel Kapitalizm*, 2001
[7] Electronic Stability Program.

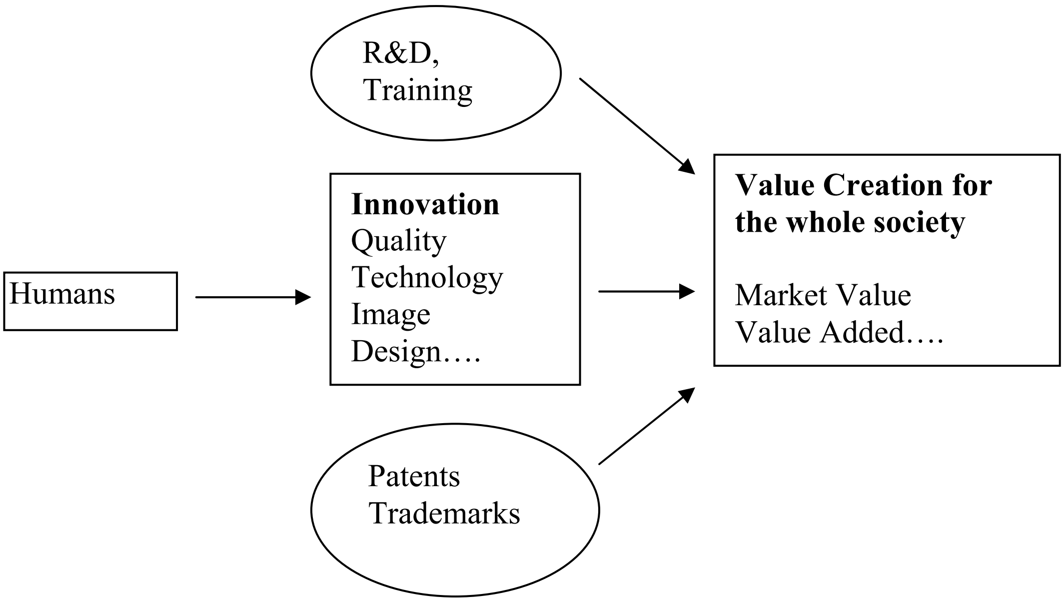
on creating a favourable environment that promotes the development of technology, design, image or in compact terms "intellectual property". Real value lies in the ability to create and add value in all kinds of products produced. The current system surely favours those that develop these innovations[8]. Even more value lies in products that also incorporate the "identity" or cultural heritage of the country as image along with technology. But developing the ability to create these intangibles will be very important regardless of the political or economic system. Those innovations and inventions have been the main driving force behind the advancement of humanity. They will always remain that way, and hopefully one day everyone on earth will be able to benefit from these developments regardless of his wealth.

Based on the above ideas, this thesis aims to look at the importance of value creation and real welfare increasing factors in the Turkish manufacturing sector. It tries to quantify the relative importance of intangible capital like R&D, patents and trademarks that can be used as proxies for innovative activity. These are at best crude and incomplete proxies of the actual value creation discussed above. However, it is a first look to these factors in the economy, which must be the basis for future research since to the best of my knowledge such research has not been done for Turkey before. Its main aim is to see whether the Turkish companies give importance to value creative or welfare improving activities and whether this has any effect on their performance improvement. Value Creation is the most important concept in this framework and it can be measured in many ways. Market Value and contributions to value added to the economy are only two of the measures.

[8] Innovation is a very broad term that is explored in the next section but in this thesis it is mainly used in place of any activity that adds value to a product, process or service.

The general model that I tried to explain so far can be summarized as follows:

Figure 1. 1: The general model of value creation



In this imperfect but simple model, humans are the major factor behind the value creative activities. Innovation is one of the major contributions of humans, which includes but is not limited to improvements in quality, technology, image and design. R&D (research and development), patents and trademarks can collectively be considered "intellectual capital" or property which contribute to performance and value creation. Value creation or "adding value" can be measured in various ways, but in this model these are measured by the residual market value and value added (production or output).

In the literature, most studies that relate innovation to firm performance follow two main branches. One relates innovation to productivity (via value added or output) and the other to the market valuation of the company. In this thesis, my focus is on value creation rather than performance alone which is a broader and more accurate measure in my view. The organisation of the thesis is as follows:

The first section reviews the general literature that looks briefly into the innovation process to gain insights and ideas and later proceeds to explore the relatively limited number of studies that relate innovation to the market value of the firms. The theory behind the research and empirical evidence regarding the valuation of knowledge assets will be discussed. Based on the literature, the link between market value and innovation will be explored and the formation of an innovation index for the firms in the Istanbul Stock Exchange will be discussed. This index will make it possible to rank the firms in terms of their innovative efforts. In the third part, the role of innovation in the production process will be explored in the context of a Cobb-Douglas production function approach. A graphical examination of some of the differences between innovating and non-innovating firms are discussed next. A supplementary questionnaire of selected executives will be helpful in gaining expert opinions and additional insights which is discussed in the last section just before the conclusion.

2. LITERATURE REVIEW

2.1 BACKGROUND

In today's competitive world, innovation is seen as the key to increasing the welfare of a society. An important determinant of economic growth is technical progress or innovation. While there is general agreement that technological innovation is the fundamental force driving progress in market economies, the innovation process itself is not well understood. Successful innovation is a complex set of interactions that draws upon not only science, engineering and technology, but social, political and economic factors as well. Individual firms and entire industries must innovate continuously, or risk losing ground to others who do. The role of information technologies in the innovation process is also very important. They certainly speed up the process of innovation and the productivity of industrial laboratories today is twice what it was a couple of decades ago.

The ability to innovate and benefit from innovation will likely become more and more important in the pursuit of economic success and the latest developments in the world trade. However, economic success should not be the main driving force behind innovation. Benefiting the whole society must be the ultimate goal.

Austrian economist Schumpeter is best remembered for his views on economic growth and innovation. He argued that there had been "creative destructions" associated with industrial cycles 50-60 years long since the 1800s. In his view, each of these business cycles was unique, driven entirely by different industries and technologies. For example steam, rail and steel mark the cycle for the mid 19th century. Similarly, digital networks and new media are thought to have started another wave of innovation in the 1990s (*The Economist*, 1999).

It is generally argued that patents or other government incentives are important motives for innovation. Other theories assert that market structures also affect rates of research and timing of innovations. Joseph Schumpeter initiated modern research about the effects of market structure on innovation. In the Schumpeterian view, there is a positive relationship between innovation and market power, and large firms are more innovative than small ones. Schumpeter argues that, innovation is more important than price competition because it is a more effective means of gaining advantage over competitors. Thus, patents allow to gain market power by imposing costs on potential imitators (Schumpeter 1950).

The model of the innovation process is characterized by research efforts (inputs) and research outputs or innovations generated by those inputs. Usual input measures include R&D spending and number of R&D employees. Innovation output has been measured by patents awarded and sales of new products.

2.1.1 Definitions and concepts

'Technological progress' is a rather vague term which, at its broadest, includes any contribution to economic growth that is not derived strictly from quantitative increases in physical inputs. R&D has a significant role in driving technological progress.

Technology, broadly defined, is the term used to describe how production takes place. Through production, consumers obtain access to a wide range of economically and socially valuable goods and services. When *technological innovation* occurs, the producers employ new, usually more efficient methods of production and very often also achieve qualitative improvements in the goods and services produced. This is an important source of economic growth (IC 1995).

Technological innovation may be distinguished from other forms of innovation relating to management techniques and organizational structures, seeking access to new sources of supply for material inputs, and devising novel marketing strategies (administrative innovation). These aspects of innovation are complementary to technological innovation.

Both economic theory and empirical analysis suggest that technological progress has the potential to be a major contributor to economic growth in any country. The extent to which it actually does contribute to growth varies from country to country. The conventional focus for discussions of innovation was a single event, the introduction of a novel production method or product. But innovation is more accurately viewed as a continuous, complex and often unpredictable *process* (OECD 1992, p. 24).

There are various definitions of "innovation" that appear in the literature. Definitions may vary but above all innovation is something that adds value to a firm or society. The Business Council of Australia, defines innovation as follows: "In business, innovation is something that is new or significantly improved, done by an enterprise to create added value directly for the enterprise or indirectly for its customers."[9] The definition may be incomplete but the key word here is "added value" or value creation that is the main starting point of this thesis.

[9] Business Council of Australia 1993, Managing the Innovating Enterprise, BCA, Melbourne. p. 3

Critical ingredients of the technological innovation process are the creation, transfer and use of knowledge about technology. *Knowledge* is a stock (an asset) to those who possess it; *research* is any activity, which adds to that stock. Of the new knowledge created by research, some serves as an input into other knowledge-producing activities while some is used as an input in developing new products or production methods. This distinction is the conceptual foundation for dividing research into *basic* and *applied* components.

New technology has not only an artefact dimension (a novel physical process or product) but also the dimensions related to the new knowledge required to produce the artefact, know-how and skills (derived from learning-by-doing) and to organizational structures.

In other words, knowledge relevant to technological innovation may be *embodied* in a physical object, like a machine, or *disembodied.* Disembodied knowledge may be documented knowledge (in a patent or blueprint) or an element of human capital: knowledge and know-how carried in the human brain which may result from formal training or informal learning-by-doing and which may or may not be possible to articulate[10] (IC 1995).

Another important concept is “spillovers”. In general, spillovers occur when R&D activity undertaken in one organisation creates benefits or cost reductions elsewhere which are not reflected fully in the rewards reaped by the organisation which carried out the research in the first place. It is possible for this to happen because: (1) the

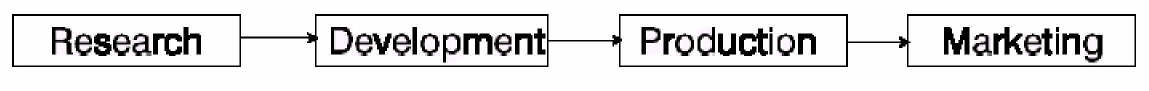
[10] This is sometimes called tacit knowledge which is not written anywhere (codified) but it exists as knowledge among employees and in the company culture. It is an important part of intangible capital.

organisation which generated the knowledge may be unable to prevent others from using it (imitation and reverse engineering are common occurrences) and (2) a given piece of new technological knowledge can be employed simultaneously by any number of firms and at no extra cost of provision.(IC 1995).

2.1.2 Models of the innovation process

Much effort has been devoted, within the literature on innovation, to developing models of the innovation process. In early discussions of innovation and science and technology policy, the so-called linear model provided the explicit (and often implicit) basis for analysis. The first generation model suggested that scientific research is the prime-mover of innovation. In other words, innovation is driven or 'pushed' by new technological opportunities revealed through research.

Figure 2.2: The conventional linear model of innovation



Source: Kline and Rosenberg 1986.

The emphasis on interaction is central to the third and later generation models. At a more general level, engineers engaged in innovation activity in all firms interact with each other, and with the organisations, institutions and individuals offering access to the existing base of scientific and technological knowledge. More often than not such interaction will resolve technological problems. But when it fails to do so, firms resort to undertaking or commissioning research.

When research is undertaken in-house, the nature of the interaction will depend on the organisation of the company: fourth and fifth generation models emphasize that corporate innovation should be viewed as a team effort in which research groups are designed to include specialist researchers, production engineers and marketing personnel. This enables many of the feedback loops in the third generation model to be internalized within the innovating team and all aspect of the process to be addressed from the start.

Inputs to innovation include the intellectual and physical services of labour, the utilisation of capital equipment like computers and lathes, and disembodied knowledge. Outputs include documented ideas and knowledge (publications and patents), acquired skills, prototype devices and the products and production processes which constitute innovations themselves. While there is no official data on numbers of new devices, such inventions would often have been accompanied by a patent application. Trends in patent applications may therefore provide a guide to the outcomes of R&D (IC 1995).

A variety of measures of innovative or technological activity have been used in the literature. They can be classified as measures of either innovative inputs or output. Measures of innovative output include the number of patents, the number of significant innovations, and various indices of the market value of innovations. The most frequently used measures of inputs into the innovation process are R&D expenditure and number of personnel involved in R&D. One problem with R&D expenditure and employment data is that they are subject to errors and biases caused by financial reporting and accounting practices. (Cohen and Levin 1989, Kleinknecht 1987).

Regarding measures of innovative output, the main problems with patent counts are that patents differ greatly in their economic value and that the propensity to patent varies significantly across industries. Furthermore not all innovations are patented. Attempts to count the number of significant innovations, on the other hand, are subject to some arbitrariness and possible biases in the evaluation procedure. It has also been argued that major innovations are often inefficient initially, but undergo a series of small and gradual improvements whose market value is greater than the value of the basic innovation (Symeonidis 1996).

Despite these limitations the above mentioned are the most available measures of innovation and can be considered sufficient for research purposes. Some studies have also found that various innovation measures like patents and R&D are significantly correlated. Moreover, patent counts and the number of trademark or brand applications have been used in the literature with some degree of success. There are also some techniques that the authors have used to overcome these issues.

2.1.3 Why firms innovate

The central role of innovation as a driving force for economic growth appears in little doubt. The reason firms innovate lies in the sources of inter-firm competitiveness: lower production costs; better products; better distribution, delivery and after-sales service[11]. Each of these can be achieved by firm-level innovation involving processes, products and organisational innovation. Left to compete in terms of price alone, with given products and technology, there is little scope for individual firms to enhance their

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[11] This is called the value chain. In this thesis the main focus is on intellectual property but it also affects the value chain through product and process improvements as a result of research and innovation.

profits even temporarily — unless they receive legislative protection, or gain unique access to a vital input, or find a way of colluding with rivals over price setting. If a firm can *change* the products it sells or the technology it uses, this gives it a whole new range of competitive weaponry. In this sense, the prospect of undertaking R&D is a spur to competition because it provides a major extra dimension within which firms may compete with each other.

Firms use technological information to provide themselves with competitive weapons in addition to price. Innovation enables them to cut costs, improve and change their products and offer better delivery and after-sales service. It also offers firms the prospect of taking a strategic advantage if they move first to pre-empt potential or emerging opportunities. Moving first is not, however, a sufficient condition for commercial success: profitable innovation also calls for the use of complementary assets to ensure rapid and sustained market penetration (IC 1995).

In general, it may be argued that where economic incentives and pressures to undertake R&D are greatest, the ratio of R&D to sales or value added will be highest. This ratio is called the R&D intensity. Higher R&D intensity ratios may reflect: abundant technological opportunities; favourable market demand characteristics; and relatively higher levels of appropriability (IC 1995).

Many reasons have been advanced to support the idea that private investments in R&D would not, without government intervention, accord with desirable levels for society:

Externalities: External benefits from R&D accrue to those other than the innovator without adequate recompense. These are spillovers under another name and are characterised by the same attributes of non-rivalry and non-appropriability. They can result in inadequate incentives for private investment in R&D.

Risk and uncertainty: R&D is claimed to be an activity which will be avoided by private investors because of its high risk and the difficulties in determining likely outcomes from investment in R&D.

Information: Trading in the results of R&D (knowledge) is limited by the fact that to be fully informed in advance about a purchase is to acquire the R&D itself. The seller of information therefore necessarily has information that the buyer cannot have.

Indivisibilities: Many research projects require large investments to produce results. This is thought to discourage investment in R&D, especially if the research has applicability to many firms (IC 1995).

2.1.4 Patents and Intellectual property rights

Intellectual property (IP) is the term that describes the ideas, inventions, technologies, artworks, music and literature, that are intangible when first created, but become valuable in tangible form as products. Some classic forms of IP are – patents, copyright, trademarks, and other evolving forms (WIPO 2003).

IP is the commercial application of imaginative thought to solving a technical or artistic challenge. It is not the product itself, but the special idea behind it, the way the idea is expressed, and the distinctive way it is named and described. The word “property” is used to describe this value, because the term applies only to inventions, works and names for which a person or group of persons claims ownership. Ownership is important because theory assumes that potential economic gain provides a powerful incentive to innovate[12].

It is also important to note that IP results from innovation based on existing knowledge. It is the result of creative improvements on what has worked well in the past, or of creative new expressions of old ideas and concepts (WIPO 2003).

Firms protect the results of their research in many ways. These include manufacturing and researching in secret, focusing effort where there are 'first mover' advantages, contracting researchers not to work with competitors, disguising their products in ways that make reverse engineering more difficult and so on.

There are a also range of policy instruments designed to provide intellectual property rights. The best known is the patent system, but others include design rights, trademarks, plant breeders rights, copyright, circuit layouts and the legal protection of confidential information. These instruments vary in the nature and scope of protection provided. For example, a patent confers the inventor with the exclusive right over the commercial exploitation of the invention, but copyright only provides protection to the expression of ideas against copying. Intellectual property rights work better for some goods than others. For chemicals and pharmaceuticals where formulas may be precisely specified, they are, in the form of patents, relatively effective. For other industries in which good ideas may be implemented in a number of forms, patents are less useful — indeed in some industries, researchers choose not to patent at all because it merely serves to advertise their discoveries to competitors. And even in industries in which

[12] "Private ownership" of intellectual property is rationalized by economic theory but the social rationale is highly disputable. Many argue that intellectual property should not be private and it should belong to humanity.

intellectual property rights have some effect, there are likely to be elements of research that will inevitably leak and cannot be protected (IC 1995).

Patents provide an inventor with exclusive rights to a new and useful product, process, substance or design. Patents, which give the inventor or creator of a new product an exclusive right to sell it, have both desirable and undesirable effects. The chief benefit is that they encourage more innovative activity. The chief disadvantage is that new products may be sold at excessively high prices if no substitute is available. A longstanding literature in the innovation and economics literatures has established, however, that the effectiveness of patents varies greatly across industries and technological areas (Perloff and Carlton 1994).

The design of an ideal patent system has many complications including the likelihood that if patent protection is made too tight, there is a danger of incurring social cost through 'patent races' (akin to the common pool problem as there would be a substantial monopoly prize for the winners, and further incentive to join the race because of negligible scope for spillovers to outsiders). (Dosi 1988).

An important study regarding patents is the Carnegie-Mellon Survey of Industrial R&D in the United States (Cohen, Nelson, and Walsh 2000). This survey found that patents were a relatively ineffectual mechanism by which firms in the semiconductor industry recoup R&D investments (both in absolute terms and relative to firms in other industries) and that firms now rely more heavily on secrecy than they did in the early 1980s. Based on a sample of 14 responses in the "semiconductor and related equipment" industry, Cohen et al. (1996) report that the ranking of appropriability mechanisms for product innovation in decreasing order of importance is 1) product complexity; 2) secrecy; 3) lead time; 4) complementary sales and service; 5) complementary manufacturing; with patents and other legal means a distant sixth and seventh. The ranking for process innovations was similar, although patents were found to be even less effective for this kind of innovation

In general, most studies find that firms use patents for reasons that often extend beyond directly profiting from it by commercialisation and licensing. In addition to prevention of copying, the most prominent motives for patenting include the prevention of rivals from patenting related inventions (i.e. patent blocking) , the use of patents in negotiations and the prevention of suits. As the theoretical literature suggests, patents are used for different reasons in "discrete" product industries such as chemicals, versus "complex" product industries, such as telecommunications equipment or semiconductors. (Cohen, Nelson, and Walsh 2000).

The legal basis for granting of patent rights in Turkey was the patent Law of March 23, 1879. This Law was based on the French patent law, existing at that time. The previous Law of 1879 must be regarded as not corresponding to modern trends in that field as shown in recent patent laws enacted in a number of countries, particularly in Western Europe. It provided for a system of mere registration of patents without prior examination as to substance. This system foreseen in the Law was, however, no longer applied in its original form.

In 1994 Turkey signed the General Agreement on Tariffs and Trade (GATT) and took an important step towards integrating its economy with the world. One important part of the GATT was the protection of intellectual property rights which also include patents along with other rights. Although patent rights were present in Turkey before

1994 (established in 1879), they were mostly limited in use and not enforced (for example pharmaceutical patents were not granted). In 1995, the patent rights were strengthened and a new law was passed according to the TRIPS (Trade related intellectual property rights) agreement. In order to protect patent rights, The Turkish Patent Institute was established. Patent protection of the pharmaceuticals had been excluded from the patent protection by the Transitional Provision up to January 1, 2000 for processes and January 1, 2005 for products.

2.1.5 The importance of innovation

Innovation is a very important strategy but companies in Turkey only recently have started to stress its importance in their activities. This was partly due to the economic environment and partly to the legal framework, which were only lately developed. Many companies did not give importance to developing new products but focused their efforts on efficient production. However, some Turkish consumer electronics companies like Arçelik, Vestel and Profilo have increased their R&D spending substantially in recent years and they even hold several patents in various small but important inventions. Telecommunications equipment companies like Netaş are also renown for high levels of R&D.

In today's world, the products have a very different nature. The soft side of the products is becoming very important. This "software" can be defined as the additional value added to the product apart from its physical value. These include quality, design, brands and technology. They are important because their value added to the product has virtually no limit. The intellectual property rights were set up to protect this soft side of the products. Once, production efficiency was very important. Producing the lowest cost product was regarded as a serious advantage. But the GATT agreement has enabled the free flow of goods all around the world and now production has gained mobility. Companies can shift production to the country with the lowest cost (Ertuna 2000).

The hardware side of the products has limited value whereas most of the income is generated from the soft side. All these points indicate that countries that can produce the soft side of the products such as technology and design will be the winners. The current regulatory environment favours developed countries because they are the ones who own the know-how. Since intellectual property rights are strictly protected, whereas the hardware or the physical products can freely travel all around the globe, developed countries are clearly in a better position. They can produce the products where the cost is lowest but they retain the soft side value of the products that are protected.

According to the World Development Report[13], the real projected incomes for the richest one third of countries rose by an annual 1.9 per cent between 1970 and 1995 and the middle third went up by 0.7 per cent in the same period. The bottom third showed no increase at all. Statistics show that the sectors in which poor countries traditionally earned their export income – primary commodities (agriculture and minerals) – shrank from about 70 per cent of world trade in 1900 to about 20 per cent at the end of the century. It is argued that the opportunities for growth in the world market have shifted from raw or semi-processed commodities towards manufactured goods and services and, within these categories, towards more knowledge-intensive segments.

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[13] Cited in Bruce R. Scott and Paul W. Cherington, "The Great Divide in the Global Village," Foreign Affairs: January/February 2001

All these developments have important implications for the policies that should be adopted by countries such as Turkey. First of all, competing for cheap labor is no longer a good strategy in today's environment. If developing countries such as Turkey want to be major players in the world, they should concentrate on developing their own technology and know-how. They should compete with the soft side of the products and not only by efficient production. This could be only possible by increasing innovative or research efforts, which is the only way to compete in the international markets. In this respect, developing countries should strive to develop and create their own brands and intellectual property. It is important to understand that creating successful brands, is only possible if backed by product research and development. Successful development policies give priority to putting in place the elements needed to help a country's citizens compete in this increasingly knowledge-based commercial environment. These essential elements include education, national capacity-building, the promotion of entrepreneurship and the nurturing of a business-friendly environment.

2.2 Previous Literature on Innovation and Market Value

There is a growing literature that examines various aspects of the impact of innovation upon economic performance. Mainly there are two main strands: one focusing upon the impact of R&D on market valuation (for a review see Hall, 1999) and the other on productivity (e.g. Griliches, 1995 and Mairesse and Mohen, 1996). The market valuation approach was first proposed by Griliches in 1981 and was later used by many authors including Hall (1993a, 1993b, 1999). In this section the literature on the market valuation approach is reviewed and the next section looks into the productivity[14] literature.

Firm valuation is a well-established subject in finance. Though there are many different methods and shortcomings, the underlying principle is to estimate the market value of the firm based on its expected earnings and tangible assets. As the economy advances however, the tangibles of a firm are losing their old importance and the intangible values of a firm, such as its knowledge base and its innovative efforts are becoming more and more important. The recent WIPO (2003) publication "Intellectual Property – A Power Tool for Economic Growth" includes certain statistics showing that intangible intellectual assets have overtaken physical assets as the most important corporate assets in an increasing number of countries.

Expected growth opportunities or innovative capability are one of the main factors that investors use in evaluating companies. However, the old valuation models are not always able to account for these increasingly important intangibles of a firm. The valuation of intangible assets like innovation and R&D are very difficult, if not impossible, to quantify.

The market value of a firm's shares ultimately reflects the value of all its net assets. When most of the assets are physical, such as plant and equipment, or inventories, the link between stock prices and asset values are relatively apparent. Moreover, the book values of physical assets are recorded on firms' financial statements. A firm with negligible physical assets may have value that stems from a skilled work force, superior methods of production, brand name or image etc. In such cases the intangible assets

[14] In contrast to the literature, I conceptually define "productivity" as value creation. This distinction

represent important sources of firm value but they are not reported in firm's financial statements. One type of activity that creates intangible assets is R&D which has lately been the subject of much attention. The next section reviews the literature on how innovation and market value is linked.

2.2.1. Theory and Empirical Evidence

Hall (1999) reviews many of the studies that look into the valuation of intangibles. She argues that private firms should have an interest in evaluating the economic returns to their innovative activities. The most common quantitative approach to this measurement problem was to relate total factor productivity or profit growth to measures of innovation. However this approach had shortcomings as mentioned in Hall such as time mismatches, time lags and data unavailability. One other method of evaluating the private returns to innovative activity is to relate the valuation placed by the financial markets on a firm's assets to its Research and Development expenditure, patenting activities and other measures of innovation. This method works only in well functioning financial markets such as the United Kingdom or the US.

Hall mentions that there are three strands of literature in valuing innovation assets. One is used by the accountants to value intangibles to help guide in decision making and legal cases (examples are Chauvin and Hirschey 1993, Lev and Sougiannis 1996). Second come financial economists and investors who try to construct the fundamental value of publicly traded firms for investment purposes. This involves valuing the intangible assets created by R&D and other innovative activities. Finally, policy makers

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will be explained in the next section.

and economists try to quantify innovative activity for understanding its contribution to growth and as a guide for strategies.

One of the best measures of private returns to innovation is the market value of firms. In a market economy, the economic "value " of a good is usually the price at which it trades in the marketplace. Thus, the returns or profit available from an intangible asset would be the price at which it trades on the market. However, this is quite difficult in the case of R&D or innovation. It is not possible to separate the relevant tangible assets used in production and sell them off to determine the appropriate price because they are usually bundled.

Hall gives the example of a pharmaceutical firm. She argues correctly that it is not easy to separate the knowledge of how to make a particular chemical entity from the other assets of the pharmaceutical firm that converts this entity into a marketable drug. This is the same as determining the value of factory-installed automobile air conditioning to consumers by selling it separately from the car in which it was installed. The solution used in the literature is to use the hedonic regression method. This is done by trying to determine the marginal value of a particular intangible asset by regressing the market price for firms that possess the asset on various characteristics of the firms, including the book value of the intangible asset of interest.

The assumption behind this method is that financial markets price the bundles of assets that compose a firm (plant and equipment, knowledge assets, inventories etc) correctly and that the marginal shadow value (gross rate of return) of the knowledge asset in the market place can be inferred from the regression coefficient estimate.

Most studies that will be mentioned later have tried to measure the value of knowledge assets by relying on the fact that publicly traded corporations are bundles of assets whose values are determined every day in the financial markets. Since the work of Waugh (1928) and Griliches (1961) hedonic equations have been widely used to measure the prices of individual characteristics bundled into heterogeneous goods. Thus, these studies aim to measure the marginal value of an additional dollar of investment in a given type of corporate asset.

The most typical model of market value hypothesizes that the market value of a firm is a function of the set of assets that it comprises:

$$V(A_1, A_2, A_3 \ldots) = f(A_1, A_2, A_3 \ldots)$$

where f is an unknown function that describes how the assets combine to create value. Hall argues that, if the firm invests in the various assets A1, A2, A3… according to a value maximising dynamic program, and if the stock market is efficient, the function f will be the value function associated with that dynamic program.

In the case with a single asset and constant returns to scale of the profit function, the market value V will be a multiple of the book value of asset A, with a multiplier (shadow price) equal to Tobin's q[15]. However Hall mentions that this model has 3 shortcomings: 1) the shadow price may not be stable over time, 2) the functional form of the above equation is unknown and 3) we must assume market efficiency to allow unbundling.

[15] Tobin's Q is defined as the Market Value of Assets divided by the estimated replacement cost. Q values below 1 imply that the firm is earning a return less than the required rate.

Hall mentions that two specifications of the value function are used in the literature: an additively separable linear specification as used by Griliches (1981) and then a multiplicative separable specification of the Cobb-Douglas form. These two forms differ in that the additively separable version assumes that the marginal shadow value of the assets is equalized across firms while the Cobb-Douglas version assumes that the value elasticity is equalized.

Hall defines a specification of the firm-level market-value function that is predominant in the literature: an additively separable linear specification, as was first used by Griliches (1981) and his various co-workers.

According to Hall, the advantage of this specification is that it assumes that the marginal shadow value of the assets is equalized across firms. The linear model is given by

$$V_{it}(A, K) = q_t (A_{it} + \gamma_t K_{it})^{\sigma_t} \qquad (1)$$

where A_{it} denotes the ordinary physical assets of firm i at time t and K_{it} denotes the firm's knowledge assets. Both variables are in nominal terms. In the above equation q_t is the market valuation coefficient of firm's total assets reflecting its differential risk and monopoly position, and γ_t is the relative shadow value of knowledge capital to tangible assets. σ_t is approximately unity when there are constant returns to scale.

Taking logarithms of the above equation and rearranging to avoid heteroscedasticity, the estimating equation used in many of the studies becomes the following:

$$\log V_{it} = \log q_t + \sigma_t \log A_{it} + \sigma_t \log(1 + \gamma_t K_{it} / A_{it})$$

Here, γ_t measures the shadow value of R&D assets relative to the tangible assets of the firm and $q_t\gamma_t$ measures their absolute value (when σ_t is approximately unity). The intercept of the model can be interpreted as an estimate of the logarithmic average of Tobin's q for manufacturing corporations during the relevant period. Many authors however have used the approximation Ln (1+x) = x when x is small and obtained the equation below which can be estimated using ordinary least squares:

$$\log V_{it} = \log q_t + \sigma_t \log A_{it} + \gamma_t K_{it} / A_{it} \qquad (2) \quad \text{or alternatively}$$

$$\log (V_{it} / A_{it}) = \log q_t + \gamma_t K_{it} / A_{it}$$

If the assumption of constant returns is true (σ_t is unity), it is possible to move the log of ordinary assets to the left hand side of the equation and estimate the model with the log of the conventional Tobin's q as the dependent variable. Many of the studies in the literature are based on the variations of the above model.

Similarly, one of the simplest (but it had shortcomings) of the procedures that the researchers used was to regress the excess of market value over book value of the assets on various measures of intangibles such as R&D (Hall 1999).

Previous Empirical Research Using R&D

Appendix 1 presents a summary of the earlier work relating the market value of individual firms to innovation indicators such as R&D and patenting. Most of this prior literature has used US data and the linear form of the value equation. The table shows that researchers using data for the US manufacturing firms usually conclude that R&D spending in the current year is capitalized into the market value at a rate between about 2.5 and 8 (mean being around 5 to 6) and that the stock of R&D is valued between .5 to 2 times the value of ordinary assets. In general, the addition of industry dummies does not change the estimates (Hall 1999).

The studies summarized in Appendix 1 have different focuses: Jaffe's 1986 paper for example is an investigation into the contribution of R&D of other firms that are in the same technology space as the firm in question to its patenting, profits and market value. He found that the raw contribution to market value was rather weak and slightly negative, but the contribution was positive and significant when the firm in question had a good sized R&D program of its own.

Cockburn and Griliches (1987) attempted to use measures of appropriability from the Yale Survey on innovation to explain variations in the shadow value of R&D in different firms and industries with very limited success. Megna and Klock (1993) focused on the effects of rivalry in R&D in the semiconductors industry. Most of the earlier US results reported are for the late sixties and seventies. Later work by Hirschey, Richardson and Scholz (1998) and Hall revealed that this was a period of relatively high valuation in the market and the shadow value of R&D does not display much stability.

In 1993, Hall estimated both pooled and cross section estimates of equation (2) based upon a sample of 2480 US companies for 1973-91. K was represented by R&D flows (expenditures) or stocks (constructed using a 15% per annum depreciation). In addition, she also includes a two year moving average of cash flow and growth rate of sales (as a proxy for future growth prospects). Hall found that the relative valuation coefficient had declined rather abruptly during the 1980s in the US (6 in 1973, around 2 in 1991). One reason was the decline in the value of R&D assets that were mostly concentrated in electronics and computing industries. This suggested that the private returns to R&D done in those industries were not very long-lived for that period.

Hall states that there are only a few studies of the market value of innovative assets that use non-US data. For the United Kingdom, Blundell, Griffith, and van Reenen (1995) use innovation data rather than R&D, and Stoneman and Toivanen(1997) use R&D data for 1989 through 1995. They find that the coefficient of R&D spending varies over time for their firms with a range from zero to 4.3.

Research using Patent Data

Many studies in this area rely on maintained hypotheses that patents are a proxy for inventive output, and patent citations are a proxy for knowledge flows or knowledge impacts. The use of patent data in the economic analysis of technological change has a fairly long history, which stretches back to the pathbreaking analyses of Schmookler and Scherer (1965). The availability of information from the U.S. patent office in machine-readable form in the late 1970s spurred greater interest in econometric analyses using these data; much of the resulting early work is reported in Griliches. Until recently, research that uses patents in the market value equation (in addition to or in place of R&D) has been somewhat limited, primarily because of the difficulty of constructing firm datasets that contain patent data.

Most of the work shown in Appendix 1 and described here has been done by Griliches and his co-workers using the database constructed at the NBER (National Bureau of Economic Research) that contained data on patents only through 1981. The other papers in the table use a cross section constructed by Connolly et al.(1988) for 1987 of Fortune 500 companies, and datasets involving UK data, one of which uses innovation counts rather than patents.

Hall states that , when patents are included in a market value equation, they typically do not have as much explanatory power as R&D measures, but they do appear to add information above and beyond that obtained from R&D, as one would expect if they measure the "success" of an R&D program. Griliches, Hall, and Pakes (1991) show that one reason patents may not exhibit very much correlation with dollar-denominated measures like R&D or market value is that they are an extremely noisy measure of the underlying economic value of the innovations with which they are associated. Therefore the number of patents held by a firm is a poor proxy for the sum of the value of those patents and we should not expect the correlation to be high. If the number of citations received by a patent is indicative of its value, then weighting patent counts by citation intensity should mitigate the skewness problem and increase the information content of the patents.

Shane (1993) regresses Tobin's Q for 11 semiconductor firms between 1977 and 1990 on measures of R&D stock, patent stock, and patent stock weighted by citations and finds that the weighted measure has more predictive power than the unweighted measure, entering significantly even when R&D stock is included in the regression; that is, there is independent information about the success of R&D in the weighted patent count measure.

For the UK, Stoneman and Bosworth (1994) estimated a similar model to that of Hall (1993), for 180 UK companies over the period 1984-92. They omitted an advertising variable but included patent grants and investment in tangible capital.

In general these results suggested that innovative activity and R&D in particular impacted positively on market value but R&D and patents did broadly the same job. Many of the studies mentioned by Hall conclude that citation-weighted measures of patents have the potential to be a more precise economic measure of innovation than patents by themselves.

Key Findings from the Recent Work

Recently, a few other studies have examined firms outside the US. Hall and Oriani (2003) have analyzed evidence from a panel of manufacturing firms in Europe. Their sample consists of manufacturing companies publicly traded in France, Germany, Italy, the United Kingdom and the United States. For all the countries, the period of observations goes from 1989 to 1998.

Their model is based on the following equation, which is derived from equation (2) and can be estimated using OLS:

$$\text{Log}\,(V_{it} / A_{it}) = \log q_t + \Upsilon\, K_{it} / A_{it}$$

where A_{it} denotes the ordinary physical assets of firm i at time t and K_{it} denotes the firm's knowledge assets. They measure K, R&D capital as a perpetual inventory of the past and present annual R&D expenditures assuming a growth rate of 8% and a depreciation rate of 15%. However, most authors use current year's R&D as a proxy for the stock variable K. The current year proxy generally works well, perhaps reflecting the stability of R&D expenditures such that the stock and flow are proportional. They argue that, when the data set includes only limited time series of R&D expenditures, together with the well known problem of establishing the economically correct rate of depreciation of knowledge, it would be difficult to construct a reliable measure of the R&D stock.

They find that in France and Germany the R&D capital is positively valued by the stock market. In fact, the coefficients of K/A are positive (0.28 in France and 0.34 in Germany), statistically significant at the one per cent level. However, they are considerably less than the equilibrium value of unity and significantly lower than some of the coefficients obtained by similar analyses on the US (e.g., Hall, 1993a, 1993b) or the UK (e.g., Blundell et al. 1999; Oriani and Sobrero, 2002; Toivanen et al., 2002), although they are in agreement with results obtained by Hall (2000) using US data for the same period as here.

In their analysis they deal with two main specific difficulties limiting data availability in the analyzed countries: the fact that R&D disclosure is not compulsory, drastically reducing the number of observations for which R&D is reported; and the small size of the stock markets, as compared to the UK and the US, restricting the number of publicly-traded firms that could be included in the sample.

They try to correct the biases by using panel techniques in order to account for firm-specific effects and build a sample selection model in which the probability that a firm discloses R&D investments was modelled as a Probit function of firm size and leverage as well as industry-specific variables (R&D intensity and output growth).

Bosworth and Rogers (2001) investigate how R&D and intellectual property activity influence the market value of firms in Australia using a similar approach based on Tobin's q. They also include patent and trademark applications in their models to improve its explanatory power. They use current year's R&D expenditures for a measure of research capital. They estimate the following model:

$$\text{Log } V = \log A + \text{R\&D/Assets} + \text{Gearing} + \text{Patents /Assets} + \text{Trademarks /Assets}$$

Their findings suggest that R&D and patent activity are positively and significantly associated with market value but the private returns to R&D in Australia are low compared to other countries. Their R&D coefficient is 2.79 which is at the lower end of estimates (2.5-8). Feeney and Rogers (2003) also estimate a similar model for the Australian manufacturing firms. In their model they also define the intangible capital K by current year's R&D. In their model R&D and patents are significant whereas the trademarks to assets ratio is significant at only 15%.

Toivanen et al (2002) is a recent study for the UK market. They estimate an extended version of equation (2). They include debt equity ratio, change in log of sales, the firm's market share and other firm and industry specific effects as independent variables. They use R&D expenditures to total assets ratio for the innovation related variables because of data availability issues. They addressed the sample selection bias issue in the cross section estimates using Heckman's (1979) sample selection model. They did this by calculating the MILLS ratio from a probit model with a dummy dependent variable (1,0 – i.e. whether R&D is reported or not). Their cross section and panel results jointly indicate that R&D has a significant and positive impact on firm's market values in the UK even after taking account of sample selection issues. However, they argue that the UK market may be short termist to a degree and the estimates of the impact of R&D on market value may be downward biased.

Feeny and Rogers (2003) estimated an extended form of equation (2) with trademarks and patents in addition to R&D expenditures with the log of market value as the dependent variable. Then they used the weights from the regressions with significant coefficients to form an innovation index. However, in their study, the coefficients on the trademark intensity and design intensity variables were not significantly different from zero, so they were not included in the index. To ensure that the index is reliable they used three different regressions to recalculate the index and looked at the correlations between the indexes.

In summary, the key findings from the somewhat limited literature on the market valuation of the intangible assets associated with industrial innovation is as follows:
R&D assets are valued by financial markets. A reasonable fraction of the variance in market value that remains after controlling for ordinary assets is explained by either R&D spending or the stock of R&D. However there is also a fair amount of unexplained variance at least in the US and Britain. The R&D coefficient is not stable over time in either the US or the United Kingdom. Studies for the US manufacturing firms usually conclude that R&D spending in the current year is capitalized into the market value at a rate between about 2.5 and 8 (mean being around 5 to 6). It is lower in the UK and Australia, estimated to be at around 4 and 2 respectively.

Patents are informative above and beyond R&D, although the correlation is much weaker. The average R square for the Tobin's q - R&D relationship is approximately.15, while that for the patents-R&D relationship is about .08. Citation weighted patents are slightly more informative than patents. The average R- square for citation weighted patents alone is about .10

2.3 Literature on Innovation and Value Added

In addition to the literature on market value and innovation, many researchers have attempted to measure the effects of innovation on productivity. R&D may be viewed as a means of increasing productivity, or the amount of physical output produced from a given level of 'traditional' inputs such as labour and physical capital.

Although the literature that uses the Cobb-Douglas function cites the term "productivity", my interpretation differs in the way that I try to measure the role of innovation or intellectual property in value added. Productivity is used in the following section in reviewing the literature but its interpretation in the models I estimate is conceptually different as I will explain in detail later.

2.3.1 Theory and Empirical Evidence

Since the 1960s, research and development (R&D) investment has been regarded as an important factor in the improvement of productivity levels. The rationale is that knowledge, which can be created and accumulated through the R&D efforts of a firm or industry, will subsequently become available to product innovations or to the production process (Mansfield, 1965; 1969), and as a result, nation-wide economic development is promoted. Based upon this rationale, the advanced countries have invested significantly on R&D activities.

The majority of the literature revolves around two major research questions; the first of is the extent to which R&D influences productivity, whilst the second is concerned with the rates of return provided by R&D. Numerous studies have attempted to estimate the marginal product of R&D capital, or the rates of return on R&D investment (see for example Griliches, 1980; 1994; Scherer, 1983; 1993; Griliches and Lichtenberg, 1984; Goto and Suzuki, 1989).

Based upon several different levels of data aggregation, or different types of estimation model, these studies demonstrate that the output elasticity of R&D lies between 0.06 and 0.14, whilst the rates of return on privately financed R&D investment are between 20 per cent and 50 per cent. However, these studies have continually failed to produce consistent results, with some even failing to determine the contribution of R&D to productivity growth (Link, 1981; Griliches and Lichtenberg, 1984).

Most studies in the literature estimate the relationship between R&D and either output (the production function approach) or production costs (the cost function approach). Both methods treat R&D just like any other factor of production, like labour or physical capital. A third method often used is a variant of the production function approach and relates R&D to total factor productivity (TFP). (IC 1995).

The approach used in most studies is an augmented version of the Cobb-Douglas production function. A measure of R&D capital is then included in the list of explanatory variables in addition to the usual factors of production, that is labor and physical (tangible) capital like structures and equipment. One problem is to estimate the R&D capital stock since there are no entries in company balance sheets. For this reason, R&D capital has to be calculated by means of historical or "perpetual inventory" method, which is also the method used for physical capital (Mairesse & Sassenou 1991).

The theoretical framework for the R&D and productivity studies with three factors has the following general form:

$$Q_{it} = A\ e^{\lambda t}\, C_{it}^{\alpha}\, L_{it}^{\beta}\, K_{it}^{\gamma}\, e^{\varepsilon} \qquad (3)$$

Where Q is a measure of output (actual production or sales or value added), L a measure of labor (often taken as the number of employees), and C and K are measures of physical and research capital respectively. A denotes a constant; α, β and Υ are the elasticities of production with respect to physical capital, labor and R&D capital. In this specification, λ is the rate of disembodied technical change that is assumed to occur for all the companies externally. ε is the error term for the equation reflecting the effects of unknown factors, approximations and other disturbances. The subscripts i and t denote the firm (or sector) and the period (year) respectively.

Most of the existing literature is based on the above Cobb-Douglas formulation for assessing the impact of innovation on productivity and they are mainly interested in the elasticity Υ of R&D capital, as well as its marginal productivity or rate of return which can be easily derived as $\Upsilon\,(Q/K) = \partial Q / \partial K$.

The biggest advantage of using the Cobb-Douglas function is that when expressed in terms of logarithms, it can be estimated as a linear regression, either in levels for a given year, or first differences or in growth terms.

$$\mathrm{Ln}(Q) = a + \lambda t + \alpha\,\mathrm{Ln}(C) + \beta\,\mathrm{Ln}(L) + \Upsilon\,\mathrm{Ln}(K) + \varepsilon \qquad (4)$$

The growth or first difference formulation is the difference in logarithms for time t and t-1 and it is practically equal to the usual rate of growth for any variable x.

Knowledge capital can be estimated based on past R&D expenditures for estimating the elasticity. If data is not available, R&D expenditures alone can be used. In this case the coefficient of K must be interpreted as the marginal productivity or rate of return rather than the elasticity. In many of the studies the equation defining the R&D capital is frequently written as :

$$K_t = RD_t + (1-\delta)RD_{t-1} + (1-\delta)^2 RD_{t-2} + \ldots = RD_t + (1-\delta)K_{t-1}$$

Where K_t is the R&D capital at the end of year t , RD_t the deflated R&D expenditures during year t and δ the rate of R&D depreciation which is assumed to be constant. In most of the relevant literature the rate of R&D depreciation is taken as 10-15% and it is shown that the estimate of the elasticity is not very sensitive to the depreciation figure used. The initial stock of R&D capital is frequently calculated as follows:

$$S_0 = \frac{R_0}{(g+\delta)}$$

where S_0 is the stock of R&D capital at the beginning of the first year for which R&D expenditure data is available, R_0 is the expenditure on R&D, during the first year, and g is the average annual logarithmic growth of R&D expenditures (Mairesse & Sassenou 1991).

Many researchers have estimated a slightly different but equivalent form of the production function in order to avoid estimating the R&D capital. In the simplest of these formulations, total factor productivity is directly related to R&D expenditures and instead of the elasticity, the coefficient ∂ measures the rate of return to R&D.

$$\Delta \Pi_{it} = \lambda + \rho(RD/Q)_{it} + \eta_{it}$$

Examples of studies that estimate 'traditional' production functions include Coe & Moghadam (1993), Cuneo & Mairesse (1984), Griliches & Mairesse (1984), Hall & Mairesse (1993), for industrial R&D and Griliches (1964), and White & Havlicek (1982) for agricultural R&D.

Most of the econometric studies measure the percentage increase in output, costs, profits, or total factor productivity that occurs in response to a one per cent increase in R&D (the elasticity with respect to R&D) or the change in total output, costs, profits, or total factor productivity that results from a one unit (dollar) increase in R&D (the marginal product of R&D). The rate of return to R&D appears to vary considerably depending on the methodology employed, data used (time series or cross sectional) and whether the analysis is at the firm, industry or country level (IC 1995).

Key Findings in the Literature

The relationship of productivity growth and R&D investment has been a subject of considerable interest and analysis both in policy analysis and economic literature. Many studies that were summarized in 1972 by Mansfield, indicated that R&D expenditures contribute substantially to the growth of output in a variety of industries. Most studies that are discussed are obtained from regressions that directly express (in terms of logarithms) the Cobb-Douglas function with an R&D capital stock measure (equation 4).

In any general examination of previous studies, there are two main considerations; the first is the level of data aggregation, and the second is the type of estimation model used. At firm level, Griliches and Mairesse (1984; 1990) and Cuneo and Mairesse (1984) used time series data to estimate the contribution of R&D based on the production function model. They found that the approximate output elasticity of R&D capital lies between 0.06 and 0.10. In a cross-sectional study, Griliches (1995) further demonstrated that the output elasticity of R&D stock was around 0.09-0.14. Adopting the model of R&D intensity, Griliches (1986) and Lichtenberg and Siegel (1989) showed that in US manufacturing firms, the rates of return on R&D were between 10 per cent and 39 per cent.

Goto & Suzuki (1989) further concluded that the rates of return on R&D investment in Japanese manufacturing industries tended to be around 40 per cent, and Wakelin (2001) demonstrated that the rates of return on R&D capital were around 27 per cent in UK manufacturing firms. However, in an earlier study, Link (1983) found that the R&D coefficient in US manufacturing industries in the 1970s failed to achieve statistical significance.

The estimated magnitudes of the elasticities and rate of return to R&D vary considerably depending on whether the study is cross sectional or time series, the method of estimation and the sample (firm, industry or country). However, most studies suggest a strong relationship between R&D and output growth or productivity. R&D elasticities at firm level tend to be around 10 to 30% and the rates of return around 20 to 30%. For the industry data, the elasticities vary between 8% and 30% (Nadiri 1993).

At industry level, most researchers adopt an R&D intensity model. Terleckyj (1974), Griliches and Lichtenberg (1984), Scherer (1993) and Griliches (1994) each found that the rates of return on privately financed R&D investment were between 20 per cent and 50 per cent in US manufacturing industries, whilst Goto and Suzuki (1989) showed that the estimated R&D rates of return in Japanese manufacturing industries were around 26 per cent.

In a similar study, Vuori (1997) and Hanel (2000) found that the rates of return on R&D investment within manufacturing industries in France, Finland and Canada were around 19 per cent, 14 per cent and 34 per cent, respectively. It should be noted, however, that Scherer (1983) concluded that the impact of R&D on productivity was insignificant.

Griliches conducted a study in 1980 using a very large data set of US industrial firms for the period 1958-1963. The study made use of data obtained from the National Science foundation R&D annual survey. R&D elasticity amounted to 0.07 for manufacturing firms but with quite differing values by industry ranging up to 0.12 for the chemical and petroleum industries. In a study conducted by Griliches and

Lichtenberg in 1984, rate of return to process R&D varied between 58% and 76% whereas, the range for product R&D was 20% to 30%.

There are two points worth noting from any examination of the previous studies. First of all, most of the empirical findings demonstrate that R&D investment does have a significant effect on productivity growth or value added; but we should also keep in mind that such a general summary of prior empirical studies may be overoptimistic because of the 'file drawer' problem, i.e., the likelihood of studies supporting the null hypothesis (no significant results) being rejected and therefore buried away in file drawers (Rosenthal, 1979; Begg and Berlin, 1988).

Second, estimations with the R&D intensity model often neglect the obsolescence of R&D. Most of the previous studies have substituted R&D expenditure for increments in R&D capital in order to avoid the difficult task of measuring R&D capital; however, such a substitution not only neglects the reduction in the effective appropriation of knowledge but also overestimates the net rates of return on R&D.

In most cases, case studies of individual projects appear to yield considerably greater variation in their estimates of both the private and social returns to R&D than do the econometric studies. The upper bounds are often considerably higher, ranging in the case studies reviewed up to 2970 per cent, than the econometric studies whose upper bound is 329 per cent.

Cross sectional studies tend to yield higher estimates of the rate of return to R&D than do time series studies. As Mairesse & Sassenou (1991, p. 9) note for firm level studies, this may reflect the absence of any variables representing the characteristics common to all firms within the industry. The inclusion of these variables yield lower estimates of the returns to R&D (IC 95).

Whilst still being subject to considerable variation, the econometric studies estimate that the return to the firm undertaking R&D expenditure (that is the private rate of return) is in the order of 10 to 55 per cent. Other cross-sectional studies confirm the role of R&D capital as a significant factor contributing to productivity differences among firms. The estimated elasticities γ range on average from 0.05 to 0.20 and are significantly higher for the scientific sectors than for other manufacturing industries (Mairesse and Sassenou 1991).

It must be noted that most of the literature is not 100% comparable, and some estimates also lack robustness. R&D effects may be intrinsically uncertain and they occur with long lags and may change over time as well as between sectors. Although there is a wide range of estimates of the rate of economic return to R&D, most studies confirm a relationship between R&D and productivity. Some results from the empirical studies is presented in appendix 2.

3. METHODOLOGY AND EMPIRICAL RESULTS

It is important to note that the studies in the literature discussed in the last two sections are mostly conducted in the 1961-2003 period and the problem of quantifying intangible capital and assessing its effects on performance improvements is still unresolved. It is an ongoing issue that will become more and more important as the role of value adding activities increase in the new century.

My understanding of the literature's interpretation of major concepts like productivity is conceptually different. Factors like efficiency and productivity were very important at the times these studies were conducted but it may not be an accurate term for the 21st century. My interpretation is not only to measure the increased amount of output per a given value of inputs, but the "value" that results from using intellectual capital in the production process. As discussed in the Introduction, recently the world has undergone major changes not only in political and economic terms but also in the pace of technological advancements[16]. The GATT agreement in 1994, greatly increased the importance of "intellectual property" in the production of physical goods. Labor efficiency in production was no longer an optimal strategy. Instead, value and image creation have become the major factors for economic development and prosperity.

In the light of these ideas, I conducted both approaches in this thesis, namely the market valuation approach and the "productivity" or value added approach. However, my contribution to the literature is different in both my interpretation of the concepts and the specification of the models. The major focus of the thesis is on value creation,

[16] Recall that mobile phones and the Internet only have a 10 year history as we know them today.

operationalized by market value and value added. In market value regressions I try to measure the impact of image and intellectual property on the market value of the firms. For this reason I include advertising expenditures as an image creating factor and patents, trademarks etc. as the extent of intellectual property activity. The construction of the innovation index as has been recently done in the literature is an attempt to construct a measure for the "intangibles" which is still far from perfect.

On the production side, I try to collectively measure the importance of this innovation index on value added of the firms. To the best of my knowledge this will be the first time it is used in a production function context. Instead of focusing on the effect of R&D alone on productivity, as has been done in the literature, I examine the "value adding" potential of intellectual property. To make this clear consider the value (or price) of an automobile. You can be very efficient in producing the car (the physical product) by cutting costs and using robots in the production process etc. But if you lack "intellectual property" or "innovation" your car will not be fitted with advanced security systems like ABS and ESP[17]. In the new world, these are the actual components that add the real value to the car.

It must be noted here that value creation is a very broad term that can be affected by other factors like the ones in the value chain. Value chain includes R&D, design, production, marketing, distribution and after-sale service. The focus of this thesis, however, starts from the definition of intellectual property, which may affect all steps of the value chain through innovation. In this respect, it can be said that this study takes a cross-section of the concepts in the value chain. A good example is that of Alcatel, where R&D engineers also take part in marketing and service.

[17] Anti-Lock Breaking System and Electronic Stability Program respectively.

The following sections discuss the methodology and empirical results for both the market value and production function approaches respectively.

3.1 Innovation and Market Value

3.1.1 Empirical Methodology and Data

Under the reasonable assumption that investors favour higher returns over lower, the stock market places a value on R&D spending because of its role in increasing profits and ultimately dividends. One source of increase stems from the reductions in costs due to process improvements and the other from increases in revenues, which come from new or improved products.

The market valuation approach, assumes that the capital markets are efficient and the market valuation of a company should be a forward looking indicator of firm performance reflecting the discounted sum of future dividends, which in turn should be closely related to the discounted sum of future profits. This approach states that market values should also reflect the future expected returns to R&D (and including other tangible and intangible capital, such as goodwill). It follows from these assumptions that the impact of R&D or "innovative efforts" on firm performance will be reflected in the market value-R&D relationship.

The intuition behind using the Tobin's q (or market to book value ratio) model is quite simple. A firm's stock price (hence market value) will be above book value if the firm's expected rate of return is higher than the required rate of return. Thus, this excess of market over book value is a measure of the firm's economic goodwill [18].

As discussed before, the general model is based on the extended Tobin's q model in which the value of companies reflects the market's perception of the flow of future profits and dividends. It is widely accepted that these are driven by firm's tangible and intangible assets and in particular innovative capability (e.g. intangible assets created by R&D activity).

There may be concerns that using market data may introduce noise into the true relationships but this is a problem in almost any empirical study. Furthermore, there have been some studies recently about the efficiency of the Istanbul Stock Exchange, which state that they "cannot reject the null hypothesis that the CAPM applies and Turkish securities markets are efficient." (Dew 2001).

The Basic Model

The model that will be estimated in this study is based on the specification first proposed by Griliches in 1981 and later used by others like Hall. I have made some modifications and improvements to this model by including additional variables that I thought would provide additional explanatory power and insight. In its basic form it is a very simple and intuitive model stating that the residual market value beyond the physical assets depend on intangibles of the firm:

$$\log V_{it} = \log q_t + \sigma_t \log A_{it} + \gamma_t K_{it} / A_{it} \quad (5)$$

[18] White, Gerald, Ashwinpaul Sondhi and Dov Fried. 1994. *The Analysis and Use of Financial Statements*. John Wiley &Sons Inc.

where A_{it} denotes the ordinary physical assets of firm i at time t and K_{it} denotes the firm's knowledge assets. q_t is the market valuation coefficient of firm's total assets reflecting its differential risk and monopoly position, and γ_t is the relative shadow value of knowledge capital to tangible assets (i.e. $(\partial V / \partial K) / (\partial V / \partial A)$). The same model can also be stated as below if one assumes that there are constant returns to scale:

$$\log (V_{it} / A_{it}) = \log q_t + \gamma_t K_{it} / A_{it} \qquad (6)$$

Equations 5 and 6 are the basis for more detailed specifications used in empirical analysis. Specifically some of the firm effects can be proxied by other explanatory variables that may vary over time. I also included advertising expenditures to assets ratio to account for investment in brand names and debt to equity ratio to account for risk. Intellectual property is proxied by patents and trademarks. To make it clear the model is presented below in table 3.1:

Table 3. 1 : The market value model

The total market value that is not explained by the physical assets are accounted for in two dimensions**: Innovation and Risk**

Dependent variable	Independent Variables
Total Market Value --------→ (defined as the total value of equity plus debt)	Total Assets **Innovation Variables** R&D Exp./ Assets[19], (RDTA) Advertising Exp. / Assets (ADVASSET) Patents/Assets Trademarks/Assets **Risk variables** Debt to equity ratio Financial Expenses /Sales

In the above model, assets are used as an explanatory variable. It is also possible to move the log of assets to the right hand side and use Tobin's q as the dependent variable. However, using Tobin's q as the dependent variable assumes that there are constant returns to scale and the asset coefficient is 1. This is indeed the case as it will be seen, but in this model, the assets are included in the independent list to assess whether this assumption is true. Basically, both specifications measure the same thing and the results are not affected.

A preliminary study[20] that I conducted for the Istanbul Stock Exchange in 2001 considering the growth prospects of selected firms, offers support for such a specification. In that study I tried to explain the variances in the market values (note

[19] The correlation coefficient between R&D/Assets and R&D/Net Sales is .96 and significant at the 1% level. Thus we can be confident that this formulation will not affect the results empirically (see appendix 4).

[20] Turman Ari, "Determinants of Firm Value in the Istanbul Stock Exchange", June 2001, unpublished working paper.

that V is defined as market value of equity plus debt) of 33 manufacturing firms traded on the Istanbul Stock Exchange. The firms were not chosen randomly. They were mostly in the electronics and chemical sectors for which research and innovation were very important. The variables that were the most significant in explaining the variations in market value for the sample were R&D/Sales, net income growth rate and dividend yield. If innovation (R&D/Sales) is used together with the other two ratios mentioned above, more than 78% of the variation in market value can be explained for the firms in the sample. These results are further explored in this study.

Data

The sample for this study includes the manufacturing firms traded on the Istanbul Stock Exchange. The sample period covers 1995 – 2002 for 109 firms in the manufacturing sector.

The sample is constructed so that it is representative of the firms traded on the stock market provided that all firms have the required data. The distribution of the sample by sectors is as follows: Food and Beverage **12%,** Textiles **16%,** Paper Processing **4%,** Chemicals&Plastics **17%,** Non-Metallic Mineral Production **19%,** Metal Main Sector **9%,** Metal Products, Machines&Automotive **16%,** Technology&Electronics **5%,** and other **2%.**

The data is pooled to reach a sample size of 871 after missing data are removed. The main reason missing data occurs is because some of the firms were not listed on the stock market before 1997. Outliers[21] were examined but I retained them because they

[21] I define them as observations that are $\pm$ 3 standard deviations away from the mean.

were not truly aberrant and they could contain important information regarding the population.

Total market value is defined as the market value of the equity plus the book value of debt[22]. The total equity value is directly obtained from the Istanbul Stock Exchange for the closing prices of the stocks for each year end. Apart from financial statement data, I obtained patent and trademark data from the Turkish Patent Institute[23] for the whole sample period for all the companies that had applied for patents or trademarks. It must be noted however that, most companies did not apply for patents or trademarks so the reliability of such data is not as high as those obtained in the US or Australia. Apart from these, the other variables can easily be obtained from the firm's financial statements.

It may well be argued that the data (especially R&D expenditures reported in the income statements) may not be reliable enough to use in this study. However, since we are measuring the valuation of innovative efforts by the stock market, these are one of the most important pieces of information available to the investors. Assuming that the stock market is efficient, investors will use this information to assess the future growth prospects of the firms. This will shed light on whether the investors are using this information to evaluate the companies.

Benchmarking and the Construction of an innovation index

Benchmarking refers to the method of comparing a firm's performance to a set of comparable firms. In this case, benchmarking innovation involves the process of comparing firms with respect to their innovative effort and the outcome of this effort.

In this study, following the market value regressions, I combine different measures of innovative activity (to the point that data is available) into a single figure taking firm size into account. The index[24] can be formed by a weighted sum of the various components:

$$I = \alpha R + \beta P + \chi T \qquad (6)$$

Where R is R&D intensity (R&D/Assets), P patent intensity, T trademark intensity and so on. In this formulation, I assume that R&D expenditures is a proxy for R&D capital stock. Considering the relatively short history of R&D activities this may be a logical assumption. Moreover, the correlation coefficient between R&D / Assets and R&D / Net Sales is .96 and significant at the 1% level. Thus we can be confident that this formulation will not affect the results empirically.

Firms which do not undertake any innovative activities will record a zero for each component and consequently have a zero score for the index. In particular, it is arguable that the weights should be derived from a regression that links performance to the innovative activities. Assuming weights can be found from large sample analysis, these will reflect an 'average' impact of innovation on performance.

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[22] Alternatively, the market value of debt can be used but it is very hard to construct and prone to errors.
[23] The number of patent and trademark applications of each company for each calendar year.
[24] Such an index has been created for a sample of Australian firms in a recent study (Feeny and Rogers 2003).

At a theoretical level the most logical choices of weights are the coefficients on the R&D, patent, trademark and design variables, since these represent the average 'impact' on market value.

3.1.2 Empirical Results and Discussion

The Market Value regressions

Based on the 109 manufacturing firms traded on the Istanbul Stock Exchange for the period 1995-2002, several regressions were run to assess the impact of innovation on the market value of the firms. After examining the data, the major variables that will be used in regression analysis were rechecked for various assumptions of the model. It was seen that most were normally distributed after taking the natural logarithms and would not violate normality assumptions. Descriptive statistics and correlation coefficients of selected variables can be found in appendix 7. The model was outlined in table 3.1.

In its most basic form the first regression includes only R&D/Total assets (RDTA) and the log of assets as the independent variables. The sole purpose of this model is to investigate the assumption behind the market value equation in its simplest form.

Table 3. 2: The basic market value regression

Model Summary[b]

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.964[a]	.930	.930	.47693	.930	5746.110	2	868	.000

a. Predictors: (Constant), RDTA, LOGASSET

b. Dependent Variable: LN market value

The adjusted R-square of this model is .93 which indicates that the model explains 93% of the total variance in market value. The F statistic of the model is highly significant indicating good fit. The coefficients and the t-values are presented below in table 3.3. Both independent variables are highly significant as seen from their t-values. The coefficient of total assets is in line with its expected value i.e. around unity. The surprising part of the model is the coefficient for the R&D to assets variable which is also highly significant and positive. The gross rate of return for the research and development of the firms in the sample is 6.093, which falls within the range of coefficients estimated for US data (2.5-8). This coefficient also implies that investment in research and expenditures is valued at about 6 times the investment in physical capital.

Table 3. 3: The basic market value regression coefficients

Coefficients [a]

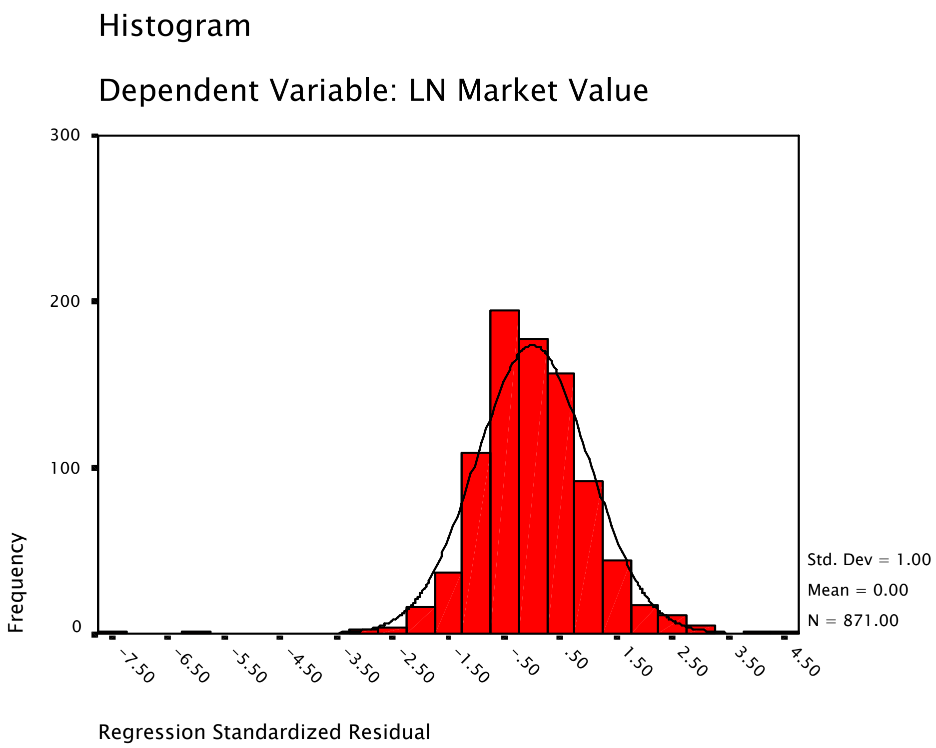
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	.113	.163		.694	.488	-.207	.433		
	LOGASSET	1.015	.010	.955	104.461	.000	.996	1.034	.968	1.03
	RDTA	6.093	1.221	.046	4.990	.000	3.696	8.489	.968	1.03

a. Dependent Variable: LN market value

At first the regression may seem spurious but it confirms many of the preliminary studies I have conducted before with limited samples and time frames. It seems that the stock market values R&D expenditures and companies that invest in R&D will have increased market values in return. Since R&D is not a very common strategy in Turkey, those firms that seriously invest in innovation are noticed and valued as such by the investors. The residual plots in figure 3.3 below also indicate that the multiple regression analysis assumptions are met. The scatterplot of the residuals versus the predicted dependent values are dispersed equally around 0, indicating no violations of normality, nonlinearity or time based dependence.

Although R&D expenditure figures may not be very reliable, as I will discuss later, it is one of the most important pieces of information that investors can use to differentiate companies in regard to innovative efforts.

Figure 3. 3 : Plot of residuals for the basic market value regression



A second regression includes ADVASSET (advertising expenditures to asset ratio) to see if brand image has any effect on market value along with innovation (table 3.4). The adjusted R-square of the model does not improve much, it remains around .93 as before. The positive and significant coefficients of physical assets and R&D variables remain the same. Advertising expenditures also is positively correlated with excess market value[25], but its effect is much lower than that of R&D. The standardized B coefficients indicate that R&D is twice more effective than advertising in explaining intangible capital. The reason for this may lie in imperfect data that does not exactly measure our intended construct (i.e. brand image) but an alternative explanation is possible which is discussed next in an extended model.

Table 3. 4: The market value regression with advertising expenditures

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.017E-02	.165		.183	.855		
	RDTA	5.576	1.231	.042	4.528	.000	.945	1.058
	LOGASSET	1.017	.010	.957	104.768	.000	.963	1.038
	ADVASSET	.695	.256	.025	2.713	.007	.974	1.027

a. Dependent Variable: LN market value

A more detailed alternative to this model is discussed next.

The next model includes an advanced form of the basic model used in the literature with additional variables. Basically this model assumes that the market value of the firms are affected in two dimensions. One is the innovative effort of the firms as measured by R&D to total assets (RDTA) and advertising expenditures to total assets (ADVASSET). The second risk dimension is measured by the debt to equity ratio or TFENS (Financial expenses to net sales). As seen in table 3.5, these variables explain 93 % of the variation in market value on an adjusted basis. The first interesting result is the coefficients of the major two explanatory variables namely natural log of total

[25] Excess or additional market value indicates the unexplained market value after taking into account the physical assets. It is not calculated but "inferred" from the significant coefficients for the innovation or

assets and RDTA ratio. Regardless of model specification these two variables are always significant and positively associated with market value indicating that the market value of the firms is a function of the firms' physical assets and intangible assets.

Table 3. 5: The market value regression with Financial Expenses to Net Sales

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.965[a]	.931	.930	.4741	.931	2910.029	4	866	.000

a. Predictors: (Constant), TFENS, ADVASSET, LOGASSET, RDTA

b. Dependent Variable: LN Market Value

As seen in table 3.6 below the physical assets of the firm explain most of the variance in the market values of the firm. As before the RDTA (R&D to total assets) variable is significant at the 1 % level and has again a coefficient of 5 which is again in line with major US and UK studies. This coefficient is a little higher compared to Australian studies which are in the range of 2-3. This may imply that since R&D is not a widespread strategy in Turkey, those firms that undertake innovative efforts are relatively valued more. However, it may be as well caused by small differences in model specification and the nature of the data but the overall picture is more or less the same.

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intellectual property variables in the regressions.

Table 3. 6: Coefficients for the market value regression with Financial Expenses to Sales

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	-6.051E-02	.170		-.356	.722			
	LOGASSET	1.019	.010	.959	104.768	.000	.963	.963	.937
	RDTA	5.339	1.233	.040	4.329	.000	.217	.146	.039
	ADVASSET	.689	.256	.024	2.693	.007	-.011	.091	.024
	TFENS	-2.058E-02	.009	-.020	-2.203	.028	.050	-.075	-.020

a. Dependent Variable: LN market value

Continuing with the model in table 3.6, the advertising expenditures to assets variable also positively and significantly affects market value but its effect as measured by its regression coefficient is lower than that of R&D. Image and innovation are only effective if they can create synergy. Keeping in mind that this measure is a crude approximation to the brand building efforts of the firms, its relatively low effect compared to R&D may be explained by the fact that brands are only as valuable as the products behind them. A brand image may be created temporarily by investing huge sums in advertising but if the product behind it fails to fulfil its promises, in terms of bad quality etc. the brand image will collapse and its value adding potential will be minimal. Innovative efforts as measured by R&D however, tend to be a result of long range planning which is expected to add value far and beyond that of advertising in the long range.

On the risk side of the equation are two major risk ratios that are debt to equity and the financial expenses to sales ratio. The financial expenses to net sales ratio is highly significant at the 2 % level and negatively affects market value which is the expected sign. The Debt equity ratio also negatively affects market value equation when included but it is correlated positively (.49) with the TFENS ratio and captures more or less the same effect. For that reason including one of the ratios will be sufficient.

The inclusion of these risk ratios is important because it is well known that most companies in Turkey majorly use short term bank credits for their financing needs. This is very risky because of high interest volatility and maturity mismatches. In fact, in a previous study we have shown that the dominant factor that causes companies to be most affected in times of crisis is the financial expenditure factor. The inclusion of these debt ratios in this model is based on theory as well as empirical work on the Turkish manufacturing industry we have conducted before. They also help capture the effects of the 2000 crisis, and improve the power of the regression model.

The same model, this time estimated with the debt ratio instead of TFENS is shown in table 3.7 below. The interpretation of the coefficients are very close to the previous model but the R-square has increased a little to .96 suggesting that both models are very successful in capturing the intended effects.

Table 3. 7: **The market Value Regression with Debt to Equity Ratio**

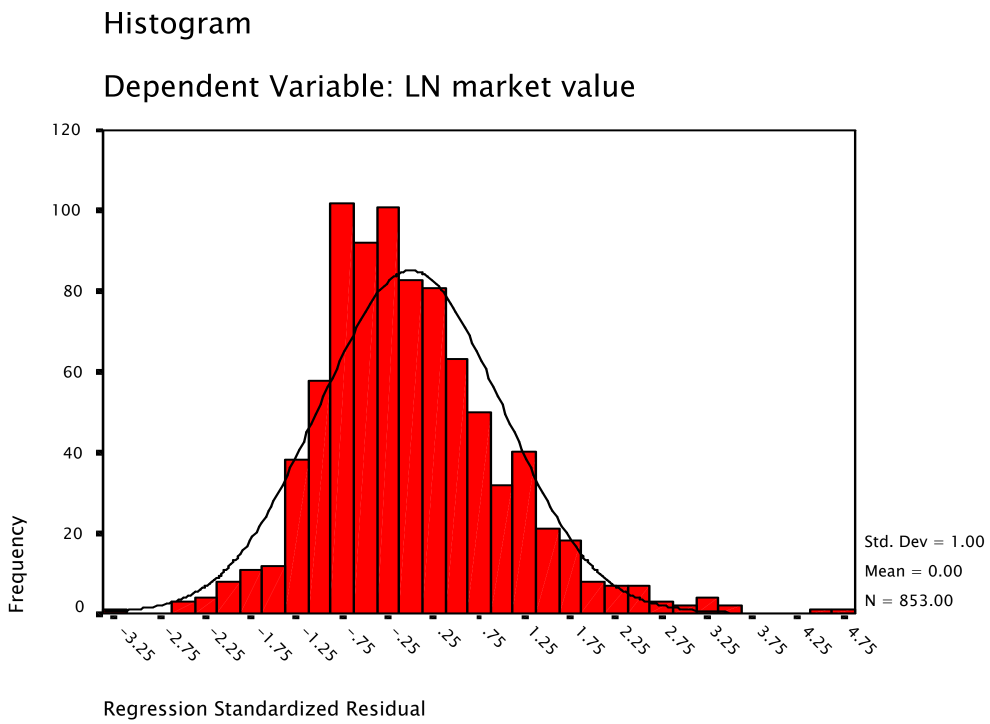
Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	4.029E-02	.132		.306	.760	-.218	.299
	LOGASSET	1.012	.008	.981	132.141	.000	.997	1.027
	RDTA	3.823	.938	.030	4.076	.000	1.982	5.663
	ADVASSET	.627	.200	.023	3.143	.002	.236	1.019
	DEBTEQ	-.225	.011	-.143	-19.617	.000	-.247	-.202

a. Dependent Variable: LN Market Value

An analysis of the standardized residuals suggest that they are normally distributed with no significant pattern or clustering that would suggest heteroscedasticity or autocorrelation. The plot of the studentized residuals also show no significant effects that may obscure the reliability of the estimates. Multicollinearity is also not an issue since the VIF values reported in the outputs are around 1 and less than the limit value of 10 (see tables 3.4 and 3.9).

Figure 3.4: Plot of Residuals for the market value regression with Debt to Equity Ratio



In summary, the innovative efforts as approximated by R&D and advertising, together with risk factors measured by the debt to equity ratio are quite successful in measuring the variation in the market values of the firms.

This result can be tested in an alternative way. Instead of including the real amount of R&D expenditures in the equation, one can create a dummy variable called RDDUMMY which takes the value of one if the firm undertakes any R&D activity and takes the value of 0 otherwise. The mean of this variable is .43 suggesting that around 43% of the firms in the sample undertake some kind of R&D activity. This makes this variable a good candidate for inclusion in the regression equation. In this way, it will be possible to test whether investing in R&D has any effect on the market value of the firms.

As seen in table 3.8 below, the model's R-square is above 0.95 and the independent variables are the same as the previous model except the R&D variable which is now taken as a dummy variable as explained above. Once again all the other variables are significant and the direction and amplitude of their effect on market value is comparable to previous models. The R&D dummy variable is significant at 1% suggesting that there is a significant difference between innovative and non-innovative firms regarding their market values.

Table 3.8: **The market Value Regression with dummy variable (R&D, 0,1)**

Model Summary[b]

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.978[a]	.956	.955	.3607	.956	4572.198	4	848	.000

a. Predictors: (Constant), RDDUMMY, DEBTEQ, ADVASSET, LOGASSET

b. Dependent Variable: LN Market Value

Table 3.8 (continued)

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	4.491E-02	.134		.335	.737	-.218	.308
	LOGASSET	1.010	.008	.979	127.046	.000	.995	1.026
	ADVASSET	.687	.199	.025	3.455	.001	.297	1.078
	DEBTEQ	-.230	.011	-.147	-20.123	.000	-.252	-.207
	RDDUMMY	8.418E-02	.026	.024	3.180	.002	.032	.136

a. Dependent Variable: LN Market Value

Constructing the innovation index

The last stage of the market value approach is to construct an innovation index based on a composite measure of R&D, patents and trademarks. This approach is only used in an Australian study and the principle is to use the regression weights to construct an index that measures the average impact of intellectual capital on market value. Building on the previous model, two new variables, patents to assets and trademarks to assets are included in the analysis. As seen in table 3.9, the other variables in the model maintain their interpretation from the previous models. This indicates that basic innovation and risk measures are quite robust to model specification and maintain their significance between different specifications.

The patent and trademark variables that will be used to build the innovation index are however not very significant (significant at 20%). As I mentioned before it is because of the nature of these data; for many of the companies in the sample the data is not available. Furthermore unlike US, the data is not easily accessible to most investors, indicating that the efficient markets hypothesis that the market value equation is partly built on may not hold in its normal form but it will require strong form efficiency. In other words, these data are not readily and widely available as financial statements data and their interpretation is more difficult given the current level of applications in patents and trademarks. It must be noted that, as mentioned in literature review before, Toivanen et al (2002) also found significant but negative coefficients for patent data for the UK market. They explained the results in terms of appropriability conditions. For Australian data, patents are significant but trademarks are not.

Table 3.9: **Constructing the innovation index, Model Summary and Coefficients**

Model Summary [b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.984[a]	.968	.968	.3150	.968	5203.759	5	847	.000

a. Predictors: (Constant), DEBTEQ, TRMARKA, PATENTA, RDTA, LOGASSET

b. Dependent Variable: LN Market Value

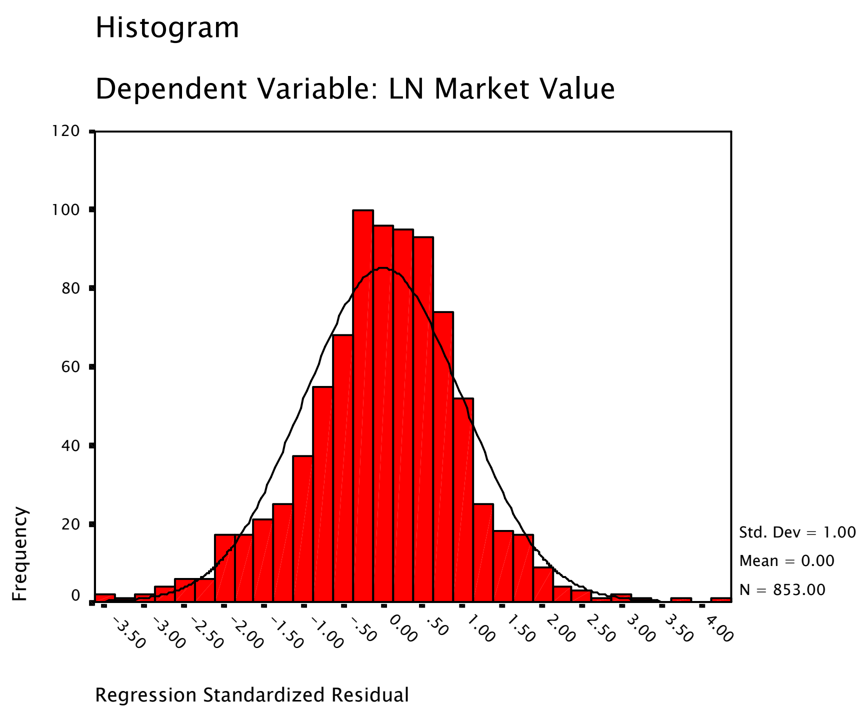
Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-.622	.116		-5.380	.000					
	RDTA	4.221	.812	.032	5.196	.000	.23	.18	.03	.96	1.05
	LOGASSET	1.005	.007	.941	147.778	.000	.89	.98	.90	.92	1.09
	PATENTA	4.123	3.385	.007	1.218	.223	-.01	.04	.01	1.00	1.00
	TRMARKA	9.658	9.228	.006	1.047	.296	-.16	.04	.01	.97	1.03
	DEBTEQ	-.677	.010	-.418	-67.519	.000	-.30	-.92	-.41	.97	1.03

a. Dependent Variable: LN Market Value

As a general rule, including the variables that have a t-statistic above 1, will increase the adjusted R-square of a regression model.[26] Therefore it can be argued that even if not significant at desired levels, patents and trademarks add some contribution to the explanatory power of the model both on theoretical and at empirical levels. After all there is nothing special about 5% significance levels. The increase in R-square to .97 form .93 also justifies the inclusion of these variables.

Figure 3. 5: Plot of residuals for the innovation index regression



Based on the relatively higher t-values and since the inclusion of patent and trademark variables are justified on theoretical grounds, an innovation index can be constructed by using the regression coefficients. The index would take the following form:

$$I = 4.221 \text{ (R\&D / Assets)} + 9.658 \text{ (Trmark / Assets)} + 4.123 \text{ (Patents / Assets)}$$

---

[26] Haitovsky, Y. "A Note on the Maximization of R^2." American Statistician (Feb 1969): 20-21

This index can be constructed for each year in the sample but an average index based on the pooled data may also be appropriate. The index values are then averaged for each company in the sample to reflect an overall performance measure based on innovation. The R&D, trademark and patent values are taken as their intensity to account for firm size. Examining this index (appendix 3), it can be seen that the most innovative companies are in the electronics and automotive sector which is quite reasonable. Arçelik ranks sixth on this index, because it increased its R&D efforts considerably only after 2000. Since the index is an overall average for the whole period and takes firm size into account, Netaş ranks first. Vestel on the other hand ranks 19th on the index, once again because it was not taking R&D seriously before the year 2001. It must be noted however that Arçelik has accumulated a considerable amount of patents, ranking it first in patent count for the whole sample. On the other hand Pınar Süt and Kent Gıda have the lead in the number of trademarks granted, which is quite an interesting result. This may signify that company image is also an important factor. (see appendix 3).

In Turkey, two companies stand out for their efforts to enhance their image with their recent advertisements. One of them is Arçelik with its famous "çelik" character and the other is Vestel with its emphasis on digital technology. The common points of these companies are their emphasis on building a brand image that is associated with quality, innovation and technology.

The case of Arçelik is especially important because its recent efforts indicate that it will attempt to produce its own technology in-house rather than obtaining them through licenses from other companies. It is also trying to create a favorable company image by advertising its patented technologies like "DirectDrive". In the early years, technology was not available in Turkey, and many products could only be produced by the way of know-how obtained from abroad. A very good example to this is automobile production which first started as an assembly line by parts and technologies obtained from abroad.

One would expect these companies to score higher on the innovation index, and this turns out to be especially true for Arçelik. This can be considered an indication that the markets actually value the efforts of these companies.

The ranking of the index seems not to change much from year to year. Since the index is a composite measure and the regression coefficients of R&D are quite robust to differences in model specification, the rankings and the index values are quite stable summarising the snapshot of the sampling period quite accurately. This result is also consistent with the Feeny and Rogers (2003) study where they also find that the index values based on different years in the sample do not change much with Spearman rank correlations ranging between .75 and .80.

The weights of the patent and trademark components may not be very accurate but this shouldn't be a problem since the index is based on the relative importance of each measure rather than their absolute value. As we have seen in the regression coefficients R&D has the most weight in the rankings and its impact on market value is much higher than the other components.

3.1.3 Summary

To sum up the results for the market value side of the empirical analysis, the results indicate that innovative efforts of the companies or their intellectual property have a positive affect on market values. Especially the R&D indicator is highly significant in all of the regressions, and does not seem to be affected by model specification. The total market value after controlling for the effect of total assets can be explained by R&D and to a lesser degree by advertising expenditures. The R&D coefficient of 6 is significant at the 1% level and at par with most of the US studies which are in the range 2.5 to 8. This indicates that increasing R&D spending will increase market value around six times more than simply investing in physical assets alone. The regression results are presented in table 3.10 below. As mentioned previously, R&D/Net sales, R&D/Assets and constructed R&Dcapital/Assets[27] ratios are all highly correlated and can be used as proxies for the intangibles of a firm. The same results with R&D capital in place of R&D expenditures are presented in appendix 4. The results are almost identical.

Also based on the regressions an innovation index was calculated which is a composite measure capturing the effects of R&D, patents and trademarks with that of R&D being the most significant. The rankings based on the index are quite logical with telecommunications and automotive companies being the most innovative followed by Arçelik which explicitly announces that its first priority is innovation.

[27] The methods for computing R&D capital are explained in detail in the literature section. Since R&D history is rather short in our sample, R&D expenditures are a very good proxy for R&D capital. The correlations and regression results also confirm this. See appendix 4 for results obtained by using constructed R&D capital.

It can be argued that R&D expenditure figures from the financial statements and patent and trademark counts are a very crude and biased measure of the real innovative capability of the firms. However, this same problem is encountered in all the other empirical studies conducted so far. The difficulty arises from the fact that innovation is very hard to measure because it is intangible. Even more detailed company data may not solve this problem completely, because innovative capability is a multi-faceted and a very complicated measure that depends on many things that range from the amount of R&D investment to the organizational culture and even to the IQ level of the employees.

Nevertheless, our aim was to measure whether additional or residual market value was created by the innovative efforts of the companies and the results so far indicate that the answer is positive. This is a significant result because it confirms some of my previous analyses with limited samples, that indicated a positive relationship between total market value and R&D.

Table 3.10: Market Value Regressions Summary

Log of Total Market Value as the dependent Variable

	R1	R2	R3	R4	R5
Explanatory Variables					
LogAssets	**1.015**	**1.017**	**1.012**	**1.01**	**1.005**
	(104.46)	(104.76)	(132)	(127)	(147.8)
R&D exp./ Assets	**6.1**	**5.58**	**3.82**		**4.22**
	(4.99)	(4.528)	(4.08)		(5.19)
Advertising Exp./ Assets		**0.695**	**0.63**	**0.69**	
		(2.713)	(3.14)	(3.46)	
Debt-Equity Ratio			**-0.22**	**-0.23**	**-0.68**
			(-19.62)	(-20.12)	(-67.5)
R&Ddummy				**0.08**	
				(3.18)	
Patents/Assets					**4.12**
					(1.22)
Trademarks/Assets					**9.66**
					(1.05)
Adjusted R-square	0.93	0.934	0.96	0.95	0.97
Observations	871	871	853	853	853

Notes: The numbers in bold are regression coefficients. t-statistics are in parentheses. All the variables are significant below 5% levels except patent and trademark variables which are significant at 20%.

One should always keep in mind however, that causality is never proved in econometric analyses. Furthermore, there are many other factors affecting market value that were not controlled for in this study. Similarly, asset size may be an important determinant of innovative capability and hence market value since R&D is a very risky and expensive endeavour. These issues must be analyzed in future studies.

3.2 Innovation and Value Added

3.2.1 Empirical Model and Data

Methodology

To assess the role of "intellectual property" in the value added, a production function will be estimated where knowledge assets is also an input like labor and capital. One way to do this is by econometrically estimating a production function directly, in which output is a function of labour, capital, the stock of knowledge capital and some additional variables likely to affect value creation. In most of the literature discussed the following form is used which is the familiar Cobb-Douglas production function.

If production can be explained by the stock of knowledge capital and other factors, then the model can be rewritten as:

$$Q = A \; e^{\lambda t} C^{\alpha} L^{\beta} K^{\gamma} Z^{d} \qquad (8)$$

where *K* is the stock of knowledge capital (approximated in the literature by R&D expenditures or patent stock). A is a constant, C and L are capital and labor respectively and *Z* is other factors affecting measured productivity. In the production function approach, a log linear version of the above equation would be estimated directly:

$$Ln\,(Q) = a + \lambda\, t + \alpha\, Ln\,(C) + \beta\, Ln\,(L) + \Upsilon\, Ln\,(K) + d\, Ln\,(Z) + \varepsilon \qquad (9)$$

with no further restrictions placed upon the parameters. The estimate of Υ would provide a direct estimate of the percentage increase in output obtainable from a one per cent increase in knowledge stocks, holding all other factors constant.

The new growth theories have stressed the importance of several factors apart from R&D that are likely to affect production growth such as human capital. For example including a skill variable such as the ratio of scientists and engineers to total employment may be an important factor. However, the use of these variables are limited by data availability.

As I mentioned before, my interpretation of this functional form differs in the way that I try to measure the role of innovation or more broadly the "intellectual property" in value creation. Productivity may not be an accurate term because my interpretation is not only to measure the amount of output per a given value of inputs, but the value added that results from using intangible capital in the production process. I actually consider the innovation variable as a separate factor of production that measures the amount of value created apart from physical inputs used. In other words I attempt to quantify the value of the soft side of the products that is added to its physical value.

In my model I link this study with that of the market value one, by using the innovation index in the Cobb-Douglas production function. Since the innovation index is a weighted average of R&D, patent and trademark intensities it may provide a better approximation for the innovative capital of the firms. To the best of my knowledge such an index has not been used in a production function context. The model is outlined in table 3.11:

Table 3.11: **Measuring the effect of welfare increasing factors on value added**

Dependent Variable	Independent Variables
LOG of Value added (or sales)	LOG Assets LOG Labor Time (years) Innovation index (intellectual factors)

Data

The data for the above variables were obtained from the Istanbul Industry Association where data on labor and capital of 500 selected companies is published each year. Capital will be taken as the net physical assets[28] and labor as the average number of employees for each calendar year. The sample includes the same companies from the market value regressions but it is further reduced because not all of the companies appear in the ISO index and missing values resulting from negative value added. The number of observations for this part of the study contains 576 observations.

Furthermore, output is generally measured by sales or value added. The correct econometric formulation for the dependent variable is to use either sales minus the materials and services purchased from others or to use value added which is found by summing the wages distributed, the rents and interest and the net profit plus any taxes incurred. The use of these variables are limited by data availability. The gross value added measure is only calculated by Istanbul Sanayi Odası in Turkey. In this study, both formulations for the dependent variable are used to see if any differences exist. In

[28] Total assets net of depreciation.

the literature both kinds of measures are used making it very difficult to compare the studies including this one.

3.2.2 Empirical Results and Discussion

To investigate whether value creation as measured by value added (or sales) is also influenced by knowledge capital, labor and capital data was collected.. The model was outlined in table 3.11.

Apart from labor and capital (assets) a third term λt (time) measures the disembodied technical change or the change in production occurring naturally as time passes. First the traditional production function is estimated to see the situation more clearly before any innovation measures are included. This formulation uses sales as the dependent variable to measure output. LOGLABR is the natural logarithm of the average number of employees and LNNASSET measures net physical assets in natural logarithms. "Year" is the time trend variable which takes a value of 1 for 1995, 2 for 1996 and so on. This time trend supposedly represents the cumulative increase in knowledge (disembodied) over time[29].

The first model uses sales as the dependent variable but since materials and services purchased form other companies has not been deducted, the results are not as reliable as the value added regression that is discussed next.

[29] This interpretation of the time trend variable as a measure of disembodied technical change may be criticised, but it is commonly used in econometric studies (see Terleckyj 1974).

This model is included here to see the results as it has been sometimes used in the literature. As seen below in table 3.12, the regression based on the Cobb-Douglas production function is significant with an adjusted R-square of 0.93.

Table 3.12 : **The Production function with Log of Sales as the dependent Variable**

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.963[a]	.927	.926	.4395	.927	2320.087	3	549	.000

a. Predictors: (Constant), YEARS, LOGLABR, LNNASSET

b. Dependent Variable: LOGSALES

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1.492	.278		5.369	.000	.946	2.038
	LNNASSET	.841	.027	.843	30.677	.000	.788	.895
	LOGLABR	.166	.031	.099	5.278	.000	.104	.227
	YEARS	.063	.016	.089	3.829	.000	.031	.095

a. Dependent Variable: LOGSALES

All the independent variables are highly significant below 1% and the model explains the variation in production levels of the firms successfully. The standard errors of the coefficients are very low and their t-statistics are above 3 indicating the estimate is reliable. Based on the coefficients it can be seen that net physical assets account for 84 % of the output whereas the share of labor is around 17%. In other words, a 10% increase in physical assets will increase production by 8.5% whereas a 10% increase in labor will increase production by 1.7%. Disembodied technical change (years) accounts for 6% of the variation and we can assume constant returns to scale based on the coefficients. In general, the literature suggests that R&D investment increases the demand for capital but decreases demand for labor. The original form of the Cobb-Douglas function can be written as follows. Taking the antilogarithm of the constant term:

$$Q\ (\text{sales}) = 4.442 \cdot C^{.84}\ L^{.17} \cdot e^{.063\,t}$$

Where C is physical capital and L is labor as before.

Measuring the effect of innovation on production as measured by sales

The second step consists of estimating the role of intellectual property in this production function. As mentioned before various procedures has been used in the literature, but almost all of them include a third variable in this equation besides labor and capital, which is R&D capital. R&D capital is calculated based on the perpetual inventory method first proposed by Griliches. Directly including the flow variable R&D expenditure is also possible with a small change in the interpretation of the coefficient. However, there is little “innovation” in the literature about the inclusion of this third variable, most studies revolving around the same methods and variables. Although most studies find a significant positive effect of R&D related variables the calculation of the figure is based on arbitrary depreciation rates. The exact depreciation rate is very hard to estimate and may only be approximated.

The model that will be used here differs from the previous literature in that instead of using a single R&D based figure, a composite measure calculated in the first part of the study is added to the production function. This innovation index consists of R&D, patent and trademark intensities combined into a single figure based on the regression weights. The natural logarithm of this index is taken as a proxy for the innovative efforts of the firms which is theoretically hypothesised to affect value creation. Thus, this index can be considered to be a better proxy than R&D alone, and to the best of my knowledge this is the first time it is used in a production function.

Moreover, I interpret the innovation index variable as a separate factor of production that produces the intangible value added to the products. In this interpretation, the third term measures value creation rather than productivity.

The results of the regression is shown below in table 3.13. All the variables are the standard ones used in the previous model, except the innovation index which is taken as the natural logarithm of the weighted averages of R&D, patent and trademark intensities.

Table 3.13: **Production function including the innovation index**

(Dependent Variable is Log of Sales)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.964[a]	.929	.928	.4344	.929	1784.305	4	548	.000

a. Predictors: (Constant), INNOVIND, YEARS, LOGLABR, LNNASSET

b. Dependent Variable: LOGSALES

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	1.356	.277		4.894	.000	.812	1.901		
	LNNASSET	.847	.027	.849	31.191	.000	.794	.900	.176	5.69
	LOGLABR	.181	.031	.109	5.795	.000	.120	.243	.370	2.70
	YEARS	.062	.016	.088	3.810	.000	.030	.094	.245	4.08
	INNOVIND	.028	.007	.044	3.723	.000	.013	.042	.916	1.09

a. Dependent Variable: LOGSALES

The estimated function is the following:

$$Q\ (\text{sales}) = 3.881\ .\ C^{.84}\ L^{.18}.\ K^{.028}.\ e^{.062\ t}$$

As in the standard version of the model, the model is good at explaining the relationship between output and the factors of production, with net physical assets and labor highly significant as before. The disembodied technical change as measured by the year variable accounts for 6 % of the variation in sales as before. The constructed innovation index is also significant with a t value of 3.72. Its coefficient of .028

suggests that a 10% increase in the index value (which can be achieved by a 10% increase in either patents, R&D or trademarks, will increase sales by around 0.3 %.

This estimated elasticity of the role of intangible capital in the production function, which is around 2.8 %, is at the lower end of the estimates reported in the literature, which range from 1 to 30%. One reason might be that for the firms in the sample, the role of intellectual capital has a marginal role in value creation. But it must be noted that this study is not directly comparable to previous literature because of both conceptual and data differences. However, there is a significant clue that intellectual property plays a role in increasing the value of sales or output.

The Production function with Value Added as the dependent variable

The previous formulation used sales as the dependent variable. A better alternative is to use value added which is obtained from Istanbul Sanayi Odası. Firms with negative value added in any year are excluded from the analysis.

The estimated production function with gross value added instead of sales is presented below. The R-square of the model is .79, indicating good fit.

Table 3.14: **The production function with Value Added as the dependent Variable**

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.895[a]	.800	.799	.7016	.800	764.82	3	572	.000

a. Predictors: (Constant), YEARS, LOGLABR, LNNASSET

b. Dependent Variable: LNVALUE

Table 3.14 (continued)

Coefficients [a]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.	95% Confidence Interval for B Lower Bound	Upper Bound
1	(Constant)	1.606	.437		3.672	.000	.747	2.464
	LNNASSET	.743	.042	.762	17.514	.000	.660	.826
	LOGLABR	.221	.048	.135	4.571	.000	.126	.316
	YEARS	.053	.025	.078	2.101	.036	.003	.103

a. Dependent Variable: LNVALUE

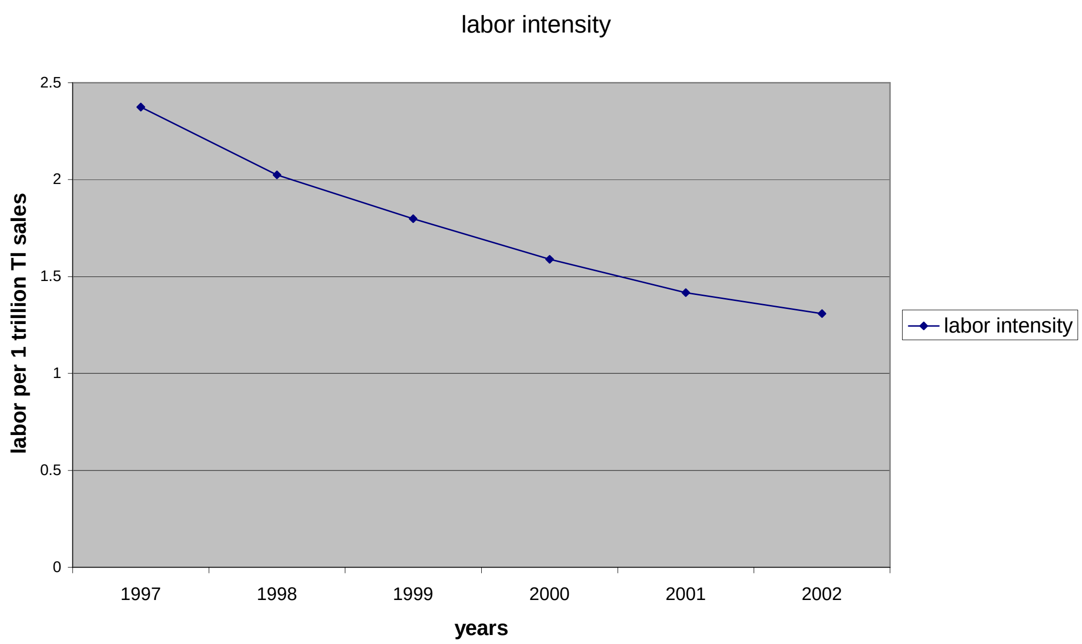
Based on the results, the function estimated is the following:

$$Q\ (\text{value added}) = 4.982.\ C^{.74}\ L^{.22}.\ e^{.053\,t}$$

The elasticities of labor and capital are around 22% and 74% respectively which indicates a little increase in the share of labor compared to the previous model. The relatively low share of labor may be a characteristic of the specific sample used which matches those traded on the stock exchange with the biggest 500 firms study released by Istanbul Sanayi Odası. The number of companies used in this sample is 75. The original sample is reduced because of missing data or negative value added.

The relatively low share of labor may be attributed to the relatively low labor intensity of the firms in the sample relative to the 500 firm sample. The labor intensity per 1 trillion TL sales in this sample is around 2.3 compared to the whole sample where it is around 3.5. Furthermore it is declining in the recent years indicating that the role of labor for these companies is either decreasing or they are downsizing which will result in a reduced share of labor.

Figure 3.6 : labor intensity per 1 trillion TL of sales



As expected the time trend or disembodied technical change is again around 5 % as it was in the previous model. All the other variables do not change much indicating that the shares of labor and capital are relatively stable around these values for this sample.

Does innovation has any effect on Value added?

Estimating the same function with the innovation index is presented below. As discussed before, this index consists of R&D, patent and trademark intensities combined into a single figure based on the regression weights. The natural logarithm of this index is taken as a proxy for the innovative efforts of the firms. This index can be considered to be a better proxy than R&D or R&D capital alone. Moreover, I interpret the innovation index variable as a separate factor of production that produces the intangible value added to the products. In this interpretation, the third term measures value creation rather than productivity. The estimated production function can be seen below in table 3.15:

Table 3.15: **Production function and the innovation index (Value Added)**

(Log of Value Added is the dependent Variable)

Model Summary [b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.896[a]	.802	.801	.6997	.802	577.580	4	570	.000

a. Predictors: (Constant), INNOVIND, YEARS, LOGLABR, LNNASSET

b. Dependent Variable: LNVALUE

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	1.488	.439		3.389	.001	.626	2.351		
	LNNASSET	.747	.042	.766	17.630	.000	.663	.830	.184	5.43
	LOGLABR	.238	.049	.146	4.861	.000	.142	.334	.387	2.59
	YEARS	.054	.025	.078	2.116	.035	.004	.103	.254	3.94
	INNOVIND	.026	.012	.043	2.221	.027	.003	.049	.914	1.09

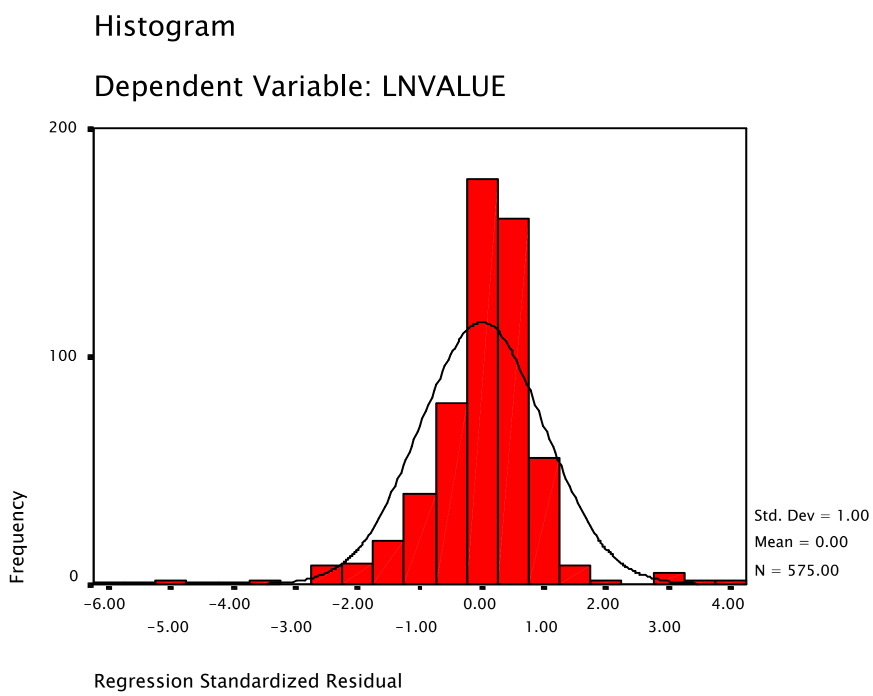
a. Dependent Variable: LNVALUE

The model parameters and elasticities do not change much except a small increase in R-square and both the time trend variable and the innovation variable have significant coefficients.

$$Q\ (\text{value added}) = 4.428 \, . \, C^{.75}\ L^{.24} . \ K^{.026} . \ e^{.054\, t}$$

In the previous model with sales as the dependent variable, innovation has a role in explaining the increase in sales even after controlling for labor and capital. This same result is also observed in this model with value added as the dependent variable, with labor and

Figure 3. 7: Plot of Residuals for the value added regression with the innovation index



capital having elasticities of .24 and .75 respectively. Since the innovation index measures the effect of residual growth after controlling for the effect of the time trend, its contribution to value added is around 2.6% as before. The composite innovation measure is significant at 2.7% whereas the time trend is significant at 3.5% level.

One interesting finding is that the time trend seems to contribute more to increases in value added than intangible capital[30]. The relatively stable coefficients between the different models suggest that intellectual property contributes to value added by half of the contribution of the time trend or disembodied technical change. Comparing this to the other studies in the literature it indicates that this value is relatively low. However, since the studies in the literature are so diverse and differ so much in their specification and variables used, a direct comparison is not possible. It is clear however that as found in the literature, research does have an effect on value added (or productivity as used in the literature). Our interest in this case was to measure its elasticity and value creating potential.

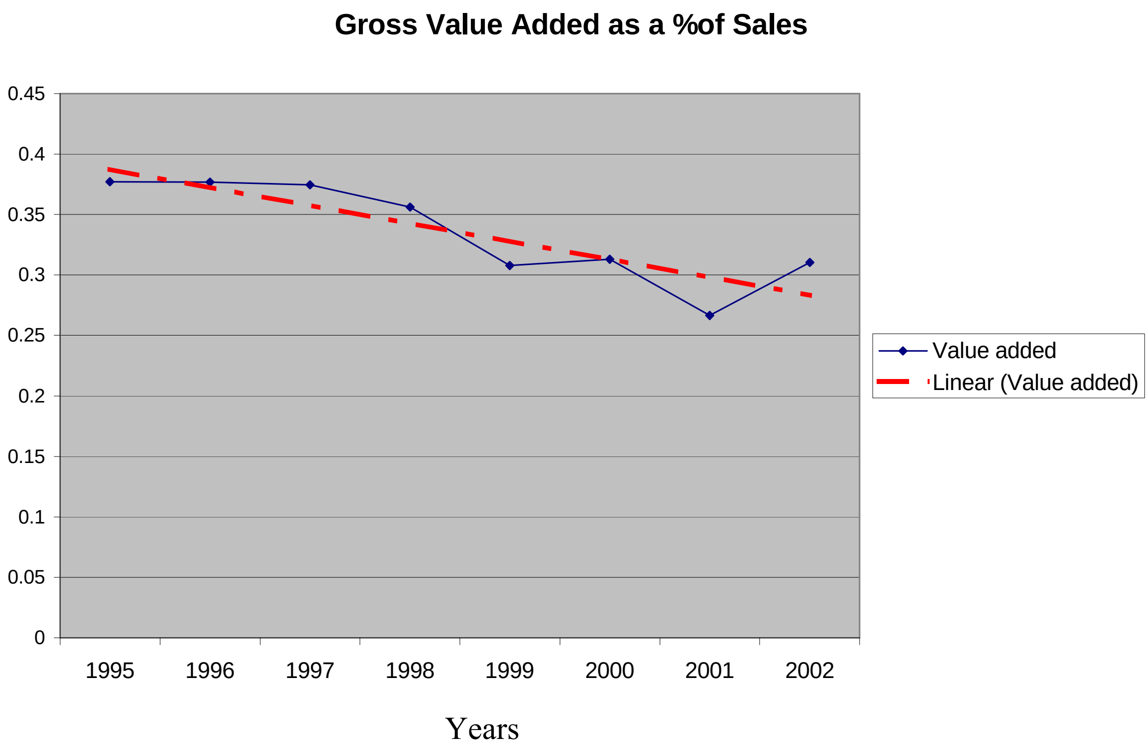
There may be several explanations for the relatively lower value of research elasticity in the above models. One is the importance given to research in those countries where the studies are carried out, mainly US and Japan. In those countries it is not uncommon to observe companies contributing more than 10% of sales to R&D whereas, here the mean is hardly 0.3% for the whole sample. More importance must be given to research in Turkey, in order to increase national wealth and welfare.

One other important finding is the declining share of gross value added in sales. According to ISO, the relative percentage of value added in sales was around 28% in 1992 whereas it fell to almost 19.5% in 2001. It started to increase after 2002, but this is not captured in this study since the period covered is 1995-2002. By looking at the following graph it is possible to see from the fitted trend line that the percentage of value added in sales is constantly decreasing since 1995 except 2002.

[30] Intellectual property, research capital and intangible capital are used interchangeably and they are measured by the innovation index. My interpretation of these concepts focuses on their value adding potential rather than their exact definition. OECD collectively calls them intellectual assets.

This decrease in value added relative to sales may explain the relatively lower elasticities for research. This can be interpreted as the decline in the value creating power of the firms. After taking into account the effects of labor and capital there is little increase in value added that can be explained by a time trend or disembodied technical change although it is still promising to observe that investing in research does actually increase value added to some extent.

Figure 3.8: Gross Value added as a percentage of Net Sales with fitted trend line



3.2.3 Summary

The regression results are summarized below in table 3.16:

These results indicate that intellectual property efforts of the companies significantly affect their value added with an elasticity of 2.6% and a confidence level of 97%. They are also parallel to the results (2.8%) obtained from the model with sales as the dependent variable which increases the confidence level. However, it must be noted that the value added of the companies as a percentage of sales for this sample is actually declining since 1995. Although there is some significant positive effect in sales and value added attributable to time and innovation, this effect is quite lower than expected.

Table 3.16: Production function regression summary with Value Added as the dependent variable:

	R1	R2
Explanatory Variable		
LogAssets	**0.74**	**0.74**
	(17.51)	(17.63)
LOGLabor	**0.23**	**0.24**
	(4.57)	(4.86)
Time	**0.05**	**0.05**
	(2.10)	(2.11)
Innovation Index		**0.026**
		(2.22)
Adjusted R-square	0.79	0.8
Observations	576	576

Notes: The numbers in bold are regression coefficients. t-statistics are in parentheses. All the labor and asset variables are highly significant at 1% level and the Innovation index and time are significant at the 3% level.

It can be argued that Turkish companies are not doing their best to exploit the recent economic and political environment which favors those that invest in value creating activities such as R&D, branding and identity. The most worrying fact is that the value added created by the first 500 companies as percentage of net sales has been declining until 2002. A modest increase is observed after 2002 but it is not in the period analyzed by this study.

Future work can be done to address the recent trend of the value added created by the companies after 2002. Despite all these, Turkey has a great potential for creating value in the global markets. Investing in education and technology are vital for producing products with great value and identity. These must be the priorities for Turkey if it wants to increase its welfare in the 21st century.

4. A Complementary Questionnaire and Logistic Regression

In addition to the empirical analysis a questionnaire was prepared whose purpose is to complement the empirical findings by obtaining expert opinions on key issues. The empirical results alone may not be very meaningful if they are not backed up with an additional insight into the opinions of managers and executives.

4.1 Questionnaire Results

This part of the study consisted of personal interviews and a standard questionnaire. The questionnaire was administered to managers and executives who were responsible for their company's future strategy or were knowledgeable about the innovation process. The sample may not be representative but this is not a problem since the aim is to obtain expert opinion. Therefore the results may not be generalizable to the whole population, but the results may still provide valuable insight about the best practices and most common issues regarding innovation.

20 executives were contacted, which were not necessarily chosen from the companies in the sample, although some companies were also included in the empirical part of the analysis. Some managers refused to participate in the study and some of them did not reply at all.. Some executives refused to fill a questionnaire but accepted only a brief interview. The managers that participated were promised that their names or companies would be kept confidential so the results and insights are only provided anonymously. In this section results from the 8 questionnaires will be discussed, which are both the most insightful and also provide a good representation of the major sectors involved.

These include textiles, food, chemicals and cosmetics, white goods, automotive, electronics and engineering**.** All of the companies contacted indicated that they had an R&D department but there is no way to know that all answers are correct. 75% of the companies specified that they invested between 1-10% of net sales to employee training and R&D.

A copy of the questionnaire can be found in appendix 6. The questionnaire was inspired by a study conducted by the Economist Intelligence Unit (2004) but it was complemented and revised to suit the requirements of the study. The findings of the questionnaire are also presented in a compact form backed up by interpretations and comments of the respondents (see appendix 5).

Almost 75% of the respondents indicated that the most important factor to their company's current strategy was to improve customer relationships. Constructing a favourable brand image and new product development were the next important strategies. 25 % of the respondents said that cost cutting and improving risk management were one of the three most important priorities for their company.

These results are quite parallel to the ones obtained by the world-wide survey that *The Economist* conducted. In that survey, cost cutting, improving customer relationships and R&D/product development were the first three most important strategies cited by the respondents. Interestingly, cost cutting was the most primary strategy for the world-wide sample whereas in our sample it is ranked fourth. This may be because the questionnaire sample used in this section was not random but rather a judgement sample. This may explain the importance these companies attach to brands and R&D.

Similarly 50% of the respondents indicated that over 20% of their current sales was represented by products less than 3 years old.

Comparing the results for the roadblocks to successful R&D, 75% of the respondents marked economic factors as the most important obstacle for successful innovation. Insufficient knowledge about the expectations of end users/customers ranks second indicating that market research is of crucial value in developing new products. Companies that lack a research function may have difficulty in developing new products. Also some respondents mentioned insufficient regulatory protection for intellectual property but as expected these companies were in the chemicals and cosmetics sector which had foreign connections.

One executive in the automotive industry also mentioned the lack of qualified personnel hindering the research efforts. In his opinion, research and development had to be performed by devoted and aspiring engineers. Also supplying them with a favourable and motivating environment was crucial for the success and continuity of such projects.

Economic factors were also the major obstacle in front of R&D efforts in The Economist survey, but in my opinion, innovation must be regarded as an important tool in both bad and good times because those companies that are able to differentiate their products will be able to stand out in the crowd and thus be able to charge higher prices than their competitors even during crises. In a study that we conducted two years ago for studying the effects of the 2000 crisis on the companies, it was seen that, most of the companies had increased their operating profit margins in response by charging higher unit prices. This was a response to cover the increasing costs of financial expenses. However, a company that runs an R&D department and has made it a part of its culture to improve continuously, will be justified in charging higher prices for its differentiated and high quality products. These ideas are best summarised by the quotes of Dr Frank Niedarlaender, Director of R&D strategy for BMW in Germany: “Innovation is a continuous process that you can’t stop and restart easily. We don’t cut back on R&D even in difficult economic times because innovative features and design are the main reasons why people buy premium cars.” (The Economist Intelligence Unit , 2004).

When asked to rate the factors forcing companies to innovate in Turkey, almost all the executives ranked more demanding customers in the first place. Customer demands, and market pressures from the competitors were the most important factors driving the need to innovate. These results are exactly the same for the global sample. These results confirm that innovation is one of the most important factors affecting firm performance in an age of rapid technological change and demanding customers.

87 % of the respondents would prefer to develop new products by their own efforts. Working with partners comes second but it is evident that managers fear that imitation by competitors is a major concern for their intellectual property. Only one of the respondents said he would work with universities or other institutions for undertaking research. This should be promoted however, because joint projects connecting companies and universities may enhance the value of innovation for the society rather than confining it to one company.

A chemical company manager indicated in the interview that precise measurement tools and small scale machines used in the production process necessary for their business were very expensive and had to be imported. This indicates the importance of local technology development. If the technology used in those measurement tools had been available in Turkey, this executive would be able to obtain them more easily. This is a very good example for the importance of inter-industry spillovers. Other companies may benefit the knowledge base created by joint research efforts of universities and industries. If this knowledge base is made available, then they may develop new uses based on it without infringing patent or intellectual property rights. In fact this is one of the reasons why patents are granted but unfortunately most of the time it does not work as expected, especially in the pharmaceuticals where the poor may be deprived of new treatments because of patent rights. These policy issues are not fully resolved yet, extending beyond the scope of this study.

The last close ended question was the performance criteria the managers would expect to improve most as a result of R&D investments. Industrial organization theory suggests that, companies that invest in R&D may increase the quality and differentiation of their products and hence charge higher prices resulting in an increase in operating profitability. The "software" side of the products, including brands, design, quality, image and technology are becoming more and more important in today's trade environment. As this thesis has argued, companies investing in R&D may be better positioned as they will be able to charge higher prices both in the domestic markets and for their exports.

Especially, R&D may help companies increase their exports. In fact this is also expressed by a manager in the white goods sector. He indicated that, the European Union imposed sanctions on imports by bringing rules about low energy consumption and banning the use of certain materials in production to limit low priced imports from

China and the Far East region. This clearly indicates that this firm will increase its chances to export to Europe by improving its production and quality. Low energy consumption is a major factor behind the recognition of this company's products in foreign markets.

Responding to their expectations about the most benefit they would get as a result of R&D investments, almost all of the respondents unanimously expected the quality of their goods and services to improve followed by profitability and productivity respectively. Next came market value of the company, but interestingly only two of the respondents aimed an increase in exports.

This shows that improved quality is the first priority for companies investing in research followed by profitability and productivity. Exports seem to be affected by other factors as well including the real exchange rate and foreign connections.

Most executives indicated they did not make detailed performance analyses for new products. One executive of a chemical products company said they were continually monitoring the profitability obtained from new products but they were having difficulty in obtaining detailed statistics about the actual satisfaction level of their new products among customers. Only two executives out of 8 admitted that they were conducting regular surveys to find out the success rate of newly developed products. This once again stresses the importance of research functions within firms both in the development and after sale stages.

Summarising some general results obtained from the open ended questions, it is possible to say that economic factors and lack of qualified personnel are the most important factors hampering more productive innovative efforts. One textile executive indicated that they expected to gain competitive advantages as a result of R&D but lack of qualified personnel and limited feedback from customers made things difficult. This once again stresses the importance of co-ordinated innovation efforts especially with customers.

4.2 Differences among Firms based on innovative activity

This part of the study aims to materialise some of the hypotheses expressed in the last section. Especially, we want to test the factors that differentiate between R&D doing firms from other firms that report zero R&D. For this purpose the innovation index is recoded into a categorical variable by assigning 1 to firms who have positive values and zero to those firms that have a value of zero for this index indicating that they have no innovative activity at all.

Logistic Regression is ideally suited for this study. It is quite robust to assumption violations and may provide additional insights. Basically two categories of firms, those undertaking some kind of innovative effort and those that do not invest in innovation are expected to differ based on performance criteria like Return on Equity and Return on Assets. Moreover, the operating profit ratios of those firms that undertake research is expected to be higher since they will be able to not only differentiate their products but also charge higher prices based on quality and image etc.

Based on the innovation index it was determined that 59% of the firms in the panel sample undertake some kind of innovative activity. This categorical variable is the dependent variable. The independent variable include major performance ratios like

ROE and ROA. Additionally, Exports to net sales and operating profit to net sales ratio was included to test the hypotheses just discussed in the previous section.

The model can be expressed as follows:

Dependent variable = Exports to net sales, operating profit margin, two
(Innovation index (0, 1)) performance ratios (ROE and ROA)

The following output shows the results of the logistic regression. The stepwise approach was used to let the model select the significant variables.

Table 4.17: Logistic Regression Model Summary

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	1604.102	.094	.127
2	1503.263	.163	.220

The model's success is measured by the log likelihood figure for which lower values are better. At step 2, this value improves indicating that the inclusion of independent variables is justified. Nagelkerke R-square is .22 which is interpreted the same way as regression R-square. This is quite low indicating that the model's classification success is not very good. However, the percentage of correctly classified cases is close to 70% at step 2 which indicates that the independent variables provide some explanation for the differences among the two groups since we would expect 59% correct classification by chance.

Table 4.18: Logistic Regression Classification Results

Classification Table [a]

	Observed		Predicted INDEXDUM .00	Predicted INDEXDUM 1.00	Percentage Correct
Step 1	INDEXDUM	.00	647	124	83.9
		1.00	336	179	34.8
	Overall Percentage				64.2
Step 2	INDEXDUM	.00	604	167	78.3
		1.00	246	269	52.2
	Overall Percentage				67.9

a. The cut value is .500

The independent variables found to differentiate between the groups are only two, exports to net sales (EXNS) and the operating profit ratio (OPNS). These results provide data based support for the hypotheses that firms involved in some kind of innovative activity are able to maintain higher profit margins and their export ratios are higher.

Table 4.19: Logistic Regression Results: Differentiating Variables

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95.0% C.I.for EXP(B) Lower	95.0% C.I.for EXP(B) Upper
Step 1[a]	EXNS	2.855	.271	111.212	1	.000	17.378	10.222	29.543
	Constant	-.928	.077	144.942	1	.000	.395		
Step 2[b]	EXNS	2.271	.279	66.153	1	.000	9.693	5.607	16.756
	OPNS	5.655	.605	87.325	1	.000	285.779	87.278	935.742
	Constant	-1.373	.096	202.584	1	.000	.253		

a. Variable(s) entered on step 1: EXNS.

b. Variable(s) entered on step 2: OPNS.

Both variables are significant with the operating profit margin differentiating most with a coefficient of 5.6. These results indicate that firms that undertake some kind of innovative activity are on average expected to have higher export levels and operating margins. This is the expected result discussed in the previous section. Intellectual property investments help companies improve the quality and differentiation of their products enabling them to charge higher prices and increase their exports.

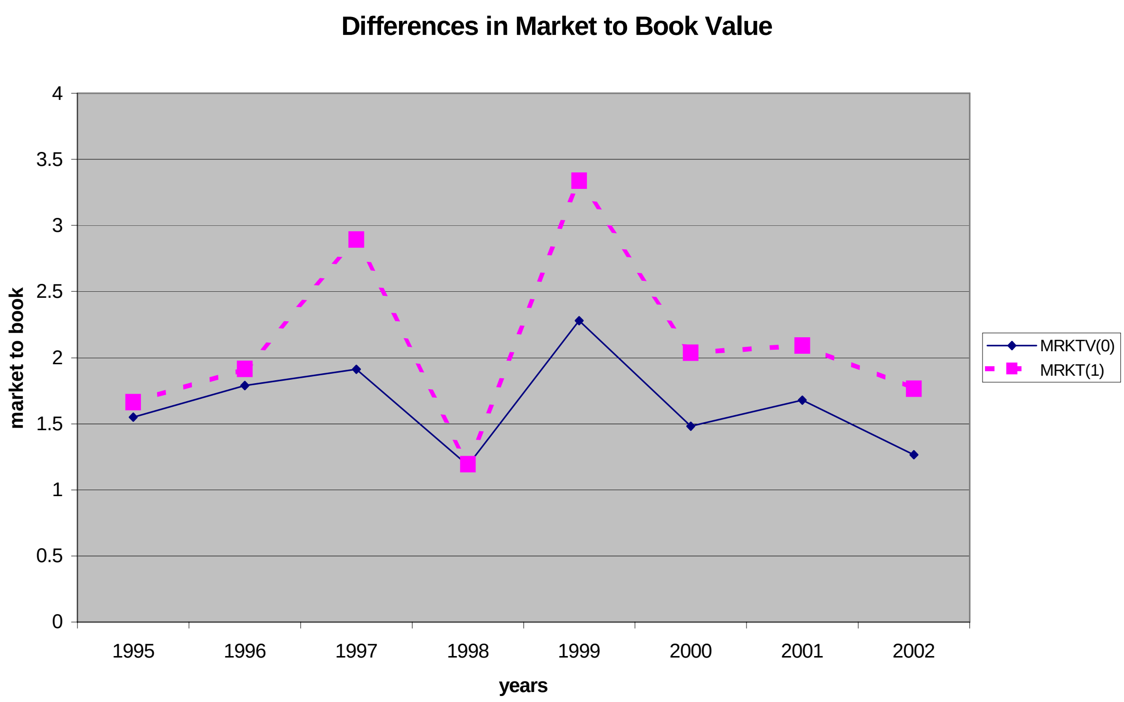
However, it must be noted that the explanatory power of the model is not very good and the classification results are not very accurate. Other performance variables are also not entered into the model by the stepwise procedure indicating that there is not a very clear cut difference among the groups and other unknown factors may be at play. But we can still take some meaning out of this regression which tells us that exports and operating margins are one of the important variables that are affected by the innovative activities of the firms.

4.3 Graphical Examination of firm differences based on their innovative activity

Most of the hypotheses that were mentioned in this thesis can also be analyzed graphically using the trends of the variables over time. The firms are split into two separate groups based on their innovative activity. Those firms that have at least one kind of innovative activity are put into one group and those firms that score zero on the innovation index are analyzed separately. The dotted lines in the graphs represent the firms that have at least one kind of innovative activity.

To examine the differences of the market values of the firms, one can analyse the market to book ratios of the firms based on their innovative activity. It can be seen from the graph that the market to book ratios of the innovative firms are consistently higher over the years than the ordinary firms supporting the regression results. It is evident that the market values investments in innovative activity. It is also evident from this graph the fluctuations in market value caused by the crises of 1998 and 2000. (figure 4.9)

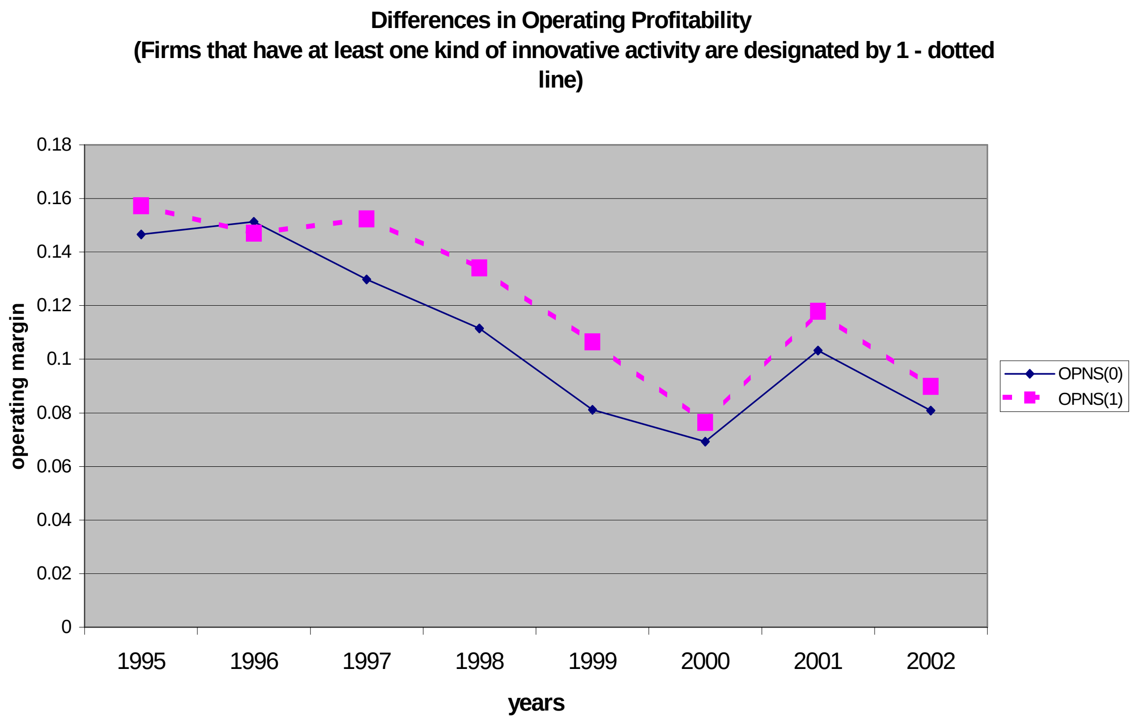
Figure 4.9: Market –Book Value Differences for Innovating and Non-Innovating Firms



One other important factor mentioned previously were the differences in operating profitability of the firms. It was hypothesized that those firms that invest in research will be able to increase their operating margins by charging premium prices based on product quality and features. This hypothesis which is also supported by the logistic regression results, seems to be one of the most important factors differentiating the firms.

It can be seen from this graph (figure 4.10) that the operating profitability of the firms increased substantially in 2001 when the economy was in a deep crisis. This response is also well observed in previous studies which is a response to the increase in financial expenses. It can be seen that innovative firms were able to raise their operating profitability higher on average.

Figure 4.10: Operating Profitability Differences for Innovating and Non-Innovating Firms

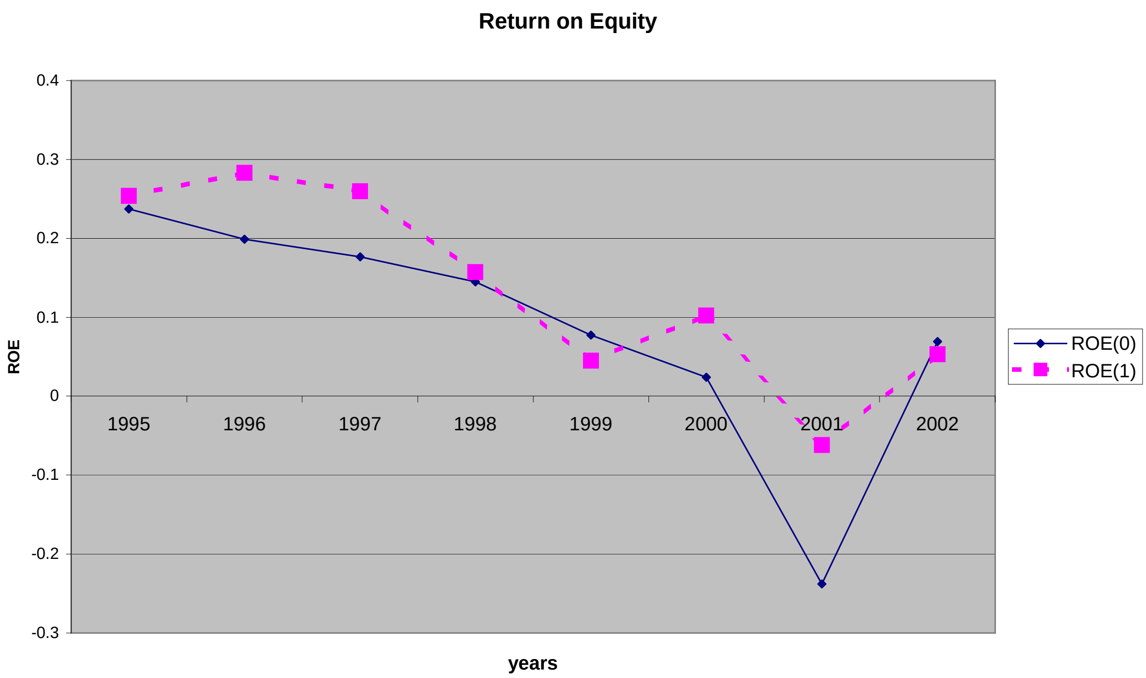


The companion to the above graph is the return on equity ratio which measures the return to the shareholders after taking into account financial expenses and taxes. The damage of the crisis to the firms is evident from this graph. There seems to be not a significant difference among firms during normal business cycles. What is interesting is that, the firms investing in intellectual property seem to be less affected by the crisis because they were able to increase their operating margins higher than the other firms.

It is also informing to note that the second graph is almost a mirror image of the first showing the devastating effect of financial expenses (figure 4.11)

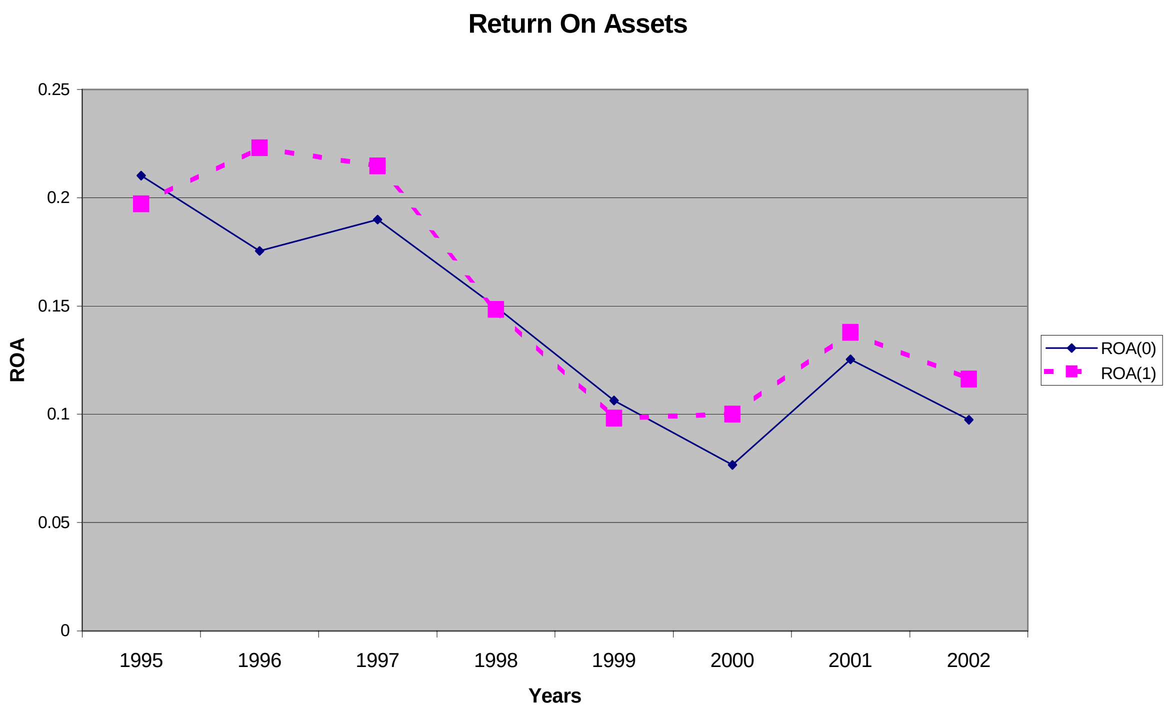
This fact is also evident from the Return on Assets (earning before interest to total assets), where the ratio is higher in 2001 because of the increases in operating margins. The increasingly unbearable cost of the financial expenses however, wiped out this small increase in operating profit. (see figure 4.11 and figure 4.12)

Figure 4.11: **Return on Equity Differences for Innovating and Non-Innovating Firms**



The debt structure of the innovative firms seem to differ from the non-innovative firms, indicating that the most innovative firms investing in research finance their funds by equity rather than debt. This may be related to their higher market values which may make it easier to raise funds in the market. Also the debt burden of highly innovative companies is a little lower than the others which may be explained by better credit ratings. This may be another benefit of investing in research which increases growth prospects (figures 4.13 and 4.14)

Figure 4.12: Retun on Assets Differences for Innovating and Non-Innovating Firms



Visual examination of the return on assets performance (figure 4.12) of the innovating and non-innovating firms does not seem to differ much. This indicates that the main differences are caused by financial burden and debt structure which are taken into account by the return on equity.

Figure 4.13: Financial Expense Differences for Innovating and Non-Innovating Firms

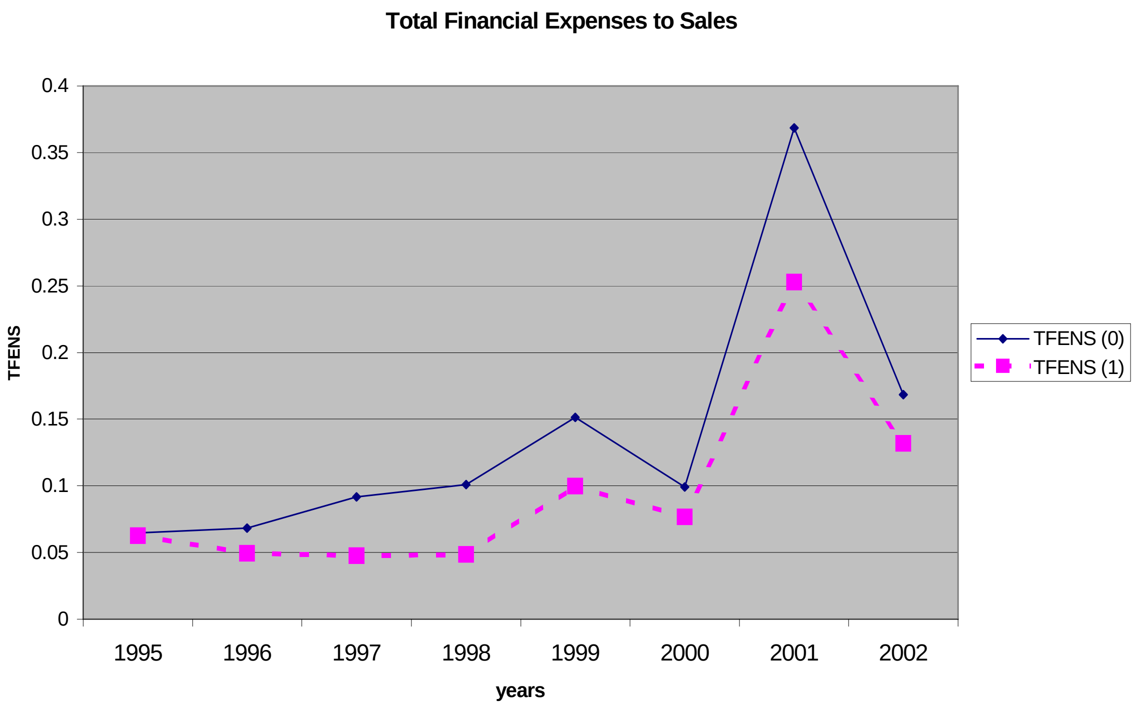
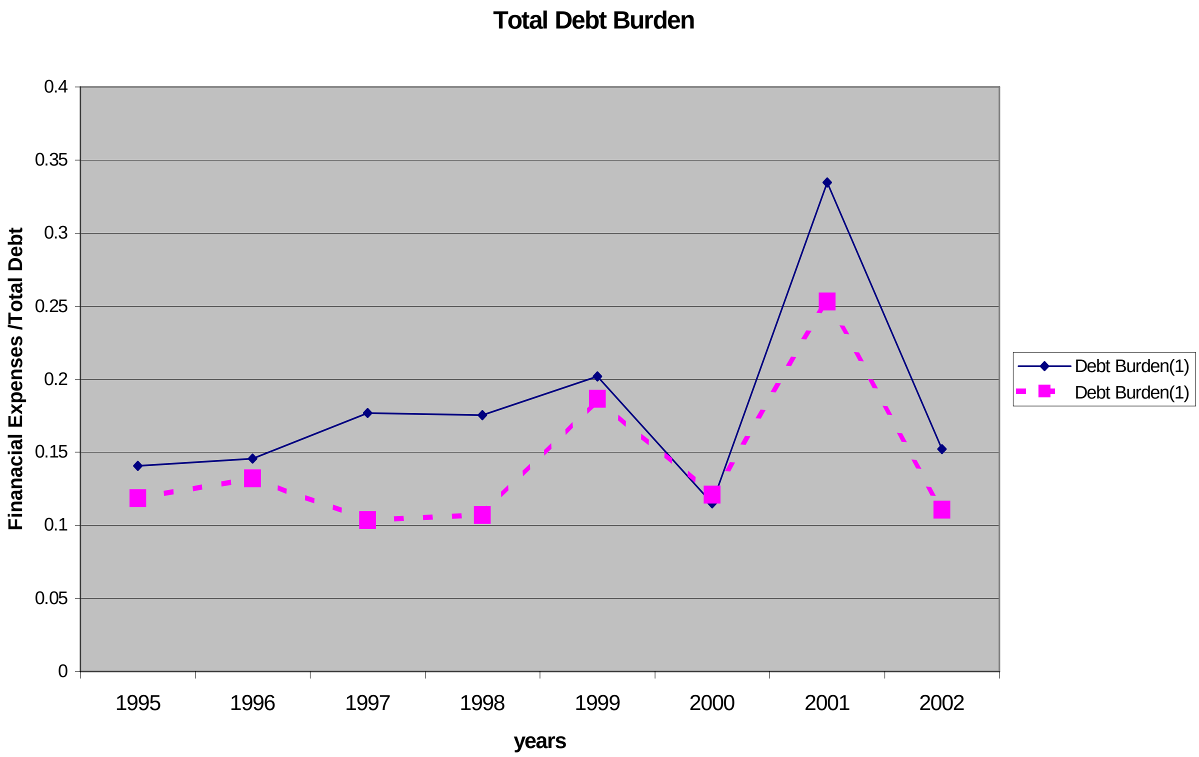


Figure 4.14: Total Debt Burden Differences for Innovating and Non-Innovating Firms



In regard to export performance, companies seem to increase exports when the domestic market contracts. Actually there are two peaks for exports, one in 1999 and the other in 2001. These years are characterized by crises and domestic demand contraction. On the contrary in 2000, domestic boom in demand reversed this trend. Export performance between those investing in research and those that do not does not seem to differ significantly except 2001 and 2002. But it can be seen that for the years when exports increase, this increase is much higher for firms that seriously invest in research. This may be explained by the insights obtained from the interviews where some managers indicated that the European Union was imposing some rules on imports like low power consumption and environmentally friendly materials. The increased level of exports may be explained by the better quality of products (figure 4.16).

Figure 4.15: Asset Turnover Differences for Innovating and Non-Innovating Firms

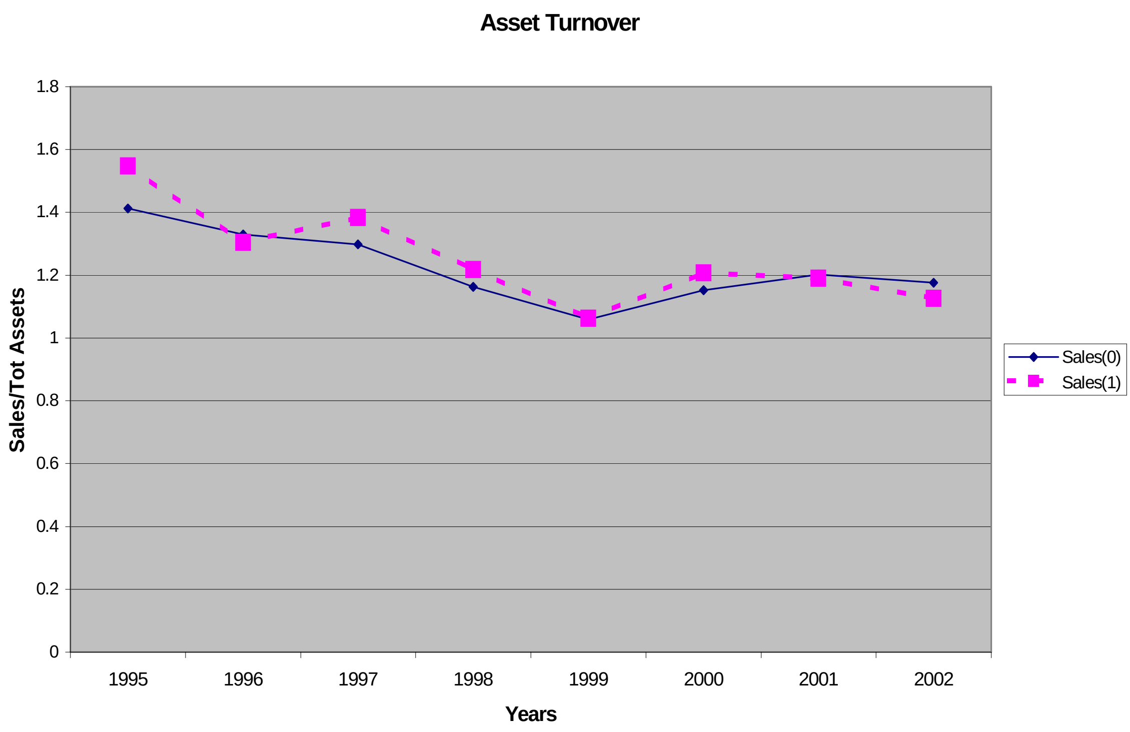
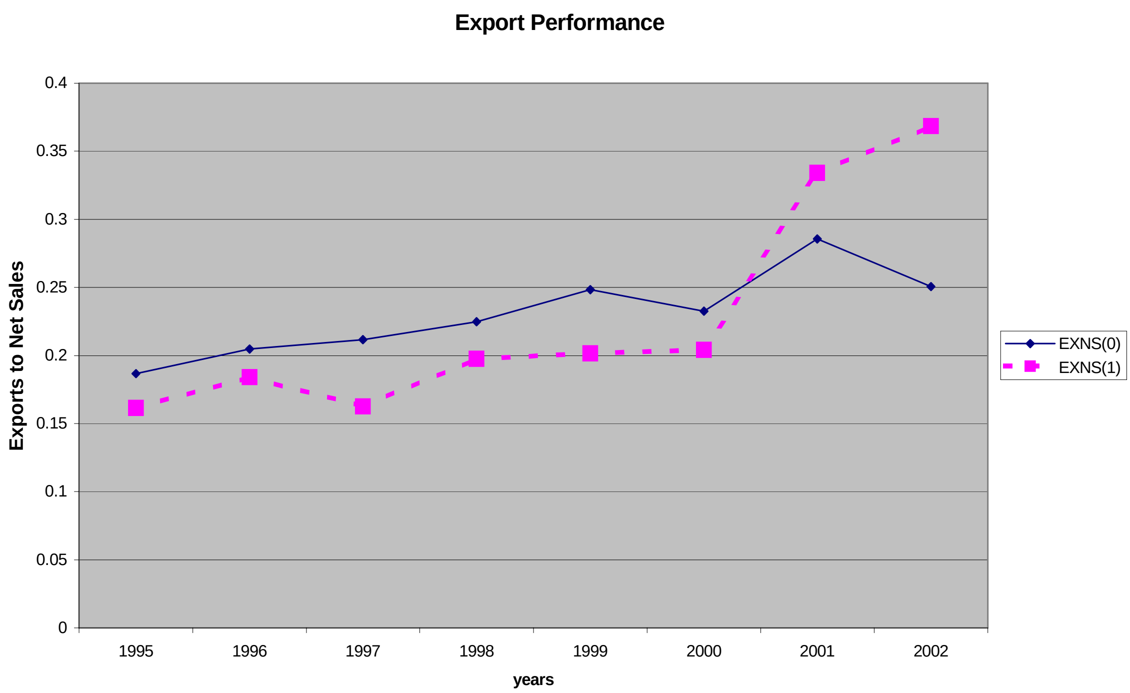


Figure 4.16: Export Performance Differences for Innovating and Non-Innovating Firms



5. CONCLUSION AND LIMITATIONS

This thesis tried to examine the importance of the welfare increasing factors in the Turkish manufacturing sector. Innovation was mainly defined as any activity that "adds value" and the main emphasis of the thesis was on value creation. Just as an Electronic Stability System[31] increases the value of an ordinary car, innovative activities and intellectual property increase the market values of the companies and their production as measured by value added. In other words we measured the impact of innovation or intellectual property upon economic performance, which is measured by the market valuation of the firms and their value added.

The results indicate that there is indeed a relationship between market value and innovation. Innovation or intellectual property as measured by R&D, patents and trademarks adds value beyond the physical assets alone, explaining the total market value. Increasing the R&D intensity by 1% will increase market value by around 4% to 6%. Thus, the marginal shadow value (the gross rate of return) of knowledge assets is 4 to 6 times higher than those of physical assets and this result is significant at 1%. Since R&D is not a widespread practice in Turkey, those that invest in research seem to be valued more than the others resulting in higher shadow values. This may reflect the economic goodwill of the firms that invest in technology to create their own brands and image. Similarly, the risk variables as measured by debt-equity ratio or financial expenses to net sales, has a negative effect on market value. Since the work of Griliches in 1981, most studies examined the US and UK markets but there are only a

[31] The European New Car Assessment Program strongly recommends that your next car is fitted with an ESP (Electronic Stability Program) system which drastically reduces the chances of losing the control of your car by adjusting the braking and power on the wheels. It is a security system that increases the safety of the cars. www.euroncap.com

handful of studies for Europe or Asia. For this reason this study was an important step towards examining the case for Turkey.

The construction of an innovation index which combines R&D, patent and trademark intensities of the firms into a single index enabled us to rank the companies in terms of their innovative capability and success. For example, companies like Arçelik and Vestel have recently embarked serious advertising campaigns to indicate that they are different and innovative. Their rank on this index seems to support their advertising claims which is especially true for Arçelik. However, the most innovative two companies are Netaş Telekom and Alcatel since the index takes the firm size into account. Arçelik ranks sixth and Vestel is 19th.

The estimation of the augmented Cobb-Douglas production function provided additional insights regarding the importance of intellectual factors in terms of their elasticity with respect to value added. The knowledge assets were represented by an innovation index based on R&D, patent and trademark intensities. The weights were based on their relative contribution to market value. The estimation of the production function shows that the time trend variable which measures disembodied technical change is around 5% and significant. The contribution of intellectual property to value added (or its elasticity with respect to value added) is 2.6 % and significant at the 3% level. These results are very similar for either value added or sales which makes us more confident. This indicates that investing in value creating activities contributes to value added, explaining the variation beyond labor and capital alone. However, this is in the lower range of estimated elasticities based on US and UK data which range between 1 and 30%, though an exact comparison cannot be made due to differences in model specification.

One other finding is the relatively low elasticity of labor which is around 25%. These results seem to be amplified in the present sample which is constructed by matching those companies traded in the stock market with the ISO 500 sample. The low elasticity of labor can also be observed in the declining labor intensity graph (figure 3.6) which may explain the low coefficient. This may be the result of downsizing.

Another important observation was that the value creating potential of the companies seems to have been declining since 1995 as a percentage of sales (see figure 3.8). Only a decent growth is observed in the latter years (after 2002) which are not enough to counteract the previous years' losses. This may explain the relatively lower elasticity for the innovation index variable in the model. The innovation factor is intended to explain the additional growth after accounting for the role of labor, capital and the time trend. Since there is no observable growth in value added relative to sales, the role of innovation seems minimal but it is still significant. It can be argued that Turkish companies are not doing their best to exploit the recent economic and political environment which favors those that invest in value creating activities such as R&D, branding and identity. Future work can be done to address the recent trend of the value added created by the companies after 2002.

Finally, a questionnaire was prepared to obtain expert opinion about R&D practices and difficulties encountered by managers. It was found that economic factors, lack of qualified personnel and insufficient market research were the most important obstacles for successful research. The role of R&D in overcoming export regulations was also stressed by most of the executives. Appendix 5 summarizes some of the findings. A simple logistic regression based on the innovation index values (0,1) indicated that operating profitability and exports to net sales seem to differentiate most between the firms though the results are not very reliable and the model may be improved in future studies.

Most studies in the literature employ very different methodologies and this makes comparisons among studies very hard. Better and more accurate data is needed to assess the real contribution of innovation. There are still serious drawbacks in trying to measure a valid and reliable numerical figure for the term “intangible assets” and it is approximated by R&D, patents, trademarks or intellectual property.

It should be mentioned as a last note however, that the sample used to test the above relationships was limited due to data availability. R&D data in Turkey is only available for publicly traded companies and value added can only be obtained through Istanbul Sanayi Odası surveys. These restrictions make it very difficult to work with larger and more representative samples. Although the distribution of the sectors seems adequate, one must keep in mind that a wider and more representative sample may produce more assuring results, especially for the questionnaire. Future work can also be done to analyze the case for individual sectors such as pharmaceuticals and electronics. Similarly, there may be firms that intentionally do not disclose their intellectual property such as patents and trademarks. There may be also many other intervening variables like firm size affecting market values and value creation. All these limitations must be taken into consideration before interpreting the results and jumping to conclusions. Despite all these, and considering the difficulties associated with the Turkish stock market, i.e. low volume and depth, insufficient market efficiency, quality of data etc. the results are promising in that at least some significant tunes can be distinguished from the noise.

This study can at best be considered a first look at the crucial role of intangible assets in the development of an economy. Much research needs to be done in this area. There is a great need for more accurate and comprehensive data regarding intangible assets. Annual economy wide surveys conducted by associations like Istanbul Sanayi Odası should also collect statistics regarding innovation like the ratio of employees employed in R&D or the amount invested in employee training etc.

Returning to the main purpose of the thesis, Turkey needs to give more importance to increase its value adding potential for at least three reasons. The first one is the current global political and economic system which favours those that can create intellectual property. Only those that can innovate and create value will get the lion's share from the world trade. Second, the value created as a result of innovative activities is the essence of humanity which will ensure that the world will have a chance to be a better place in the future. For example, improving and developing new nature friendly energy sources will help reduce the environmental damage the global community has caused for so many decades. Third, adding value or innovating is one of the best ways for an individual to express himself. Self- expression or self –actualisation is one of the greatest needs of humanity.

Whatever the significance or the results of statistical analyses one thing is certain. The advancement of the humanity as a whole depends highly on the innovative efforts of the firms and governments all around the world, and this should also be the first priority for Turkey. In an ideal world, the improvements in knowledge and technology, will be created jointly by the whole society, and benefit the whole society in return, without the intellectual property rights that limit their possession.

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Appendix 1: Market Value-Innovation Studies in the Literature

Market Value - Innovation Studies with R&D and Patents

Study	Country (industry)	Years	Functional Form	Other Variables	R&D Coeff	R&D Stock Coeff	Patent or Innov Coeff	Comments
Griliches 1981	US	1968-74	Linear (Q)	Time & Firm dummies, [log Q(-1)]		1.0-2.0	.08 to .25 ?	units appear to be 100 pats
Ben-Zion 1984	US	1969-76	Linear (V)	Ind dummies, Investment, Earnings	3.4 (0.5)		.065 (.055)	No time dummies?
Jaffe 1986	US	1973, 79	Linear (Q)	Time & tech dummies, C4, mkt share, Tech pool, interactions		7.9 (3.3)		3SLS even higher
Hirschey, Weygandt	US	1977	Linear (Q)	Adv, C4, growth, risk	8.3 (1.4)			Compare durable/non-dur.
Connolly, Hirsch, Hirschey 1986	US	1977	Linear (EV/S)	Growth,risk,age,Mkt share,C4,Adv, Union share, Ind dummies	7.0 (0.8)		4.4 (0.6)	Unexpected patents
Cockburn, Griliches 1987	US		Linear (Q)	Industry appropriability (Yale survey)				
Griliches, Pakes, Hall 1987	US							
Connolly, Hirschey 1988	US	1977	Linear (EV/S)	Growth, risk, C4, Adv	5.6 (0.6)		5.7 (0.5)	Bayesian estimation
Connolly, Hirschey 1990	US	1977	Linear (MV/S)	Adv, MS, C4, risk, growth, inv	5.7 (0.7)		5.7 (0.5)	Patent surprise
Hall 1993a	US	1973-91	Linear (V)	Assets, Cash flow, Adv, Gr, time dummies	2.5-3.0 (.8)	0.48 (.02)		By year also
Hall 1993b	US	1972-90	Linear (Q)	time dummies	2.0-10.0	0.5-2.0		By year, LAD; absolute coeff
Johnson, Pazderka 1993	US							
Thompson 1993	US							
Megna, Klock 1993	semiconductors	1977-90	Linear (Q)	Rivals R&D and patents		0.82 (0.2)	0.38 (0.2)	Patent stock
Chauvin, Hirschey 1993	US	1988-90	Linear (V)	Cash Flow, growth, risk, adv, MS, ind dums	6.47 (.35)			Compares size, non-mfg/mfg
Blundell, Griffith, van Reenen 1995	UK	1972-82	Linear (V)	Time dummies,Assets,Mkt share			1.93 (.93)	Innovation counts
Stoneman, Toivanen 1997	UK	1989-95	Linear (V)	Assets,Debt,Growth,Mkt share,investment, Cashflow, time dummies, Mills ratio	2.5 (1.5)		insig.	Selection correction; by year
Chauvin , Hirschey 1997	US	1974-90	Linear (V)	Cash flow, beta, growth-Adv, growth-MS interaction, ind dummies				can't derive R&D coeff.
Hirschey, Richardson, Scholz 1998	US	1989-95	Linear (Q)	Earnings, R&D and patents	1.7 (0.5)	0.20 (.06)	3.30 (.65)	Current impact, sci link, deprec

Source: Hall (1999)

Appendix 2: Previous Literature on Innovation and Production

Firm level econometric estimates of the gross rate of return to industrial R&D in Japan and the United States (per cent) [a]

				Rate of return to:				
Study	*Year*	*Country*	*Time period covered*	*The firm undertaking the R&D*	*Other firms within the same industry*	*Industry* [b]	*Firms in other industries*	*National* [c]
Bernstein & Nadiri [d]	1989a	USA	1965 to 1978	17	2 to 9 (6)	19 to 26 (13)		
Bernstein & Nadiri [dh]	1989b	USA	1959 to 1966	19 to 30 (24)				
Clark & Griliches	1984	USA	1970 to 1980	18 to 20 (19)				
Griliches [g]	1980a	USA	1963	27				
Griliches	1986	USA	1967, 1972 & 1977	33 to 62 (46)				
Griliches & Mairesse	1983	USA	1964 to 1973		41		19	
Griliches & Mairesse [g]	1984	USA	1966 to 1977	30				
Griliches & Mairesse [g]	1986	USA	1973 to 1980	25 to 41				
Griliches & Mairesse [g]	1986	Japan	1973 to 1980	20 to 56				
Jaffe [de]	1986	USA	1973 & 1979	32 to 36 (34)			–5	32
Lichtenberg & Siegel [g]	1989	USA	1972 to 1985	13				
Lichtenberg & Siegel	1991	USA	1972 to 1985	13				
Link [fg]	1981b	USA	1971 to 1976	nss				
Link [g]	1983	USA	1975 to 1979	5				
Mansfield	1980	USA	1960 to 1976	28				
Minasian [f]	1962	USA	1947 to 1957	25				
Minasian [g]	1969	USA	1948 to 1957	54				

Adapted from : Industry Commission of Australia (1995). **Notes**: nss Not statistically significant at 90 % level of confidence.
a Statistically significant at 90%, b Industry return includes both the firm undertaking the R&D and other firms within the same industry returns.

Appendix 3: The innovation index

The index values are standardised so that the highest value is 100. The index values are calculated as the weighted sum of average R&D, patent and trademark intensities for the period 1995-2002. In this way, asset size is taken into account. The weights are the coefficients obtained from the market value regressions. For example, the highest index value is that of Netaş being .33 and it gets a value of 100. Alcatel has an index value of .273 and is ranked 2nd with 82.88 points.

(During the period 1995-2002)

company	Innovation index	Mean R&D exp (in 000)	Total no.of trademarks	Total no.of patents
NETAŞ TELEKOM.	100.00	6,344	15	12
ALCATEL TELETAŞ	82.88	4,214	1	0
FORD OTOSAN	58.27	15,389	3	0
ASELSAN	36.29	4,741	5	9
TOFAŞ OTO. FAB.	31.76	6,278	77	0
ARÇELİK	27.64	9,137	139	273
BOSCH FREN SİST.	26.85	233	0	0
ALARKO CARRIER	23.92	425	2	1
BEKO ELEKTRONİK	16.04	1,794	11	15
OTOKAR	15.37	564	8	0
ÇBS BOYA	14.38	180	153	0
BRİSA	13.27	1,451	27	0
PINAR SÜT	10.13	396	222	0
EGE SERAMİK	9.91	390	13	0
AKIN TEKSTİL	9.61	346	3	0
ÇEMTAŞ	8.97	126	1	0
SARKUYSAN	6.85	192	1	0
T.DEMİR DÖKÜM	6.81	280	47	0
VESTEL	6.35	2,144	18	8
ECZACIBAŞI İLAÇ	6.21	614	29	3
AKSU İPLİK	5.29	106	19	0
MARSHALL	5.10	229	172	1
AKSA	5.01	440	2	0
BSH PROFİLO	4.71	700	8	0
DÖKTAŞ	4.69	147	1	0
RAKS EV ALETLERİ	4.30	32	0	2
KORDSA DUPONT	3.89	404	1	0
AYGAZ	3.89	504	195	4
ALTINYILDIZ	3.87	137	23	0
UŞAK SERAMİK	3.64	26	1	0
KÜTAHYA PORSELEN	3.63	98	28	0
MUTLU AKÜ	3.48	53	7	0
DEVA HOLDİNG	2.43	148	78	0
ESEM SPOR GİYİM	2.11	22	13	0
BURSA ÇİMENTO	1.89	30	0	0
DURAN OFSET	1.80	1	4	0
EDİP İPLİK	1.67	24	4	0
BOSSA	1.67	284	3	0

TİRE KUTSAN	1.56	20	1	0
BORUSAN BORU	1.50	30	4	0
ECZACIBAŞI YAPI	1.25	153	0	6
SASA	1.22	218	0	1
RAKS ELEKTRONİK	1.17	45	36	2
KARSU TEKSTİL	1.07	48	2	0
PETKİM	1.00	446	33	0
BURÇELİK	0.99	7	0	1
DİTAŞ DOĞAN	0.77	2	1	0
BANVİT	0.75	23	25	0
TRAKYA CAM	0.61	221	7	0
TUKAŞ	0.54	34	25	0
AKAL TEKSTİL	0.53	21	3	0
DARDANEL	0.32	8	92	0
YATAŞ	0.28	1	35	0
EREĞLİ DEMİR CELİK	0.26	287	1	1
ANADOLU CAM	0.25	22	5	0
VİKİNG KAĞIT	0.20	4	45	1
KARTONSAN	0.12	3	5	0
GEDİZ İPLİK	0.10	0	0	0
ÇİMENTAŞ	0.08	1	0	0
KEREVİTAŞ GIDA	0.05	1	41	0
FRİGO PAK GIDA	0.05	0	9	0
OKAN TEKSTİL	0.01	0	1	0
KENT GIDA	0.01	0	321	0
TAT KONSERVE	0.00	0	138	0
HEKTAŞ	0.00	0	23	0
PİMAŞ	0.00	0	15	2
KONYA ÇİMENTO	0.00	0	5	0
OYSA ÇİMENTO	0.00	0	4	0
ABANA ELEKTROMEK.	0.00	0	1	0
KONİTEKS	0.00	0	1	0
İZOCAM	0.00	0	23	0
PINAR SU	0.00	0	12	0
UKİ KONFEKSİYON	0.00	0	5	0
LÜKS KADİFE	0.00	0	2	0
T.TUBORG	0.00	0	23	1
KONFRUT GIDA	0.00	0	1	0
SÖKTAŞ	0.00	0	9	0
KAPLAMİN	0.00	0	1	0
MERKO GIDA	0.00	0	10	0
DERİMOD	0.00	0	2	0
BAGFAŞ	0.00	0	1	0
SÖNMEZ FİLAMENT	0.00	0	5	0
EMİNİŞ AMBALAJ	0.00	0	1	0
ÜNYE ÇİMENTO	0.00	0	5	0
MARDİN ÇİMENTO	0.00	0	2	0
BATI ÇİMENTO	0.00	0	3	0
GÖLTAŞ ÇİMENTO	0.00	0	2	0
İZMİR DEMİR ÇELİK	0.00	0	2	0
OLMUKSA	0.00	0	1	0
FENİŞ ALÜMİNYUM	0.00	0	3	0

YÜNSA	0.00	0	1	0
ERBOSAN	0.00	0	1	0
GÜBRE FABRİK.	0.00	0	2	0
TURCAS PETROL	0.00	0	5	0
BOLU ÇİMENTO	0.00	0	2	0
ADANA ÇİMENTO (A)	0.00	0	1	0
PETROL OFİSİ	0.00	0	12	0
TÜPRAŞ	0.00	0	2	0
AFYON ÇİMENTO	0.00	0	0	0
AKÇANSA	0.00	0	0	0
ANADOLU GIDA	0.00	0	0	0
ANADOLU ISUZU	0.00	0	0	0
ÇBS PRİNTAŞ	0.00	0	0	0
ÇELİK HALAT	0.00	0	0	0
CEYTAŞ MADENCİLİK	0.00	0	0	0
ÇİMSA	0.00	0	0	0
DENİZLİ CAM	0.00	0	0	0
EGE ENDÜSTRİ	0.00	0	0	0
EGE GÜBRE	0.00	0	0	0
GOOD-YEAR	0.00	0	0	0
HAZNEDAR REFRAKTER	0.00	0	0	0
İHLAS EV ALETLERİ	0.00	0	27	4
PARSAN	0.00	0	0	0

Appendix 4: Market Value Regression Results with R&D capital
All other variables are the same as discussed in the text

	R1	R2	R3	R4	R5
Explanatory Variable					
LogAssets	**1.013**	**1.015**	**1.011**	**1.01**	**1.004**
	(100.1)	(100.3)	(127)	(127)	(142.6)
R&Dcapital/Tangible Assets	**4.5**	**4.1**	**3.38**		**3.73**
	(3.92)	(3.5)	(3.91)		(4.97)
Advertising/Assets		**0.68**	**0.59**	**0.69**	
		(2.6)	(2.92)	(3.46)	
Debt-Equity Ratio			**-0.22**	**-0.23**	**-0.68**
			(-19.49)	(-20.12)	(-67.3)
R&Ddummy				**0.08**	
				(3.18)	
Patents/Assets					**4.11**
					(1.21)
Trademarks/Assets					**8.81**
					(.95)
Adjusted R-square	0.92	0.93	0.96	0.95	0.97
Observations	839	839	822	822	822

Notes: The numbers in bold are regression coefficients. t-statistics are in parentheses. All variables are significant below 5% levels except patents and trademarks which are significant at 20% levels.

Correlations for alternative measures of intangible capital:

Correlations

		RDTA	RDNETS	RDCAPTA
RDTA	Pearson Correlation	1.000	.955**	.711**
	Sig. (2-tailed)	.	.000	.000
	N	871	871	839
RDNETS	Pearson Correlation	.955**	1.000	.747**
	Sig. (2-tailed)	.000	.	.000
	N	871	871	839
RDCAPTA	Pearson Correlation	.711**	.747**	1.000
	Sig. (2-tailed)	.000	.000	.
	N	839	839	1243

**. Correlation is significant at the 0.01 level (2-tailed).

RDTA: R&D expenditures / Assets

RDNETS: R&D expenditures / Net Sales

RDCAPTA:R&D capital /Assets

Appendix 5: Findings of the questionnaire for obtaining expert opinion

The questionnaire was administered to managers and executives who were responsible for their company's future strategy or were knowledgeable about the innovation process. All answers may not add up to 100 because of rounding or because respondents could give multiple answers to some questions.

Results:

- **The most important three factors to your company's current strategy (% respondents)**

1. **to improve customer relationships………………….. 75**
2. **Constructing a favorable brand image……………… 62**
3. **R&D and new product development…………………62**
4. Cost cutting…………………………………………….. 25
5. Entering new markets………………………………….. 25
6. Improving risk management and compliance…………. 25
7. Entering new strategic partnerships……………………. 12

- **Percentage of your current sales represented by products less than three years old?**

Over 20%…………….50% of the respondents
16-20%……………….25% "
Less than 20 %……… 25% "

- **Percentage of your current sales invested in R&D annually ?**

6-10%……………….38% of the respondents
1-5%……………….. 62% "

- **Roadblocks to successful R&D in Turkey (% respondents)**

1. economic factors the most important obstacle………………………………75
2. Insufficient knowledge about the expectations of end users/customers…….50
3. Poor upfront market research………………………………………………..37
4. lack of qualified personnel…………………………………………………..37
5. insufficient regulatory protection for intellectual property………………….25

- **The factors forcing companies to innovate in Turkey (the first 4 factors)**
  (scale of 1 to 4, 1=significant force, 4=not a force)
  (no. of repondents out of 8)

	1	2	3	4
1. more demanding customers	7	1	0	0
2. Development of new technologies	4	3	1	0
3. market pressures from the competitors	3	4	1	0
4. Interest in co-developing products from customers	3	3	0	1

- **Preferred method of innovation (% respondents)**

- develop new products by their own efforts………………………………. 87
- Working with partners to co-develop products……………………………38
- work with universities or other institutions for undertaking research…… 12

- **The performance criteria you would expect to improve most as a result of R&D investments? (% respondents)**

- the quality of their goods and services……………75
- profitability ………………………………………62
- productivity………………………………………37
- market value………………………………………37
- increase in exports………………………………..25

Some Insights and conclusions

- Companies that lack a market research function may have difficulty in developing new products and monitoring after sales customer satisfaction

- lack of qualified personnel and economic factors impair the research efforts

- A continuous research effort may help in difficult economic times by allowing to charge higher prices through differentiation and quality

- joint research projects by companies and universities may enhance the value of innovation for the society through spillovers

- R&D may help companies increase their exports by enabling them to comply with regulatory obstacles in Europe (e.g. low power consumption, environmentally friendly materials etc)

Appendix 6: The questionnaire

1. What is your primary industry?……………………….

2. What are your main functional roles? ………………

3. Of the following priorities, please indicate in order **the three** that are most important to your company's current strategy?

   - Improving customer relationships ……………………
   - R&D / new product development ……………………
   - Cost cutting………………………………………..
   - Entering new markets ………………………………..
   - Brand-building (brand image)……………………….
   - Entering new strategic alliance partnerships ………..
   - Improving risk management and compliance ……….
   - Mergers & acquisitions ………………………………

4. **Approximately** what percentage of your company's current sales is represented by products less than three years old?

0%……… 1-10%…… 11-15%……. 16-20%……. Over 20%…….

5. How much is invested annually by your company in R&D as a percentage of sales?

%0…… 1-5%……. 6-10%……. 11-15%…… over %15……….

6. What are the roadblocks to successful R&D at your company? (or reasons for not conducting R&D at all) . You can select more than one entry.

   - Economic factors / time and cost overruns………………………………
   - Poor upfront market research…………………………………………….
   - Failure to gather sufficient or relevant end-user input ……………………
   - Lack of strategy / poor inter-departmental communications………………
   - Insuffiicent regulatory protection for intellectual property, patents etc……
   - Other (please explain)…………………………………………………….

7. In general, what do you believe are the forces driving R&D today?
   Please rate **each on a scale** of 1 to 4, where **1=significant force** and **4=not a force**

   - More demanding customers, driving the need for innovative products …….
   - Market pressure to keep up with competitors' innovation ………………….
   - Development of new technologies ……………………………………………..
   - Shorter product life cycles ……………………………………………………..
   - Interest in co-developing products from customers …………………………
   - Pressure from senior managers to boost innovation …………………………

8. What is your company's **preferred** method for innovating and producing new products?

   - Innovate and develop products in-house ……………………………..
   - Work with partners to co-develop products ………………………….
   - Buy or license existing technology and customise it …………………
   - Sponsor universities or institutions to undertake research ………….
   - Other (please explain)…………………………………………………

9. If you have an R&D program, did you try to measure its contribution to the company performance such as productivity and profitability? If so, very briefly explain your method.

10. Which of the following performance criteria would you expect to **improve most** as a result of R&D investments? You can choose multiple entries in order of importance.

    - market value of the company………………………..
    - profitability……………………………………………
    - productivity in general………………………………..
    - improved quality of goods and services………………
    - increase in exports…………………………………
    - Other (please explain)………………………………..

11. Please explain very briefly the problems/obstacles you face in your business in regard to new product development and R&D.

Adapted from a survey conducted by The Economist Intelligence Unit (2004).

Appendix 7: Descriptive Statistics and Correlation Coefficients of Major Variables

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
LOGASSET	879	16.78	1.69	12.44	21.90
RDTA	871	.0043	.0135	.0000	.1239
RDNETS	871	.0037	.0115	.0000	.0901
ADVASSET	871	.0767	.0637	.0000	.4115
LN Market Value	877	17.16	1.79	9.63	22.39
EXNS	879	.26	.24	.00	.95
OPNS	879	.13	.15	-1.55	.45
ROE	879	.02	2.37	-65.47	4.16
ROA	879	.44	1.20	-4.60	23.28
DEBTEQ	853	2.22	11.44	-35.26	240.04
LOGLABR	561	6.76	.97	3.83	8.92
LN VALUE ADDED	569	16.18	1.58	11.47	22.93
TFENS	871	.14	.36	.00	5.61
PATENTA	871	.00032	.0032	.0000	.0586
TRMARKA	871	.00026	.0012	.0000	.0241
Valid N (listwise)	553				

Correlations

		LNmarket Value	LOGASSET	RDTA	RDNETS	DEBTEQ	LNVALUE	LOGLABR
LNmarket value	Pearson Correlation	1.000	.963**	.217**	.229**	-.016	.852**	.492**
	Sig. (2-tailed)	.	.000	.000	.000	.633	.000	.000
	N	1091	877	871	871	853	613	605
LOGASSET	Pearson Correlation	.963**	1.000	.179**	.195**	.132**	.872**	.527**
	Sig. (2-tailed)	.000	.	.000	.000	.000	.000	.000
	N	877	879	871	871	853	569	561
RDTA	Pearson Correlation	.217**	.179**	1.000	.955**	-.079*	.142**	.182**
	Sig. (2-tailed)	.000	.000	.	.000	.021	.001	.000
	N	871	871	871	871	853	561	553
RDNETS	Pearson Correlation	.229**	.195**	.955**	1.000	-.046	.140**	.188**
	Sig. (2-tailed)	.000	.000	.000	.	.181	.001	.000
	N	871	871	871	871	853	561	553
DEBTEQ	Pearson Correlation	-.016	.132**	-.079*	-.046	1.000	.050	.175**
	Sig. (2-tailed)	.633	.000	.021	.181	.	.245	.000
	N	853	853	853	853	853	551	544
LNVALUE	Pearson Correlation	.852**	.872**	.142**	.140**	.050	1.000	.502**
	Sig. (2-tailed)	.000	.000	.001	.001	.245	.	.000
	N	613	569	561	561	551	640	632
LOGLABR	Pearson Correlation	.492**	.527**	.182**	.188**	.175**	.502**	1.000
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.
	N	605	561	553	553	544	632	632

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).