"R&D, INNOVATION AND STOCK MARKET PERFORMANCE:

A STUDY ON THE ISTANBUL STOCK EXCHANGE”

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"R&D, INNOVATION AND STOCK MARKET PERFORMANCE: A STUDY ON THE ISTANBUL STOCK EXCHANGE"

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ABSTRACT

R&D, INNOVATION AND STOCK MARKET PERFORMANCE: A STUDY ON THE ISTANBUL STOCK EXCHANGE

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MA in Financial Economics, Graduate School in Social Sciences

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Investing in R&D and innovation is crucial for companies that want to stay ahead of their competitors and introduce new products and services. Technological activities provide not only operational benefits to companies but also financial improvements in financial markets. This study investigates the relationship between technological indicators and stock market performance of firms. I study the effect of technological indicators such as R&D expenditures and patents owned by firms on performance indicators, including market to book ratio, price to earnings ratio and market value. Results show that innovation and technological activities improve market performance of companies on ISE. I also analyze the relationship between technological indicators and stock return volatility. I find that there is two-way relationship between stock return volatility and R&D expenditures, with each variable negatively affecting the other.

Keywords: R&D, innovation, patent, stock return volatility, stock return, portfolio selection

ÖZET

AR-GE, YENİLİK ve HİSSE SENEDİ PİYASASI PERFORMANSI: İSTANBUL MENKUL KIYMETLER BORSASI ÜZERİNE BİR ÇALIŞMA

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AR-GE' ye yatırım yapmak, rakiplerinin önüne geçmek ve yeni ürün ve servisler üretmek isteyen şirketler için çok önemlidir. Teknolojik faaliyetler sadece operasyonel fayda sağlamakla kalmayıp ayrıca şirketlerin finansal piyasalardaki gelişimine de yardımcı olur. Bu çalışma teknolojik göstergeler ve şirketlerin hisse senedi piyasası performansı arasındaki ilişkiyi araştırmaktadır. Ben bu çalışmada AR-GE harcamaları ve şirkeltlerin sahip olduğu patentler gibi teknolojik göstergelerin, piyasa değeri defter değeri oranı, fiyat kazanç oranı ve piyasa değeri gibi performans göstergelerine olan etkilerini araştırıyorum. Sonuçlar, inovasyon ve teknolojik faaliyetlerin IMKB'deki şirketlerin piyasa performansını geliştirdiğini göstermektedir. Ayrıca teknolojik göstergeler ve hisse senedi fiyatı volatilitesi arasındaki ilişkiyi incelediğimde hisse senedi fiyatı volatilitesi ve AR-GE harcamaları arasında iki yönlü bir ilişki buldum.

Keywords: AR-GE, İnovasyon, Patent, Hisse Senedi Getiri Volatilitesi, Hisse Senedi Getirisi, Portföy Seçimi

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Chapter 1: Introduction

Obtaining technological advancements through R&D is crucial for companies, especially for manufacturing ones. Firms invest in Research and Development in order to develop new products or processes, as well as to explore and create new knowledge about scientific and technological subjects to enable the development of valuable new products, processes, and services. Companies can develop new products or improve existing ones in order to differentiate themselves in the market. In order to achieve these developments, companies should invest in R&D activities. In this study I undertake three distinct but related analyses on manufacturing firms traded on the Istanbul Stock Exchange (ISE). First I analyze the effects of R&D and innovation indicators on market performance of firms. Second I attempt to create a stock that uses innovation indicators to predict future success. Third I investigate the relationship between technological indicators and stock return volatility, in order to uncover potential relationships between R&D, innovation and firm-level risk.

Investing in R&D helps companies to improve their products, processes and services. As Özçelik and Taymaz (2004) stated in their paper, innovations and R&D activities are crucial for the international competitiveness of Turkish manufacturing firms. But how can these changes allow companies to differentiate themselves in the market? Firstly, improved products and services will allow companies to benefit from increased customer attention and sales. Unsurprisingly, customers will prefer better products and services. Secondly, improved processes will help the company to make more efficient use of its labor, equipment, capital and time inputs, which leads companies to reduce costs and so increase profits. Moreover, decrease in costs allows companies to make output price reductions and increase sales volume. Finally, in many countries including Turkey, investing in R&D provides tax advantage to the companies, since governments want to increase R&D activities in their countries.

By reducing costs, increasing sales and profits, enterprise value of companies investing in R&D also increases. Thus, these companies have higher investment potential. In light of this information, it is obvious that investment in technology is a necessity for companies in many industries. In his paper Thomas (2001) stated that as technologies develop, companies must innovate in order to keep up with the latest ideas. If they do not, they may be left behind by competitors developing more advanced and marketable products.

Due to the positive externalities associated with R&D, R&D expenditures are usually subsidized by governments. In order to increase R&D activities, Turkish Government applies some incentives. According to Turkish Revenue Administration's Law No. 5746, R&D activities provide tax advantage, insurance premium support, and documentary taxes indemnity to firms. Özçelik and Taymaz (2007) found that public R&D support for Turkish companies significantly and positively affect private R&D investments.

Increased understanding of the benefits o innovation and incentives provided by the Turkish government has led to an increase in the R&D activities in Turkey. Figure 1.1 plots the percentage of R&D expenditures in Turkey within GDP between 2002 and 2011 (the sample period used in the current study). As it can be seen from the figure, R&D expenditures' portion in Gross Domestic Product of Turkey has an increasing trend. Actually the percentage of R&D expenditure approximately doubled in ten years. Although Turkey as a developing country has a low R&D percentage compared to developed countries, its growth within last ten years is commendable. That said the overall figures remain quite low as of 2011 compared to developing nations.

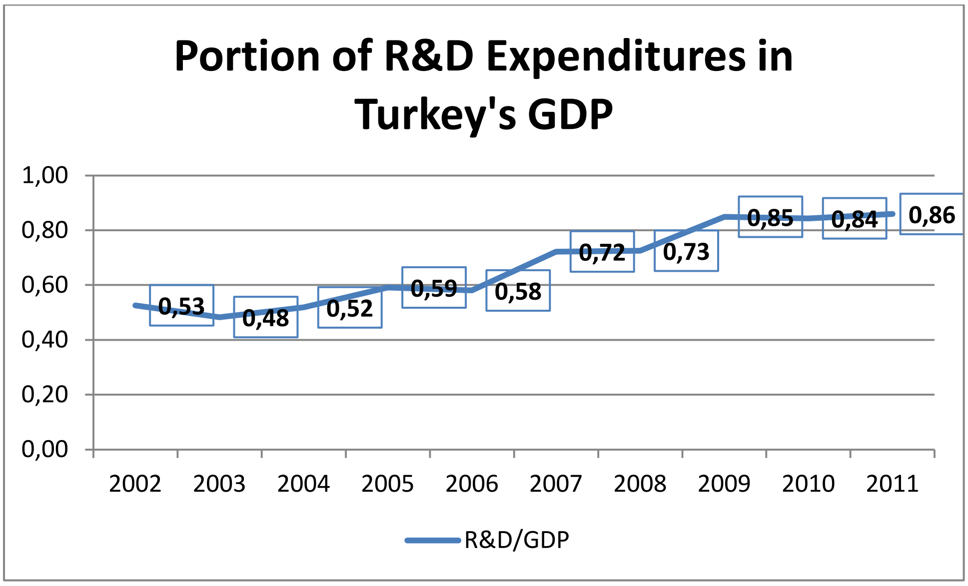

Figure 1.1: Portion of R&D Expenditure in GDP in Turkey
(Source: Turkish Statistical Institute)

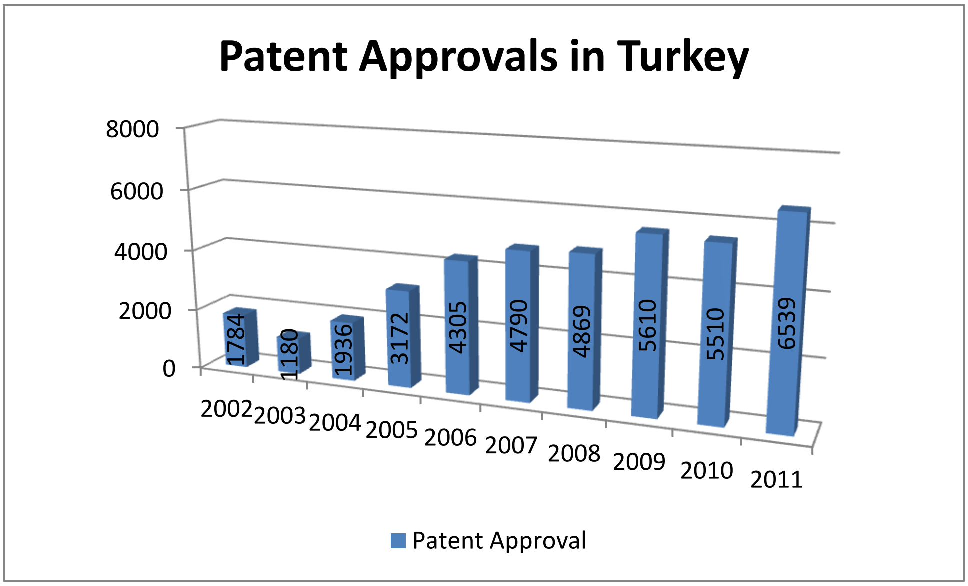

Figure 1.2: Patent approvals in Turkey (Source: Turkish Patent Institute)

Just like R&D expenditures, patent approvals have been on an increasing trend in Turkey. While patent approvals' count was 1784 in 2002, it reached to 6539 in 2011 as seen in the figure 1.2. Growth of patent approvals count is approximately 400 percent in ten years. Increase in both R&D portion and patent approvals show that importance of technological innovation is better understood, and companies have given more attention to it over the past decade.

In order to analyze a company's innovation ability, patent portfolio of the company can be evaluated according to its size, growth and quality. Wide portfolios, portfolios with a high growth rate or portfolios including highly cited patents show that the company has greater innovation ability. Also R&D expenditures and R&D intensity, which is portion of R&D expenditures in sales revenue, of the company can be indicators of company's technological competence. Companies with higher R&D expenditures or R&D intensity have relatively higher technological competence.

This study undertakes various analyses relating R&D expenditures, patents and company performance for manufacturing firms' stocks traded on the ISE. The rest of the study is organized as follows. Chapter 2 introduces the previous literature on all analysis performed. Chapter 3 introduces the data set that will be used through the thesis. In Chapter 4, I study the relationship between measures of a firm's innovative performance (R&D expenditures and patents) on various performance indicators focusing mainly on market to book ratio, price to earnings ratio and market value. I find that R&D expenditures and patents are good predictors of a company's market to book ratio, price to earnings ratio and market value. Using main findings from Chapter 4; Chapter 5 proceeds to a portfolio selection exercise that utilizes information on the R&D expenditures and patents of a given firm. It is shown that using R&D and patents can be used to construct portfolios that perform much better than the ISE100 index. For the construction of this portfolio, I use a method due to Thomas (2001) that identifies firms that are undervalued or overvalued by the market according to the estimated relationship between innovation indicators and stock performance. Chapter 6 analyzes the relationship between technological activities of firms and their stock return volatilities. I find that stock return volatility and R&D expenditures have a two-way relationship, with both variables affecting the other negatively with a lag. Therefore, while increased R&D expenditures reduce firm-specific risk, increased risk causes firms to deviate resources away from R&D. Finally, Chapter 7 concludes.

Chapter 2: Literature Review

This chapter reviews previous strands of literature that are relevant for the analysis performed in the current study. Many authors have studied the relationship between R&D expenditures and companies' economic performance. Parasuraman and Zeren (1983) found a high correlation between R&D expenditures and company performance, also between R&D expenditures and sales. Franko (1989) revealed that R&D is a significant indicator of following sales growth. Morbey and Reithner (1990) found a positive correlation between R&D intensity and ten years sales growth. Thomas (2001) revealed that R&D expenditures were highly correlated with profits, and even more highly correlated with sales. Additionally, the study by Hall et al. (2005) show that patent citations contain significant information on the market value of firms, in addition to R&D and simple patents counts, thus enriching the toolkit available to economists in trying to tackle empirically the intangible assets, and in particular the "knowledge stock" of firms. They found that R&D intensity, patents to R&D ratio and patent citations have positive effect on market value. Furthermore, Pakes (1984) investigated the dynamic relationships between the number of successful patent applications of firms, a measure of the firm's investment in inventive activity (its R&D expenditures), and a measure of firm performance (its stock market values).

Previous literature also studied the relationship between patent indicators and corporate performance. Narin et al. (1987) found high correlation between patent citation and profits and sales by analyzing U.S. pharmaceutical companies. Chakrabarti (1990) explained twelve percent of sales growth and fourteen percent of new product announcements with number of patents granted in mechanical and electrical engineering companies. Furthermore, study of Pakes (1985) exhibits significant correlation between changes in R&D expenditures or patent applications and stock market value of the company. Comanor and Scherer (1969) found that they can explain some of the variation by examining the relationship between patents granted and sales. Deng et al. (1999) used technology indicators in order to forecast companies' market to book ratios and found that these indicators are correlated with future economic performance. They also found that the volume of companies' research activity, the impact of companies' research on subsequent innovations, and the closeness of research and development to science are reliably associated with the performance R&D intensive companies.

An early line of literature studies R&D and patent indicators in order to predict companies' economic performance. Lately, many authors also used patent citations (in addition to patent counts and R&D expenditures) as a measure of patent quality in related situations. The fundamental assumption of patent citation analysis is that a highly cited patent is technologically important and this is supported by previous studies such as Trajtenberg (1990), Carpenter et al. (1981), Breitzman and Narin (1996), and Albert et al. (1991). It is also suggested that patent citations are indicators of patents' commercial value.

Deng et al. (1999) exhibited that the links between R&D, technological change, and economic growth have been theoretically and empirically established at the national, industry, and corporate levels. In particular, empirical research has established that corporate R&D is strongly associated with subsequent gains in companies' productivity, earnings, and stock prices. According to Harhoff et al. (1999), patents which are considered as commercially valuable by their owners have more citations than patents which are considered as less valuable. Moreover, Thomas (1999) showed that renewing highly cited patents is more probable than renewing relatively fewer cited patents. The logic behind this indication is that since renewing the patent is costly, patent owners prefer to renew patents which can provide commercial return greater than its renewal cost. Thus, it can be argued that highly cited patents are also the ones that provide higher commercial returns.

For portfolio selection part of this study, literature is not too wide. The portfolio selection exercise I perform mostly builds on Thomas (2001) and Narin et al. (2005), who used technological indicators such as R&D expenditures, patents granted and patent citations for portfolio selection, leading to portfolios that perform better than market indices.

Mazzucato and Tancioni (2008) asserted that the basic idea is that when a firm introduces a new technology, its stock price rises due to the expectations regarding the positive impact of the new technology on its productivity. Pastor and Veronesi (2009) claimed that the reason that high tech firms have prices that appear unjustifiably high is not due to irrationality, but due to the effect that new technology has on the uncertainty about a firm's average future profits. The main implication of these two studies is that investment in technology increases stock price of the company. However, after technologic developments lose their importance, or they are already recognized by the market, stock prices start declining. Thus, investment in technology should be performed on a continuous basis in order to increase value of the company.

Studies mentioned are based on accounting related performance such as sales and profits and also stock market performance such as stock returns. Technological indicators also have relationship with stock return volatility and this relation is examined by some studies. There are two viewpoints about the relationship between R&D and volatility. That first one asserts that they have positive relationship and R&D activities increase stock return volatility. For example, Mazzucato and Tancioni (2008) found a positive and significant relationship between idiosyncratic risk, R&D intensity and various patent related measures. On the other hand, the other viewpoint claims that R&D activities increase company performance and thus decrease volatility. For instance, Xu (2006a) found that stock return volatility leads to decrease in R&D. Moreover, Xu (2006b) reported a significant impact of R&D strategy in terms of drug discovery and development diversification on share price volatility. According to their results, firms with more diversified drug portfolios are associated with lower share price volatilities. Another study investigating a relationship between technological activities and stock return volatility is by Chan et al. (2002), who provide evidence that R&D intensity is positively associated with return volatility.

In their study, Mazzucato and Tancioni (2008) found evidence suggesting that there is a positive and significant relationship between idiosyncratic risk, R&D intensity and the various patent related measures. Furthermore, Pastor and Veronesi (2006) found that high uncertainty about the average productivity of a new technology leads to the high volatility. Chow and Fung (2008) studied the relationship between stock return volatility and innovation by using multivariate Garch structure and they found a negative relationship between these two variables. In the next chapter data used in this study will be introduced.

Chapter 3: Data

In this chapter I introduce the dataset used in all the analysis that follows. The sample used in this study includes companies in manufacturing industry which are traded in Istanbul Stock Exchange (ISE) for at least two years. The reason behind choosing manufacturing industry is the fact that effects of R&D are more crucial in companies which produce concrete products. Choosing manufacturing industry enables me to exclude financial and service sector companies which have relatively less R&D activity or none at all. Some companies were excluded from the sample due to data limitations in financial statements. Moreover, some companies have more than one stock traded on the Istanbul Stock Exchange. In such cases, only one of the stocks is included in the dataset. In total, 21 of 175 companies in manufacturing industry are excluded from the study, leaving a total of 154 firms in the sample. Fundamental firm-level variables obtained for these firms are market to book ratio, market value, R&D expenditure, R&D intensity, patent size and stock return of companies. The study spans the ten year period between 2002 and 2011.

The market to book ratio also known as price to book ratio or price to equity ratio is calculated by dividing closing price of the stock end o the year by the book value per share which is obtained by dividing book value of the company to shares outstanding at the end of the year . Like Griliches (1998) stated in his book chapter, the reason of using stock market values as an “output” indicator is its quick responsiveness while other indicators of success, such as profits or productivity, are likely to reflect it only slowly and erratically. Book value is the value of a company as shown in its accounts and it is taken as shareholders’ equity in this study. Shareholders’ equity and shares outstanding data were derived from annual financial statements of the companies. Stock price data of the companies was taken from Matriks Data Terminal for each day between 2002 and 2011. Secondly, R&D expenditures data is obtained from annual financial statements (income statement) of companies and it is also used to calculate R&D intensity, which is defined as portion of R&D expenditures in sales revenue which is also derived from financial statements (income statement) of companies for each year. Thirdly, company specific data on patent size was derived from Turkish Patent Institute database by examining companies' patent files one by one and classifying data from 2002 to 2011. To date each patent, I used the issue date of patents. Finally, stock return of a company is percentage increase in stock price in related year and it is calculated using the Matriks Data Terminal. This is a database covering all stock price and financial statements data of ISE companies.

For parts of the analysis, it is preferable to use a stock of R&D and patents instead of their annual (flow) values. For this purpose, R&D and patent stocks are calculated using a perpetual inventory method assuming the traditional 15 percent depreciation rate.

Since I do not have information on patent citations for Turkish patents, I restrict my analysis to R&D and patent related measures. Technological indicators used in this study are listed below.

R&D Expenditures: The amount spent on Research and Development activities during a year according to companies' financial statements.

R&D Intensity: The portion of a company's R&D expenditures for a year in sales revenue of the same year.

R&D Stock: Sum of 85 percent of previous year's R&D Expenditures stock and present year's R&D Expenditure flow. Only R&D Expenditure flow was used for the first year (2002). The stock of accumulated R&D expenditure is calculated by the perpetual inventory method assuming 15% depreciation as in the equation below.

$$R\&D\ Stock_{i,t} = 0.85 * R\&D\ Stock_{i,t-1} + R\&D_{\ i,t} \quad (3.1)$$

Patent Counts: The number of patents granted to a company during the year.

Patent Stock: The Stock of patents as calculated by the perpetual inventory method assuming 15% depreciation as in the equation below.

$$Patent\ Stock_{i,t} = 0.85 * Patent\ Stock_{i,t-1} + Patent\ Counts_{\ i,t} \quad (3.2)$$

Patent /R&D Ratio (Patent Intensity): The ratio calculated by dividing Patent Stock of a firm in a year to R&D stock of a firm in corresponding year.

In addition, I use simple indicator variables (dummies) to record the incidence of reporting R&D expenditures and applying for patents. These are listed below:

No Patent Indicator: A dummy variable that shows has patent flow in a year (0) or not (1).

No Patent Stock Indicator: A dummy variable that shows whether a company has patent stock in a year (0) or not (1).

No R&D Indicator: A dummy variable that shows has R&D flow in a year (0) or not (1).

No R&D Stock Indicator: A dummy variable that shows whether a company has R&D stock in a year (0) or not (1).

R&D Persistence Indicator: A dummy variable which shows whether a company made continuous R&D spending (1) or not (0). A company is classified as continuous R&D spender if it made R&D expenditure in 6 or more years out of 10.

Performance indicators used in this study are listed below:

Annual Return of Stock: Each stock's yearly return in Istanbul Stock Exchange.

Market to Book Ratio: Ratio calculated by dividing Market value of a a company to its book value (shareholders' equity). Shareholders' equity represents the amount by which a company is financed through common and preferred shares. It is calculated by subtracting total liabilities from total assets.

Market Value: The value calculated by multiplying market price of a stock with shares outstanding of that stock.

Price to Earnings Ratio (P/E): An equity valuation measure defined as market price per share divided by annual earnings per share.

Stock Return Volatility: Each firm's volatility of return in Istanbul Stock Exchange.

Total Assets: The sum of current and long-term assets owned by a company.

Sample statistics for all important variables are shown in Table 3.1. There are 1540 observations including 154 firms between 2002 and 2011 in this study. 101 of these

154 firms are R&D spenders and 74 of them are continuous R&D spenders. Continuous R&D spenders are the companies investing in R&D at least six years out of ten. Sample of firms obtained 6335 patents over the sample period, and spent 1,147,389,388 TL on Research and Development. All TL values in this study are deflated by 2003 Turkish Producer Price Index. Correlations between variables of interest are shown in Table 3.2 below.

Table 3.1 Sample Statistics

Variable	Mean	Std. Dev.	Min	Max
R&D intensity(R&D exp./Sales Revenue)	0,002	5,114	0,000	0,050
Patent stock/R&D stock ratio	3,288	4,307	0,003	219,154
Market to book ratio	0,721	3,155	0,010	426,519
Price to earnings ratio	7,188	4,266	0,023	1377,185
Market value	33,771	5,842	0,197	4310,254
Total assets	92,691	4,270	2,802	5821,475
R&D stock	0,643	11,213	0,000	118,217
Patent stock	5,550	5,300	0,232	491,890
Stock price volatility	0,001	0,001	0,000	0,018
Annual return of stock	0,126	0,567	-1,938	2,865
Sales revenue	80,981	5,160	0,016	15274,652
R&D expenditure flow	1,294	1,741	0,000	55,087
Patent flow	4,045	3,502	0,000	141,000

Table 3.2 Correlation Matrix

Variable Name	Abbrev.	lrdsr	lpatr	lta	lrds	lps	r	lsr	lrd	lp
Ln(R&D intensity)	lrdsr	1.00								
Ln(patent stock /R&D stock ratio)	lpatr	-0.20	1.00							
Ln(total assets)	lta	0.11	-0.05	1.00						
Ln(R&D stock)	lrds	0.63	-0.31	0.54	1.00					
Ln(patent stock)	lps	0.22	0.78	0.31	0.35	1.00				
Annual return of stock	r	-0.02	0.07	-0.02	-0.05	0.04	1.00			
Ln(sales revenue)	lsr	0.09	-0.06	0.92	0.55	0.31	-0.03	1.00		
Ln(R&D expenditure flow)	lrd	0.53	-0.21	0.36	0.72	0.27	-0.03	0.40	1.00	
Ln(patent flow)	lp	0.18	0.63	0.26	0.31	0.82	0.04	0.28	0.24	1.00
Dependent Variables										
Ln(stock price volatility)	lgrcvol	0.06	0.06	-0.40	-0.20	-0.07	0.07	-0.36	-0.21	-0.05
Ln(market to book ratio)	lmtb	0.14	0.08	0.002	0.09	0.14	0.14	-0.003	-0.01	0.16
Ln(price to earnings ratio)	lpe	0.20	0.03	-0.04	0.09	0.09	-0.01	-0.06	0.07	0.11
Ln(market value)	lmv	0.16	0.01	0.79	0.45	0.31	0.08	0.71	0.26	0.29

Chapter 4: R&D, Innovation and Stock Performance in the ISE

In this chapter, I test whether observable indicators of a firm's innovation and technological capabilities have any effect on its overall performance and the performance of its stocks traded on the ISE. In other words, I study whether R&D and patents are valued by investors in the Istanbul Stock Exchange.

The aim of this chapter is to investigate effects of technological indicators on economic performances of companies. For this purpose, technological indicators were regressed on market performance indicators. As mentioned in Chapter 3, market performance indicators are market to book ratio, price to earnings ratio and market value, and technological indicators are R&D intensity, R&D stock, patent stock and patent stock/R&D stock ratio. Using these indicators, various models were applied to data. The fundamental idea in these models is using market to book ratio, price to earnings ratio or market value as a dependent variables and using technological and other indicators as independent variables. Initially, R&D and patent indicators were regressed on market to book ratio. Since a ratio is used as dependent variable, independent variables were chosen to be appropriate ratios as well.

4.1. Market to Book ratio

In order to study the effect of R&D and patents on market to book ratio, I use the following specification.

$$ln(MTB)_{it} = \beta_0 + \beta_1 \, ln\left(\frac{R\&D\ Stock}{Sales}\right) + \beta_2 \, ln\left(\frac{Patent\ Stock}{R\&D\ Stock}\right)$$

$$+ \beta_3 I(R\&D\ Stock = 0) + \beta_4 I(Patent\ Stock = 0) + \beta_5 I(R\&D\ Persistence)$$

$$+ \sum_{t=2003}^{2010} \delta_t \, .I(year = t) + \mu_i + u_{it} \qquad (4.1)$$

Where; MTB is market to book ratio, I (statement) is an indicator that takes a value of one when the statement in parenthesis is true, μi is permanent firm-specific effect and u_{it} is usual error term.

I estimate Equation 4.1 using panel data method. I conducted a Hausman Test for all the regressions and the test suggested using Fixed Effects method for all specifications. Thus I prefer Fixed Effects method for all regressions. However, after using fixed effects method, I also applied Random Effects method to regressions in order to see the effect of R&D persistence, since this variable is differenced-out in the fixed effects setting.

In order not to lose observations with zero R&D or patent counts I use “ln (1+R&D Stock)” and “ln (1+Patent Stock)” instead of “ln (R&D Stock)” and “ln (Patent Stock)”. I control for the effect of having no R&D stock by including a dummy variable indicating “R&D indicator”. The same procedure is applied to R&D, patents and patent stocks as well. Because of using logarithm of these variables, I added 1 all these values in order to prevent missing values (ln [0] is meaningless). Thus these dummy variables were added to equation to control this effect. I also estimated these regressions while excluding zero observations. These give similar results. I next present main empirical specifications and findings.

Table 4.1 reports results of market-to-book ratio regressions. In column 1, I regress R&D intensity on market-to-book ratio. In column 2, I do the same exercise, this time using patent stocks. Higher patent intensity is not associated higher market to book ratio but higher R&D intensity. In column 3, I use both indicators together. Results are very similar. In all equations coefficient of R&D intensity is positive and significant. It shows that higher R&D intensity is associated with higher market to book ratio.

Table 4.1 **Market-to-Book Ratio Regressions**

	Dependent Variable: ln(Market-to-Book Ratio)			
	1	**2**	**3**	**4**
	FE	**FE**	**FE**	**RE**
ln(R&D Intensity)	12.18***		12.73***	12.62***
	(5.83)		(5.98)	(6.47)
ln(Patent Stock / R&D Stock Ratio)		-0.00759	0.0556	0.0500
		(-0.18)	(1.28)	(1.56)
No R&D stock Dummy	-0.295**		-0.252*	-0.146
	(-2.76)		(-2.37)	(-1.51)
No Patent Stock Dummy		-0.571***	-0.480***	-0.274**
		(-4.70)	(-4.00)	(-2.59)
R&D Persistence Dummy				-0.458***
				(-3.49)
Year Dummies 2003-2010	YES	YES	YES	YES
Constant	-0.477***	-0.403***	-0.475***	-0.306*
	(-6.48)	(-5.19)	(-4.99)	(-2.39)
N	1401	1401	1400	1400
R^2	0.230	0.215	0.244	0.241
Adjusted R^2	0.131	0.114	0.145	0.157

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Patent intensity has a negative coefficient when it is regressed alone. However its coefficient is positive when it is regressed together with R&D intensity. In addition, its coefficient is insignificant at the 5 % level in all equations. Coefficient of R&D stock dummy is negative in all equations and significant except one equation. It shows that having no R&D stock makes companies less valuable. Coefficient of patent stock dummy is also negative and significant in all equations. Like having no R&D stock, having no patent stock makes companies less valuable. Finally, R&D persistence dummy has a negative and significant coefficient. It is expected that continuous R&D activities improve value of companies; nevertheless in this regression result is exactly opposite.

4.2. Price to Earnings Ratio

Next, I turn to the determinants of price to earnings ratio. The following regression specification is used for this purpose.

$$ln(PE)_{it} = \beta_0 + \beta_1 \, ln\left(\frac{R\&D\ Stock}{Sales}\right) + \beta_2 \, ln\left(\frac{Patent\ Stock}{R\&D\ Stock}\right)$$
$$+ \beta_3 I(R\&D\ Stock = 0) + \beta_4 I(Patent\ Stock = 0) + \beta_4 I\ (R\&D\ Persistence)$$
$$+ \sum_{t=2003}^{2010} \delta_t \, .I(year = t) + \mu_i + u_{it} \qquad (4.2)$$

Where, PE is price to earnings ratio, I (statement) is an indicator that takes a value of one when the statement in parenthesis is true, μi is permanent firm-specific effect and u_{it} is usual error term.

Results of price to earnings ratio regressions are reported in Table 4.2. Initially R&D intensity was regressed on price to earnings ratio in column 1. Then patents intensity was regressed on it in column 2. Higher R&D intensity is associated with higher price to earnings ratio but higher patent intensity is not. I found that having no R&D

stock or patent stock have negative effect on price to earnings ratio. Finally they are used in the equation together. Results do not change except losing significance of R&D and patent indicators. R&D intensity has a positive and significant coefficient in all equations.

Table 4.2 **Price to Earnings Ratio Regressions**

	Dependent Variable: ln(Price to Earnings Ratio)			
	1	**2**	**3**	**4**
	FE	**FE**	**FE**	**RE**
ln(R&D Intensity)	24.71^{***}		23.41^{***}	19.53^{***}
	(5.38)		(5.00)	(4.95)
ln(Patent Stock / R&D Stock Ratio)		-0.114	-0.0256	-0.0387
		(-1.77)	(-0.39)	(-0.83)
No R&D stock Dummy	-0.355^{*}		-0.283	-0.126
	(-2.20)		(-1.77)	(-0.87)
No Patent Stock Dummy		-1.096^{***}	-0.965^{***}	-0.615^{***}
		(-5.99)	(-5.31)	(-3.90)
R&D Persistence Dummy				-0.343
				(-1.74)
Year Dummies 2003-2010	YES	YES	YES	YES
Constant	1.587^{***}	1.901^{***}	1.738^{***}	1.968^{***}
	(14.11)	(16.42)	(11.95)	(10.35)
N	1018	1019	1018	1018
R^2	0.226	0.226	0.252	0.246
Adjusted R^2	0.0794	0.0791	0.108	0.132

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In equation 4, R&D persistence indicator is added to the list of independent variables. It has an insignificant and negative effect on price to earnings ratio. 1 percent increase in R&D intensity leads to approximately 20 percent increase in price to earnings ratio. Moreover, having no R&D stock decreases price to earnings ratio as 35 percent in equation 1. Finally having no patent has a remarkable negative effect on price to earnings ratio.

R&D intensity has a positive effect and patent intensity has a negative effect on firm's price to earnings ratio. R&D stock and patent stock indicators have negative coefficients in these equations as well. Coefficient of patent stock indicator is significant in all equations, but coefficient of R&D stock indicator is only significant when it is regressed alone. R&D persistence dummy has a negative and insignificant coefficient. Results from price to earnings ratio regressions are very similar to results of market to book ratio regressions. Having no R&D stock or no patent stock deteriorates companies' value in this equation as well. Unexpectedly, continuous R&D performers have lower price to earnings ratio overall.

An interesting finding from this analysis is that price to earnings ratio and market to book ratio are not affected by patents significantly, but are strongly associated with high R&D expenditures.

4.3. Market Value

Finally, I analyze the determinants of market value. Market value is specified according to the following equation.

$$ln(MV)_{it} = \beta_0 + \beta_1 \, ln(Total\ Assets) + \beta_2 \, ln(R\&D\ Stock) + \beta_3 \, ln(Patent\ Stock)$$
$$+ \beta_4 I(R\&D\ Stock = 0) + \beta_5 I(Patent\ Stock = 0) + \beta_6 I(R\&D\ Persistence)$$
$$+ \sum_{t=2003}^{2010} \delta_t \, . I(year = t) + \mu_i + u_{it} \quad (4.3)$$

Where, MV is market value, I (statement), is an indicator that takes a value of one when the statement in parenthesis is true, μi is permanent firm-specific effect and u_{it} is usual error term.

Table 4.3 **Market Value Regressions**

	Dependent Variable: ln(Market Value)				
	1 **FE**	**2** **FE**	**3** **FE**	**4** **FE**	**5** **RE**
ln(Total Assets)				0.792***	0.845***
				(12.44)	(24.03)
ln(R&D Stock)	0.747***		0.648***	0.509***	0.346***
	(9.27)		(8.11)	(6.66)	(5.91)
ln(Patent Stock)		0.291***	0.210***	0.151***	0.0819**
		(6.43)	(4.69)	(3.55)	(2.63)
No R&D stock Dummy	-0.371***		-0.280**	-0.210*	-0.115
	(-3.40)		(-2.61)	(-2.06)	(-1.26)
No Patent Stock Dummy		-0.601***	-0.561***	-0.454***	-0.336***
		(-4.79)	(-4.61)	(-3.55)	(-3.31)
R&D Persistence Dummy					-0.589***
					(-4.57)
Year Dummies 2003-2010	YES	YES	YES	YES	YES
Constant	2.965***	2.778***	2.724***	-0.680*	-0.496**
	(34.60)	(27.92)	(23.16)	(-2.30)	(-2.66)
N	1475	1474	1474	1474	1474
R^2	0.310	0.299	0.342	0.412	0.676
Adjusted R^2	0.224	0.212	0.259	0.337	0.406

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In market value regressions, firstly R&D stock and patent stock are regressed on dependent variable separately. In column 1, I used R&D Stock as a single regressor and found that it has a positive and significant effect on market value. R&D stock indicator's coefficient is negative and significant. Additionally, 1 percent increase in R&D stock leads to 0.7 percent increase in market value and having no R&D stock decreases market value as 37 percent. It means that higher R&D stock higher market value and having no R&D stock decreases market value of the companies. Like R&D stock, patent stock has a positive and significant coefficient when it is regressed alone in column 2. Also, coefficient of patent stock indicator is negative and significant. Thus, it can be understood that companies owning more patent stock have greater market values and having no patent stock deteriorates market value of companies. Furthermore, a 1 percent increase in patent stock leads to 0.3 percent increase in market value and having no patent stock decreases market value as 60 percent.

When R&D stock and patent stock variables are regressed on market value together in column 3, results do not change significantly. R&D stock and patent stock both have positive and significant coefficients. In addition, R&D stock and patent stock dummies have negative and significant coefficients in this equation as well and magnitudes of coefficients are very similar to previous equations. Results are as expected so far. However technological indicators are not the only variables affecting market value of companies. Furthermore, the size of the company can affect market value of the company as well. Thus, I added the natural logarithm of total assets in column 4 and 5 to control for possible size effects. Results are similar to those in previous columns, but there are slight changes. First of all total assets have a positive and significant coefficient. This means that market value of the company depends also on size of the company. Although they are still positive and significant, coefficients of R&D stock and patent stock decreased by approximately twenty percent. R&D stock dummy and patent stock dummy have still negative and significant coefficient.

In column 5, I estimate Equation 4.3 by adding an indicator for R&D persistence. In order to identify the coefficient of this variable, I use the Random Effects method instead of Fixed Effects method. Using random effects method, in final equation

R&D persistence dummy was added to model. Results are very similar to the previous equation. Total assets, R&D stock and patent stock have positive and significant coefficients although there are some changes in magnitudes. R&D stock indicator has still negative coefficient but it lost its significance. Additionally coefficient of patent stock dummy is negative and significant just like in fourth equation. Finally R&D persistence dummy has negative and significant coefficient like in market to book ratio and price to earnings ratio regressions. To sum up, innovation and technology and also company size affect market value of companies positively. However, continuous R&D spenders face with decrease in market value.

Since 2008 marks the beginning of a global financial crisis, market value regressions were applied to data before 2008 in order exclude the potential effects due to this crisis. There are some differences from regression using whole sample. Results of this analysis are reported in Table 4.4. R&D stock has positive and significant coefficient when it is regressed alone, but coefficient of R&D stock dummy becomes positive and loses its significance. Patent stock's coefficient is still positive when it is regressed alone but it also loses its significance, and patent stock indicator has negative but insignificant coefficient. When R&D stock and patent stock variables are used in the equation together, coefficient of R&D stock is positive and significant but coefficient of paten stock is negative and insignificant. Furthermore R&D stock dummy's coefficient is positive and patent stock dummy's coefficient is negative, however they are both insignificant.

Table 4.4 **Market Value Regression(Before 2008)**

	Dependent Variable: ln(Market Value)				
	1 **FE**	**2** **FE**	**3** **FE**	**4** **FE**	**5** **RE**
ln(Total Assets)				0.484***	0.785***
				(5.51)	(17.42)
ln(R&D Stock)	0.359***		0.368***	0.337***	0.283***
	(3.56)		(3.63)	(3.38)	(3.67)
ln(Patent Stock)		0.00174	-0.0211	0.0123	0.0463
		(0.03)	(-0.31)	(0.18)	(1.05)
No R&D stock Dummy	0.0942		0.104	0.151	0.289**
	(0.76)		(0.84)	(1.23)	(2.59)
No Patent Stock Dummy		-0.147	-0.188	-0.0819	-0.0425
		(-1.05)	(-1.35)	(-0.59)	(-0.36)
R&D Persistence Dummy					-0.0792
					(-0.48)
Year Dummies 2003-2007	YES	YES	YES	YES	YES
Constant	1.933***	2.105***	2.008***	-0.146	-1.499***
	(19.93)	(16.66)	(13.67)	(-0.35)	(-6.10)
N	871	871	871	871	871
R^2	0.552	0.544	0.553	0.571	0.683
Adjusted R^2	0.452	0.443	0.452	0.474	0.564

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Similar to previous regressions, total assets are added to equation, and its coefficient is positive and significant. Both R&D stock and patent stock have positive coefficients, but coefficient of Patent stock is insignificant. Coefficients of R&D stock and patent stock indicators are both insignificant. In final equation, there are four fundamental differences from whole sample market value equation which are insignificant coefficient for patent stock, positive coefficient for R&D stock dummy, insignificant coefficient for patent stock dummy and insignificant coefficient for R&D persistence dummy. In fact, it is not remarkably different. Signs of coefficients are same except R&D stock dummy. Merely, some of the coefficients just lost their significance. In next sub-chapters, I used some other independent variables in order to see effects of abrupt R&D changes, industry differentiation, R&D incentives and foreign shareholders.

Abrupt Changes in R&D

Since rapid changes in R&D expenditures are more visible and they can affect market values of companies, this can be a stock selection method for investors. In previous chapters I investigated effects of R&D stock on market value. In this part, I compare effects of persistent R&D and abrupt R&D on market value. In order to identify abrupt R&D, I calculated growth rates of R&D expenditures by using differences of natural logarithms. Then I summed up average of these growth rates with their standard deviation. I named growth rates greater than this value as abrupt R&D and assigned a dummy variable which is 1 for abrupt R&D and 0 otherwise. I added this dummy into market value regression without changing any other variables. Effects of other variables do not change and abrupt R&D dummy has an insignificant coefficient under these circumstances. In addition, I used abrupt R&D dummy with other specifications and its coefficient is still insignificant. Hence, I can conclude that persistent R&D is a better indicator than abrupt R&D for market value.

R&D Incentives

In 2008, R&D support law, which provides many benefits to R&D spenders, is passed by Turkish government. Thus, some firms increased their R&D activities and some of them identified their previous operating activities as R&D activities in order to benefit from the privileges. In order to avoid this effect I used a dummy variable named as R&D incentive dummy which is 1 for years after 2008 and 0 otherwise. I found that R&D support law does not significantly affect market value of the companies. Also, I had used observations before 2008 in order to avoid effects of financial crisis and results were very similar to full observation regressions. Thus, results of regression of observations before 2008 and R&D support dummy give same conclusion.

Industry Differences and Foreign Shareholders

Being in different industries and having foreign shareholders can be effective on market value of companies. Initially, since there are different levels of competition in different industries, effects of technological indicators on market value can vary in different industries. Secondly, having foreign shareholders can affect market value because of technological advancements of foreign companies. In order to find whether there are such effects or not, I added industry dummies and percentage of foreign shares in all shares. There are 25 industries in this study and 25 dummies were added to differentiate these industries. In addition to that, I analyzed big industries such as building materials, food and textiles separately and results were very similar. Moreover, percentages of foreign shareholders were taken from Public Disclosure Platform’s company information database. Both these two dummies do not have any significant effect on market value of companies. It can be said that industry differentiation and connection to foreign companies do not have an effect on market value.

Chapter 5: Using Innovation Indicators for Portfolio Selection

So far I investigated effects of technological indicators on performance indicators of companies. In this chapter, I will make a portfolio selection exercise using results from previous chapter. The idea of this chapter is that a company has an investment potential if its technological ability is not recognized by the market. The results of study by Cincera et al. (2009) show that in most cases, the R&D portfolios values (top R&D investing firms of the sample analyzed) are higher than the corresponding figures at the aggregated level (all shares stock or sector), hence indicating that the firms of the R&D portfolio are outperforming most of the other firms in a given stock market or sector. In order to determine these companies in this study, I developed a model which calculates value of a company according to its patent size, R&D expenditures and R&D intensity. The technological value, which is forecasted market value of a company by using technological indicators, is compared to actual value, which is value of the company observed in the market. A company is considered as undervalued, if its technological value is greater than its actual value. An undervalued company has an investment potential. On the contrary, a company is considered as overvalued, if its technological value is less than its actual value. It means that value of an overvalued company is not supported by its technological ability.

R&D stocks and patents are intangible assets. I have shown that firms with higher R&D stocks and patents enjoy higher market value in the stock market. If such technological capabilities are not taken into account by investors, they can potentially be used to devise portfolios that will outperform common indices or mutual funds, etc. In this part of the study, market value model used in previous chapter was applied to stocks of ISE manufacturing companies. Coefficients calculated from market value regression were written in equation and variables' values were used for identifying technological market value of a stock. Before calculation, it is better to have a look development of Manufacturing Sector. Market Value of Manufacturing Sector companies has increased over the years. Manufacturing sector's average market value can be seen in the figure below. Excluding 2008 and 2011, average market value has increased in all years. Falls in these two years are related with economic crises.

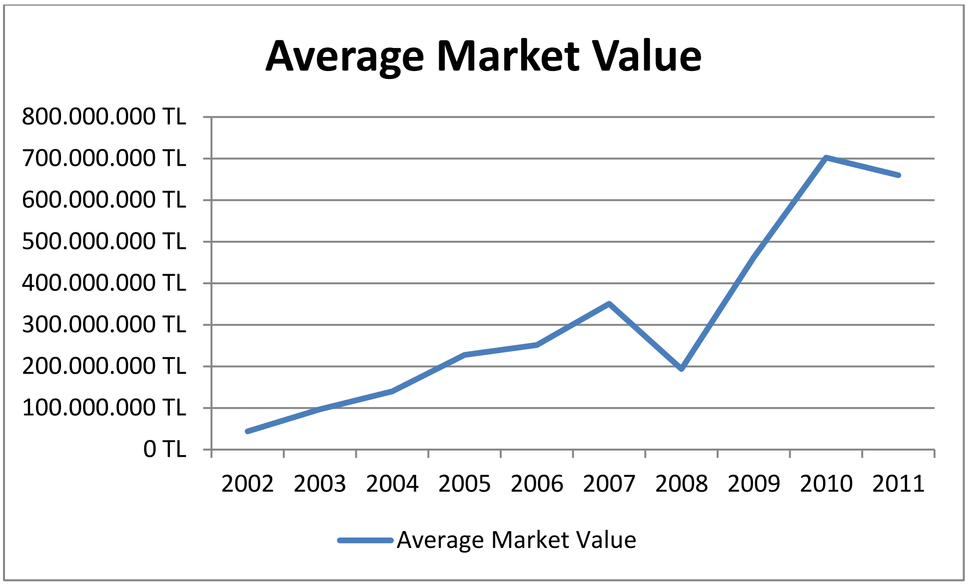

Figure 5.1: Average Market Value of Manufacturing Sector Firms

For the portfolio selection exercise, I take estimated coefficients from Table 4.3 Column 5 which is as follows:

$$ln\binom{Market}{Value}_{it} = -0.5 + \ 0.85\, ln(Total\ Assets) + \ 0.35\ \ ln(R\&D\ Stock)$$

$$+\ 0.08\ \ ln(Patent\ Stock) - \ 0.12\, I(R\&D\ Stock = 0)\ -\ 0.34\, I(Patent\ Stock = 0)$$

$$-\ 0.59\, I(R\&D\ Persistence)\ +\ \sum_{t=2003}^{2010} \delta_t\, .\, I(year = t) \qquad (5.1)$$

Technological market values of each stock were calculated as fitted values and then they are compared with actual market values of stocks with respect to formula below for years 2002 to 2011. The idea behind the portfolio selection I adopt as follows: I calculate the fitted value for market value equation given above. I call this value as the firm's technological market value. Then for comparing these two values I used a ratio named comparison ratio, technological market value divided by actual market value.

$$Comparison\ Ratio = \frac{Technological\ Market\ Value}{Actual\ Market\ Value} \qquad (5.2)$$

Comparison ratio calculates investment potential of a stock. Higher the comparison ratio means higher the investment potential. It means that a company, with a high comparison ratio, is technologically able one and its' potential was not recognized by the market yet. Comparison ratios for each year were put in descending order and then first 20 stocks were chosen as the portfolio of next year. The table showing stocks each year's portfolio can be seen below.

Table 5.1 Stocks in Technology Portfolio for each year

2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ADANA	ADEL	AFYON	AFYON	AFYON	AFYON	AFYON	AFYON	ATEKS	ARCLK
ADEL	AKALT	AKALT	AKALT	AKALT	AKALT	AKSA	ASLAN	BERDN	ASUZU
BANVT	CEMTS	AKSA	AKSA	AKSA	AKSA	ARCLK	ATEKS	BRKO	ATEKS
CELHA	DENTA	BAKAB	ASLAN	ASLAN	ASLAN	ASLAN	BAKAB	BRMEN	BOSSA
DENTA	DEVA	BFREN	BAKAB	BAKAB	ATEKS	ATEKS	BERDN	BURCE	BRMEN
DEVA	ECILC	CBSBO	BERDN	BERDN	BAKAB	BAKAB	BRMEN	CBSBO	CBSBO
ECILC	EREGL	DEVA	BISAS	BISAS	BERDN	BERDN	CBSBO	DYOBY	DERIM
ECYAP	ERSU	DITAS	CBSBO	CBSBO	BISAS	BRMEN	DERIM	EMKEL	DESA
EMKEL	FENIS	EMKEL	DITAS	ECILC	BOSSA	CBSBO	DESA	EPLAS	DYOBY
EREGL	GENTS	EPLAS	ECILC	ESEMS	BRMEN	EGSER	DYOBY	ESEMS	ECILC
ESEMS	GUBRF	FENIS	FENIS	FENIS	CBSBO	EMKEL	EGSER	FRIGO	EGSER
FENIS	IDAS	GENTS	FMIZP	FMIZP	DARDL	ESEMS	EPLAS	GEDIZ	EPLAS
GENTS	KLMSN	KLMSN	GENTS	GEDIZ	ECILC	FRIGO	ESEMS	GEREL	ESEMS
IDAS	KRDMA	KOZAA	IDAS	KLMSN	FENIS	GEDIZ	GEDIZ	GOLDS	GOLDS
KUTPO	KUTPO	KUTPO	KLMSN	KUTPO	FMIZP	MAKTK	GOLDS	PRTAS	IDAS
MEMSA	PARSN	MAKTK	KUTPO	MAKTK	GEDIZ	PRTAS	PRTAS	SERVE	PRTAS
PETUN	PETUN	MUTLU	MAKTK	MEMSA	KUTPO	SKTAS	SKTAS	USAK	USAK
PINSU	PINSU	PARSN	SKPLC	PRTAS	MAKTK	USAK	USAK	VESTL	VESBE
PNSUT	PNSUT	SKPLC	SKTAS	SKTAS	VESTL	VESTL	VKING	VKING	VESTL
SKTAS	SKTAS	SKTAS	SODA	VESTL	YATAS	YATAS	YATAS	YATAS	YATAS

In order to test that if there is a problem of choosing same stocks all the time, how many times on average a stock takes place in portfolio was calculated. There are 10 different portfolios and 20 stocks in each these portfolio. It means that it must be 200 choices on aggregate. Out of 200 choices, there are 66 different stocks in this study which means that a stock exists in a portfolio approximately 3 times on average. It is not a concentrated choice when compared to 10 portfolios.

The portfolios of each year consist of 20 stocks and equal capital is paid for each stock. For instance, if there is 1000 TL as capital, there are 50 TL investments in each stock. Each year's portfolio is converted into cash at the end of the year and then the money is used as capital at the beginning of the next year for the new portfolio.

Figure 5.2 shows the comparison between each year's portfolio return and ISE100 index return. In the figure, it can be seen that technology portfolio makes more return than ISE100 index in 8 years out of 10. In addition to that, return of 2012 is calculated as the return until November 12. It is a meaningful result that technology portfolio is better than ISE100 index in 80 percent of years in the study. Moreover there is a correlation between technology portfolio and ISE100 index, since they have positive and negative returns in same years. Average return of technology portfolio is 50 percent while it is 30 percent for ISE100 index.

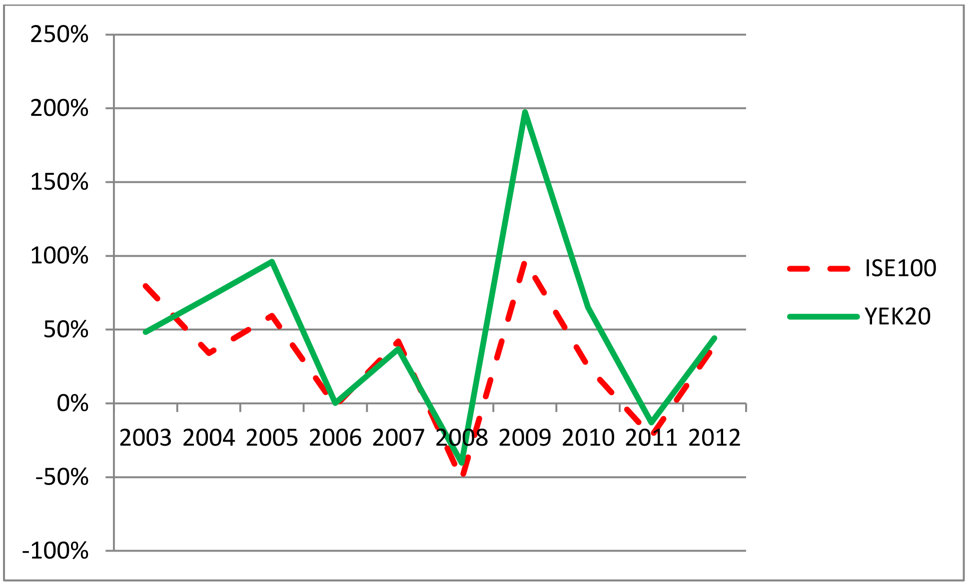

Figure 5.2: Comparison between technology portfolio and ISE100 index

In order to see success of technology portfolio much better, the figure 5.3 was prepared. The figure shows that the change of 1000 TL capital in ten years when it is invested in technology portfolio, ISE30 index, ISE100 index or ISE technology index. As it can be seen from the figure 1000 TL invested in technology portfolio reaches to approximately 25.000 TL while 1000 TL invested in ISE100 or ISE30 indexes reach to nearly 7000 TL. Furthermore, ISE technology index reaches only 3500 TL in ten years. The fact that technology portfolio is approximately four times greater than ISE100 and ISE30 indexes in ten years makes this study more meaningful.

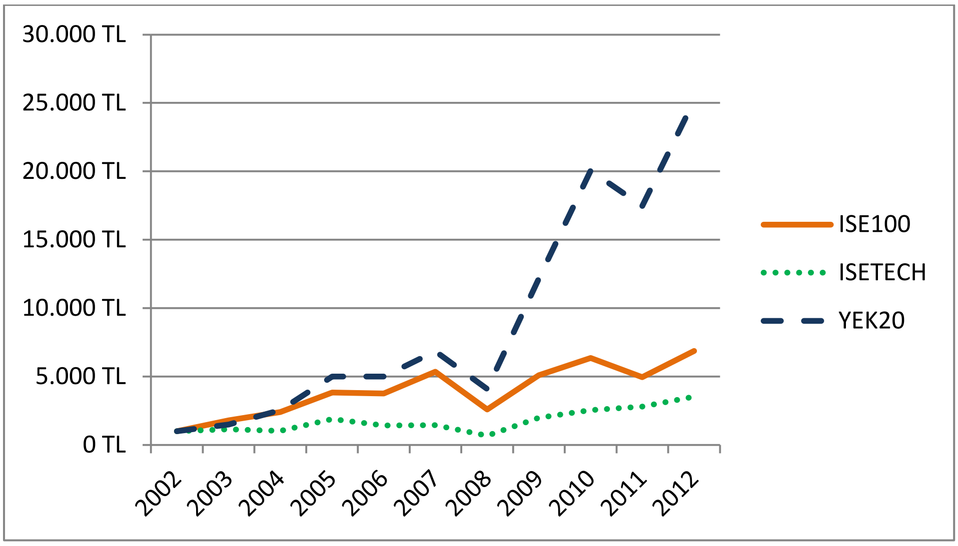

Figure 5.3: Change of 1000 TL invested in different portfolios in ten years

ISE100 and ISE30 indexes move very similar, in fact after ten years investment activity, 1000 TL capital invested in ISE100 becomes 6881 TL and same capital invested in ISE30 becomes 6894 TL. Thus, only ISE100 index is used in the figure. There is only 13 TL difference between these two indexes in ten years. It is obvious that being able to make a return which is approximately four times of these indexes is a good result in a market that there are too many similarities between indexes. Figure 5.4 is daily version of Figure 5.3.

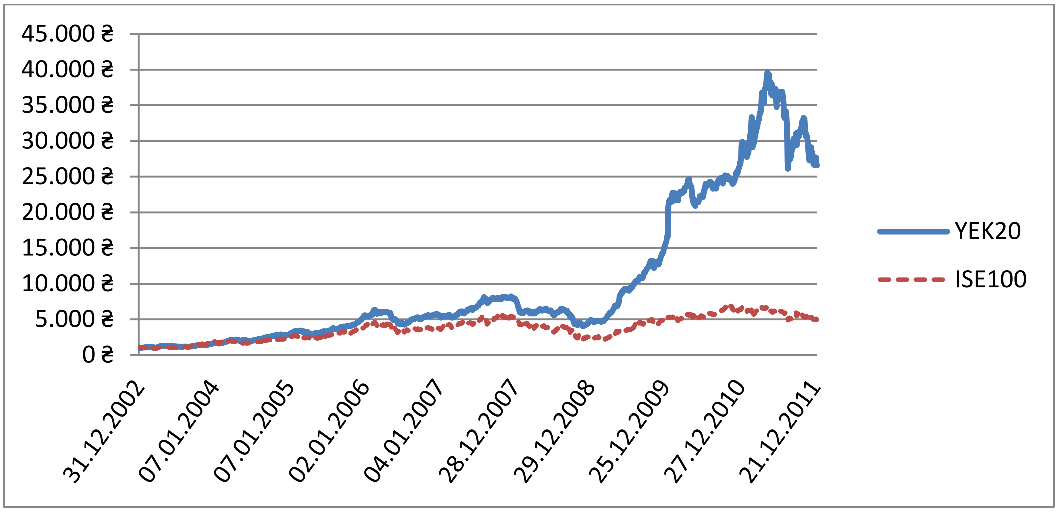

Figure 5.4: Change of 1000 TL invested in different portfolios in ten years (daily)

Chapter 6: Innovation and Stock Return Volatility

In this chapter, after examining effects of innovation performances on economic performances, I will investigate whether innovation has an effect on volatility or not. In order to do that, I look at the relationship between idiosyncratic stock return volatility and innovation indicators. It is possible that R&D and volatility affect each other via different mechanisms. Firstly, firms may be reluctant to invest in R&D during turbulent times, and secondly R&D activities may improve expected value of companies, thus increase their volatility. It is known that R&D expenditures may respond to risk differently than other forms of investment such as capital inputs. On the other hand, R&D expenditures themselves may mitigate risk by signaling future profitability to investors and through direct effects on future favorable market outcomes.

There are various alternatives for measuring stock return volatility. One can look at the standard deviation of daily returns over the year, look at the ratio of maximum and minimum returns in a year, or get fitted volatility from a Garch specification. Firstly, a standard deviation show how much variation exists from the mean and standard deviation of a serial is calculated by taking square root of its variance. Secondly, ln (max/min) is dividing maximum value of a serial to minimum value of same serial and taking natural logarithm of the result. These two methods are simple and practical to use. Garch method is slightly more complex than previous methods and it has some different specifications in it. I calculated stock return volatility with these three methods, but I use Garch specification since its results are superior to the others'. Thirdly, the fundamental idea behind Garch is that volatility is a function of lagged squared returns and lagged variances. A Garch(1,1) model lags on only one squared return and only one variance. With these caveats in mind, I prefer to use a Garch volatility series rather than the more crude indicators of volatility described above. I first extract the daily volatility in each of the stock return series as fitted values from a Garch (1, 1) process. For each of the 154 firms in the sample, I estimate the following Garch (1,1) specification. Garch (1,1) has three parts. Each is a weighting factor multiplied by, correspondingly, the long-run variance, a single lagged return squared, and a single lagged variance. The specification can be expressed as:

$$y_{it} = \mu + u_{it}$$

$$\sigma_{it}^2 = \mathrm{Var}\ (u_{it})$$

$$(\sigma_{it})^2 = \gamma\ (V_L) + \alpha\ (u_{it-1})^2 + \beta\ (\sigma_{it-1})^2 \qquad (6.1)$$

Where; V_L is long-run variance, u^2 is the most recent squared return and σ^2 is the most recent variance. Alpha, beta and gamma are all weights and their sum should be equal to one. After calculating volatility values for each stock I started the analysis by applying simple regressions with volatility, R&D, patents and other relevant controls. I used fixed effects and random effects methods in the equation below.

6.1. Determinants of Stock return volatility via Single Equation Panel Data Analysis

The determinants of stock return volatility are analyzed according to Equation 6.2.

$$\ln(grcvol)_{it} = \beta_0 + \beta_1\, Return + \beta_2 \ln(R\&D) + \beta_3 \ln(Patent\ Counts)$$
$$+\beta_4\,(Sales\ Revenue) + \beta_5 I(R\&D = 0) + \beta_6 I(Patent\ Count = 0)$$
$$+ \sum_{t=2003}^{2010} \delta_t \,.\, I(year = t) + \mu_i + u_{it} \qquad (6.2)$$

Where; R&D stands for annual R&D expenditure (flow), return is annual return of a stock, grcvol is stock return volatility, I (statement) is an indicator that takes a value of one when the statement in parenthesis is true, , μi is permanent firm-specific effect and u_{it} is usual error term.

Table 6.1 reports the results of volatility regressions. R&D expenditures and Patents are regressed on stock return volatility separately. Then they are used in the same equation together. Finally Sales Revenue was added to model. These regressions are conducted by using fixed effects method. Additionally, two equations are also regressed with random effects method.

Annual return of the stock has positive and significant coefficient in all equations which indicates that risk-return trade-off is present. It means that the higher return, the higher volatility. R&D expenditures' coefficient is negative and significant in first equation. Hence, investing in R&D makes companies more stable. However R&D dummy has also negative but insignificant coefficient. Patents owned in related year decreases volatility just like R&D expenditures. Nevertheless, coefficient of patent dummy is negative. It means that having no patent flow in a year decreases volatility of that year. When R&D expenditures and patents are regressed on stock return volatility together, results do not change. Signs and significances of their coefficients are same.

Table 6.1 **Volatility Regressions**

	Dependent Variable: ln(Stock Price Volatility)					
	1 **FE**	**2** **FE**	**3** **FE**	**4** **FE**	**5** **RE**	**6** **RE**
Annual return of stock	0.287*** (16.25)	0.289*** (16.38)	0.289*** (16.43)	0.290*** (16.60)	0.284*** (16.04)	0.286*** (16.27)
ln(R&D expenditures)	-0.0215* (-2.50)		-0.0190* (-2.21)	-0.0150 (-1.75)	-0.0245** (-3.01)	-0.0130 (-1.60)
ln(Patents)		-0.0588*** (-3.71)	-0.0559*** (-3.52)	-0.0500** (-3.17)	-0.0522*** (-3.40)	-0.0387* (-2.55)
ln(Sales Revenue)				-0.0618*** (-4.46)		-0.0886*** (-7.83)
No R&D dummy	-0.186 (-1.73)		-0.160 (-1.49)	-0.129 (-1.21)	-0.211* (-2.05)	-0.105 (-1.03)
No Patent Dummy		-0.0415 (-1.56)	-0.0434 (-1.64)	-0.0419 (-1.59)	-0.0387 (-1.46)	-0.0330 (-1.26)
Year Dummies 2003-2010	YES	YES	YES	YES	YES	YES
Constant	-1.906*** (-17.21)	-2.076*** (-70.38)	-1.872*** (-16.51)	-1.648*** (-13.36)	-1.809*** (-16.08)	-1.562*** (-13.71)
N	1466	1466	1465	1463	1465	1463
R^2	0.358	0.360	0.365	0.376	0.365	0.374
Adjusted R^2	0.278	0.279	0.284	0.295	0.148	0.284

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Technological indicators are not the only variables that affect stock return volatility. Company size also may affect it. Sales revenue as a size indicator was added to model. Its coefficient is negative and significant which means that higher sales make stock prices more stable. The coefficients of technological variables do not change after this addition. Only coefficient of R&D expenditures loses its significance and coefficient of patents has a lower significance.

Using random effects method, in fifth and sixth equations, signs of all coefficients are same with fixed effects method. Without sales revenue variable, annual return of stock, R&D expenditures, patents and R&D dummy variables have significant coefficients. Nonetheless, after adding sales revenue to the equation, coefficients of R&D expenditures and R&D dummy lose their significance.

It can be concluded that technological investments increase stability and decrease volatility of stocks. This result is logical since the companies in this study are not high-technology firms. Also having higher company size decreases stock return volatility.

6.2. Determinants of Stock return volatility via Panel Data Vector Autoregression

Both R&D and volatility can affect each other. To see this two-way relationship, I adopt a VAR specification for Panel Data by using Stata Codes presented in study of Love and Ziccino (2006). The reason behind using vector autoregression is being able to see simultaneous effects. The fundamental equation used in this part is below.

$$\begin{pmatrix} RD\ Expenditures \\ Volatility \end{pmatrix} t = \begin{pmatrix} \alpha_0^1 \\ \alpha_0^2 \end{pmatrix} + \begin{pmatrix} \beta_{11}\beta_{12} \\ \beta_{21}\beta_{22} \end{pmatrix} \begin{pmatrix} RD\ Expenditures \\ Volatility \end{pmatrix} t\text{-}1 + \begin{pmatrix} u_1 \\ u_2 \end{pmatrix} \qquad (6.3)$$

In order to see fixed and random effects separately two sub-methods which are mean-differenced equation and levels equation were applied to data. Mean-differenced equation shows R&D variation by differencing the mean and including permanent effects. On the other hand, levels equation shows R&D without differencing the mean. First method provides us to keep R&D variation in the regression. Various variables are used in vector autoregression model. The results of first mean-differenced equation are reported in Table 6.2.

Table 6.2	Volatility Regressions **Method:** Panel Data Vector Autoregression(mean-differenced equation)		
Equation 1	**Dependent Var:ln(Stock Price Volatility)**		
	Coefficient	Standard Error	t-value
Ln(Stock Price Volatility)	0.232	0.312	0.742
Ln(R&D Expenditure)	-0.002	0.007	-0.223
Equation 2	**Dependent Var: ln(R&D Expenditure)**		
	Coefficient	Standard Error	t-value
Ln(Stock Price Volatility)	-4.721	3.078	-1.534
Ln(R&D Expenditure)	0.619	0.080	7.720

As seen in the table, first lags of variables affect current values positively and R&D expenditure's coefficient is significant, but coefficient of stock return volatility is insignificant. Furthermore R&D expenditure and stock return volatility affects each other negatively although coefficients are insignificant. It means that higher R&D expenditure makes stock price less volatile and higher uncertainty makes firms reluctant to invest in research and development.

Table 6.3	Volatility Regressions **Method:** Panel Data Vector Autoregression(levels equation without differencing)		
Equation 1	**Dependent Var: ln(Stock Price Volatility)**		
	Coefficient	Standard Error	t-value
Ln(Stock Price Volatility)	0.991	0.006	163.770
Ln(R&D Expenditure)	-0.004	0.002	-2.690
Equation 2	**Dependent Var: ln(R&D Expenditure)**		
	Coefficient	Standard Error	t-value
Ln(Stock Price Volatility)	-0.438	0.059	-7.397
Ln(R&D Expenditure)	0.883	0.013	67.166

The previous regression was applied by using levels equation without differencing. Results in Table 6.3 are very similar to Table 6.2. Coefficients of first lag variables are positive and also significant. Additionally, R&D expenditure and stock return volatility affects each other negatively just like in previous regression. However in this equation, their coefficients are significant.

Same variables were applied in vector autoregression by using two lags. Results from this analysis are reported in Table 6.4. Signs of coefficients are still same for both lags. Previous values of variables affect themselves positively and their coefficients are significant. Although they are insignificant, coefficients of stock return volatility and R&D expenditure are negative when they are regressed on each other. Conclusion made for previous regressions is valid also for this equation.

Table 6.4 **Volatility Regressions**
Method: Panel Data Vector Autoregression(levels equation without differencing)

Equation 1	**Dependent Var: ln(Stock Price Volatility)**		
	Coefficient	Standard Error	t-value
Ln(Stock Price Volatility) (t-1)	0.687	0.030	23.083
Ln(R&D Expenditure) (t-1)	-0.002	0.003	-0.828
Ln(Stock Price Volatility) (t-2)	0.313	0.031	10.146
Ln(R&D Expenditure) (t-2)	-0.001	0.003	-0.206
Equation 2	**Dependent Var: ln(R&D Expenditure)**		
	Coefficient	Standard Error	t-value
Ln(Stock Price Volatility) (t-1)	-0.002	0.221	-0.008
Ln(R&D Expenditure) (t-1)	0.679	0.051	13.341
Ln(Stock Price Volatility) (t-2)	-0.395	0.224	-1.765
Ln(R&D Expenditure) (t-2)	0.230	0.051	4.502

I used more lags in these equations. Although signs of coefficients do not change, their standard errors increase so much that their significance decrease. The reason of this decrease can be multicollinearity between lags of variables. It is known that R&D expenditures is a highly persistent variable, hence it is collinear with its own lags. Instead of R&D expenditure, R&D dummy is used in next equation.

Table 6.5	**Volatility Regressions** **Method:** Panel Data Vector Autoregression(levels equation without differencing)		
Equation 1	**Dependent Var: ln(Stock Price Volatility)**		
	Coefficient	Standard Error	t-value
Ln(Stock Price Volatility)	0.990	0.006	163.566
R&D Dummy	-0.061	0.021	-2.926
Equation 2	**Dependent Var: R&D Dummy**		
	Coefficient	Standard Error	t-value
Ln(Stock Price Volatility)	-0.039	0.005	-8.081
R&D Dummy	0.848	0.015	55.445

Table 6.5 reports the results of levels equation using stock return volatility and R&D dummy. Very similar outcomes to previous equations are taken from this regression and all coefficients are significant. Previous lags of R&D dummy and stock price affect current values positively. Moreover, stock return volatility and R&D dummy affect each other negatively. This means that uncertainty makes firms reluctant to invest in R&D, and making R&D investment makes stock price less volatile.

Finally, patents were added to VAR equations. Results of this regression are in Table 6.6. All of the coefficients except one are significant as Table 6.6. Signs of coefficients are as expected. R&D expenditures and patents make stock price more stable and decrease volatility. Stock return volatility or uncertainty makes companies less willing to make R&D investment or patent appliance. Finally patents and R&D expenditures affect each other positively. Increased R&D investment causes owning more patents and more patents encourages firms to make more R&D expenditures.

Table 6.6 **Volatility Regressions**

Method: Panel Data Vector Autoregression(levels equation without differencing)

Equation 1	**Dependent Var: ln(Stock Price Volatility)**		
	Coefficient	Standard Error	t-value
Ln(Stock Price Volatility)	0.989	0.006	157.509
Ln(R&D Expenditures)	-0.004	0.002	-2.341
Ln(Patents)	-0.012	0.010	-1.178
Equation 2	**Dependent Var: ln(R&D Expenditures)**		
	Coefficient	Standard Error	t-value
Ln(Stock Price Volatility)	-0.401	0.061	-6.601
Ln(R&D Expenditures)	0.877	0.014	62.701
Ln(Patents)	0.179	0.082	2.197
Equation 3	**Dependent Var: ln(Patents)**		
	Coefficient	Standard Error	t-value
Ln(Stock Price Volatility)	-0.071	0.011	-6.275
Ln(R&D Expenditures)	0.010	0.003	3.034
Ln(Patents)	0.758	0.021	35.373

Using various methods and variables, the results show that in manufacturing industry of Turkey, increased technological activities of companies make stock prices less volatile. It also shows stability and profitability for the future. On the other hand, increased stock return volatility or uncertainty makes companies reluctant to invest in research and development.

Chapter 7: Conclusion

In this part, I will summarize detailed study from previous chapters. Investment in Research and Development and increased technological activities are crucial for companies, especially for manufacturing ones. Well-used technology improves companies' value and helps their development. Moreover, technological activities affect also performances of companies in financial markets.

This study has three fundamental objectives which are analyzing effects of innovative performance on market performance of firms, creating a portfolio by using technological indicators and investigating relationship between technological indicators and stock return volatility. As mentioned in fourth chapter technological indicators usually have positive and significant effects on market performance of companies. R&D intensity affects market to book ratio positively and significantly. Furthermore patent stock/R&D stock ratio has positive effect on market to book ratio but it is insignificant. Increase in R&D intensity also causes increase in price to earnings ratio. Third market performance indicator analyzed in chapter four is market value. It is affected positively by R&D stock, patent stock and size of the company. While analyzing market value performance of firms, some control variables such as no R&D stock and no patent stock dummies were used. Having no R&D stock or no patent stock decreases market performance of companies significantly.

I also investigated effects of industry differences, R&D incentives, abrupt R&D changes, and foreign shareholders. Related variables were added to models in order to see these effects. I found that industry differences, R&D incentives and having foreign shareholders do not have any significant effects. Moreover, having greater R&D stock is more effective than abrupt R&D changes.

The second part of the study is portfolio selection, using technological indicators. Coefficients calculated in market value regression were used in portfolio selection part. Technological (theoretical) market values which are fitted market values calculated by using coefficients from market value regression, were computed and compared with actual market values, values observed in the market. Companies having technological market values greater than actual market values were classified as undervalued companies. These undervalued companies were arrayed according to their investment potential and top twenty firms were used as a portfolio. The result was commendable. Portfolio created with technological indicators outperformed ISE 100 and ISE 30 indices. Actually, value of technological portfolio increased approximately four times greater than value of ISE indices in ten years.

I investigated effects of technological indicators on stock return volatility in the final chapter. Various methods such as fixed effects, random effects and panel data vector autoregression were used in order to determine these effects. Results show that technological indicators are negatively related with stock return volatility. It can be considered that technological advancements provide stability and profitability for the future and makes stock prices less volatile. On the other hand, increase in stock return volatility reduces technological activities. This means that uncertainty makes firms reluctant to invest in technology.

To sum up, technological indicators have direct effect on financial performance of companies as discussed in this study. The weakness of this study is limitations of patent data. Turkish patent data is not detailed enough. Thus it is not possible to classify patents according to their quality. Since data limitations exist in Turkey, I am planning to apply the methodology used in this study to U.S. data which is detailed enormously in order to get better results. Moreover, patent citations and science linkages can be used in order to identify patents according to quality.

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