Patent Thickets

An Empirical Study of Vicious Circles

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Executive Summary

In this thesis we measure the impact of patent thickets on US firm value in the period 1980-2004.

We combine patent data from NBER with firm-level financial data from Compustat, and conduct econometric fixed effects analysis on the consolidated panel dataset.

We find evidence that patenting is individually rational for firms, and that rival patenting and fragmentation of patent rights are detrimental to firm value. Subsequently, we analyze two distinct datasets: one covering discrete industries such as consumer discretionary & staples, and one covering complex industries such as IT. We find that firms in discrete industries are unaffected by competitor patenting, while firms in complex industries are impeded by patenting even from firms that are not direct competitors. Our results suggest that firms in complex industries are trapped in a prisoner's dilemma, that is, a common reduction in patenting would make everyone better off.

“As Sir Isaac Newton put it, each scientist "stands on the shoulders of giants" to reach new heights.

Today, most basic and applied researchers are effectively standing on top of a huge pyramid, not just on one set of shoulders. Of course, a pyramid can rise to far greater heights than could any one person, especially if the foundation is strong and broad. But what happens if, in order to scale the pyramid and place a new block on the top, a researcher must gain the permission of each person who previously placed a block in the pyramid, perhaps paying a royalty or tax to gain such permission? Would this system of intellectual property rights slow down the construction of the pyramid or limit its height?”

- Shapiro 2001, Navigating the Patent Thicket

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Part I

Introductory Remarks

Chapter 1 Introduction and Research Design

1.1 Motivation

Despite philosophical skepticism such as proposed by Aldous Huxley (1937): "*Technological progress has merely provided us with more efficient means for going backwards*", economists broadly agree that technological progress is a fundamental driver of economic growth (Solow 1956, Abramovitz 1956, Aghion, Howitt 2009, Romer 1994, Cameron 1996, Jaffe, Lerner 2011).

In the neoclassical growth model, first introduced by Solow (1956), technology is taken to be exogenous "manna from heaven", not affected by policy changes (Cameron 1996). This viewpoint is unsatisfying when trying to understand the complex system of innovation and growth in modern economies. As a result, endogenous growth models, where technological progress is an outcome of the economic system, have emerged (Grossman, Helpman 1991, Grossman 1993, Romer 1994, Aghion, Howitt 1990). In such setting, R&D is at the center of the model and creates technological spillovers that increase productivity growth and subsequent innovation. This is in line with the cumulative nature of modern innovation, and provides insight to how agents operate within the economic system. Acknowledging the central role of R&D investment and knowledge spillovers, it is natural to study the system of intellectual property and how it affects innovation and growth.

The patent system has been a leading instrument for governments, used to increase R&D incentives, and it is broadly recognized as a key component in technological progress and economic growth in the United States (Khan, Sokoloff 2001, Moser 2012, Galasso, Schankerman 2013).

There has always been discussions about the efficiency of the patent system, the 19th century "Sewing machine wars", the "agrarian patent crisis" and the post-war "railroad patent crisis" are examples where patenting has resulted in inefficiencies or temporary market breakdown (Lampe, Moser 2009, Chien 2012). Recently the critique from academics, policy makers and media have risen, and claims of a broken system that impede rather than an incentivize innovation have become commonplace (Federal Trade Commission 2003, Federal Trade Commission 2011, Jaffe, Lerner 2006, Bessen, Meurer 2008, Chien 2009).

When critics want to emphasize the poor quality of the US patent system, silly patents, such as "methods for swinging a swing" (US Patent No. 6,368,227) or "a method of combing hair over a bald spot (US Patent No. 4,022,227), are often used as evidence (Bessen, Meurer 2008). Though these exemplify issues at the patent office, more damaging is it, when patents of questionable validity are enforced in court. This is what happened when Amazon.com (NASDAQ:AMZN) in 1999 was granted a business-method patent for a "Method and System for Placing a Purchase Order via a Communications Network" (which effectively gave the company the exclusive right to let costumers make a purchase online with a single mouse "click") and later sued barnesandnoble.com (NYSE:BKS), claiming that the webpage's use of "Express Lane" purchasing was infringing the patent. The result was that B&N was forced to shut down their Express Lane service even before the company had the opportunity to try to prove that Amazon's patent was invalid (Jaffe, Lerner 2011). In a broader sense, researchers increased attention to "troll behavior"[1] indicate that for some companies, a patent strategy no longer relies on "freedom to operate" but rather "freedom to litigate" (Bessen, Ford & Meurer 2012, Bessen, Meurer 2012, Chien 2010, Lemley, Melamed 2013, Reitzig, Henkel & Heath 2007).

A related concern is that of the patent "thicket" defined by Shapiro (2001): "*a dense web of overlapping intellectual property rights that a company must hack its way through in order to actually commercialize new technology*". Complexity[2] and fragmentation of ownership rights may constrain firms from innovating without facing extensive licensing and holdup costs through bargaining difficulties and patent litigation. In the extreme case, the thicket might completely block access to some technologies, or stifle innovation by raising associated costs to the point, where it outweigh positive gains from conducting R&D (Galasso, Schankerman 2013, Cockburn, MacGarvie & Müller 2010). The US economy, with the IT sector in front, is growing evermore complex. This is ominous as both theoretical and empirical research indicate that the more cumulative and complex an industry[3] is, the greater is the risk of ending up in a patent thicket problem (Hall et al. 2012, Cockburn, MacGarvie 2011, Cockburn, MacGarvie & Müller 2010, Lemley 2013, Bloom, Schankerman & Van Reenen 2013, Galasso, Schankerman 2013, Hall 2004).

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[1] Excessive rent extraction from non-competitors through patent litigation and the threat of lockdown like barnesandnoble.com

[2] A product is complex if it as input draws on several, potentially patented, innovations (e.g. smartphones)

[3] We use the term Complex (discrete) industry as short for an Industry where the technology is complex (discrete).

Patent thickets were first debated regarding the semiconductor industry and the rise of software and business method patents (Hall, Ziedonis 2001, Hall, Ziedonis 2007, Ziedonis 2004). Today, it is most horribly exemplified in the smartphone industry. RPX Corporation (NASDAQ:RPXC) estimates a single smartphone to be covered by 250,000 patents and producers are continuously involved in infringement litigation (Chien 2012).

This is the reason many researchers have declared the patent system "broken" and called for patent reforms or even abolition of the system (Lemley 2007, Lemley 2012, Macdonald 2004, Jaffe, Lerner 2011, Denicolò, Halmenschlager 2010, Chien 2009, Chien 2012, Schultz, Urban 2012, Bessen, Meurer 2008). Others find that the patent system is working well (Merges 2006), and the (until recently) Director of the USPTO David Kappos argued in November, 2012 (Kappos): "*…it's important to note that, during the so-called smartphone patent wars, innovation continues at breakneck pace. A system like ours, in which innovation is happening faster than consumers can keep up, cannot fairly be characterized as "broken". Nor can it be said that the U.S. is just a receiver of all this innovation. Most of the innovation is taking place right here. Broken? What?*" In this thesis we set out to investigate patent thickets further.

1.2 Research Question

The purpose of our research is to further examine the patent thicket problem. We want to know if the existence of overlapping and fragmented intellectual property rights is pernicious to economic growth. We want to look at the performance across a wide section of firms and industries, but also analyze the effect on complex and discrete industries separately. With empirical analysis we want to identify how firms are affected by patent thickets, and whether firms are trapped in a prisoner's dilemma.

To operationalize this aim, we investigate the following research question:

How does patenting affect firm value?

This question is broken down into four sub-research questions (SRQ):

- SRQ 1. *Do firms benefit from accumulating knowledge assets?*
- SRQ 2. *Do patent thickets affect firms negatively?*
- *SRQ 3. Are pernicious effects of patent thickets worse in complex industries?*
- SRQ 4. *Are firms trapped in a prisoner's dilemma?*

We study the impact on market valuation of US firms in the period 1980-2004. SRQ 1-4 are proposed as hypotheses in *Chapter 4 Hypotheses*. Through empirical analysis SRQ 1-3 are verified, and SRQ 4 is verified for firms in complex industries. All results are presented and discussed in *Chapter 9 Results*.

1.3 Contribution to Literature

With more than 100 peer-reviewed papers, academics have over the last decade granted much attention to "the patent thicket problem" (Hall et al. 2012). But despite a growing concern, econometric evidence is limited (Noel, Schankerman 2013). In this section we discuss the novelty of our research by comparing data and methodology to earlier empirical work on patent thickets.

Two of the most important empirical studies are Hall and Ziedonis (2001) and Ziedonis (2004), both focusing on the US semiconductor industry in the 1980s and 1990s. Hall and Ziedonis (2001) indirectly answer the patent paradox and the increase in patenting in the 1990s with defensive patenting behavior. Ziedonis (2004) is the first to use a direct measure of fragmentation, and finds that greater fragmentation of patent rights increase patenting. Both these papers focus only on how patent thickets affect firms' patenting behavior.

A newer paper, which also has similarities to our research, is that of Noel and Schankerman (2013) on strategic patenting in the software industry. Like our research, they study the impact of a patent thicket and strategic patenting on firm market value. But where Hall and Ziedonis (2001), Ziedonis (2004) and Noel and Schankerman (2013) only look at a single complex industry (Semiconductor and Software), we conduct econometric regression analysis on all US companies[4] as well as on complex industries and discrete industries.

Compared to previous research, our research also contributes in the following ways: First, we use a newer dataset dating up to and including 2004. Second, we develop a new fragmentation index[5] that not only include backward citations, but also patent count and number of claims. Third, we introduce a segmented approach to industry classification, we investigate how rival patenting in both operating and technology space affects market value. This is somewhat in line with Bloom, Schankerman and Van Reenen (2013), who use patent-data to create technology proximity, where we rely on firm-based industry proximities. Our analysis also differentiate from previous literature on a variety of small parameters, we address these as they become relevant.

On the conceptual side we develop an easily comprehendible framework "A Vicious Circle" to explain the interrelated effects that constitute a patent thicket.

1.4 Delimitations

In this section we address the limitations of our thesis. Despite a short presence in academic research, *patent thickets* are a wide topic with an extensive literature within economics and commercial law. We discuss commercial law at various points through the paper; however we must stress that our modest contribution is primarily within the field of economics and the empirical study of patent thickets, as we are not experts in law. For a detailed discussion of law related to patent thickets we refer to Merges & Duffy (2011).

Our study is conducted on US firms in the period 1980-2004; as such our empirical results do not extend to the patent systems in Europe or elsewhere, though empirical research indicate that patent

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[4] All companies available and with sufficient data from Compustat, discussed in *section 6.2*
[5] Inspired by the index originally invented by Ziedonis (2004)

thickets also impose negative effects in Europe and Japan (Hall et al. 2012, Hall et al. 2013, Von Graevenitz, Wagner & Harhoff 2012, Cockburn, MacGarvie & Müller 2010).

Our data does not cover the period that underlie recent debates over patent trolls in the smartphone industry, although we argue that it has similarities with high tech industries in our dataset. To our knowledge there are no related empirical studies of patent thickets with newer US data.

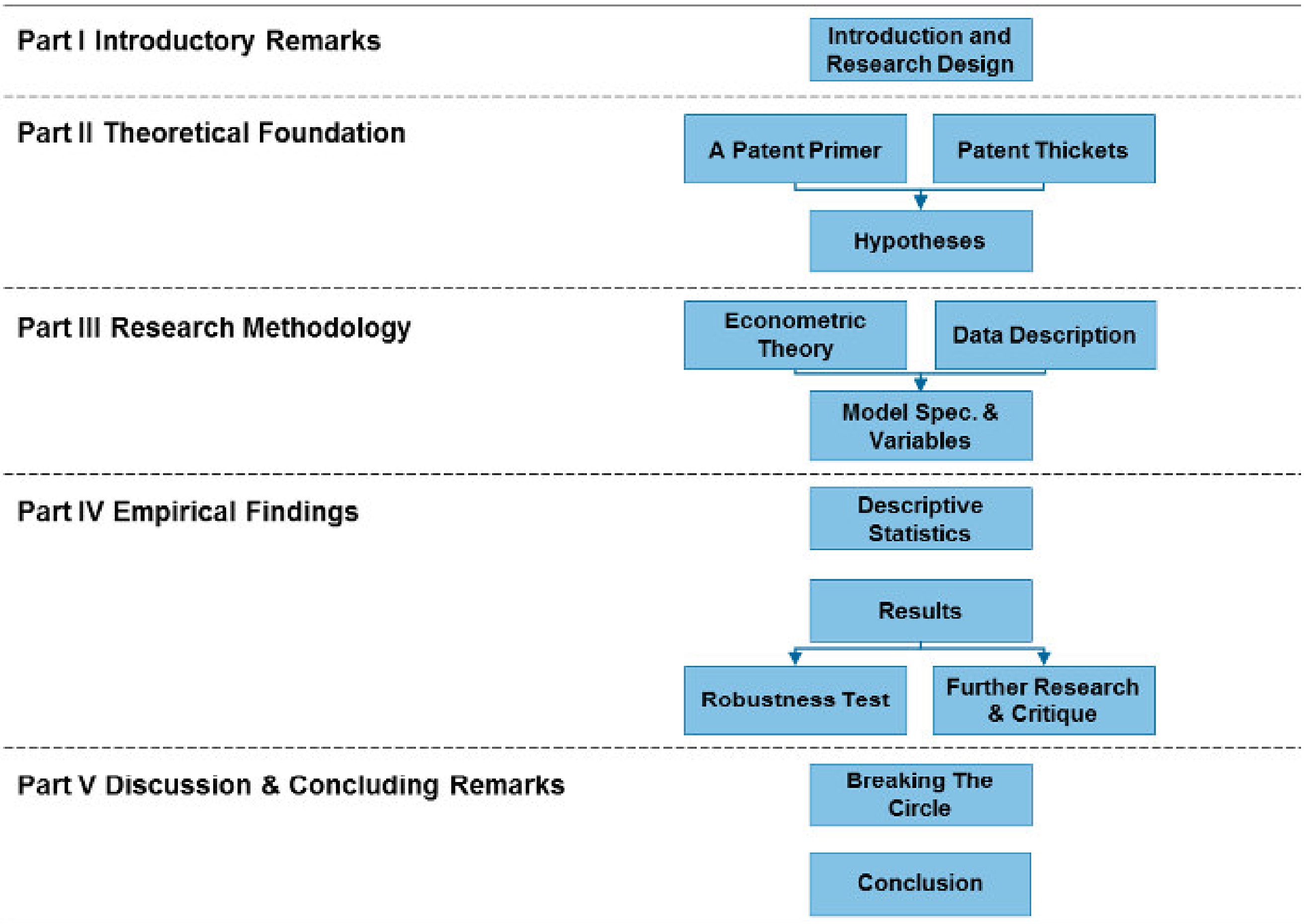
Innovation and intellectual property is a wide area of research; our focus is on the effect of patent thickets. We only glance at knowledge spillovers and we do not address other/related topics regarding intellectual property rights.

Patent laws and interpretations are dynamic. Reforms and critical court decisions are made throughout our data period and afterwards. Though we discuss some of these policy changes, we do not directly address them in our data analysis, and policy recommendations based on our empirical findings and earlier research, might already be outdated.

1.5 Structure

This thesis is divided into five parts. Part I, our introductory remarks, is concluded with this section. In Part II we lay the theoretical foundation for our research; the economics of patents and patent thickets, summarized into testable hypotheses. In Part III we explain our research methodology; the econometric theory, data processing and our model. In Part IV we present empirical findings and address robustness of empirical results and further research. Finally in Part V we discuss how to improve the patent system through policy changes, and conclude on our work.

Figure 1.1: Thesis Structure



Part II

Theoretical Foundation

Chapter 2 A Patent Primer

This chapter serves as an introduction to patents and the economic system around it. We do not survey all economic literature on patents, but rather introduce the basic principles of a patent system and related issues that researchers have debated. The following structure is imposed: *2.1 Origins of Patents*; *2.2 Requirements of the Modern Patent, the PTO, Federal Circuit and ITC*; *2.3 The Basic Tradeoff*; *2.4 Length and Breadth*, *2.5 Modeling Innovation,* and *2.6 The Patent Paradox*.

2.1 Origins of Patents

The concept of a patent does not come from modern economy. The Venetian Statute of 1474 is often considered the first example of patent law, where the Venetian Republic offered exclusive rights to inventors who brought new technologies to the city (Moser 2012). Patent laws were later adopted by other European governments in order to attract foreign technology, but unlike the patent system we know today, patents were given to people who brought technology into the country, rather than inventors (David 1992). Furthermore it is not clear that the motivation was to enhance innovation or economic growth, this is illustrated by the early British patent system, where the monarch used patents to raise revenue through high fees or grant monopolies over trade in specific goods to friends of the Crown (Khan, Sokoloff 2001).

In 1623 the English Parliament passed Britain's Statute of Monopolies, which specified that patents should be used to reward inventors. It transferred the right to grant a monopoly from the King to the Parliament, though several features still reflected royal privileges, thus casting doubt whether the system spurred innovation (Scotchmer 2004, Moser 2012, Khan, Sokoloff 2001). On the other hand, a landmark book by North and Thomas (1973) on the impact of property rights on economic development in Europe argues, that this shift was critical for the way of thinking that later encouraged the Industrial Revolution in England.

The world's first modern patent system dates back to 1793. In the early days of the United States Constitution Congress was instructed to: "*To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries*" (Longley 2014). This clause is the foundation of the patent system we know today, and is often recognized as the corner stone in technological progress and economic growth in the United

States (Moser 2012, Khan, Sokoloff 2001). There are (at least) two issues related to this conclusion. First, it is extremely difficult to fully comprehend the counterfactual situation, a world where a patent system had never been invented. Second, given that intellectual property rights did play an important role in technological progress and economic growth in the United States and Europe, there is no telling if the system at hand is efficient?

A major drawback of the first patent act was that a patent could be obtained for practically anything, even if the invention had already been patented or had been known and used for many years (Merges 1999). In the next section we explain the requirements of a modern patent.

2.2 Requirements of the Modern Patent, the PTO, Federal Circuit and ITC

Since the 18th century, the US patent system has legally evolved in many directions (Moser 2012). This section introduces the basic mechanisms behind granting, appealing and enforcing patent rights. First in subsection *2.2.1 Information from Patents* we explain three information measures related to patents. Second, in subsection *2.2.2 The United States Patent and Trademark Office* we explain how an innovation is patented under the United States Patent and Trademark Office. Third, in subsection *2.2.3 Litigation and the Court of Appeals for the Federal Circuit* we discuss patent enforcement and the role of the Court of Appeals. Fourth, in subsection *2.2.4 The International Trade Commission* we briefly explain the role of the ITC, a parallel court system.

2.2.1 Information from Patents

In this subsection we briefly explain *patent claims*, *backward citations* and *forward citations*, as these measures are used throughout our thesis.

A patent consists of a number of claims, which define the boundaries of patent protection, hence when a company infringes a patent, it is infringing one or more claims of the patent. Lately it has been criticized that patent claims, especially in complex technologies such as software, are defined too broad (Bessen, Meurer 2008).

In the same way as academics cite earlier literature, a patent also contains citations on related previous patented innovations. These citations are called *backward citations*. The number of backward citations indicates how many different components the technology builds on. When information on backward citations is collected, it is possible to compute a corresponding measure called *forward citations*, which is the number of subsequent patents that cite a given patent. Hence the number of forward citations provides information on how many future innovations build on a given innovation, which can be interpreted as patent value (Scotchmer 2004).

2.2.2 The United States Patent and Trademark Office

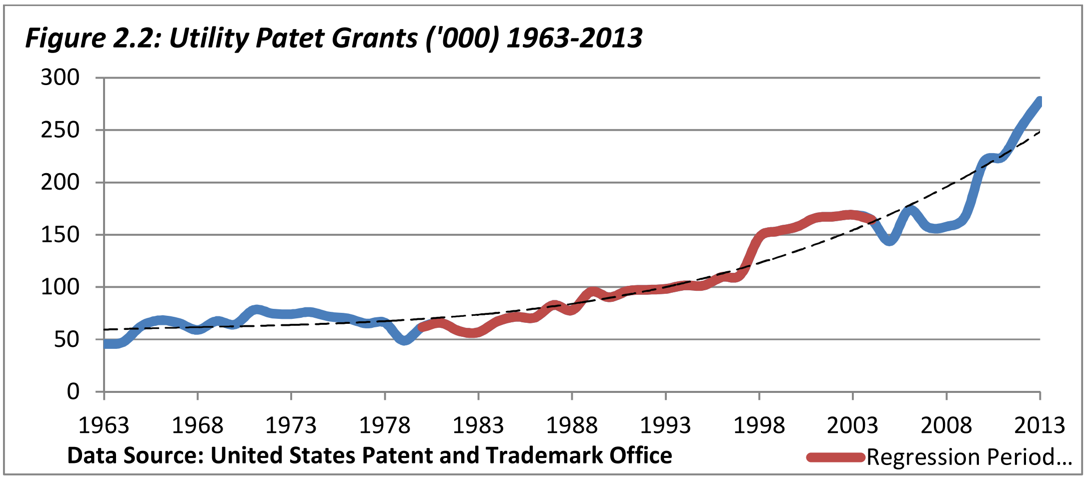
For an invention to be patentable under The United States Patent and Trademark Office (PTO), it must meet four basic requirements (Scotchmer 2004):

Figure 2.1: Patent Requirements

Subject matter	An invention must either be (1) a machine, (2) a manufactured product, (3) a composition made from two or more substances, or (4) a process for manufacturing objects.
Utility	The invention must have some positive benefit to society.
Novelty	The patent's content (teaching) must differ from what has been previously used in a publication.
Non-obviousness	If the invention would be obvious to somebody with "ordinary skills" in the given technology, the invention cannot be patented.

Once a patent has been granted, it works in many ways like regular property. It can be traded, rented (licensed), transferred or abandoned (Rockett 2010). The lifespan of the patent is 20 years from application date, but can be abandoned earlier, by ending payments of regularly maintenance fees (Lemley 2001).

Practically the above requirements are implemented to secure, that a patent "makes sense" in a technological, economic and political way. However the requirements (and other aspects of the patent law), leave room for interpretation, which have given rise to much debate about what should and should not be patentable (Jaffe, Lerner 2011, Bessen, Meurer 2008).



In the period 1980-2004[6] the average increase in patent grants pr. year was 5.44 percent (Figure 2.2). This is often referred to as "the patent explosion" (Jaffe, Lerner 2011, Hall 2004). The PTO has been criticized for being too lenient with patent granting, hence having some responsibility for the increase (Jaffe, Lerner 2011). Beside the PTO, the Court of Appeals has been blamed for being too pro-patent (Hall, Ziedonis 2001, Hall 2004, Matthew D. Henry, John L. Turner 2006, Jaffe, Lerner 2011). We turn to this next.

2.2.3 Litigation and the Court of Appeals for the Federal Circuit

If a patent holder is of the opinion that somebody is infringing her patent, she can initiate a lawsuit. The initial litigation is undertaken in a district court, and before 1982, appeals were heard in various circuits, which had different interpretations of the patent law. Involved parties would race for appeal lawsuits in patent-friendly or patent-skeptical districts depending on which side of the table they were on, and because the Supreme Court rarely stepped in, the decision depended to some degree on which lawyer filed the documents first (Jaffe, Lerner 2011). As a result Congress stepped in and established the centralized appellate court in 1982, *the Court of Appeals for the Federal Circuit* (CAFC) to replace the 12 Circuit Courts of Appeal (Merz, Pace 1994). Though the CAFC streamlined patent law interpretation, it has been widely criticized for being too pro-patent and facilitating loose standards for

[6] Regression period

granting, resulting in many weak patents[7] (Hall, Ziedonis 2001, Hall 2004, Matthew D. Henry, John L. Turner 2006, Jaffe, Lerner 2011). Coinciding with *the patent explosion*, there has been a *litigation explosion*, as the annual number of patent lawsuits filed in the US has more than doubled during the 1990s (Bessen, Meurer 2005).

Researchers argue that the introduction of the much criticized software and business method patents (Bessen, Meurer 2008, Chien 2012) can be attributed to a critical decision by the CAFC in the State Street Bank v. Signature Financial Group case in 1998, where the CAFC held that business methods could be patented, which caused an explosion in business method patents (Jaffe, Lerner 2011).

2.2.4 The International Trade Commission

Parallel to the district courts, the International Trade Commission (ITC) can provide injunctive relief against imports that infringe domestic intellectual property (Chien 2011). The original purpose was to protect domestic firms from foreign piracy, but the ITC is increasingly overlapping with US district courts creating duplicative litigation[8], and have been criticized for being pro-plaintiff and anti-foreigner (Chien 2009). Interesting in relation to our study is that the ITC does not award damages but purely injunction relief, meaning that the infringing company must pull products from the market, which generally decrease welfare and have dramatic impact on the infringer's business (Chien, Lemley 2012). We return to discuss injunction and damages in detail in *section 3.2*. Next we look at the basic economic idea of granting a patent, and the tradeoff that follows with it.

2.3 The Basic Tradeoff

Regulators find themselves in a time consistency problem, ex ante they want to spur innovation by giving special privileges to innovators, but ex post welfare would benefit from distribution of the technology (Motta 2004).

Introducing patents remove the problem of inconsistency by granting innovators monopoly rights for a fixed period over their invention (Tirole 1988). However the antitrust concerns of monopoly have left

[7] Weak patents, is a term used for patents that, if taken all the way through the court system is likely to be invalidated. Weak patents are common; see e.g. Lemley & Shapiro (2005).
[8] Around two thirds of ITC cases have a district court counterpart (Chien 2011)

regulators to strike a balance between antitrust and innovation interests (Maurer, Scotchmer 2006, Adelman, Juenger 1975).

The basic theoretical models of patents pose a tradeoff between increased economic incentives for innovation through strong patent protection rights and a deadweight loss in consumer surplus by underutilization as a result of monopoly pricing power (Nordhaus 1969).

Another virtue of patents as an incentive mechanism is, that the decision making is decentralized. Anyone with a good idea can invest time and money in that idea with hope of future payoff without negotiating with an authority for grants. In this way the reward is linked to the social value of the invention, and inventors (and investors) will compare social value to social costs when deciding whether to invest. Furthermore decision makers themselves bear the risk of misjudgment, so no one should object to the development of the invention (Scotchmer 2004).

2.4 Length and Breadth

Recognizing the existence of a tradeoff between innovation incentives and a deadweight loss, researchers have studied which length (duration) and breadth (strength) combinations that provide sufficient incentives while minimizing welfare loss (Nordhaus 1969, Gilbert, Shapiro 1990, Scherer 1972, Klemperer 1990). Legally a patent is granted a duration of 20 years from the date of filing, but truncation can occur if patent owners fail to pay the maintenance fees of the patent (Scotchmer 2004). The breadth of a patent is legally not as clear cut, and depends on patent claims and the *doctrine of equivalents*, which states that the patent claim covers any product that: "*does the same work in substantially the same way to accomplish substantially the same result*" (Scotchmer 2004).

It is straightforward to bridge the legal term of length into economics, whereas breadth is less obvious. Scholars have traditionally measured breadth as either "how costly it is to find a noninfringing substitute for the protected market" or "how similar a product must be to infringe a patent" (Scotchmer 2004).

Given two policy levers (length and breadth), economists have discussed what the optimal tradeoff is. The simple answer is: the combination that minimizes the deadweight loss under the condition that sufficient incentive for innovation is created. But as with most answers in economics "*it depends*".

Cornelli & Schankerman (1999) find that the optimal balance depends on firm specific R&D productivity; Klemperer (1990) finds that it depends on product market characteristics, and so forth. Discussing the optimal balance of length and breadth is beyond the scope of our thesis, but later on we cover issues related to patents with long lives, where ownership rights shift hands, as well as patents with diffuse breadth boarders, resulting in overlapping technology rights. For now, it is important to note that intellectual property design is a complex matter and that theory suggests that the "one size fits all" model might not be optimal (Bessen, Meurer 2008, Scotchmer 2004).

2.5 Modeling Innovation

We now turn to some specific setups for innovation. First we present a simple setup known as a *patent race*. Secondly we look at a more complicated setup with *cumulative innovation*.

2.5.1 Patent Race and Licensing Agreements

A *patent race* refers to a setup where two or more innovators compete in discovering an innovation and securing it from imitation through a patent (Jensen 2009).

A simple setup introduced by Dasgupta and Stiglitz (1980) is an incumbent monopolist and a potential entrant, who compete in R&D to innovate a cost reducing technology modeled as a memoryless Poisson process. The first firm to successfully innovate is granted an infinitely lived patent, resulting in either a monopoly with lower costs (if incumbent wins race) or an asymmetric duopoly.

Two effects are at play in such a model; the *efficiency effect* dictates that the monopolist has more to gain from innovation, because monopoly profits are higher than the total competitive profit. For small innovations this effect is dominant and incentivizes the monopolist to do the most R&D. The *replacement effect* dictates that higher levels of R&D will move the discovery forward and hence fasten the monopolist's replacement. For large innovations, that potentially could make the entrant a new monopolist, this effect dominates (the efficiency effect is = 0 since the entrant would also gain monopoly power), which results in the entrant doing the most R&D. In general the theory concludes that competition in R&D yields more innovation, possibly even more than what is socially optimal (Belleflamme, Peitz 2010).

A patent race hereby pinpoints an important downside of a decentralized decision making system; because of the inefficiency of allocating resources to innovate the same thing twice. Among others, Abramowicz (2007) discuss the use of a centralized auction system as an alternative to the patent race.

Once the outcome of the patent race has been decided the winner can choose whether to license the innovation to competitors. In a simple Cournot setup Katz & Shapiro (1985) show that cost reducing technologies will be licensed out if gains are minor. However a significant innovation will be kept exclusively to utilize the product market advantages, hence the diffusion fall short of social optimum where all technologies are licensed. Sakakibara (2010) confirms empirically that only patents of low value will be licensed. Furthermore Kamien, Oren & Tauman (1992) show in both a Bertrand and Cournot setup that depending on the magnitude of the innovation, a nonproducing innovator will license to one or more firms. We discuss licensing in a complex and fragmented patent system later on. For now we note, that left unregulated, firms will not always be able to reach an optimal licensing agreement.

2.5.2 Cumulative Innovation and Spillovers

In reality rather than a single race, firms participate in a continuum of races where products are constantly succeeded by newer versions (Schumpeter 1942). In this context the notion of spillovers become relevant. The existence of spillovers is well documented (Jaffe 1989, Noel, Schankerman 2013). Generally spillover is a term used for the externality effect one R&D project may have on another, but also patent grants may generate spillovers by disclosing innovations. The economic literature distinguishes between internal spillovers that relate to the firm’s other innovation activities and external spillovers that exert a positive externality effect on other firms including competitors. Belenzon (2006, 2012) develops a model where companies decide on their investment strategy based on how good they are at internalizing spillovers, hereafter using patent citation data he shows that companies that are better at internalizing spillovers have higher return on investments. Intuitively the existence of a positive externality on a competitor should reduce R&D and patenting incentives; Schneider (2008) shows in a two period model that firms may turn to secrecy rather than patenting in order to have an advantage in a later patent race, and Moser (2011) shows that historically secrecy has been a common strategy when competitors were not able to reverse engineer the end product.

However it may also be the case that patent holders benefit, as spillovers flow the other way, when a competitor imitates (Bessen, Maskin 2009).

When filing a patent firms automatically disclose the content of their innovation, this facilitates technology diffusion, and in principle makes the technology a public good as soon as the patent expires (Motta 2004, Tirole 1988). In reality two opposing effects may affect the firm specific cost of disclosure. First, patents do not provide perfect protection, as it is often possible to work around a patent, with the information disclosed, giving competitors an option to “free ride” (Tirole 1988, Moser 2011). Second, the patent applications often only partially disclose the innovation (Jaffe, Lerner 2011) and Scotchmer (2004) argues that companies rarely bother to learn from newly issued patents.

Spillovers may skew the distribution of research, in particular innovations that have low stand-alone value but high spillovers (such as basic research) are at risk of being foregone and hence should be subsidized (e.g. a university conducting public funded basic research) (Spence 1984). On a related note Chang (1995) shows how innovations that have low stand-alone value but high spillover effects should enjoy a broad protection, however his model does not account for R&D incentives of subsequent innovators.

Breadth and length of patent protection becomes more complicated when cumulative innovation is introduced; too broad a protection could inhibit a whole line of research by demotivating follow up innovations (Scotchmer 1991). O'Donoghue, Scotchmer & Thisse (1998) define lagging breadth that protects against the entry of inferior products, and leading breadth that protect from innovations that are only small improvements. They conclude that lagging breadth should be accompanied by leading breadth in markets that tend to have rapid turnover of power. Leading breadth can also be used to induce the optimal level of R&D (O'Donoghue 1998).

2.7 The Patent Paradox

It appears that firms in many industries consider trade secrets and early-mover advantages as the main means to get return on R&D investments, and in recent surveys managers claim that lead time and learning curves are more effective to protect intellectual property, than patents are (Belleflamme, Peitz 2010). This stands in contrast to the patent explosion observed since the mid-1980s[9], and is sometimes referred to as "the patent paradox" (Belleflamme, Peitz 2010). Hall & Ziedonis (2001) interviewed industry representatives in the semi-conductor industry and found that firms did not prioritize patents to protect R&D returns, but observed that their propensity to patent increased heavily since the mid-1980s.

Firms operating in complex and cumulative industries might constitute patent portfolios, which in aggregation have more value than their stand-alone value as these can be used as "bargaining chips" in licensing- and infringement negotiations (Belleflamme, Peitz 2010). This strategic accumulation of patent portfolios is a possible answer to the alleged "patent paradox".

Next, in *Chapter 3 Patent Thickets* we discuss this in further detail.

Chapter 3 Patent Thickets

Recently there has been a growing discussion about the emergence of patent thickets as explanation to the patent paradox (Parchomovsky, Wagner 2005, Hall, Ziedonis 2001). Patent thickets are explained as a phenomenon that occurs in complex technologies, where products, as input, require many different components that have scattered ownership. These components have overlapping functionality, and may be used in many different products (Hall et al. 2012).

In this chapter we look at incentives and behavior that cause patent thickets to form. In *3.1 Complex Industries and Royalty Stacking* we discuss the preconditions for the development of a patent thicket. In *3.2 Litigation Risk* we discuss the risk and costs of being litigated. In *3.3 Strategic Patenting* we discuss firms' strategic reactions, when operating under the preconditions. In *3.4 Inappropriate Grants at the Patent Office* we explain issues with incentives and resources at the PTO related to patent prosecution[10]. Finally in *3.5 A Vicious Circle* we sum up and tie the problems together to get a full picture of the interconnected problems that form patent thickets.

[9] See *Figure 2.2*

[10] The process of granting patents

3.1 Complex Industries and Royalty Stacking

Complex technologies are composed of modular technology components, which are generally patented, have overlapping functionality and may be combined in various ways to create a variety of different products (Hall et al. 2012). In contrast a discrete technology is one where patents are tightly linked to specific products (e.g. chemicals) (Cohen, Nelson & Walsh 2000, Von Graevenitz, Wagner & Harhoff 2012, Hall 2004). By this definition complex technologies are naturally cumulative; new innovations make room for new ways to combine existing components potentially increasing the number of products exponentially. We shall in the following define a complex (discrete) industry as an industry where the technology is complex (discrete).

Information technology is an often-referred complex industry (Cockburn, MacGarvie 2011, Noel, Schankerman 2013, Merges 2006), but Hall et al. (2012) notes that industries in general are becoming increasingly complex. Since many components are combined in each product, a firm operating in a complex industry is likely to require licensing agreements with many different parties. This introduces an economical problem known as royalty stacking. Royalty stacking stems from the fact that intellectual property rights of value-adding product inputs are spread across several owners. Royalty stacking consists of two well-known phenomena from industrial organization; Double marginalization (Spengler 1950) and the Cournot compliments effect (Cournot 1838).

3.1.1 Double Marginalization

Double marginalization occurs because an upstream monopolist (patent owner) license on a per unit basis to a downstream monopolist (innovator). The innovator, when pricing his innovation, will not internalize the negative effect on the patent owners demand. This leads to a double markup that decreases total output below that of an integrated monopolist and hence decreases welfare (Spengler 1950, Varian 2010). Monopolies are not a necessary condition for the double marginalization effect to cause welfare loss, the presence of market power at both upstream (imagine a patent that requires a cost to bypass) and downstream (having a positive margin) is sufficient to create a welfare loss (Lemley, Shapiro 2006).

3.1.2 Cournot Compliment Effect

The Cournot compliment effect occurs when several patentees do not take into account the negative externality effect that their licensing fee has on the demand of other patentees. The Cournot compliment effect is growing in the amount of patentees that have a claim on component patents, and results in a total licensing fee higher than what a monopolist controlling all component patents would charge. Hence, also the Cournot complement effect decrease welfare and more so the more fragmented the ownership structure of the components (Cournot 1838, Shapiro 1989, Shapiro 2001). Heller & Eisenberg (1998) look at the Cournot complement effect in the context of patents, and compare it to the tragedy of the commons[11]. They call it the tragedy of the anti-commons; a resource is underused because of excessive property rights all of which claim a share of the pie.

3.1.3 Inadvertent Infringement

The sheer amount of patents make it complicated for a firm ex ante to establish whether their technology is infringing patents, therefore the risk of infringement is likely risen (Macdonald 2004, Blind et al. 2006, Lemley 2001, Quillen, Webster 2001, Shapiro 2001). The risk of inadvertently infringing is highest for firms in complex industries with technical components; but firms may also infringe a patent on a trivial innovation (Reitzig, Henkel & Heath 2007, Merges, Nelson 1990). Overlooking patents or tacitly using patented technology exposes firms to risk of litigation. In the next section we look at patent litigation, and why this poses a serious threat to the producing firm.

3.2 Litigation Risk

We now discuss the potential consequences of a firm getting caught in litigation over an infringed patent. A litigation process may require substantial management and economic resources, which impact operations and product development, particularly in small firms (Chien 2012a, Tucker 2011). Only about 1.5 percent of patents are ever litigated and only about 0.2 percent ends up in court. Most disputes are settled in confidentiality before the jury cast a decision (Lemley 2001). In order to properly understand why cases are so often settled, we discuss the two potential remedies that can follow from

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[11] In the tragedy of the commons a scarce resource is overused because it is not protected by property rights, e.g. overfishing of the oceans.

ending up in court: preliminary injunction and damages.

3.2.1 Preliminary Injunction

A plaintiff has the option to ask for preliminary injunction, shutting down the revenue stream of the infringing product before it has been established whether there is an infringement[12]. This can be a severe holdup cost for a firm in a competitive industry, particularly if products have a short life cycle or large early-mover advantage. A direct competitor may want a preliminary injunction to avoid further damage in the competitive landscape; however a non-competing patentee can still benefit from an injunction threat, to obtain bargain power over royalty fees, even in the case of weak patents (Lemley, Shapiro 2006, Shapiro 2006, Chien 2010). Lanjouw & Lerner (2001) show that injunction, even from an invalid patent, pose a particularly large threat to financially weak companies, as it is often difficult to obtain financing for litigation. Even financially strong firms may decide not to challenge a weak patent. This is because it would have to bear the cost of litigating, and invalidating the patent will serve as a positive externality on competitors that also pay licensing fees (Farrell, Shapiro 2008, Lemley, Shapiro 2005, Lemley, Shapiro 2006).

A groundbreaking Supreme Court decision in 2006 between eBay and Merc. Exchange L.L.C. largely ended the preliminary injunction practice as extortion in the federal court system (Chien, Lemley 2012). Majority Judge Thomas in the unanimous Court opinion asked that lower courts assessed the four-factor test before granting injunctive relief: "*(i) it has suffered an irreparable injury; (ii) remedies available at law are inadequate to compensate for that injury; (iii) considering the balance of hardships between the plaintiff and defendant, a remedy in equity is warranted; and (iv) the public interest would not be disserved by an injunction*" (Thomas 2006). This decision has considerably decreased preliminary injunctions. It is important to have a balanced approach; a categorical refrain from injunction will lead to "false positives" where appropriate injunctions are not granted (Denicolò et al. 2008). A credible threat of injunction can still be achieved at the ITC, where the four-factor test does not apply. The ITC has seen a sharp rise in patent cases since 2006 (Chien, Lemley 2012, ITC 2013).

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[12] We distinguish between preliminary injunction, which can be granted at the beginning of a case, and permanent injunction, which is granted at the end of a case won by the plaintiff. Preliminary injunction is the interesting remedy when discussing patent thickets.

3.2.2 Damages

In the US patent system, the plaintiff has the option to ask for damages for "lost profits" if the infringement of the patent has had consequences for the business conduct of the patentee, or (if lost profits cannot be claimed) reasonable royalties (35 U.S.C. 284). The literature suggest that there is a tendency to overcompensate patentees, an example is inventor J. H. Lemelson v. Mattel who was awarded a "reasonable royalty" of almost US$ 25M (4,5% of truck toy sales) in 1990 due to the infringement of a coupling patent used in toy trucks (Reitzig, Henkel & Heath 2007). From an economic standpoint it would have been relevant to include figures such as plaintiff's ability to market a similar product in the absence of infringement, or the infringers ex ante cost of replacing the infringed technology. Patents can easily claim more value than they contribute, as many innovations in a product may not even be patented (Reitzig, Henkel & Heath 2007). Courts base reasonable royalties on what has previously been agreed between firms voluntarily, this approach suffers from a circular logic since agreements between firms outside the court naturally is based on what they expect would happen in court (Lemley, Shapiro 2006). Also the publicly available information on agreements is biased: First, because royalty agreements are affected by injunction threat. Second, because royalty information is usually only disclosed if required by law, when the settlement is material to the bottom line of either party. This scenario is more likely when settlement royalties are high (Lemley, Shapiro 2006). Lastly, the court may triple damages if it finds that infringement was done willfully; this was however not the case in the J. H. Lemelson vs. Mattel case, which demonstrates that even unintended infringements can result in large damages (Reitzig, Henkel & Heath 2007).

Having laid the foundation of a patent thicket: a complex industry with royalty stacking and strong patent rights; we proceed to discuss the strategic reactions of firms operating under these circumstances.

3.3 Strategic Patenting

In this section we discuss the strategic reactions, of firms within complex and fragmented industries, to the threat of royalty stacking and litigation.

3.3.1 Freedom to Operate, Patent Arms Race

We use the much referred Semiconductor industry to showpiece what can happen in complex technologies. In the 1980s semiconductor firms would largely ignore their potential infringements. Firms would typically negotiate a cross licensing agreement with one or two big players e.g. IBM (NYSE:IBM), and a holder of an infringed patent would turn the blind eye to the infringement, as he probably also infringed patents (Levin 1982). This mutual tolerance has been challenged through the '90s and '00s by an agenda to secure freedom to operate by negotiating cross-licensing agreements on patent portfolios (Bessen 2003). Firms mass up large stocks of potentially blocking patents that can be used as bargaining chips in cross-licensing negotiations, to tip the balance of royalty fees in their favor. It is not the individual patent that bring value, but their collection into portfolios (Parchomovsky, Wagner 2005). This is a different motivation from firms in discrete industries, that largely patent for traditional reasons such as excluding competitors (Cohen, Nelson & Walsh 2000). Hall & Ziedonis (2001) confirms that in complex technologies, it is the number of patents rather than the value of the individual patent that is relevant for defense; also semiconductor firms acquire patents more aggressively if patents complementary to their products have fragmented ownership (Ziedonis 2004). Lemley (2001) refers to a discussion with a general counsel at a major semiconductor firm; they would index their patents against competitor products, and assert them if approached by a competitor. This phenomenon is known as defensive patenting or "patent arms race". However in recent years the arms have increasingly been used offensively in the courts, this we turn to next.

3.3.2 Freedom to Litigate, Patent Trolling

Having amassed large arsenals of patents, firms easily get tempted to extract rents from their patent property by asserting them against others, especially when they do not operate in the business themselves[13]. Texas Instruments (NASDAQ:TXN) was one of the first firms actively adopting a patent mining strategy for extracting rents from their intellectual property rights (Shapiro 2001, Galasso, Schankerman 2010). Indeed one of the biggest patent owners in the US, IBM (NYSE:IBM) already in 2001 had a yearly licensing revenue exceeding USD 1.5 Billion (Hosteny 2006). There is often

[13] One example is the "CIF Licensing" division of General Electric (NYSE:GE) (Chien 2010)

asymmetry between parties when patents are litigated for rent extraction. Individuals who do not sell products or older firms with large patent portfolios that are no longer significant in the marketplace, are not interested in cross-licensing, and may instead litigate operating firms (Lemley 2001). However litigation takes place between all combinations of litigators and infringers (Chien 2009).

A big debate is rising in academia and the media about the emergence of so called Patent Trolls[14] (Reuters 2014, NY Times 2012, Chien 2010, Allison J.R., Lemley M.A., Walker J., 2011, Lemley, Melamed 2013, Schwartz, Kesan 2012). Patent trolls are companies whose business model is to exploit the weaknesses of patent thickets by acquiring patents and asserting them against operating companies, threatening with injunction and large legal costs, eventually forcing a licensing settlement (Reitzig, Henkel & Heath 2007, Lemley, Melamed 2013). Trolls do not produce and are therefore not vulnerable to counterclaims of infringement (Chien 2009). Patent trolls may operate through shell companies that have low discovery costs related to putting forward documents for a case. They exploit this cost advantage by making the case complex and hence expensive for a defendant to find and put forward the required documents (Patent Fairness 2013). Operating as a subsidiary also makes the cost of bankruptcy low. This incentivizes defendants to settle, as there is no monetary compensation to be gained by winning in court (Chien 2012b).

Patent trolls are also known for taking drastic measures in their rent extraction efforts; one being litigating customers of alleged infringes (Tucker 2011, Patent Fairness 2013), another being to file a vague claim that their patent is being infringed and using the subsequent discovery period as a “fishing expedition” to build the case while the defendant suffers from discovery costs and holdup (Patent Fairness 2013). The trolls allege that their business model is to help entrepreneurs claim value from their innovation (Bessen, Ford & Meurer 2012). Distinguishing between innovative operating firms and patent trolls that tax innovators can be impractical; many firms operate in a grey zone, where troll activities are only part of their business. Our focus is not to label certain companies “trolls” rather we are interested in trolling behavior, that is, excessive rent extraction from patents through litigation and threat of holdup. In the same way a monopolist clearly presents effects of market power, a patent troll

[14] A more polite term for patent troll is a Patent-Assertion Entities (PAE).

pinpoint issues related to trolling behavior. We use the term patent troll to describe a firm that practice trolling behavior.

It is likely less costly for a patent holder to look for possible infringing products, than for a producer of a complex product to look for all possible patents the product could infringe (Reitzig, Henkel & Heath 2007). This suggests an asymmetry between trolls and producers favoring the trolls and making it burdensome ex ante for producing firms to avoid litigation risk. Even if a firm searches prior art before committing to components in its product, it may not be protected against litigation. Applicants that file for a patent exclusively in US are not forced to disclose the content of the patent until grant. A so called continuation regulation ensures that an applicant can forfeit his application while submitting a new, claiming the same innovation and filing date as the original application. In this way a patentee can keep his patent submerged like a submarine until he decides it is worth pursuing litigation (Lemley 2001, Quillen, Webster 2001). Submarine patents have traditionally been used to take industries by surprise, a patentee would ask for continuations on an approved patent; each time asking for a slightly wider patent, and adjusting it to the trends in the industry. Then several years later, after billions of dollars have been invested in a seemingly unpatented technology, the submarine would emerge, demanding large royalties (Lemley, Moore 2004). Regulation was adjusted in 1999 to limit the abuse of submarine patents; generally firms have to disclose the content of their patent 18 months after filing, and instead of covering 17 years from grant, they cover 20 years from application (Lemley, Moore 2004). However as long as a company commits to only filing its patent in the US, it is not required to disclose the content of the patent, and even if it does, continuations may result in a broader patent once granted, wherefore others cannot determine their liability for present actions (Merges, Duffy 2011). A patentee might also find it valuable to sacrifice some years of a patents life to be able to surprise a mature industry – the result is that submarine trolling is still a viable strategy (Reitzig, Henkel & Heath 2007, Lemley, Moore 2004, 35 U.S.C. 122). Furthermore the willfulness regulation described in *subsection 3.2.2* disincentivizes a thorough search because of the risk of triple damages.

Hall & Ziedonis (2007) show that the risk of being litigated has increased in the Semiconductor industry, but do not find evidence that semiconductor firms themselves have become more aggressive.

Chien (2009) show that the proportion of litigation cases involving trolls[15] has increased from 22% to 36%[16] in the period 2000-2008. This support the idea that the increased risk found by Hall & Ziedonis (2007) is caused by trolling behavior. All litigation, whether from trolls or producing companies, works effectively as a tax on innovation (Shapiro 2001, Chien 2012b) and may reduce entry into an industry (Hall, Ziedonis 2007). Ironically, the effort of defensive patenting might have caused an increase rather than a decrease in litigation. This can be explained by trolling behavior and the fact that patents tend to shift hands when intellectual property rights are put on sale at "the arms marketplace" (Chien 2010, Reitzig, Henkel & Heath 2007).

Having discussed the motivation for firms to acquire vast amounts of patents we next proceed to analyze why aggressive patenting has not been stopped at the PTO.

3.4 Inappropriate Grants at the Patent Office

The PTO prosecutes patent applications, and has been accused of lenient interpretation of the guidelines (Scotchmer 2004). Schuett (2013) finds that the patent office has a moral hazard problem because compensation packages are based on the number of completed cases. Approving applications is less time consuming than rejecting, because the PTO has to document why the proposed patent is invalid (Lemley 2001), in fact the PTO can never finally reject an application, and a persistent applicant can file a broad patent involving many claims that would take up lots of time, giving the examiner every incentive to grant the patent (Allison et al. 2003, Lemley, Moore 2004). Sandburg (1999) estimates that on average 18 hours are spent reviewing a patent application, this includes reading the application that may cover several claims and reviewing prior art in a potentially technical field. This seems like a short time to deal with an important decision. The leniency at the patent office is self-reinforcing, as the number of patents grows so does search costs, which further reduce prior art search. The result is inappropriate overlapping patents that often do not meet the requirements of novelty and non-obviousness (Merges 1999).

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[15] She uses the term Non-Practicing Entities (NPEs), defined as *"a corporate patent enforcement entity that neither practices nor seeks to commercialize its inventions"*.

[16] Based on number of defendants, in high tech industry (hardware, software and financial inventions), contains both suits by Trolls and Declaratory judgment filed by a potential infringer in order to get certainty on the matter.

These “weak” patents would in principle be ruled invalid if taken all the way through the court system, but the threat of expensive litigation and potential injunction, ensures that settlement and extraction of royalties can take place. A similar problem arises when submarine patents are granted at a time where the patented innovation is widely used (Lemley 2001). Low quality examination also means that vague and overly broad claims will be allowed, i.e. patents with “fuzzy boundaries” (Bessen, Meurer 2008).

Software- and business method patents[17] have been heavily criticized for having fuzzy boundaries as they often have abstract claims and are prone to litigation (Bessen, Meurer 2008). Indeed some software patents (granted either by the PTO or at the CAFC) suffers from obvious flaws, such as a) abstract to the degree that even specialists cannot tell the boundaries b) too obvious (based on old technology) c) too broad, as it covers technologies not invented at the time of patenting (Bessen, Meurer 2008). Some argue that software patents are abstract by nature and therefore should not be patentable at all, others that only some business method patents are bad and that early adaption issues are still haunting the software industry[18] (Bessen 2011, Bessen, Meurer 2008, Merges 1999).

Surely a patent system that does not grant any invalid patents is utopia. The ideal is to avoid issuing invalid patents that could cost effectively be identified (Merges 1999). There are some advantages of a lenient approach at the PTO, as we saw in *section 3.2* the majority of patents are never litigated, hence a thorough review would not be cost effective for these patents. Resources are better spent if courts ask whether a patent should have been granted in the first place, instead of presuming that the PTO covers this (Lemley 2001)[19].

We have now discussed the four main drivers of a patent thicket; (i) a complex industry with royalty stacking, (ii) a strong patent system with risk of being litigated, (iii) strategic patenting incentives, and

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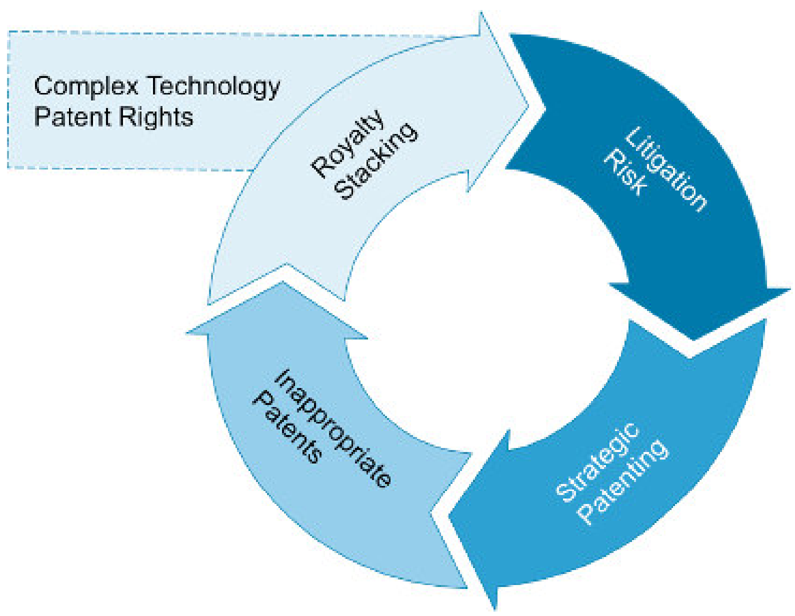
[17] Only 5 percent of software patents are granted to software-publishing firms. Most software patents are obtained by firms in telecommunications, electronics and computer industries (Bessen, Hunt 2007).
[18] Because a patent’s lifespan is 20 years, the system takes a long time to adjust to policy change.
[19] However it is likely that a more thorough review process would discourage applications for weak patents. Even if these patents were not litigated but only used for bargaining in (welfare neutral) cross-licensing negotiations, the welfare implications of prolonged review would depend on total time spend by PTO reviewing applications.

(iv) inappropriate grants. In the next section we describe the interconnectedness of these drivers and tie them together in a comprehensive framework.

3.5 A Vicious Circle

The creation of a patent thicket begins with the right circumstances; a complex industry in a market with strong patent rights. The natural fragmented ownership of patents in a complex industry leads to royalty stacking, taxing the innovators. A complex industry is opaque in patent rights and the likelihood of inadvertent infringement is high. To protect themselves against litigation, in particular risk of injunction, companies turn to strategic patenting. Strategic patenting gives firms leverage to bargain in cross licensing agreements, however, the strategic patenting leads to asymmetries in patent ownership, tempting some firms to assert their patents aggressively, making strategic patenting self-reinforcing. The pressure from patent applications put stress on the patent office that is already constrained by a bad incentive structure and lack of resources. Granting becomes lenient which incentivizes firms to apply for broader and fuzzier patents, which further increases the extent of royalty stacking and lack of transparency, and a vicious circle has emerged. Figure 3.1 gives a stylized illustration of the vicious circle that is patent thickets.

Figure 3.1: Patent Thickets, A Vicious Circle



This concludes our theoretical discussion of patent thickets; in *Chapter 12 Breaking the Circle* we shall revert to the framework and discuss potential improvements. Having established a theoretical fundament we next proceed to establish our hypotheses.

Chapter 4 Hypotheses

In this chapter we combine the theoretical background from our framework in *Chapter 3* with recent empirical research to propose a number of empirically testable hypotheses. Testing the Hypotheses answers our sub-research questions (SRQ) and eventually our overall research question.

The hypotheses are divided into four categories, each relating to a SRQ. *Section 4.1 Stock of Knowledge Assets [H1 hypotheses]* relates to SRQ 1. S*ection 4.2 Patent Thickets [H2 Hypotheses]* relates to SRQ 2. S*ection 4.3 Complex vs. Discrete Industries [H3 Hypotheses]* relates to SRQ 3. Lastly, *section 4.4 Prisoner's Dilemma [H4 Hypotheses]* relates to SRQ 4.

4.1 Stock of Knowledge Assets [H1 Hypotheses]

In relation to the first sub-research question (SRQ 1): *How do firms benefit from accumulating knowledge assets?* We estimate the impact of different measures of knowledge stocks on firm market value. We refer to these hypotheses as the *H1 hypotheses*.

Although the H1 hypotheses do not directly uncover patent thicket effects, it is relevant to understand how firms are incentivized to conduct R&D and subsequently patent innovations.

We measure knowledge assets in three ways: R&D stock, patent stock and citation stock, corresponding to the following three hypotheses.

4.1.1 R&D Stock [H1.A]

R&D is widely used to measure the value of firm knowledge assets. Prior research on US firms in different industries and time-periods find that R&D is positively related to market value (Hall 1999, Hall, Jaffe & Trajtenberg 2005, Griliches 1998, Megna, Klock 1993, Noel, Schankerman 2013, Bloom, Schankerman & Van Reenen 2013).

Following previous literature and the notion that accumulation of knowledge assets drive innovation, we propose the following hypothesis:

***H1.A**: R&D stock is positively related to market value*

4.1.2 Patent Stock [H1.B]

In conjunction with R&D stock, patent stock has been used to measure firm knowledge stocks. Researchers find that patent stock contains additional information beyond R&D stock, and that patent stock is positively related to market value (Hall, Jaffe & Trajtenberg 2005, Griliches 1998, Hall 1999, Megna, Klock 1993).

We argue that firms are individually incentivized to patent to: protect innovation, strengthen position in cross licensing negotiations and deter litigation. We propose the following hypothesis:

***H1.B**: Patent stock is positively related to market value*

4.1.3 Citation Stock [H1.C]

Following Hall, Jaffe & Trajtenberg (2005) we impose patent forward citation stock as a third knowledge asset measuring "high-quality innovations". In this way we incorporate room for heterogeneity in patent value. Researchers find that citation-weighted numbers of patents are closer related to firm market value, than Patent count (Hall 1999, Hall, Jaffe & Trajtenberg 2000, Hall, Jaffe & Trajtenberg 2005).

We propose the hypothesis that value-adjusted patent stocks are a better measure of market value than non-value-adjusted patent stocks:

***H1.C**: Citation stock is positively related to market value, and better explains market value than patent stock*

4.2 Patent Thickets [H2 Hypotheses]

In this section we propose hypotheses to answer SRQ 2: Do *patent thickets affect firms negatively?* From *Chapter 3 Patent Thickets*, we know that a patent thicket can have pernicious effects on firms operating under it. We want to verify this prediction empirically.

We look at patent thickets in three distinct ways: Fragmentation of ownership rights, rival patenting in the operating space and rival patenting in the technology space. Operating space is defined as the subset of firms that are operating in the same product market. Technology space is a wider definition of related firms that share technology, but are not in the operating space.[20]

4.2.1 Fragmented Ownership Rights [H2.A]

In *Chapter 3* we argue that royalty stacking and fragmentation of intellectual property rights (fragmentation) is costly and sub-optimal due to the Cournot compliment effect and double marginalization. Empirical research in the area suggests that fragmentation is associated with negative externalities (Cockburn, MacGarvie & Müller 2010). Noel & Schankerman (2013) find that fragmentation is negatively related to market value in the software industry. We propose the following hypothesis:

***H2.A**: Fragmented intellectual property rights in the operating space is negatively related to market value*

4.2.2 Rival Patenting in the Operating Space [H2.B]

In addition to fragmentation, large patent portfolios characterize a patent thicket. The sheer amount of patents makes prior art opaque, which increase risk of inadvertently infringement and litigation. Empirically Noel & Schankerman (2013) find that software firms' market value is negatively associated with rival patent propensity. We propose the following hypothesis:

***H2.B**: Rival patenting in the operating space is negatively related to market value*

4.2.3 Rival Patenting in the Technology Space [H2.C]

Considering *H2.B*, interpretative complications arise, as there are several effects at play when a rival chooses to patent an innovation. We categorize these effects in three: *the thicket effect*, *the spillover effect* and *the product market effect*. The thicket effect is the effect described in *subsection 4.2.2*, which we argue to be negative and dominant. The spillover effect (positive) is the diffusion of knowledge to other firms when an invention is disclosed in a patent (Almeida, Kogut 1997, Belenzon

[20] Operating- and technology space is specified in paragraph 7.2.2.2

2006, Agrawal, Cockburn & McHale 2003, Bloom, Schankerman & Van Reenen 2013). The product market effect is the negative effect that market power, granted to a patentee, have on competitors[21]. Because of the product market effect, a negative relationship between rival patenting and market value cannot with certainty be attributed to the patent thicket effect. By defining a technology space around (but not including) the operating space we isolate the patent thicket effect and spillover effect from product market effect. This provides additional information on the patent thicket problem. We hypothesize that the patent thicket effect dominates the external spillover effect:

H2.C*: Rival patenting in the technology space is negatively related to market value*

4.3 Complex vs. Discrete Industries [H3 Hypotheses]

In this section we establish hypotheses to answer SRQ 3: *Are pernicious effects of patent thickets worse in complex industries?* In *Chapter 3 Patent Thickets* we argue that pernicious effects of patent thickets are worse in complex industries. To verify this empirically we compare complex industries with discrete industries. The comparison is based on the following four aspects: Stock of knowledge assets, fragmentation of ownership rights, rival patenting in the operating space and rival patenting in the technology space.

4.3.1 Stock of Knowledge Assets [H3.A]

This subsection corresponds to *section 4.1 Stock of Knowledge Assets [H1 Hypotheses]*. To keep down the overall number of hypotheses we contract the H1 Hypotheses into one hypothesis concerning stock of knowledge assets. We argue that complex industries are cumulative and therefore generally more innovation driven, also firms are more incentivized to accumulate (low quality) patents for defensive purpose. Overall we hypothesize that the effects of knowledge assets, in particular those related to patents, are more positively associated with market value in complex than in discrete industries:

H3.A*: The effect on market value of knowledge stocks is pulled in a positive direction in complex industries compared to discrete industries*

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[21] See *section 2.3 The Basic Tradeoff*

4.3.2 Fragmented Ownership Rights [H3.B]

The empirical evidence of negative fragmentation effects stems from studies of complex industries. Hall & Ziedonis (2001, 2007) and Ziedonis (2004) examine patenting behavior in the semiconductor industry. Cockburn & MacGarvie (2009) and Noel & Schankerman (2013) find evidence of negative fragmentation effects in the software industry, and Hall et al. (2013) suggest that the thicket problem is most pronounced in telecommunications, audiovisual technology and computer. These findings are in line with our argumentation in Chapter *3 Patent Thickets*.

We establish the hypothesis that effect of fragmentation is worse in complex industries than in discrete industries:

H3.B*: The effect on market value due to fragmented intellectual property rights in the operating space is pulled in a negative direction in complex industries compared to discrete industries*

4.3.2 Rival Patenting in the Operating Space [H3.C]

Following the arguments in *Chapter 3 Patent Thickets*, we expect the patent thicket effect of rival patenting to be higher (negative) in complex industries. Also the spillover effect is expected to be higher (positive) as complex products are cumulative by nature. We do not have a clear indicator of whether the product market effect is smaller or larger in complex industries. We expect that the difference in the patent thicket effect dominates, and establish the following hypothesis:

H3.C*: The effect on market value due to rival patenting in the operating space is pulled in a negative direction in complex industries compared to discrete industries*

4.3.3 Rival Patenting in the Technology Space [H3.D]

As in subsection *4.2.3 Rival Patenting in the Technology Space [H2.C]*, we isolate the patent thicket effect and the spillover effect by defining a technology space. We argue that the difference in patent thicket effect dominates any difference in spillover effect between complex and discrete industries, and establish the hypothesis:

H3.D*: The effect on market value due to rival patenting in the technology space is pulled in a negative direction in complex industries compared to discrete industries*

4.4 Prisoner's Dilemma [H4 Hypotheses]

Noel & Schankerman (2013) argue that in the extreme case, negative externalities imposed by defensive patenting, can create a prisoner's dilemma, where all firms would be better of collectively reducing patenting, but none is willing to do so individually. They do not find evidence of such a phenomenon in their analysis of the software industry.

We challenge this conclusion, and in this section develop hypotheses to answer SRQ 4: A*re firms trapped in a prisoner's dilemma?*

We compare defensive patenting to a military arms race. Such an arms race has often been characterized as a prisoner's dilemma, and can be modeled as an iterated process with choice of cooperation, deterrence and retaliation (Snyder 1971, Snyder, Diesing 1977, Poundstone 1992, Majeski 1984). We establish our hypotheses regarding prisoner's dilemma on the work of Majeski (1984), who analyze iterated prisoner's dilemma games similar to arms races. In the following we discuss his findings and compare it to patent strategies.

Majeski (1984) makes several conclusions regarding arms races: First, termination of the game must be unknown for cooperation to occur. This is a standard property of the iterated prisoner's dilemma, which fits well into a competitive real life setting. Second, if the probability of war is small, then the likelihood of cooperation is increased. This is an interesting property, as the risk of litigation in complex industries operating under a patent thicket is high (Allison et al. 2012, Allison, Lemley & Walker 2011, Allison, Lemley & Walker 2009, Bessen 2011, Hall, Ziedonis 2007, Turner 2011), suggesting that firms in complex industries are more likely to be trapped in a prisoner's dilemma. Third, even if (from one nation's perspective) it is rational to cooperate, this is only true if the other nations are expected to reciprocate, i.e. play the same strategy. This is interesting when considering patent trolling; asymmetries across firms may result in some firms finding cooperation valuable and others not. Research suggests that patent trolls and trolling behavior is particularly pronounced in complex industries (Turner 2011, Tucker 2011, Chien 2010, Chien 2009, Chien 2012, Allison, Lemley & Walker 2009). Fourth, if one or more nations are playing to "win" (i.e. care more about relative gains than absolute gains) then cooperation cannot be induced. Generally it is a reasonable assumption to look at firms as profit maximizing, but large companies may not play "patent wars" as isolated games, rather they might play the patent war to "win", in order to subsequently increase profits on the product market. This is arguable what we observe in the smartphone patent wars (Chien 2012).

In conclusion, we strongly suspect firms in complex industries to be trapped in a prisoner's dilemma. Whether this extends to firms in general is not clear, but following the argumentation used for H2 Hypotheses, we hypothesize that it does. On the contrary we do not believe firms in discrete industries to be trapped in a prisoner's dilemma. Formally, we propose the following three hypotheses:

H4.A*: Firms are trapped in a Prisoner's Dilemma*

H4.B*: Firms in discrete industries are not trapped in a Prisoner's Dilemma*

H4.C*: Firms in complex industries are trapped in a Prisoner's Dilemma*

To verify this empirically we compare net gains of collectively reducing patenting; we elaborate on the empirical method to test the prisoner's dilemma in *Chapter 9 Results*.

This concludes Part II, In Part III we take a closer look at our research methodology.

Part III

Research Methodology

Chapter 5 Econometric Regression Theory

To empirically test hypothesized relationships we use a Fixed Effects (FE) regression model with firm- and year fixed effects. The FE model is an extension of the Ordinary Least Squares (OLS) multiple linear regression (MLR) model, and it is used to remove the pernicious effects of omitted variable bias when conducting a longitudinal (panel) study.

The purpose of this chapter is to introduce our research methodology; the focus is on underlying assumptions of OLS and FE, and related practical and theoretical issues. The theoretical arguments are based on the works of Wooldridge (2010, 2012). In *Section 5.1* we discuss model assumptions and OLS appropriability in a cross-sectional setting. In *Section 5.2* we extend the framework to work in a panel data setting and discuss related challenges and opportunities.

5.1 Cross-Sectional OLS

An introduction to OLS and a review of the five Gauss-Markov Assumptions for multiple linear regressions (MLR 1-5) can be found in *Appendix 1*. Under assumption MLR 1-4 the OLS estimator is unbiased, and under assumption 1-5 the estimator is BLUE (Wooldridge 2012). In *subsection 5.1.1* we discuss different sources of bias, particularly in relation to violation of MLR.4 (Zero Conditional Mean). In *subsection 5.1.2* we discuss model efficiency and MLR.5 (Homoskedasticity).

5.1.1 Sources of Bias

We now address issues with endogeneity that stem from violations of MLR 1-4. The bulk of our discussion will address MLR.4, which is the most important assumption (Wooldridge 2012). We address the Gauss-Markov assumptions in order, starting with MLR.1.

5.1.1.1 Functional Form (MLR.1 - Linear in Parameters)

The purpose of MLR.1 is to establish the linear relationship between the explanatory variables and the response variable; this is not a strong requirement as both the dependent and independent variables are allowed to be arbitrary functions of underlying variables of interest.

The biggest issue with regards to MLR.1 is the risk of misspecifying the functional form of the regression. This comes from using a wrong function in one or more independent variables. In *Chapter 10* we include non-linear polynomials to adjust for a possible misspecification.

5.1.1.2 Sample Selection (MLR.2 - Random Sampling)

A non-random sample can cause biased results. In our thesis the biggest concern is that our sample drawn from Compustat is not random, it likely contains larger than average firms[22], this is a problem because size might be correlated with other firm characteristics (such as R&D) and the group of left-out-firms might have a different "all else equal" effect than our sample, hence the result will be biased. Unfortunately there is no way to get around this kind of sample selection when conducting empirical analysis with databases. To avoid magnifying the bias we keep data cleaning at a minimum. A comprehensive view of cleaning and missing data is presented in *Chapter 6*.

5.1.1.3 Perfect Collinearity (MLR.3 - No Perfect Collinearity)

In the MLR model, variation between the independent variables is required to estimate by OLS. This is a natural extension of the simple linear regression that requires variation in the explanatory variable. The idea is that all independent variables have to contribute with some variation; therefore no independent variable can be without variation or be a linear combination of other independent variables already included in the model. MLR.3 is fulfilled when $\mathrm{n} \geq \mathrm{k}+1$ where n is the number of observations and k is the number of variables, and the matrix containing all observations and a column of 1's has full rank:

$$\mathrm{Rank}\begin{pmatrix} 1 & \mathrm{x}_{1,1} & \cdots & \mathrm{x}_{1,\mathrm{k}} \\ \vdots & \vdots & \ddots & \vdots \\ 1 & \mathrm{x}_{\mathrm{n},1} & \cdots & \mathrm{x}_{\mathrm{n},\mathrm{k}} \end{pmatrix} = \mathrm{k}+1$$

This requires, that there are more observations than independent variables and that independent variables are not linear combinations of other independent variables and the vector of 1's. In practice fulfilling MLR.3 is not a problem in multiple linear regressions on a dataset of our size, and in the unlikely event that it is a problem, most software packages are programmed to report an error. In relation to our study, multicollinearity in the independent variables can be an issue. We discuss this in *5.1.2.1*.

5.1.1.4 Omitted Variables (MLR.4 – Zero Conditional Mean)

When an explanatory variable (x_j) is correlated with the error term (u) then x_j is said to be endogenous in the regression model and assumption MLR.4 is violated. In applied econometrics

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[22] See *subsection 8.3.2*

endogeneity stems primary from three sources: *omitted variables*, *measurement error* and *simultaneity* (Wooldridge 2010). In this paragraph we are concerned with omitted variable bias. Measurement error and simultaneity will be discussed in following paragraphs.

A predominant issue in applied econometrics is omitted variable bias, also known as model underspecification (Wooldridge 2010). Consider *equation 5.1* as a structural (true) model, where q is an unobservable, omitted variable[23]:

(5.1) $E(y|x_1, x_2, \dots, x_k, q) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + \gamma q$

The correct regression specification would then be:

(5.2) $y = \hat{\beta}_0 + \hat{\beta}_1 x_1 + \hat{\beta}_2 x_2 + \cdots + \hat{\beta}_k x_k + \hat{\gamma} q + v$

where v is the idiosyncratic error term with zero conditional mean:

(5.3) $E(v|x_1, x_2, \dots, x_k, q) = 0$

Often, because of the unobservable nature of q, the factor will be placed in the error term and *equation 5.2* changes to:

(5.4) $y = \tilde{\beta}_0 + \tilde{\beta}_1 x_1 + \tilde{\beta}_2 x_2 + \cdots + \tilde{\beta}_k x_k + u$

(5.5) $u \equiv \gamma q + v$

If q is correlated with x_j then $\tilde{\beta}_j \neq \hat{\beta}_j$ and there is an endogeneity problem[24]. This is a serious concern, other estimates might also be biased, if their x_m is indirectly related to q (e.g. by being correlated with x_j). Since explanatory variables are rarely completely uncorrelated, it is likely that all of the estimates will be either directly or indirectly biased when relevant variables are omitted.

In our study, omitted variable bias is a risk; from a structural perspective it is impossible to come up with an equation that measures market value without simplifying. We are basically asking: what creates value in a company? And why do companies have different values? The underlying factors

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[23] Note that in the case of several unobservable factors, we still just include one unobservable variable. This can be done because of the additive nature of the model (Wooldridge 2010).

[24] Note that the assumption $E(u) = 0$ is not an issue as we can assume $E(q) = 0$ because an intercept (β_0) is included in the equation, hence we only have endogeneity issues if the unobserved factor is also correlated with any x_j (Wooldridge 2010)

include much more than what is observable on a company's balance sheet[25]. In a simple OLS model, macroeconomic fluctuations, industry specific conditions as well as firm characteristics can be sources of bias[26]. To minimize the endogeneity risk we include a set of control variables that capture some dynamic conditions in industries and firms, such as *HHI* and *ROA*[27]. When we extend the OLS framework to a panel data setting, we also include time-dummies to control for overall economic fluctuations and firm FE to capture time-invariant characteristics of individual firms.

Endogeneity from omitted variables will always be a concern in applied econometrics. No matter how sophisticated a model you use, you can never know for certain, if your explanatory variables are completely exogenous due to the unobservable nature of the error term (Wooldridge 2012).

5.1.1.5 Measurement Error (MLR.4 – Zero Conditional Mean)

A measurement error arises when an imprecise measure of an economic variable is included in the regression (Wooldridge 2012). There are two types of measurement error: a measurement error in the dependent variable and a measurement error in one or more of the independent variables.

A measurement error in the dependent variable causes bias in the OLS estimation if the error is systematically correlated with one or more of the explanatory variables. In other words, if the error in the data is random OLS is still appropriate[28] (Wooldridge 2010). There are two reasons it is relevant to discuss errors in the dependent variable in our study: a) we use Tobin's Q to measure economic rents b) we use an approximation to measure Tobin's Q. We discuss our use of Tobin's Q in *paragraph 7.2.1.1*. For now we note, that there is a risk of bias in the results due to measurement error in our dependent variable.

Traditionally measurement error in the explanatory variables has been considered more important (Wooldridge 2012). The two polar cases are a) the measurement error is uncorrelated with the observed measure of the explanatory variable b) the measurement error is uncorrelated with the

[25] Examples include organizational structure, political risk, management ability, corporate culture etc.

[26] For the case of R&D: Imagine an economic boom where firms would tend to have higher market value and invest more in R&D (macro), a firm operating as a monopolist and therefore invests less in R&D than firms operating in a competitive market (industry) or a highly skilled management that increase market value and manage the optimal spending on R&D (firm).

[27] We introduce control variables in *subsection 7.2.3*

[28] A random measurement error in the dependent variable will however increases the variance of the OLS estimators.

unobserved explanatory variable. The latter is known as the classical errors-in-variables (CEV) assumption and is the problematic case as it causes biased estimates (Wooldridge 2012). We encounter several potential measurement error issues: When using accounting data, comparability problems of inventory valuation, depreciation and fair value accounting arise, as there is room to maneuver within US GAAP[29] (Bodie, Kane & Marcus 2010). When using monetary variables over a long period it is also important to consider inflation. We deflate all prices with United States Wholesale price index (Index Mundi 2011), but measurement errors might still arise across industries or firms. Furthermore Kleinknecht (1987) show that R&D is underestimated in small firms. We control for this bias by including a categorical size variable.

5.1.1.6 Simultaneity (MLR.4 – Zero Conditional Mean)

Simultaneity can be an issue if one or more explanatory variables are determined simultaneously with the dependent variable. In such case, it could be that the independent variable is determined partly as a function of the dependent variable, which generally makes the independent variable correlated with the error term (Wooldridge 2010). In our analysis the assumption is, that when a firm invest in R&D or is granted a patent the market will respond either positively or negatively. But if the logic is reversed, for example if an increase in market value increases "free resources" which can be used on R&D or patent applications, then there is an endogeneity problem. A method to mitigate endogeneity is to use lagged independent variables (Noel, Schankerman 2013, Bloom, Schankerman & Van Reenen 2013); we do not include lagged variables in our baseline regressions, but run regressions with lagged independent variables in *Chapter 10 Robustness Test*.

5.1.2 Model Efficiency

We now discuss the variance and efficiency of a selected methodology. A larger variance means a less precise estimator and lower efficiency. First, we discuss multicollinearity between explanatory variables. Second we look at MLR.5 – Homoskedasticity.

5.1.2.1 Model Overspecification and Multicollinearity

When the explanatory variables are (highly) correlated it becomes difficult to partial out their individual effect. This is known as multicollinearity and/or model overspecification. Overspecification

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[29] Generally accepted accounting principles

will not (in contrast to underspecification) result in biased estimates, but it will inflate the standard errors, lowering the significance of variables. It follows that when it comes down to including a variable or not, it can be perceived as a tradeoff between bias and variance (Wooldridge 2012).

In this study we face multicollinearity concerns in two ways: a) between variables of interest b) by inclusion of control variables. The former concern stems from the fact that R&D-, patent- and citation-stock are correlated (mainly patent- and citation stocks). The specific correlation factors are presented in *section 8.2*. In relation to the second, we are more concerned with bias, why we include all control variables that we find relevant. In the *Chapter 10 Robustness Test* we present an alternative model specification without control variables.

Furthermore, when looking at the bias-variance tradeoff, including control variables becomes more expensive when the sample size is small (Wooldridge 2012). In this study we have a large sample and can therefore afford to include several control variables.

5.1.2.2 Homoskedasticity and Efficiency (MLR.5 – Homoskedasticity)
Homoskedasticity is when the variance of the error term (u) takes on the same value given any value of the independent variables. When this is fulfilled (together with MLR.1-MLR.4) the estimator is BLUE (Wooldridge 2012). MLR.5 is a strong assumption and is often violated in economic data (Wooldridge 2012). Luckily a violation of the assumption does not give biased estimators, only invalid standard errors. One solution to this problem is to apply *heteroskedasticity-robust standard errors* (Wooldridge 2010). There are other ways to correct for heteroskedasticity, but in a cross-sectional setting with a large sample, the robust standard error is common because it is easily applied and works well (Wooldridge 2010). We discuss our approach to standard errors in *subsection 5.2.5*.

5.2 Panel data setting – OLS Extensions

We use panel data in our analysis. Working with panel data has theoretical differences from working with cross sectional data, but the general idea about OLS and model evaluation is viable. Furthermore, understanding the potential problems using OLS, shed light on the benefits and complications that follow when using panel data.

First, we highlight important changes in relation to the Gauss-Markov assumptions. Second, we treat model extensions with time- and firm fixed effects. Third, we discuss some asymptotic properties and consistency. Fourth, we introduce robust standard errors. Fifth, we make a note on using an unbalanced panel. Finally, we discuss the choice of fixed effects over random effects.

5.2.1 Gauss-Markov Assumptions with Panel Data

The idea of making model assumptions is the same as for OLS. We want to know when: a) the estimator will be unbiased (and consistent) and b) if the model is efficient (BLUE). There are many similarities to cross sectional OLS – the model is assumed to be linear in parameters (MLR.1), perfect collinearity is not allowed (MLR.3) and in the standard case, heteroskedasticity is not allowed (MLR.5) (Wooldridge 2012). Because of these similarities, we will not restate all of the assumptions. Instead we will specifically focus on two important alterations: *strict exogeneity* and *no serial correlation.*

5.2.1.1 Strict Exogeneity

The *Zero conditional mean* assumption (MLR.4) is different when using panel data[30],

(5.6) $E(u_t|\boldsymbol{X}) = 0, t = 1,2, \dots, n.$

In other words, for each t, the expected value of the error u_t, given the explanatory variables for all time periods, is zero (Wooldridge 2012).

When *assumption 5.6* is fulfilled, the explanatory variables are strictly exogenous. This more restrictive assumption is related to the fact that we cannot assume random sampling anymore. Together with the assumptions *Linear in parameters* and *No perfect collinearity*, the assumption about strictly exogenous explanatory variables is needed to show that OLS is unbiased (Wooldridge 2012). We discuss asymptotic properties of OLS and relaxation of the strict exogeneity assumption in *subsection 5.2.4*. Now we look at some implications of this rather restrictive assumption.

To get unbiased estimators we assume that the expected value of u_t is not related to the explanatory variables in any time periods. As in cross section analysis, this is violated if variables are omitted, there are measurement errors, or simultaneity. Due to the time dimension there are two other implications to consider. First, lagged explanatory variables are not allowed to influence the dependent variable (Wooldridge 2012). In relation to our data this means that e.g. lagged fragmentation of ownership rights do not affect market value, which is likely to be violated. The second implication of strict

[30] To make the notation more manageable we introduce: $\boldsymbol{x_t} = (x_{1t}, x_{2t}, \dots, x_{kt})$ and $\boldsymbol{X} = (\boldsymbol{x_1}, \boldsymbol{x_2}, \dots, \boldsymbol{x_n})$

exogeneity is that there is no feedback from the dependent variable to future independent variables (Wooldridge 2012). In our regression this means that the market value today will not affect future patenting or R&D spending. This is intuitively wrong, but unfortunately there is not much to do about it (Wooldridge 2012).

5.2.1.2 Random Sampling and Serial Correlation

In our dataset, observations on the same cross section of firms are repeated over time. The individual firm behavior is likely to be correlated over time, and therefore the assumption of random sampling (MLR.2) is too restrictive (Wooldridge 2010). MLR.2 implied that there is no serial correlation, but as MLR.2 no longer holds true, we need to consider serial correlation more carefully.

In addition to the homoskedasticity assumption:

(5.7) $Var(u_t|\boldsymbol{X}) = Var(u_t) = \sigma^2, t = 1,2,\dots,n$

We also need an assumption on no serial correlation in the standard errors:

(5.8) $Corr(u_t, u_s|\boldsymbol{X}) = 0, for\ all\ t \neq s,$

in order for the OLS estimator, to be BLUE[31] (Wooldridge 2012).

We deal with heterogeneity and serial correlation in the standard errors by using robust standard errors, explained in *subsection 5.2.5*.

5.2.2 Firm Fixed Effects

We now turn to the benefits of using panel data. In this subsection we introduce *Firm fixed effects* and in the next subsection we introduce *Time fixed effects*. Both are included in our regression model.

Consider the omitted variable problem from *paragraph 5.1.1.4*, now in a panel data setting,

(5.9) $E(y_t|\boldsymbol{x}_t, q_t) = \beta_0 + \boldsymbol{x}_t\boldsymbol{\beta} + \gamma q_t,\ t = 1,2,\dots,n$

where $\boldsymbol{x}_t\boldsymbol{\beta} = \beta_1 x_{1t} + \beta_2 x_{2t} + \dots + \beta_k x_{kt}$ and x_{jt} indicates variable j at time t. Furthermore q_t is the unobservable, omitted variable. If the unobserved variable goes into the error, we are likely to have an endogeneity problem (Wooldridge 2010).

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[31] With strict exogeneity the estimator is unbiased in the presence of heteroskedasticity and serial correlation

Now assume that the unobserved factor can be written as:

(5.10) $E(y_t|\boldsymbol{x}_t, c) = \beta_0 + \boldsymbol{x}_t\boldsymbol{\beta} + c,$

indicating that the omitted variable *c* is constant over time, and has a constant partial effect over time. Such a variable is usually referred to as an *unobserved effect* (Wooldridge 2010).

Consider a linear unobserved effect model:

(5.11) $y_{it} = \beta_0 + \boldsymbol{x}_{it}\boldsymbol{\beta} + c_i + u_{it},\ t = 1,2,\dots,T$

with assumption FE.1 (Wooldridge 2010),

(5.12) $E(u_{it}|\boldsymbol{x}_i, c_i) = 0,\ t = 1,2,\dots,T$

The idea of estimating $\boldsymbol{\beta}$ under assumption FE.1 is to transform the equation and eliminate the unobserved effect. Because of the time-invariant nature of the unobserved effect we can use a *fixed effects transformation* where *equation 5.11* is transformed so that the individual, time-invariant effect c_i is removed[32] (Wooldridge 2010). The first step in the transformation is to average *equation 5.11* over time to get,

(5.13) $\bar{y}_i = \overline{\boldsymbol{x}}_i\boldsymbol{\beta} + c_i + \bar{u}_i$,

where $\bar{y}_i = T^{-1}\sum_{t=1}^{T} y_{it},\ \ \overline{\boldsymbol{x}}_i = T^{-1}\sum_{t=1}^{T}\boldsymbol{x}_{it}$ and $\bar{u}_i = T^{-1}\sum_{t=1}^{T} u_{it}$

Then by subtracting *equation 5.13* from *equation 5.11* for each *t*, we obtain the *fixed effects transformed* equation where c_i has been eliminated,

(5.14) $\ddot{y}_{it} = \ddot{\boldsymbol{x}}_{it}\boldsymbol{\beta} + \ddot{u}_{it},\ t = 1,2,\dots,T$

where $\ddot{y}_{it} \equiv y_{it} - \bar{y}_i,\ \ \ddot{\boldsymbol{x}}_{it} \equiv \boldsymbol{x}_{it} - \overline{\boldsymbol{x}}_i,$ and $\ddot{u}_{it} \equiv u_{it} - \bar{u}_i.$

Now with assumption FE.1 it can be shown that,

(5.15) $E(\ddot{u}_{it}|\boldsymbol{x}_i) = E(u_{it}|\boldsymbol{x}_i) - E(\bar{u}_i|\boldsymbol{x}_i) = 0$

and because each $\ddot{\boldsymbol{x}}_{it}$ is a function of $\boldsymbol{x}_i$ it follows that,

(5.16) $E(\ddot{u}_{it}|\ddot{\boldsymbol{x}}_{i1},\dots,\ddot{\boldsymbol{x}}_{iT}) = 0$

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[32] The transformation is known as ”demeaning” of the original equation (Wooldridge 2010).

hence $\ddot{\boldsymbol{x}}_{it}$ satisfies the strict exogeneity assumption of explanatory variables and the FE estimator will be unbiased (Wooldridge 2010). That is, in the presence of a time-invariant unobserved effect, the FE estimator is superior to regular pooled OLS[33].

The identifying assumption with FE is: *Unobservable factors that simultaneously affect dependent and independent variables in the regression are time-invariant*. In our thesis the unit of observation is firms and the unobserved effect therefore relates to something that is specific to the firm and constant over time. Examples of this are: company structure, industry, geographical location, company culture, brand perception and managerial ability. None of these are certain to be time-invariant. In fact, when looking at 25 years of data, it is likely that each of these at some point for some firm changed. Although the model will not perfectly capture all unobserved factors it is a viable way to cancel out many firm-specific effects that would otherwise create bias. In our analysis it is important to capture firm characteristics; depending on industry, accounting standards, management and strategy firms choose R&D- and patenting strategies differently. As these characteristics also affect market to book values, it can result in biased estimates, when using regular OLS.

When controlling either with fixed effects or control variables more is not always better. Bias and variance is a tradeoff, in particular one needs to pay attention to the possibility of over controlling; including so much control that there is hardly any variation for the explanatory variables of interest to describe.

5.2.2.1 Including Time-Invariant Explanatory Variables

The FE estimator “cancels out” time invariant effects by which it directly follows, that in order to identify the equation, all explanatory variables must have some time variation (Wooldridge 2010). Practically this means that it is redundant to include fixed dummy variables such as industry.

5.2.2.2 Time-Variant Effects

By now it is clear that FE only captures time-invariant factors. This leaves a potential source of bias – namely time-variant effects. The interpretations of these effects are firm-, industry-, and macro-level

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[33] Pooled OLS is a term used when you have a panel data and “pool” the years together as one cross sectional analysis. This is basically the method we are expanding by including time- and firm fixed effects.

effects that change over time[34]. Naturally a full set of time-firm fixed effects cannot be included[35], instead we control by including a set of relevant control variables, and adjust for macro-economic fluctuation by including *Time fixed effects*, the latter we turn to next.

5.2.3 Time Fixed Effects

So far we have looked at the FE estimator through demeaning of the regression equation. An alternative approach is to include a dummy variable for each unit of observation. This is the approach we use to include time fixed effects[36].

By including a dummy-variable for each year, we allow for different intercepts over time. This is an effective way to capture unobserved macroeconomic fluctuations. The reason for the term "macroeconomic" is that it is the same for all firms. In contrast to firm FE which is firm-specific and does not vary over time, time FE are time-specific and does not vary cross-sectionally. Consider an economic boom that increase market value, R&D investment and patent propensity, in the absence of a time FE the increase in market value might be attributed to the increased R&D and patenting rather than the boom.

5.2.4 A Note on Asymptotic Properties and Consistency

So far our focus has been bias (finite sample properties); we have not given much room to asymptotic properties and consistency. In this subsection we introduce three asymptotic properties of OLS. Basically some assumptions can be relaxed as the sample size is increased indefinitely in a fixed time period. We operate with a short panel in a large sample, why these properties have some relevance for inferences.

Most important is the relaxation of the strict exogeneity and zero conditional mean assumption,

(5.17) $E(u_t|\boldsymbol{X}) = 0, t = 1,2, \dots, n.$

For the OLS estimator to be consistent[37], we only need to assume *contemporaneously exogeneity*,

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[34]Examples of this are mentioned footnote 26.
[35] These would explain all the variation in the dataset.
[36] Technically the software will handle time FE as dummies because it is only possible to demean the equation for one unit of observation (the firm dimension).

(5.18) $E(u_t|\boldsymbol{x}_t) = 0, t = 1,2, \ldots, n$.

This is a much weaker assumption as it does not put any restrictions on how u_t is related to the explanatory variables in other time periods (Wooldridge 2012).

Furthermore we relax assumptions on *homoskedasticity* and *no serial correlation in standard errors*,

(5.19) $Var(u_t|\boldsymbol{x}_t) = \sigma^2, t = 1,2, \ldots, n$

and,

(5.20) $Corr(u_t, u_s|\boldsymbol{x}_t, \boldsymbol{x}_s) = 0, for\ all\ t \neq s$,

Assumption 5.19 is referred to as *contemporaneously homoskedasticity*, we only impose restrictions on explanatory variables at time *t*, and *assumption 5.20* relaxes restrictions on serial correlation[38] (Wooldridge 2012). In the next subsection we discuss how to relax restrictions on homoskedasticity and serial correlation.

5.2.5 Robust Standard Errors

It is possible to correct the standard errors in order to allow for arbitrary heteroskedasticity and serial correlation (conditional and unconditional). This is often referred to as robust standard errors (Wooldridge 2010). We use this feature in our regression model[39] in order to make statistical inferences robust to heteroskedasticity and serial correlation. Practically this gives credibility to the significance of regression variables, as the standard errors are increased. The correction causes OLS to be inefficient, but if the strict exogeneity assumption is violated the more efficient estimator (FGLS) will be inconsistent[40] (Wooldridge 2012). Following a precautionary principle, we prefer OLS with robust standard errors.

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[37] We further assume the time series is weakly dependent. It is out of the scope of this thesis to further discuss time series properties. For more information on this topic see e.g. Hamilton (1994).

[38] For our purpose it is enough to consider the unconditional version of *equation 5.20*, a restriction on serial correlation between $u_t$and u_s for all $t \neq s$. For further information on serial correlation see e.g. Hamilton (1994).

[39] In Stata it is referred to as "Cluster sampling" (as it statistically is handled similar (Wooldridge 2010)).

[40] If specified correctly, the *feasible general least squares* (FGLS) is more efficient than OLS with robust standard errors. It is out of the scope of this thesis to discuss FGLS. For more information see e.g. Wooldridge (2010, 2012).

5.2.6 A Note on Using an Unbalanced Panel

We use an unbalanced panel, where firms appear and drop out at different times during the sample period. When firms go out of business, the subsequent time periods are no longer randomly sampled on the cross sectional level, which can be problematic. When observations leave the panel it is called attrition. If these observations are systematically different from those remaining in the panel, it may cause a sample selection bias (Wooldridge 2012). In our FE model, we are concerned with time varying components in the error term that might be correlated with attrition, as time invariant factors are captured by demeaning.

When using a FE transformation we lose one degree of freedom for each cross sectional observation due to demeaning (Wooldridge 2012). It is clear that all else equal, using FE on a balanced panel gives more degrees of freedom than on an unbalanced; hence using FE is more expensive in unbalanced panels.

5.2.7 Fixed Effects vs. Random Effects

In econometric analysis there are several mutually exclusive extensions to pooled OLS[41]. Particular the distinction between random effects (RE) and fixed effects (FE) is often discussed in econometric text books (Wooldridge 2010, Wooldridge 2012, Gujarati 2007). We have chosen FE and do not present RE in details[42]. In general RE should only be used over FE if c_i and $\boldsymbol{x}_{it}$ are uncorrelated[43]. As this is rarely the case in economic research FE is widely thought to be a better tool for estimating "all else equal" effects (Wooldridge 2012). In our study firm unobserved, time-invariant characteristics are almost certain to be correlated with the explanatory variables of interest such as R&D and patenting behavior, why we choose FE over RE. The Hausman test confirms that FE is the appropriate choice (see *Appendix 5.A*)

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[41] For a comprehensive review of different extensions, see e.g. Wooldridge (2010).
[42] A thorough review of RE can be found in Wooldridge (2010).
[43] RE is also used in special cases, where the explanatory variable of interest is constant over time and FE cannot be used (Wooldridge 2012).

In this chapter we discussed our theoretical and practical reasoning behind choice of regression methodology. In *Chapter 6* we discuss our choice of dataset and our decisions in processing. In *Chapter 7* we look at our empirical model and variables.

Chapter 6 Data Description

This chapter introduces our primary data sources, which we combine in order to investigate the relation between firm-level patent data (NBER) and firm-level financial performance (Compustat). S*ection 6.1 NBER Patent Data* introduces the patent dataset and the processing performed in order to match patent and security data. S*ection 6.2 Compustat financial data* introduces the Compustat data on North American securities and the manipulations performed to construct the final dataset.

6.1 NBER Patent Data

We use patent data drawn from the National Bureau of Economic Research Patent Data Project (NBER PDP). The dataset contains information including *application year, grant year, number of claims, backward citations and forward citations* of more than 3.2 million utility patents[44] granted by the PTO in the period 1976-2006[45]. We consolidate the patents for each year on assignees via the PDPASS identifier, which is consistent over time and is unique to the assignee. Each observation in the final dataset represents one security in one year; the assignees however often correspond to divisions or subsidiary of a larger security (Bessen 2009). In aggregating the data four critical decisions were taken. We discuss these in detail below.

6.1.1 Subsidiaries and Acquisitions

As the analysis draws on security-specific data we consolidate assignees based on matching the security identifier *Global Company Key* (GVKEY) and year. The consolidated observation is assigned a PDPASS corresponding to the PDPASS that was first associated with the GVKEY. If several PDPASS' share this property, the lowest numerical value is chosen. This procedure ensures that each security is

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[44] Besides utility patents three minor categories exist: reissue, design and plant patents. Between 1976 and 2006 roughly 91% of patents were utility patents, 8% were design patents (USPTO).

[45] For further information on the NBER patent data file see Hall, Jaffe & Trajtenberg (2001).

only represented by one PDPASS and in the case of acquisition the new firm will have the PDPASS identifier of the acquirer. In *Appendix 6* we provide an example of the consolidation of subsidiaries and mergers for the case GlaxoSmithKline (NYSE:GSK)[46].

6.1.2 Application as Base

When aggregating patent data for a given year, we use the application year to establish whether a patent falls within the aggregation interval. The average lag between application- and grant date is historically two years (Hall, Jaffe & Trajtenberg 2005), hence the decision to use one or the other might affect results. Our approach is in line with Hall, Jaffe & Trajtenberg (2001) who argue that application year more precisely measures when an invention took place and avoids the uncertainty of volatile examination duration at the PTO. One drawback of using application date is that patents applied for towards the end of the dataset will not have been granted by 2006 and hence not appear in the dataset. We mitigate this truncation by dropping the last two years of data.

6.1.3 Look-back Period

In the regression analysis we use a five-year interval to aggregate patent data. In general by shortening the interval one implicitly assumes that only recent innovations affect performance. Conversely, a long look-back period increases truncation in the first years of the dataset.

We adjust for truncation of patent count and forward citations by dropping the first four years of data. This ensures that patent data is available for all five (current and four previous) years of aggregation for all observations. We do not adjust further for truncation in backward citations; this measure will be biased downward for the first years because many of the cited patents are not part of the dataset, e.g. the first patent in the database will by definition not have any backward citations, as citations only appear in the database if both involved patents occur.

6.1.4 Weighted Ownership

Some applications were filed jointly by several entities e.g. a company that has developed a new technology in cooperation with a university. When aggregating patent data we split patents and

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[46] Source code is available upon request.

citations equally among assignees. Note that it is hereby implicitly assumed that when a company does joint research with a university, it is only able to claim half the value of the resulting patents.

6.2 Compustat Financial Data

In order to match the scope of the patent dataset, we extract annual financial data points from Compustat for all North American companies in the time period 1975-2006, a total of 295.288 observations. The identifying information to match the Compustat data to the patent dataset is GVKEY and year. The patent data is consolidated to 91.372 security-specific observations, all matched to Compustat. The remaining 203.916 did not patent in the period, and are given zeros on patent data entries. All monetary values are stated in 2005 dollars, deflated with United States Wholesale price index (Index Mundi 2011). The index values can be found in *Appendix 3*.

Our general approach is to minimize the amount of data cleaning. The NBER dataset consists of patents granted in the period 1976-2006. We remove the last two and first four years of data due to the arguments presented in *subsection 6.1.2* and *6.1.3*. We also drop firms that have existed for less than four years, as well as observations with missing or “unrealistic” values. The final dataset consist of 79.284 observations from the period 1980-2004. Note that many firms did not report R&D spending, which heavily decreases the final dataset. Table 6.1 provides an overview of our cleaning criteria and the impact on observations.

Table 6.1: Data Cleaning

Variable	***Drop If***	***Observations***
Gross sample		295.167
Duplicates		-2
Year	Missing	-99
Year (truncation)	Below 1980, above 2004	-38.254
Short lived firm	Firms with less than four years data	-6.905
Total assets	Missing, 0, negative	-28.572
Stock price	Missing, 0, negative	-35.252
Number of Shares	Missing, 0, negative	-654
PPE	Missing, negative	-3.349
EBIT	Missing	-8.239
Sales	Missing, 0, negative	-5.100
Industry codes	Missing	-3.431
Long term debt	Missing	-231
R&D and R&Dstock*	Negative, missing*	-85.795
Outliers	R&D_s > 50 , Fcite_s > 100	-121
Observations in cleaned dataset		79.284

*R&D stock is calculated before observations are dropped

To test H1 Hypotheses and H2 Hypotheses we run regressions on the full dataset (A). To test H3 Hypotheses we compare regression results for two distinct data-subsets, one covering firms in discrete industries (B) and one covering firms in complex industries (C). Dataset B consists of 18,445 observations constructed from S&P Global Industry Classification Standard (GICS) codes 2500-3499 which is the consumer discretionary and consumer staples sectors. This subset covers retailing, media, consumer services as well as production of household-, personal care-, food-, beverage- & tobacco products[47] (S&P indices 2008), which is a good representative of discrete industries, as products are relatively simple. Dataset C consists of 24,651 observations from GICS codes 4500-5499 that cover software, semiconductors, hardware- and communications equipment and telecommunication services. These represent industries with complex products that have received much attention in the literature on patent thickets (Lemley 2002, Lemley, Shapiro 2006, Hall, Ziedonis 2001, Hall, Ziedonis 2007, Ziedonis 2004, Noel, Schankerman 2013, Cockburn, MacGarvie 2011, Cockburn, MacGarvie 2009, Hall et al. 2012, Hall et al. 2013, Chien 2012).

[47] We provide a full list of GICS codes in *Appendix 4*.

Chapter 7 Model Specification and Variables

In this chapter we specify our regression setup. In *section 7.1 Model Specification* our regression model is outlined and in *section 7.2 Regression Variables* we explain and discuss the variables used in our analysis.

7.1 Model Specification

We are interested in testing the relationship[48]:

(7.1) $$ln(q_{i,t}) = \beta_1 \frac{R\&D\_s_{i,t}}{A_{i,t}} + \beta_2 \frac{Pat\_s_{i,t}}{A_{i,t}} + \beta_3 FRAG_{i,t} + \beta_4 \frac{Pat\_ind6_{i,t}}{A\_ind6_{i,t}} + \beta_5 \frac{Pat\_ind4_{i,t}}{A\_ind4_{i,t}} + \gamma \boldsymbol{X}_{i,t} + \delta_i + \mu_t + u_{i,t}$$

On the left-hand side $q_{i,t}$ is a Tobin's Q measure for market value. On the right-hand side $A_{i,t}$ is total assets, $R\&D\_s_{i,t}$ is R&D stock, $Pat\_s_{i,t}$ is patent stock, $FRAG_{i,t}$ is our fragmentation index (based on a 6-digit industry classification), $Pat\_ind6_{i,t}$ is rival patent stocks in a 6-digit industry classification (operating space), $Pat\_ind4_{i,t}$ is rival patent stocks in a 4-digit industry classification excluding the operating space[49] (technology space) and $\boldsymbol{X}_{i,t}$ is a set of control variables. Furthermore we control for firm FE (δ_i) and time FE (μ_t), $u_{i,t}$ is the idiosyncratic part of the error term. To make regression (7.1) easy to read, we have left out notation for different industry levels. In *7.2 Regression Variables*, we consider each variable in further detail.

Alongside we use an alternative specification, where Forward citation (Fcite) stock, $Fcite\_s_{i,t}$, has replaced patent stock[50], and rival patenting in the operating- and technology space is based on Fcite stock instead of patent stock:

(7.2) $$ln(q_{i,t}) = \beta_1 \frac{R\&D\_s_{i,t}}{A_{i,t}} + \beta_2 \frac{Fcite\_s_{i,t}}{A_{i,t}} + \beta_3 FRAG_{i,t} + \beta_4 \frac{Fcite\_ind6_{i,t}}{A\_ind6_{i,t}} + \beta_5 \frac{Fcite\_ind4_{i,t}}{A\_ind4_{i,t}} + \gamma \boldsymbol{X}_{i,t} + \delta_i + \mu_t + u_{i,t}$$

where $Fcite\_ind6_{i,t}$ is rival forward citation stocks in a 6-digit industry classification (operating space) and $Fcite\_ind4_{i,t}$ is rival forward citation stocks in a 4-digit industry classification excluding the operating space[51] (technology space).

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[48] Industry indexes omitted, see subsection 7.2.2

[49] See *7.2.2.2*

[50] We also run regressions including both patent- and citation stock.

[51] See 7.2.2.2

All regressions are conducted with robust standard errors. In the following we explain all variables in detail.

7.2 Regression Variables

In this section we explain all variables in our regression models. In *subsection 7.2.1* we consider firm level variables of interest. In *subsection 7.2.2* we consider industry level variables of interest. In *subsection 7.2.3* we consider control variables.

7.2.1 Firm Level Variables

7.2.1.1 Tobin's Q

Fisher & McGowan (1983) conclude: "…*there is no way in which one can look at accounting rates of return and infer anything about relative economic profitability or, a fortiori, about the presence or absence of monopoly profits*". Out of context this may seem a bit harsh, but they have a point. Around the same time Lindenberg & Ross (1981) proposed the idea of combining accounting data as input with market valuation as output, in order to better measure monopoly rents. With this notion we present our choice of response variable, Tobin's Q.

Tobin's Q (also referred to as q) is a measure that relates firm market value to the replacement cost of its assets. Tobin's Q was originally a macroeconomic measure to evaluate investments (Brainard, Tobin 1968, Tobin 1969, Tobin 1978). If q on the margin is above one (unity), the firm has an incentive to invest, since the value of new capital exceeds its costs. Due to the theoretical relation to economic rents, such as introduced by David Ricardo (1817), the applicability of q has shown to be much wider within economic theory. Among other, Tobin's Q has been used to measure firm performance (Wernerfelt, Montgomery 1988, Lang, Stulz 1993), managerial performance (Lang, Stulz & Walkling 1989) and value effects of R&D and intangible assets (Megna, Klock 1993, Hall, Jaffe & Trajtenberg 2005, Griliches 1981)

Despite the frequent use of Tobin's Q in both theoretical and empirical economics, there is a striking lack of consensus concerning how to measure it empirically (Hall 1990, Daines 2001, Yermack 1997, Gompers, Ishii & Metrick 2003). A frequently benchmarked measure is derived by Lindenberg & Ross (1981). This is a complex and theoretical adequate measure, but cumbersome to use in regards to calculations and data requirements (Lindenberg, Ross 1981, Chung, Pruitt 1994). Perfect & Wiles (1994) compare the performance of different q's and find that a simple measure based on firm book values tends to overstate q compared to Lindenberg & Ross. It follows that there exist a tradeoff between complexity and accuracy. Our q is inspired by the specification presented by Chung & Pruitt (1994):

(7.3) $$q = \frac{MVE + PS + DEBT}{A}$$

Where *MVE* is the product of share price and common stocks outstanding, *PS* is the liquidation value of the outstanding preferred stocks, *DEBT* is the value of short-term liabilities net of short term assets plus book value of long-term debt, and *A* is the book value of total assets. This q-measure explains over 96 % of Lindenberg & Ross' measure and the signs of the coefficient estimates are unbiased and conservative (Chung, Pruitt 1994, Perfect, Wiles 1994). Because of data insufficiency[52] we use the following simplification:

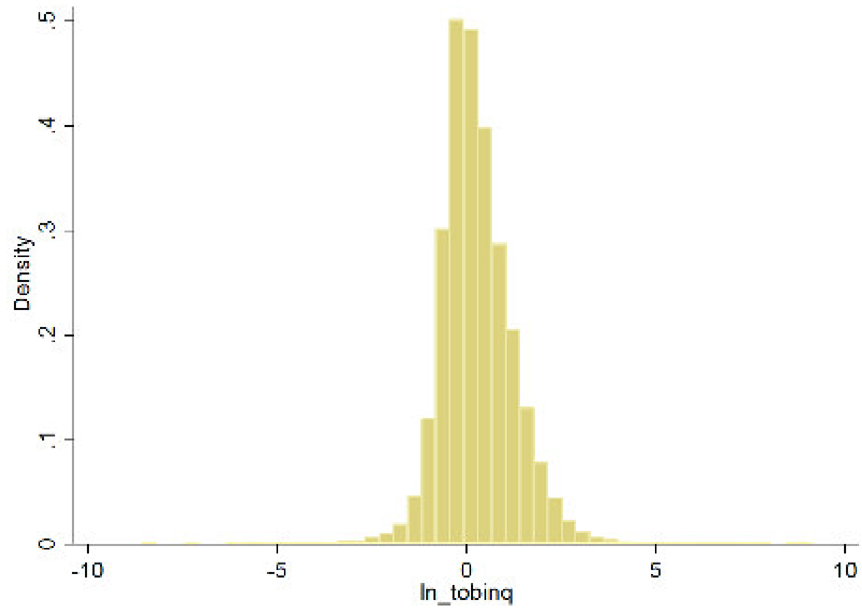
(7.4) $$q = \frac{MVE + DEBT_{LT}}{A}$$

Where *MVE* corresponds to Chung & Pruitt, $DEBT_{LT}$ is the book value of long-term debt, and *A* is the book value of total assets.

In order to get an approximately normally distributed response variable we transform q by the natural logarithm, in *Figure 7.1* we plot our log-transformed variable.

52 Results are similar (see *Appendix 8.Q*) using the specification from Chung and Pruitt (1994), however the dataset is reduced with 2.927 observations.

Figure 7.1: log Tobin's Q Distribution



7.2.1.2 Patent Stock

The patent stock is based on patent count calculated over a five-year period[53]. We use a depreciation δ= 15% as in Hall, Jaffe & Trajtenberg (2005, 2001, 2000) and Hall (1999). However our approach differs from these articles in that they use an accumulated patent stock over the full length of their dataset. Our measure contains less information but also less truncation as the same look back interval is applied to all observations:

(7.5) $$\frac{Pat\_s_{i,t}}{A_{i,t}} = \frac{\sum_{n=0}^{4} Pat_{i,(t-n)} * (1-\delta)^n}{A_{i,t}}$$

The patent stock variable is adjusted by the firm's total book assets and used to test hypothesis H1.B and H3.A.

7.2.1.3 Forward Citation Stock

The distribution of value for patents is skewed to the right, few patents are very valuable and a large number of patents have little value (Schankerman, Pakes 1987, Griliches 1998, Harhoff, Scherer &

[53] We discuss the appropriateness of the five-year period in *Chapter 11.*

Vopel 2003). As a value adjusted patent count measure we use Fcite, as the amount of Fcites a patent receives is a proxy for patent value (Trajtenberg 1990, Gambardella, Harhoff & Verspagen 2008). We follow Hall, Jaffe & Trajtenberg (2005, 2001, 2000), and adjust for future citations with a citation truncation multiplier, provided in the dataset (NBER , Hall, Jaffe & Trajtenberg 2001) The truncation weight is highest towards the end of the dataset, which could introduce inaccuracy; also a patent that does not have any past citations, is unaffected by the adjustment, even though lack of forward citations could be explained by a short patent life. The Fcite stock is calculated similarly to the patent stock:

(7.6) $$\frac{Fcite\_s_{i,t}}{A_{i,t}} = \frac{\sum_{n=0}^{4} Fcite_{i,(t-n)} * (1-\delta)^n}{A_{i,t}}$$

We use the citation stock to test hypothesis H1.C and H3.A.

7.2.1.4 R&D Stock

We base R&D stock on R&D expenditures over the last five years. Following Hall, Jaffe & Trajtenberg (2005) and Bloom, Schankerman & Van Reenen (2013) we use a δ = 15% yearly depreciation. When a firm enters the dataset we assign an initial R&D stock corresponding to the arithmetic average of the growth in the first three years. The growth is then given by[54]:

(7.7) $$g = \frac{1}{3}\sum_{n=1}^{3} \frac{R\&D_{i,(n+t)}}{R\&D_{i,(n+t-1)}} - 1$$

and R&D stock is given by:

(7.8) $$\frac{R\&D\_s_{i,t}}{A_{i,t}} = \begin{cases} \frac{\sum_{n=0}^{4} R\&D_{i,t} * \left((1-\delta)*(1-g)\right)^n}{A_{i,t}} & , if\ first\ year\ in\ dataset^{55} \\ \frac{\sum_{n=0}^{4} R\&D_{i,(t-n)} * (1-\delta)^n}{A_{i,t}} & , otherwise \end{cases}$$

Our approach to R&D differs from previous research (Hall, Jaffe & Trajtenberg 2005, Bloom, Schankerman & Van Reenen 2013) in that we only use the latest five years of R&D. The advantage of

[54] Notice that only a firm with R&D expenditures in its first year in the dataset will be assigned an initial stock. The assumption is that if a firm did not invest in R&D in the first year in the dataset it didn't invest in the prior years either.

[55] Due to the specification of the initial stock, firms that have above 100% growth in R&D in their first years will have unrealistic initial R&D stocks. We mitigate this by putting an upper bound on the initial R&D stock equal to five times the initial R&D.

this approach is that it corresponds to our patent stocks. We discuss potential drawbacks in *Chapter 11 Further Research & Critique*. The R&D stock is used to test hypothesis H1.A and H3.A.

R&D stock, patent stock and Fcite stock are correlated measures[56]. On one hand it is therefore important to include R&D stock in order to isolate the value contribution of patenting; on the other hand multicollinearity can become an issue. Following Hall, Jaffe & Trajtenberg (2005) we construct an alternative regression model where R&D, patenting and Fcite occurs recursively in the following order: R&D stock over assets, patent stock over R&D stock and finally Fcite stock over patent stock. The alternative (recursive) model is presented in *Chapter 10*.

7.2.2 Industry Level Variables

We use the S&P Global Industry Classification Standard (GICS) (S&P indices 2008) as our industry classification. This means that the fragmentation index, operating space variables and technology space variables are based on industry proximities rather than patent-technology proximities. First, in *paragraph 7.2.2.1* we describe the fragmentation index. Second, in *paragraph 7.2.2.2* we look at patent stock and Fcite stock in the operating- and technology spaces. To lighten notation we omit indexing for 6- and 4-digit industries, firm *i* belong to 6-digit industry *j* and 4-digit industry *k*, so that $i \in j \subseteq k$. wherefore *j* and *k appear in some variables.*

7.2.2.1 Fragmentation

The *Fragmentation Index* is one minus the average of the Herfindahl-Hirsh Indexes for number of claims stock (claims stock), patent stock and number of backward citations stock (Bcite stock). Since HHI is calculated on the basis of count data we adjust the measure as proposed by Hall (2005) to avoid bias. The HHI of patent stock of firm *i* in 6-digit industry *j* we calculate as:

(7.9) $$HHI\_Pat\_s_{i,t} = \sum_{n \epsilon j} \left(\frac{Pat\_s_{n,t}}{Pat\_s\_total_{j,t}} \right)^2$$

(7.10) $$Adj\_HHI\_Pat\_s_{i,t} = \frac{HHI\_Pat\_s_{i,t} * Pat\_s\_total_{j,t} - 1}{Pat\_s\_total_{j,t} - 1}$$

[56] In our sample mostly Fcite and patent count are correlated see *section 8.2 Correlations*

Where $Pat\_s\_total_{j,t}$ is the total patent stock in industry *j* at time t. We compute similar measures for claims stock and Bcite stock. The fragmentation of firm *i* in 6-digit industry *j* we compute as:

(7.11) $FRAG_{i,t} = 1 - \frac{1}{3}\left(Adj\_HHI\_Claims\_s_{i,t} + Adj\_HHI\_Pat\_s_{i,t} + Adj\_HHI\_Bcite\_s_{i,t}\right)$

The fragmentation index is calculated on the basis of the 6-digit industry classification.

The idea of using patent data to create a fragmentation measure was first proposed by Ziedonis (2004). She measures fragmentation of firm backward citations by looking at who owns the patents each patent cites, i.e. how many firms you are likely to negotiate with to use a given technology. We measure the fragmentation of patent rights among firms in a predetermined industry, and extend the index to include number of patents and number of claims. We base the fragmentation on stock measures as holdup also relates to older patents.

Backward citations are included in the fragmentation measure as they provide information on how much prior art firms in a given industry build on. Some patent types (e.g. software) have been criticized for using too few citations (Merges 1999), and in opaque, complex industries a patentee is not always aware of all prior art (Bessen, Meurer 2008). Therefore we include patent count in our fragmentation measure. We also use patent claims, as patentees use several claims to give patents broader protection (Bessen, Meurer 2008). Galasso & Schankerman (2013) find that litigated patents have relatively more claims and the average number of claims per patent has grown throughout our data period. Allison & Lemley (2002) find that the average number of claims pr. patent increased from 9.94 to 14.87 (50 %) from mid-‘70s to mid-‘90s. We argue that claims are a non-static indicator that contributes to complexity beyond information drawn from patent count.

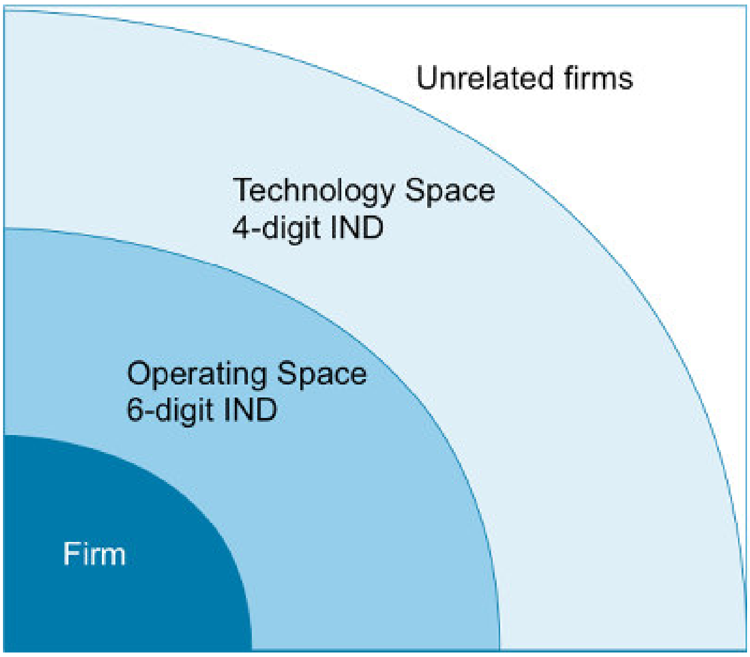
We use the fragmentation measure to test hypothesis H2.A and H3.B.

7.2.2.2 Industry Variables with Patent Stock and Forward Citation Stock

Similarly to our firm variables for patent stock and Fcite stock, we use industry variables. We use the 4-digit industry group to proxy technology space and the narrower 6-digit industry to proxy operating space. Notice thereby that we assume that any firm that is part of the operating space of firm *i* is also part of the technology space of firm *i* however the opposite need not be true.

To separate the effects at different distances, we construct variables for the operating space less the company itself, and variables for the technology space less the operating space. This is illustrated in Figure 7.2.

Figure 7.2: Circle Logic for Stock Variables



Let firm i belong to 6-digit industry j and 4-digit industry k, so that $i \epsilon j \subseteq k$ then the industry patenting variables are given by[57]:

(7.12) $\frac{Pat\_ind6_{i,t}}{A\_ind6_{i,t}} = \frac{\sum_{n \epsilon j \backslash i} pat\_stock_{n,t}}{\sum_{n \epsilon j \backslash i} A_{n,t}}$

(7.13) $\frac{Pat\_ind4_{i,t}}{A\_ind4_{i,t}} = \frac{\sum_{n \epsilon k \backslash j} pat\_stock_{n,t}}{\sum_{n \epsilon k \backslash j} A_{n,t}}$

Similar variables are created with Fcite. The 6-digit industry variables are used to test hypothesis H2.B and H3.C. The 4-digit industry variables are used to test H2.C and H3.D.

[57] industry indexes excluded to lighten notation

7.2.3 Control Variables

As described in *Chapter 5: Econometric Regression Theory*, we include a set of control variables capturing firm-specific, time-varying effects, to better estimate the "all else equal" effects of variables of interest. These control variables we present next.

7.2.3.1 EBIT (ROA)

The earnings to asset ratio (ROA) is likely to be correlated with Tobin's Q and other firm specifics such as R&D stock and patent stock, e.g. ROA of a research-intensive tech startup tend to be low (Damodaran 2012).

7.2.3.2 Net Property, Plant and Equipment (NPPE)

The property, plant and equipment to assets ratio explain the capital intensity of a firm. Ziedonis (2004) finds that capital-intensive firms patent more aggressively when operating under fragmented intellectual property rights. We control for NPPE to avoid omitted variable bias.

7.2.3.3 Sale (Asset Turnover)

The Asset Turnover (Sales/Assets) indicates how efficiently a firm generates sales. We suspect that a firm's ability to generate sales correlate with variables of interest.

7.2.3.4 Market Share

Market share can be correlated with firm ability to extract monopoly rents, which positively relates to q. The Market share variable is constructed based on revenue in the 6-digit GICS industry in a given year. Notice that market share is based on the firms in the dataset; market shares are biased upward when competitors are missing in Compustat.

7.2.3.5 HHI - Market Concentration

To further control for competitive landscape in the operating space we include a Herfindahl-Hirschman Index (HHI) based on revenue, defined at the 6-digit GICS industry level.

7.2.3.6 Size

A number of characteristics are related to firm size, e.g. Kleinknecht (1987) finds that R&D is underestimated in small firms. Researchers disagree on how to define small, medium and large enterprises (Storey 1994). We use employment, as it is easily measured and widely recognized as the most important factor[58] (Ayyagari, Beck & Demirguc-Kunt 2007, Storey 1994). We follow the European model for categorizing size through employment[59] (European Commission 2005): Micro (<10), Small (<50), Medium (<250) and Large (+250). Entries where employment is reported 0 or missing are assigned employees based on their total assets and the average number of employees pr. asset in their 6-digit GICS industry level.[60]

This concludes Part III, in Part IV we present our empirical findings.

[58] We do not differentiate in requirements between different industries.
[59] It is more simple than the US classification
[60] The resulting classification is consistent when applying the 4-digit industry classification.

Part IV

Empirical Findings

Chapter 8 Descriptive Statistics

In this chapter we provide an overview of key statistics. In *section 8.1 Variable Summary* we present basic descriptive statistics of our regression variables. In *section 8.2 Correlations* we provide an overview of the correlations between regression variables. In *section 8.3 Categorical Variables* we provide an overview of the distribution of data across our categorical variables.

8.1 Variable Summary

Table 8.1 provides descriptive statistics of dataset A[61]. R&D stock, Patent stock and Fcite stock are all skewed to the right despite adjusting for total assets of the individual firms. This is expected, as many firms have not reported R&D (or patented). The market share has a mean of 1.12, which indicates that the average market is populated with 89 firms[62]. This suggests that the 6-digit GICS industry codes provide a broad definition of operating space.

Table 8.1: Descriptive Statistics Dataset A (Full) 79.284 observations

Variable	*Mnemonic*[63]	*Median*	*Mean*	*Std. Dev.*
Ln(q)	ln_tobinq	0.17	0.28	0.95
R&D_s/A	xrd_at	0.11	0.35	1.13
Pat_s/A	sum_at_a	0.00	0.06	0.30
Fcite_s/A	hjtwt_at_a	0.00	1.13	4.93
FRAG	adj_frag_gind_a	0.82	0.76	0.21
Pat_ind6/A	sum_at_dist3a_a	0.02	0.03	0.03
Fcite_ind6/A	hjtwt_at_dist3a_a	0.26	0.53	0.69
Pat_ind4/A	sum_at_dist4_a	0.02	0.02	0.02
Fcite_ind4/A	hjtwt_at_dist4_a	0.24	0.42	0.49
Sale/A	sale_at	1.05	1.20	2.25
EBIT/A	ebit_at	0.05	-0.18	12.40
PPE/A	ppent_at	0.20	0.25	0.20
HHI_ind6	hhi_gind	717.3	1004.6	915.4
MS_ind6	mshare_gind	0.09	1.12	4.04

Note: The sample is an unbalanced panel covering 9775 firms over the period 1980-2004. Dollar figures are 2005 values in millions.

[61] For descriptive statistics for dataset B and C, see *Appendix 2.A* and *2.B*.
[62] Firms that appear in the Compustat dataset
[63] These names appear as variable names in Appendices

8.2 Correlations

Table 8.2 provides an overview of the correlations between variables in our regressions (Dataset A)[64].

Patent stock and Fcite stock are highly correlated; particularly industry variables. As a result we construct two versions of our full model, one with patent stock and one with citing stock[65]. Correlations between industry variables in the operating- and technology space are low, which can be attributed to the circular industry classification[66]

R&D stock has a correlation of 0.26 with patent stock and 0.17 with Fcite stock, which is lower than we expected, and might be caused by non-patenting firms in the dataset and the skewedness of R&D. In *Chapter 10* we run robustness regressions on only patenting firms and without R&D stock.

ROA is negatively correlated with log-q. We find this strange and do not have a good explanation, as we expect earnings to be positively correlated with market value. In *Chapter 10* we run several robustness tests[67] to capture any "odd data".

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[64] Correlations for dataset B and C can be found in *Appendix 2.C* and *2.D*.

[65] See equation 7.1 and 7.2

[66] See *7.2.2.2*

[67] E.g. without control variables, lagged independent variables and with a different q-measure.

Table 8.2: Correlations

	Ln(q)	*R&D_s/A*	*Pat_s/A*	*Fcite_s/A*	*FRAG*	*Pat_ind6/A*	*Fcite_ind6/A*	*Pat_ind4/A*	*Fcite_ind4/A*	*EBIT/A*	*PPE/A*	*Sale/A*	*MS_ind6*	*HHI_ind6*
Ln(q)	1.00													
R&D_s/A	0.24	1.00												
Pat_s/A	0.15	0.26	1.00											
Fcite_s/A	0.17	0.17	0.65	1.00										
FRAG	0.14	0.10	0.08	0.09	1.00									
Pat_ind6/A	0.13	0.11	0.12	0.15	0.21	1.00								
Fcite_ind6/A	0.16	0.09	0.09	0.17	0.19	0.87	1.00							
Pat_ind4/A	0.09	0.08	0.02	0.02	0.18	0.30	0.23	1.00						
Fcite_ind4/A	0.12	0.07	0.00	0.02	0.14	0.23	0.24	0.91	1.00					
EBIT/A	-0.06	-0.11	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	1.00				
PPE/A	-0.14	-0.09	-0.05	-0.06	0.01	-0.18	-0.17	-0.22	-0.21	0.01	1.00			
Sale/A	-0.04	0.04	-0.02	-0.03	-0.05	-0.07	-0.06	-0.03	-0.02	-0.34	0.02	1.00		
MS_ind6	-0.07	-0.05	-0.03	-0.03	-0.11	-0.01	-0.01	-0.03	-0.04	0.01	0.09	0.00	1.00	
HHI_ind6	-0.02	0.00	0.01	0.02	-0.47	0.22	0.16	0.14	0.13	0.00	-0.11	-0.01	0.15	1.00

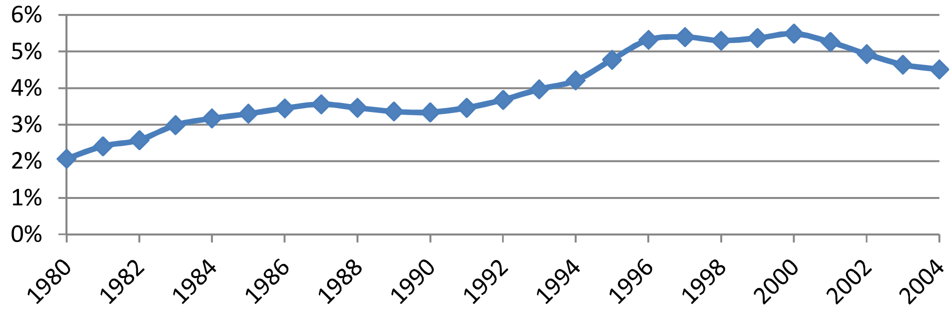
8.3 Categorical Variables

In this section we discuss the distribution of data points across three categorical variables: year, size and industry.

8.3.1 Year Distribution

A distribution of our observations across the 25 years of data can be found in *Figure 8.1*. There is a tendency that more firms are included in the dataset over time. After 2000 the number of observations declines, which could be explained by macroeconomic fluctuations. Overall we find the representation of observations in all years satisfying.

Figure 8.1: Observation Distribution

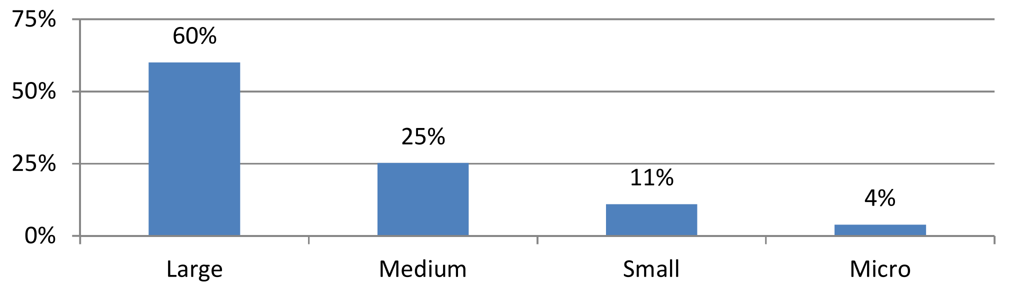


8.3.2 Size Distribution

The distribution of firms by size can be found in *Figure 8.2* there is an overrepresentation of large companies in the dataset; this expected as we use an SME (Micro, small and medium-sized enterprises) definition, where large companies are categorized as +250 employees[68]. Large companies are likely overrepresented in our sample, this is unavoidable because large firms are overrepresented at the data source. Since all patents are included in the dataset (before cleaning) we consider our coverage to be satisfying.

[68] We are mainly interested in avoiding reporting bias in startups.

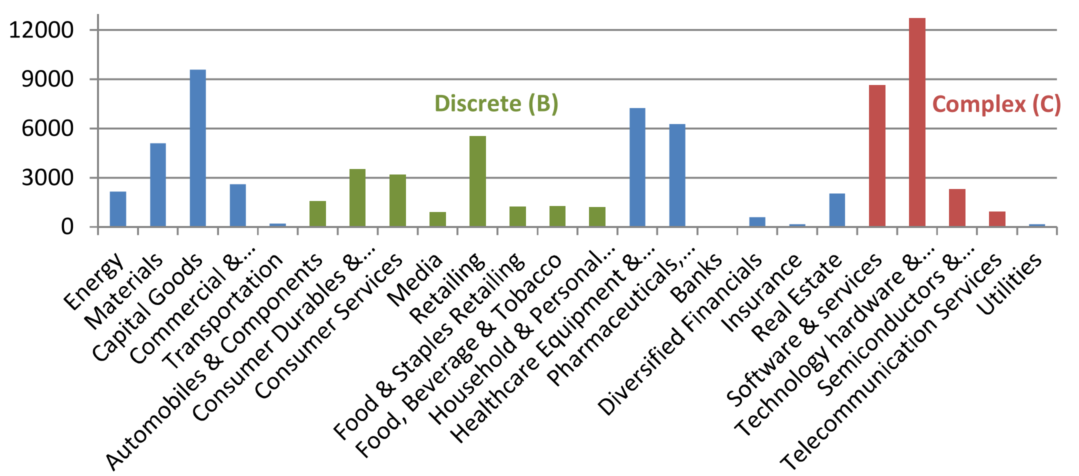
Figure 8.2: Company Size Representation



8.3.3 Industry Distribution

The distribution of firms across 4-digit industry categorization can be found in Figure 8.3. Some industries are very small e.g. Transportation (2030) only has 211 observations across the entire 25-year dataset. The transportation industry group covers Airlines, car rentals, freight logistics, marine, trucking etc. This is likely an inaccurate measure, there are more firms within this industry group, and the number can be distorted because some firms are owned by parent companies classified in other industries, or are not included in Compustat.

Figure 8.3: Industry Group Observations (4-digit)



Inaccurate industry classification distort industry variables in two ways: First, some industries will appear to have fewer patents because part of the competitive landscape are classified elsewhere. Second, some firms will appear to have more patents as subsidiaries are classified within an industry unrelated to their operations.

Chapter 9 Results

In this chapter we present the results of our regression models from *Chapter 7*. Results are presented in sections matching our SRQs from section *1.2 Research Question* and hypotheses from *Chapter 4 Hypotheses*. Section *9.1 Stock of Knowledge Assets [H1 Results]* and section *9.2 Patent Thickets [H2 Results]* are based on analysis conducted on dataset A (Full) with 79.284 observations. Section *9.3 Complex vs. Discrete Industries [H3 Results]* is based on dataset B (Discrete) with 18.445 observations and dataset C (Complex) with 24.651 observations. Section *9.4 Prisoner's Dilemma* uses all three datasets.

Table 9.1: Regressions Results Dataset A (Full)[69]

Hypothesis	Variable	I	II	III	IV	V	VI	VII	VIII	IX
H1.A	*R&D_s/A*	0.0506***	0.0465***	0.0483***	0.0464***	0.0465***	0.0468***	0.0482***	0.0468***	0.0484***
		(0.00607)	(0.00615)	(0.00610)	(0.00615)	(0.00615)	(0.00613)	(0.00611)	(0.00613)	(0.00610)
H1.B	*Pat_s/A*		0.0832***		0.0606*	0.0603*	0.0848***		0.0848***	
			(0.0218)		(0.0269)	(0.0269)	(0.0218)		(0.0218)	
H1.C	*Fcite_s/A*			0.00471***	0.00255	0.00258		0.00497***		0.00500***
				(0.00123)	(0.00157)	(0.00157)		(0.00124)		(0.00124)
H2.A	*FRAG*					-0.141**	-0.154***	-0.152**	-0.154***	-0.152**
						(0.0463)	(0.0467)	(0.0466)	(0.0465)	(0.0465)
H2.B	*Pat_ind6/A*						-1.648***		-1.657***	
							(0.405)		(0.405)	
H2.B	*Fcite_ind6/A*							-0.0439**		-0.0492**
								(0.0160)		(0.0160)
H2.C	*Pat_ind4/A*								0.472	
									(0.715)	
H2.C	*Fcite_ind4/A*									0.0611*
										(0.0250)

Notes: Based on unbalanced panel of 79,284 observations from 9,775 firms *** significance 0.001 ** significance 0.01 * significance 0.05 † significance 0.1; robust standard errors in brackets

[69] A full print of regression results for dataset A can be found in *Appendix 7.A*

9.1 Stock of Knowledge Assets [H1 Results]

In this section we discuss results related to H1 Hypotheses: Stock of Knowledge Assets. Regression results are presented in *Table 9.1*. Following equation (7.1) and (7.2), we include either patent- or citation stock as patent variables, Model 2, 6 and 8 are based on patent stock, and Model 3, 7 and 9 are based on Fcite stock. In Model 4 and 5 both variables are included.

Variables of interest are added one at the time, we see that coefficient estimates are consistent across models.

We describe significance levels with the following wording: *Highly significant* (0.1 % level), *Well significant* (1 % level), *Significant* (5 % level) and *Almost significant* (10 % level).

R&D stock is positive and highly significant in all models. This confirms *H1.A: R&D stock is positively related to market value*. When included one by one (Model 2-3 & 6-9) both patent stock and forward citation stock are positive and highly significant. This confirms *H1.B: Patent stock is positively related to market value* and the first part of H1.C: *Citation stock is positively related to market value…* The last part of hypothesis H1.C: … *and better explains market value than patent stock* is not confirmed. Both measures are highly significant, but when included together (Model 4-5) patent stock dominates. Multicollinearity explains why only one variable is significant, as we saw in *Chapter 8,* the correlation between the two variables is 0,65 (high) therefore we use one variable at the time in our main regression models.

In conclusion, the answer to SRQ 1 is *yes*; accumulating knowledge assets increase market value.

9.2 Patent Thickets [H2 Results]

In this section we discuss results related to H2 Hypotheses: Patent Thickets. As explained in *Chapter 4*, we use three different measures: Fragmentation of ownership rights, rival patenting in the operating space and rival patenting in the technology space.

9.2.1 Fragmented ownership rights

Fragmentation is negative and highly/well significant in all applicable regressions (Model 5-9). This confirms hypothesis H2.A*: Fragmented intellectual property rights in the operating space is negatively related to market value*. Our findings are in line with Noel & Schankerman (2013) who test a related measure on a software industry dataset. To our knowledge fragmentation has not been tested on a broad dataset before.

A 10 percent increase in fragmentation (evaluated at the sample mean) is estimated to reduce market value with 1.16 percentages when patent variables are based on patent stock (Model 8)[70] and 1.15 percentages when patent variables are based on Fcite stock (Model 9).

9.2.2 Rival Patenting in the Operating Space

Rival patenting in the operating space is negative and highly significant when based on patent stock (Model 6 & 8), and negative and well significant when based on Fcite stock (Model 7 & 9). This confirms hypothesis H2.B: *Rival patenting in the operating space is negatively related to market value*. Again this is in line with Noel & Schankerman (2013) who find that rival patent propensity decreases market value in the software industry. We argue that the negative patent thicket effect is more pronounced than the negative product market effect. If the product market effect is dominating, we expect Fcite stock, which is patents adjusted for value, to be the strongest indicator. Our results suggest that patent count is a better measure; this is supported by Hall & Ziedonis (2001) who argue that the relevant measure for bargaining power in cross licensing is the number of patents. An alternative explanation is that valuable innovations by competitors create valuable spillovers. Spillovers are likely to be larger for high value innovations hence more prominent in the citing based measure.

A 10 percent increase in patenting relative to assets in the operating space (evaluated at the sample mean) reduces the market value with 0.50 percent when based on patent count stock (Model 8) and

[70] The sample mean of fragmentation is 0,76 a 10% increase is then 0,076. The parameter estimate is -0,154 for model 8. In our log-level model this corresponds to an increase of 1-exp(0,076*-0,154) = 1,16%

0.26 percent when based on Fcite stock (Model 9). It is difficult to compare the effect of increased fragmentation to the effect of increased patenting as one measure is a composed index and the other is a ratio. But it seems that both fragmentation costs (Cournot compliment effect and double marginalization) and holdup costs are present across a broad range of industries.

9.2.3 Rival Patenting in the Technology Space

Rival patenting in the technology space is insignificant when based on patent stock (Model 8), and positive significant when based on Fcite stock (Model 9). We cannot confirm hypothesis H2.C: *Rival patenting in the technology space is negatively related to market value*. The result suggests that technology spillovers outweigh any patent thicket effect in the technology space, looking at the broad economy.

Summing up, we find moderate support for the presence of patent thickets in the overall economy [H2]. Fragmentation of intellectual property rights decrease company value [H2.A], but we do not find sufficient evidence to conclude that the negative effects of external patenting [H2.B] [H2.C] is due to patent thicket effects, it might be explained by competitive product market advantages. Overall we confirm SRQ 2: *Do patent thickets affect firms negatively?* Primarily based on a negative and highly significant fragmentation index.

Table 9.2: Regressions Results Dataset B (Discrete)[71]

Hypothesis	Variable	I	II	III	IV	V	VI	VII	VIII	IX
H3.A	*R&D_s/A*	0.0308**	0.0303**	0.0303**	0.0302**	0.0301**	0.0298**	0.0301**	0.0298**	0.0300**
		(0.00963)	(0.00963)	(0.00964)	(0.00964)	(0.00958)	(0.00969)	(0.00961)	(0.00969)	(0.00964)
H3.A	*Pat_s/A*		0.0363		0.0123	0.0115	0.0359		0.0358	
			(0.0230)		(0.0290)	(0.0292)	(0.0230)		(0.0230)	
H3.A	*Fcite_s/A*			0.00467	0.00407	0.00429		0.00480		0.00478
				(0.00329)	(0.00387)	(0.00390)		(0.00329)		(0.00330)
H3.B	*FRAG*					-0.181**	-0.158*	-0.163*	-0.158*	-0.164*
						(0.0649)	(0.0652)	(0.0665)	(0.0650)	(0.0663)
H3.C	*Pat_ind6/A*						3.636*		3.531*	
							(1.771)		(1.780)	
H3.C	*Fcite_ind6/A*							0.190†		0.175
								(0.109)		(0.110)
H3.D	*Pat_ind4/A*								1.006	
									(2.720)	
H3.D	*Fcite_ind4/A*									0.104
										(0.170)

Notes: Based on unbalanced panel of 18,445 observations from 2,312 firms *** significance 0.001 ** significance 0.01 * significance 0.05 † significance 0.1; robust standard errors in brackets

[71] A full print of regression results for dataset B can be found in *Appendix 7.B*

Table 9.3: Regressions Results Dataset C (Complex)[72]

Hypothesis	Variable	I	II	III	IV	V	VI	VII	VIII	IX
H3.A	*R&D_s/A*	0.0555***	0.0514***	0.0529***	0.0512***	0.0514***	0.0516***	0.0534***	0.0516***	0.0538***
		(0.00952)	(0.00972)	(0.00955)	(0.00969)	(0.00969)	(0.00972)	(0.00956)	(0.00971)	(0.00957)
H3.A	*Pat_s/A*		0.126***		0.0880*	0.0874*	0.126***		0.127***	
			(0.0376)		(0.0429)	(0.0429)	(0.0378)		(0.0378)	
H3.A	*Fcite_s/A*			0.00601**	0.00335	0.00339		0.00637**		0.00638**
				(0.00198)	(0.00222)	(0.00222)		(0.00199)		(0.00201)
H3.B	*FRAG*					-0.186†	-0.188†	-0.215*	-0.241*	-0.265*
						(0.108)	(0.108)	(0.109)	(0.110)	(0.110)
H3.C	*Pat_ind6/A*						-0.325		-1.346†	
							(0.720)		(0.726)	
H3.C	*Fcite_ind6/A*							-0.0748**		-0.136***
								(0.0235)		(0.0272)
H3.D	*Pat_ind4/A*								-4.598**	
									(1.478)	
H3.D	*Fcite_ind4/A*									-0.245***
										(0.0530)

Notes: Based on unbalanced panel of 24,651 observations from 3,171 firms *** significance 0.001 ** significance 0.01 * significance 0.05 † significance 0.1; robust standard errors in brackets

[72] A full print of regression results for dataset C can be found in *Appendix 7.C*

9.3 Complex vs. Discrete Industries [H3 Results]

In this section we discuss results related to H3 Hypotheses: Complex vs. Discrete Industries. Regression results in for discrete industries (*Table 9.2*) are compared to complex industries (*Table 9.3*).

9.3.1 Stock of Knowledge Assets

R&D stock is positive and well significant in discrete industries and positive and highly significant in complex industries. The estimators for complex industries are roughly 60% higher, which indicates that firms in complex industries are more dependent on R&D. Neither patent stock nor Fcite stock are significant in discrete industries, while in complex industries they are both positive significant. When included one at the time patent stock is highly significant (Model 2, 6 & 8), and Fcite stock is well significant (Model 3, 7 & 9). All in all, we strongly confirm hypothesis H3.A: *The effect on market value of knowledge stocks is pulled in a positive direction in complex industries compared to discrete industries*.

9.3.2 Fragmented Ownership Rights

In dataset B (discrete), fragmentation is negative and well significant in Model 5 and negative and significant in Model 6-9. In dataset A (complex) fragmentation is negative and almost significant in Model 5-6, and negative and significant in Model 7-9. It is surprising that the fragmentation index is less significant in complex industries. Evaluated at the mean, a 10 percent increase in fragmentation in dataset B reduces market value with 1.04 percent based on patent stock (Model 8) and 1.08 percent based on Fcite stock (Model 9). In dataset C a 10 percent increase in fragmentation reduces market value with 1.81 (Model 8) and 1.99 percent (Model 9). This (weakly) confirms hypothesis H3.B: *The effect on market value due to fragmented intellectual property rights in the operating space is pulled in a negative direction in complex industries compared to discrete industries*. Fragmentation has a larger impact in complex industries, but is not significant in all regression specifications[73].

[73] It is important to notice that fragmentation is significant in the complete models (8 & 9) for complex industries, which are the models we use for calculating effects on market value.

9.3.3 Rival Patenting in the Operating Space

In dataset B, rival patenting in the operating space is positive and significant when based on patent stock (Model 6 & 8) and positive and almost significant (Model 7) / not significant (Model 9), when based on Fcite stock. In dataset C, when based on patent stock, rival patenting in the operating space is negative insignificant in Model 6 and negative and almost significant in Model 8. When based on forward citation stock, rival patenting in the operating space is negative and well significant in Model 7 and negative and highly significant in Model 9. The significance-level differ across model specifications, but all estimated coefficients in dataset B are positive while all estimated coefficients in dataset C are negative. This confirms hypothesis H3.C*: The effect on market value due to rival patenting in the operating space is pulled in a negative direction in complex industries compared to discrete industries*.

The coefficient estimates in the discrete subset indicate that a 10 percent increase in rival patenting relative to assets (evaluated at the mean), increases market value 0.35 percent (Model 8) and 0.26 percent (Model 9). In the complex subset a 10 percent increase in rival patenting relative to assets (evaluated at the mean), decreases market value 0.67 percent (Model 8) and 1.30 percent (Model 9). This further confirms hypothesis H3.C.

Based on significance and coefficient estimates, rival patenting in complex industries based on Fcite stock better captures (compared to patent stock) the negative effect on market value. In *9.2.2* we argued that patent count is a cleaner measure for holdup. If this is the case, we cannot with certainty conclude that the negative effect of patenting in the operating space is due to the patent thicket effect, it could be the product market effect that dominates. Therefore it is necessary to look at the technology space. We turn to this next.

9.3.4 Rival Patenting in the Technology Space

Looking at the technology space, rival patenting in dataset C is negative and well significant when based on patent stock (Model 8) and negative and highly significant when based on Fcite stock (Model 9). These results stand in contrast to dataset B where technology space variables are insignificant, and confirms H3.D: *The effect on market value due to rival patenting in the technology space is pulled in a negative direction in complex industries compared to discrete industries*.

The significance of patenting in the technology space strongly suggests that firms in complex industries are affected by patenting of surrounding firms, not just through the competitive effect, but also through the patent thicket effect. This is not evident in dataset A (full) or dataset B (discrete). The technology space result support Hall & Ziedonis (2007), who find that product market rivals in the semi-conductor industry did not adopt an increasingly aggressive stand toward patent litigation, but became targets for litigation from outside patent owners. Our findings are evidence that patent thickets are an issue to be concerned about in complex technologies. This is in our opinion a strong result.

The estimators of rival patenting in technology space for dataset C have the highest impact on market value. A 10 percent increase in rival patenting relative to assets (evaluated at the mean) decreases market value by 1.82 percent based on patent stock (Model 8), and 2.06 percent based on Fcite stock (model 9). A possible explanation that the parameter estimates for technology space is higher than those for operating space, is that there (on average) are more firms in the technology space[74]. This means potentially more patent conflicts from an increase in patent stocks per assets.

In conclusion to this section we answer SRQ 3: *Are pernicious effects of patent thickets worse in complex industries?* Our empirical analysis clearly supports the theory, patent thickets are worse in complex technologies.

9.4 Prisoner's Dilemma [H4 Results]

In testing whether firms are trapped in a prisoner's dilemma we ask: *What if all firms reduced their patenting, would that increase value?*

To test this, we use firm level patenting, 6-digit industry patenting and 4-digitg industry patenting; we assume that the fragmentation of patents remains unchanged. As we compare simultaneous variation in variables with different distributions, we evaluate a reduction in each variable by one standard deviation[75].

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[74] Recall we define the operating space as the 6 digit industry and the technology space as the 4 digit industry excluding the 6 digit industry, see *paragraph 7.2.2.2*

[75] In *Appendix 5.B* we have performed the 10% case for control, estimates are consistent, results for complex industries remain significant, but discrete industries are insignificant.

We test the relationship[76]:

(9.1) $-\hat{\sigma}_{pat_s/A} * \beta_{pat_s/A} - \hat{\sigma}_{pat_{ind6}/A} * \beta_{pat_{ind6}/A} - \hat{\sigma}_{pat_{ind4}/A} * \beta_{pat_{ind4}/A} > 0$

using the linear combination test in STATA, the results are printed in *Table 9.4*.

Table 9.4: Prisoners Dilemma Results Based on Drop of One Standard Deviation

Dataset	*Model*	*Coef.*	*Std. Err.*	*t*	*P>|t|*	*[95% Conf. Interval]*	
Full (A)	8	.0148254	.0190624	0.78	0.437	-.0225408	.0521917
	9	-.0206079	.0167994	-1.23	0.220	-.0535381	.0123223
Discrete (B)	8	-.0889095	.0426429	-2.08	0.037	-.1725316	-.0052875
	9	-.0796922	.0401842	-1.98	0.047	-.1584928	-.0008915
Complex (C)	8	.1588666	.0595759	2.67	0.008	.0420558	.2756774
	9	.2042523	.0441417	4.63	0.000	.1177033	.2908012

In the full dataset, the effect of a decrease in patenting of one standard deviation, is insignificant, hence we are not able to confirm H4.A: *firms are trapped in a prisoner's dilemma*. Firms in discrete industries benefit from the patent system, and a reduction of all patenting would be detrimental to their value, we confirm H4.B: *firms in discrete industries are not trapped in a prisoner's dilemma*. We also confirm hypothesis H4.C, firms in complex industries are trapped in a Prisoner's Dilemma, as they would be better off collectively reducing patenting by one standard deviation. This is a strong result, indicating that in complex industries the patent system is "broken". On the contrary, patenting increases market value in discrete industries. This indicates that the patent system is working, and that patenting is closer related to innovation, than in complex industries. This answers SRQ 4: *Are firms trapped in a prisoner's dilemma?*

Table 9.5 summarizes our results for hypotheses H1-H4.

[76] When testing H4.B the inequality is reversed

Table 9.5: Results Overview

	Hypothesis	Variable	Expected	Result
Dataset A	H1.A	*R&D_s/A*	pos	√
	H1.B	*Pat_s/A*	pos	√
	H1.C	*Fcite_s/A*	pos	(√)
	H2.A	*FRAG*	neg	√
	H2.B	*Pat_ind6/A*	neg	√
	H2.B	*Fcite_ind6/A*	neg	√
	H2.C	*Pat_ind4/A*	neg	÷
	H2.C	*Fcite_ind4/A*	neg	÷
Dataset B & C	H3.A	*R&D_s/A*	more pos for C	√
	H3.A	*Pat_s/A*	more pos for C	√
	H3.A	*Fcite_s/A*	more pos for C	√
	H3.B	*FRAG*	more neg for C	(√)
	H3.C	*Pat_ind6/A*	more neg for C	√
	H3.C	*Fcite_ind6/A*	more neg for C	√
	H3.D	*Pat_ind4/A*	more neg for C	√
	H3.D	*Fcite_ind4/A*	more neg for C	√
Dataset A, B & C	H4.A	*equation (9.1)*	pos	÷
	H4.B	*equation (9.1)*	neg	√
	H4.C	*equation (9.1)*	pos	√

10 Robustness Test

In this chapter we challenge the robustness of our results. We do this by changing the underlying dataset and using alternative variable specifications. Most tests are conducted on the full dataset, however a selected few we found appropriate to test on all three datasets. In *section 10.1* we run regressions with alternative variable specifications, and in *section 10.2* we run regressions on altered datasets.

10.1 Alternative Variable Specifications

In this section we test the robustness of our results to changes in regression variable specifications. In *10.1.1* we use alternative fragmentation measures. In *10.1.2* we specify knowledge stock-variables to adjust for multicollinearity. In *10.1.3* we use an alternative depreciation rate. In *10.1.4* we use lagged independent variables. In *10.1.5* we use a polynomial specification. In *10.1.6* we disregard deflation of monetary variables. In *10.1.7* we run regressions without control variables and without R&D stock, and in *10.1.8* we use a different q measure.

10.1.1 Fragmentation Measure

Our fragmentation index is constructed as an average of the fragmentation of claim stock, patent stock and backward citation (Bcite) stock. In checking the robustness of fragmentation, we decompose the index in its three parts and run regressions with simple indexes individually. The results (for Model 8 & 9) can be found in *Appendix 8.A*. All simple fragmentation measures are negatively related to market value, however fragmentation based on Bcite stock dominates ($p<0.001$) either of the other and the combined measure.

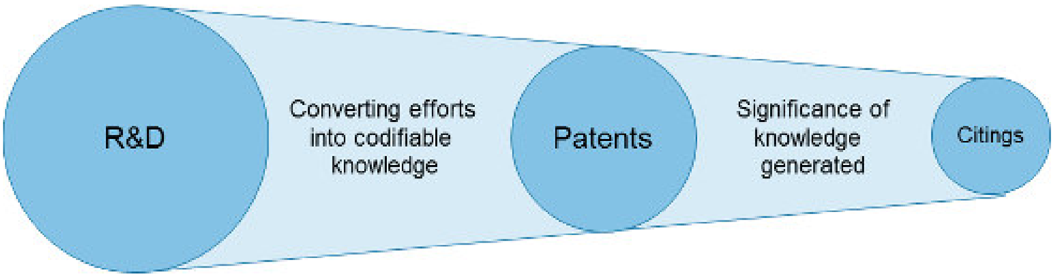
We also test the simple fragmentation index based on Bcite stock on dataset B and C. Results can be found in *Appendix 8.B*. We find that fragmentation is more severe (lower estimate with higher p value) in the complex dataset than in the discrete, and the simple index is highly significant ($p<0.001$) in complex industries, where the combined index was significant ($p<0.05$) (Model 8 & 9). This is further evidence for H3.B: *The effect on market value due to fragmented intellectual property rights in the operating space is pulled in a negative direction in complex industries compared to discrete industries.*

Furthermore we test a fragmentation index without implementing the adjustment proposed in Hall (2005) (see *Appendix 8.C*). Results are unaffected by this change, which is also indicated by a correlation of 0,993 between the two measures.

10.1.2 Recursive System

Fcite stock and patent stock are highly correlated (0.65), for this reason estimates are not significant when including both variables (model 4 & 5). Hall, Jaffe & Trajtenberg (2005) address this problem by introducing a recursive system. The idea (illustrated in *Figure 10.1*) is to view knowledge as a continuum process where R&D reveals the commitment in terms of resources, patent indicates how well resources are converted into “codifIable knowledge”, and citings indicate how significant the codifIable knowledge is.

Figure 10.1: Recursive Logic



Following Hall, Jaffe & Trajtenberg (2005), we run the following regression[77]:

(10.1) $ln(q_{i,t}) = \beta_1 \frac{R\&D\_s_{i,t}}{A_{i,t}} + \beta_2 \frac{Pat\_s_{i,t}}{R\&D\_s_{i,t}} + \beta_3 \frac{Fcite\_s_{i,t}}{Pat\_s_{i,t}} + \beta_4 FRAG_{i,t} + \beta_5 \frac{Pat\_ind6_{i,t}}{A\_ind6_{i,t}} + \beta_6 \frac{Pat\_ind4_{i,t}}{A\_ind4_{i,t}} + \gamma \boldsymbol{X}_{i,t} + \delta_i + \mu_t + \varepsilon_{i,t}$

Results for dataset A, B and C can be found in *Appendix 8.D-8.F*. For dataset A (Full), Fcite stock is highly significant and positive and patent stock is insignificant. For dataset B (Discrete), neither are significant and for dataset C (Complex) patent stock is positive significant and Fcite stock is positive highly significant. Overall results support conclusions from our main analysis.

10.1.3 Depreciation of Stock Variables

We use 15 % depreciation for R&D- and patent stocks. This is inspired by Hall, Jaffe & Trajtenberg (2005). To test the robustness of our results, we use a 20 % depreciation rate. Results are similar to those in our baseline analysis (see *Appendix 8.G*).

10.1.4 Lagged Variables

Scholars have suggested using lagged independent variables to avoid endogeneity (Hall, Jaffe & Trajtenberg 2005, Bloom, Schankerman & Van Reenen 2013, Noel, Schankerman 2013).

Our results are consistent (identical "signs"), but less significant when independent variables are lagged one time period. Results for all three datasets can be found in *Appendix 8.H-8.J.*

[77] A) We run the regression by including one variable at the time and with both patent- and citation stock as industry variables (comparable with Model 1-9 in the baseline setup). B) Missing data points are created when the denominator (R&D- or patent stock) is zero. We include dummy variables and replace missing data points with zero.

10.1.5 Polynomial Transformation

Inspired by Noel & Schankerman (2013) we run regressions with firm stock variables as polynomials of up to 5th order. We find a 5th order polynomial is significant for R&D stock, which we mostly contribute this to the skewedness of R&D values. For patent stock we find a 2nd order polynomial, and for citation stock, a 1st order polynomial is sufficient. Results can be found in *Appendix 8.K*.

10.1.6 Deflation

We deflate all monetary values to 2005-dollars with the United States Wholesale Price Index (Index Mundi 2011)[78]. To check whether deflation has an effect on results, we run our regressions on a non-deflated dataset. Our conclusions are robust to this adjustment. Fragmentation and rival patenting in the operating space are more significant compared to our baseline regressions (see *Appendix 8.L*).

10.1.7 Without Control Variables, and Without R&D Stock

As discussed in *Chapter 5* we run regressions without control variables to control for model over controlling; results can be found in *Appendix 8.M*. The significance and estimators are similar to the models in the main analysis, which indicates that our model does not suffer from over controlling. We also run regressions without R&D stock on all three datasets (see *Appendix 8.N-8.P*). The main reason for doing so is a concern for high right skewedness of R&D[79]. When excluding R&D stock we find that patent stock estimates are higher and more significant. This is not surprising as R&D- and patent stock measures are correlated. The industry variables are largely unaffected by removing R&D stock, and our conclusions are robust.

10.1.8 Tobin's Q

Because of limited data availability, we use a simplification of the Chung & Pruitt (1994) specification of Tobin's Q in our baseline specification. In *Appendix 8.Q* we include regression results with the Chung & Pruitt specification. The changed specification results in a reduction of the full dataset of 7.2%. The two q measures are very comparable; in general the estimates for R&D- and patent stock values are higher

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[78] Others have used differentiated deflation measures based on industry (Bloom, Schankerman & Van Reenen 2013)
[79] See *Chapter 8 Descriptive Statistics*

for the Chung & Pruitt specification, and fragmentation is more significant. On the other hand the estimates for industry variables are less significant.

For dataset B and C (see *Appendix 8.R* and *8.S*), results are also similar. Most noticeable is that firm patent- and Fcite stocks are significant and positively related to firm value in the discrete data under the Chung & Pruitt specification (where it was insignificant under our baseline specification). Overall our results are robust to the change.

10.2 Altered datasets

In this section we test the robustness of our results when the full dataset is altered. In *10.2.1* we only consider patenting firms and in *10.2.2* we drop small industries.

10.2.1 Patenting Firms Only

Noticing that a large portion of our sample did not apply for any patents during our regression period, we are interested in seeing if results are different if we only consider patenting firms. Following Bloom, Schankerman & Van Reenen (2013) we run our regressions on a biased sample where firms that did not patent between 1976 and 2006 are dropped. Our results are robust to this change of dataset; all variables give consistent estimates and have almost identical significance level (see *Appendix 8.T*).

10.2.2 Drop Small Industries

We are concerned that our results for industry variables are distorted by a few very small industries that may have obscure values. For this reason we conduct our analysis with a reduced dataset that only includes 4-digit industries with more than 1.000 observations over the entirety of the dataset. The results can be found in *Appendix 8.U*, and are similar to those in the main analysis. The main difference is that fragmentation is more negative (and significant) when cleaning out small industries.

11 Further Research & Critique

In *Chapter 10* we tested the robustness of our results. In this chapter we discuss weaknesses of our approach, and make suggestions for future empirical studies. In section *12.1 Alternative Model Specifications* we elaborate on drawbacks in our approach and propose alternative solutions to overcome these. In section *12.2 Model Extensions* we discuss new sources of data and how these can be used to further illuminate the topic.

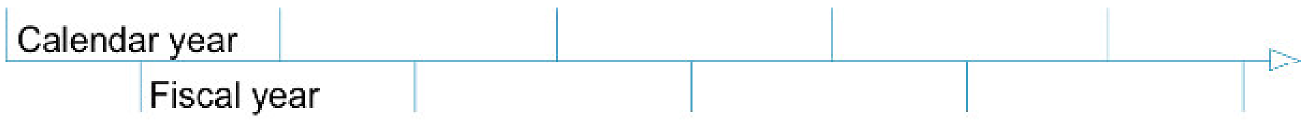
11.1 Alternative Model Specifications

In this section we propose alternative approaches, to conduct empirical analyses, with our data sources. These alternatives highlight potential weaknesses in our analysis, why they are relevant for future research.

11.1.1 Fiscal vs. Calendar Year

The NBER patent data is based on calendar year, while financial data from Compustat is based on fiscal years, which vary across securities. This introduces two problems. First, it introduces a discrepancy for firms whose fiscal years differ from calendar year as illustrated in *Figure 11.1*. Second, it introduces a discrepancy in timing of Compustat variables across firms. This will influence results in turbulent times. The first discrepancy can be solved by matching each patent with the fiscal year of the company owning the patent, but application dates are not included in the NBER dataset. The second discrepancy is harder to solve, as it does not relate to the use of patent data, but the fundamental problem of comparing firms that use different fiscal years. One approach is to reduce the interval length using quarterly data.

Figure 11.1: Fiscal vs. Calendar year



11.1.2 No Ownership Tracking

Patents are assigned to the original applicant. Currently the data provides no opportunity to effectively track ownership of patents beyond grant. Given that there is a large market for intellectual property (Chien 2010), this is a serious drawback of our data. The issue arises if patents are traded or e.g. a large conglomerate first acquire, then off hands a company after stripping it for intellectual property rights.

The severity of the lack of tracking is mitigated by the fact that only five years of patent data is used, starting from application year.

11.1.3 Depreciating Citation Stock

We assign the Fcite stock when the patent is applied for and start depreciating it immediately. We do not take into account that a patent may only be valuable later, when a new technology becomes dependent on the particular patent e.g. all citations come after four years when the technology is starting to mature. This is a simplification that may distort the result. An alternative approach is to assign citations, when they are made and depreciate the citations individually.

11.1.4 Patent Categories vs. Industry Categories

We assign patents to assignees, which are consolidated to securities. An implicit assumption is that these patents are related to the industry of the assignee. Firms however apply for patents within many different areas (Shalem, Trajtenberg 2009), some of which may be applicable in several industries. This means that thicket effects including trolling could come from a firm in a completely unrelated industry. Future research can capitalize on patent categorization to take this into account (see Bloom, Schankerman & Van Reenen (2013) for one approach). We mitigate this by using wide industry classifications and including the technology space.

11.1.5 Stock Measure Weights

We only use five years of data to calculate our stock variables for R&D, patent stock and Fcite stock. We choose to do so to accommodate problems with truncation and retain observations. One disadvantage of our approach is a somewhat arbitrary weighting scheme of past values[80]. This is illustrated in *Figure 11.2*.

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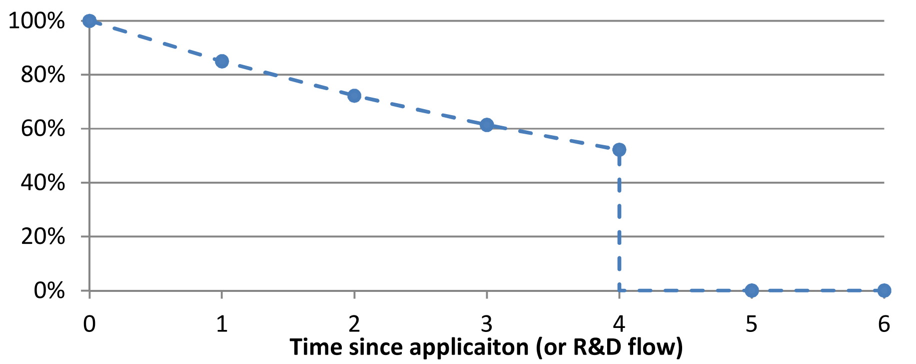
[80] We saw in *Chapter 10* that results are robust to a 20% depreciation

Figure 11.2: Stock Variable Weight Drop



11.2 Model Extensions

In this section we discuss usage of alternative data sources for future research.

11.2.1 Litigation Data

Much theory of patent thickets is based on the threat of competitors taking legal action. Therefore information on litigation and/or mediation between firms could be a valuable contribution to our analysis. Earlier empirical research use patent litigation data (Allison et al. 2012, Allison, Lemley & Walker 2011, Bessen, Meurer 2005, Mazzeo 2013), but to our knowledge it has not been incorporated in econometric analysis to measure impact on market value.

11.2.2 New Data

It would be interesting to conduct a similar analysis on a newer dataset. This may capture effects of recently debated on patent trolling (Bessen, Ford & Meurer 2012, Chien 2009, Hovenkamp 2012) and the smartphone patent wars (Chien 2012). As we saw in *Figure 2.2*, patenting has increased further post our regression period; it would be interesting to relate recent changes to our findings. To our knowledge no such data has been consolidated at present.

11.2.2 Industry Variables

Even though firms are classified in the same 6-digit industry, they are not necessarily competitors in the product market. Firms may be present in several segments and therefore be competing with different intensities. To adjust for this it is possible to find revenue split across segments[81] for all firms and use this as the basis for modeling the competitive landscape. Similarly, technology proximity could be based on their relative patenting patterns. Such approach has been implemented by Bloom, Schankerman & Van Reenen (2013).

11.2.4 Other Regions (China)

Our research is, like much empirical research on patent thickets, based on US companies (Noel, Schankerman 2013, Hall, Ziedonis 2001, Ziedonis 2004, Hall, Ziedonis 2007). Researchers have also explored patent thicket effects in Europe and Japan (Hall et al. 2012, Hall et al. 2013, Von Graevenitz, Wagner & Harhoff 2012, Cockburn, MacGarvie & Müller 2010). But as of 2011, China became the world's number one patent filer, and in 2013 China filed more than 825,000 patent applications (Yu 2014, Chyen 2011), why the study of Chinese patent thickets is an interesting topic for future research[82].

This concludes Part IV, in Part V we discuss policy improvements and conclude on our work.

[81] Segments can be retrieved from Compustat, see Bloom, Schankerman & Van Reenen (2013) for an application.

[82] Other regions would also be interesting for further research, e.g. South Korea filed more than 125,000 in 2010 (Hall et al. 2012)

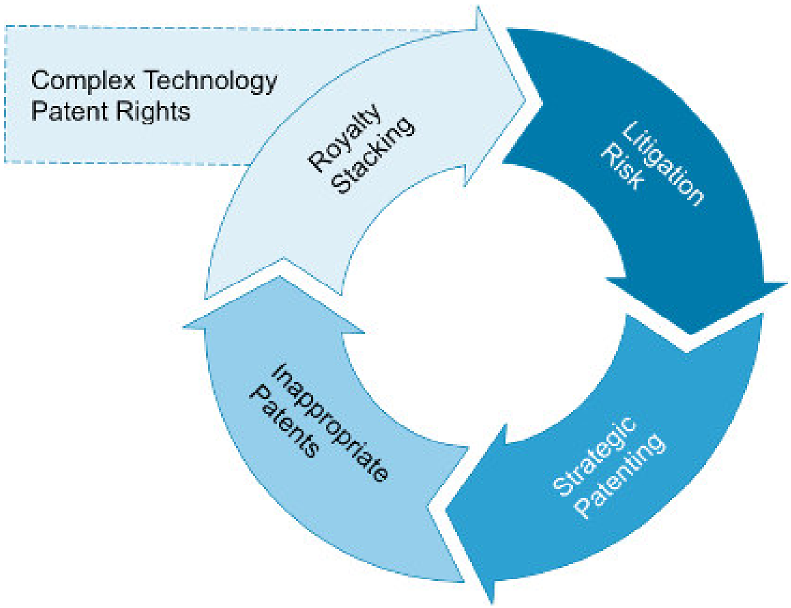
Part V

Discussion & Concluding Remarks

Chapter 12 Breaking the Circle

We have established the existence of patent thickets, in particular in complex high tech industries; the next logical question is what to do about it? In this chapter we return to our framework *A Vicious Circle* developed in *Chapter 3* to discuss policy recommendations. We review suggestions from literature and pending legislation to find potential solutions to each of the four pillars in our framework.

Figure 12.1: Patent Thickets, A Vicious Circle



In section *12.1 Reducing Royalty Stacking* we discuss patent pools as a way to get around the royalty stacking problem. In section *12.2 Reducing Litigation Risk* we discuss how changes can be made to injunction and damages practice. In section *12.3 Reducing Strategic Patenting* we discuss how to reduce incentives for strategic patenting. In section *12.4 Improving the Patent Office* we address the issue of lenient granting at the patent office. Finally, in section *12.5 The Right System* we take one step back, question the input to the circle, and look at an alternative intellectual property right scheme.

12.1 Reducing Royalty stacking

In this section we look at the problem of royalty stacking in a complex technology setting. We discussed in *Chapter 3*, that royalty stacking stems from two underlying economic problems: double marginalization and cournot compliments effect. Our results indicate that royalty stacking (fragmentation) negatively affect market value.

Royalty free Cross-licensing is an obvious solution in a two player setting, each with a blocking patent. The royalty free cross-licensing is the least costly in terms of welfare as it does not affect the producers marginal costs (Shapiro 2001). Patent pools are the natural extension of cross-licensing when more than two firms are involved. The idea is to provide one stop shopping for patent owners and third party users, instead of each firm engaging in bilateral licensing agreements (Shapiro 2001, Lerner, Tirole 2004). We discuss patent pools next.

12.1.1 Patent Pools

The earliest example of a US patent pool is from 1856, when four patent owners of complimentary technology for sewing machines bundled their technology to end a patent war, which had delayed the introduction of commercial sewing machines (Moser 2012). The US navy facilitated another early example: In 1917, litigation between the two dominating firms in the aircraft industry Wilbur Wright Company and The Curtiss Company had almost completely stopped the aircraft production. A patent pool was formed and from 1916 to 1918 the yearly production in the US rose from 83 to 11,950 aircrafts (Bittlingmayer 1988, Stubbs 2002, Moser 2012). These examples showcase that patent pools may be a valuable tool to circumvent holdups. Patent pools also introduce complications, these we discuss next.

12.1.1.1 Formation Complications

Generally the formations of patent pools are complicated for three reasons:

First, firms may have conflicting interests which can lead to tough negotiations. Layne-Farrar & Lerner (2011) show that integrated firms, interested in accessibility of the technology, are more likely to participate in patent pools. Furthermore they show that rent sharing rules and symmetry of patent portfolio value affect firm participation.

Second, information may be incomplete since the intrinsic value of a patent is unknown at formation; firms will maximize their share of the royalties by trying to include redundant patents and/or claim that their patents are particularly valuable (Aoki, Nagaoka 2004).

Third, information is asymmetric; firms possessing an essential patent have incentive to hide it, and not participate in the pool. In this way they can free ride on cooperative efforts of others and generate superior revenues (Aoki, Nagaoka 2004). This argument also works for firms that participates but have pending patents that will be essential once issued.

To avoid subsequent holdup from a free rider, pools often include grant back provisions, requiring participants and licensees to grant back subsequently patented innovations to the pool. Theory does not make a clear prediction on the effect on innovation from grant backs. Firms may be incentivized to cut R&D and instead free ride on the technology developed by other pool members (Aoki, Nagaoka 2004). On the other hand grant back eliminates subsequent holdup threat, which should facilitate more R&D (Lerner, Strojwas & Tirole 2007) . This tradeoff is exemplified in the case of the sewing machine pool, where evidence suggest that the pool lowered litigation risk, but also lowered the patenting in the industry until its dissolving in 1877 (Lampe, Moser 2009).

12.1.1.2 Antitrust Concerns

Antitrust is a major concern when firms that are otherwise competitors coordinate efforts (Belleflamme, Peitz 2010). Naturally, patent pools have attracted attention from the Department of Justice. Consensus is that pools are welfare enhancing, and should be allowed if they consist of complementary patents (as this reduce the thicket problem), and welfare decreasing if the pools consist of substituting patents (which would facilitate cartel behavior) (Lerner, Tirole 2004). Compulsory Independent Licensing (CIL) has been proposed as an effective screening mechanism to identify welfare increasing and welfare decreasing pools; welfare increasing pools are indeed more likely to allow independent licensing (Lerner, Strojwas & Tirole 2007) . The idea is that a participant in a pool consisting of substitute patents has incentives to license his patent on a stand-alone basis, which will break down the anticompetitive pools (Shapiro 2001). Lerner & Tirole (2004) show that CIL is sufficient to screen out welfare decreasing, complete[83] pools, but they do not consider cases where firms can exclude rivals from entering the pool (Brenner 2009). Furthermore these theoretical models do not consider the possibility of several pools within an industry.

[83] Covering all applicable patents, as opposed to an incomplete pool where some patent owners are excluded.

12.1.1.3 Pools for Standard Setting Organizations

Patent pools are particularly useful when standards are set for a new technology. Pools set by Standard Setting Organizations (SSOs) have particular high stakes as a patent that is ruled essential to the standard can obtain licensing fees many years into the future (Chiao, Lerner & Tirole 2007) . Leiponen (2008) shows that the success of firms participating in the standard setting of wireless telecommunications (along measures such as intellectual property value and engagement in the SSO) depended on informal alliances achieved through consortium activities outside the formal standard setting. This suggests that forming pools for new standards is a complex game, possibly covering personal relations, which poses an antitrust issue as the SSOs can be used to cripple competitors (Shapiro 2001).

The problems with holdup is exacerbated in the case of new standards, it can be extremely expensive to change technology input in a standard that is already in use (Farrell et al. 2007, Shapiro 2001, Lemley, Shapiro 2006). Intuitively the purpose of gathering technology in a standard in the first place, is to facilitate compatibility between products across producers.

As such SSOs are particularly worried about essential patents surfacing with large demands after the standard has been set. They typically require members to license standard-essential patents on Fair, Reasonable, and Non-Discriminatory (FRAND) basis (Lemley, Shapiro 2013). SSOs could reduce the risk even further by up front agreeing specifically how much a Fair and reasonable royalty is (Lemley 2007, Lemley, Shapiro 2013). Lemley (2007) presents two other creative solutions. First, SSOs should be allowed to impose a (low) maximum royalty fee for an essential patent that is not disclosed at the formation of the standard. This incentivize firms to put their innovations out in the open when standard is set. Second, a step down royalty rate e.g. the first essential patent is capped by a maximum royalty of 5% the technology’s revenue, the second a maximum of 3% then 2% etc. would help bring out patents in the open. Ideally the SSO would also be able to renegotiate royalty rates even with old patentees as more standard essential patents emerge.

Lemley (2002, 2007) notes that antitrust authorities should allow SSOs to discuss royalties. This is because SSOs serve an important role in mitigating the shortcomings of the IP system in complex industries.

12.1.1.4 Patent Pools in sum

Patent pools and SSOs are from an economic standpoint a complicated matter, and a complete analysis is beyond the scope this thesis. Patent pools have historically solved the problem of the anti-commons associated with royalty stacking albeit sometimes at the cost of collusion, and it is not guaranteed to increase innovation incentives and welfare.

We have discussed proposals, which in a standard setting context can help align patentee incentives with welfare.

12.2 Reducing Litigation risk

In this section we look the two main problems identified in section *3.2 Litigation Risk* and discuss how to improve these matters. In *11.2.1* we discuss preliminary injunction and in *11.2.2* we discuss damages and willfulness.

12.2.1 Preliminary Injunction

Interpreting the statement by Judge Thomas (2006) presented in *Chapter 3*, we find that preliminary injunction per definition only should be relevant in cases regarding "lost profits" (as opposed to reasonable royalties). This is due to factor four in the test of injunction appropriateness: *"(iv) The public interest would not be disserved by an injunction"*. In case an infringement has not resulted in lost profits, the defendant's innovation is effectively generating a new product[84], which always increases consumer surplus[85]; hence removing the product would disserve the public interest. As a minimum firms that infringe a patent but do not meet the requirements for "lost profit" damages, should be offered time to work around and implement a substituting technology, as proposed by Lemley & Shapiro (2006). This should apply in federal courts as well as the ITC.

12.2.2 Damages and Willfulness

In *Chapter 3* we found that damage awards even for "reasonable royalties" were excessive. In establishing damages, evaluating patent contribution based on the smallest possible component that cover the infringement would limit litigators in claiming value for unpatented innovations not related

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[84] Although it may compete with other products not related to the plaintiff.

[85] With the weak assumption that perfect price discrimination is not feasible.

to their patent [86]. One method to determine added value of a patent is to gather information on alternative technologies and use tools from cooperative game theory (e.g. the Shapely Value (Shapley 1952)). Judges can also consider a step down for damages[87], the argument being that the fragmented ownership structure of technology would otherwise impede the development of a product through litigation threat.

Related to damages it might be favorable to change the approach to willfulness. Lemley (2007) notes that almost all plaintiffs claim willfulness, but actual willfulness should be limited to cases where it can be proven that technology has been copied. Another issue with willfulness is that it demotivates prior art review when developing a product (Bessen, Meurer 2008, Jaffe, Lerner 2011).

12.3 Reducing Strategic Patenting

In this section we discuss measures to reduce incentives to patent, corresponding to the issues highlighted in section *3.3 Strategic Patenting*. *Subsection 11.3.1* aims at reducing defensive patenting by analyzing maintenance fees and patent life span. *Subsection 11.3.2* discusses ways to deter patent trolling strategies (which also reduce incentives to patent defensively).

12.3.1 Defensive Patenting

We discuss two possible levers for reducing defensive patenting, increasing maintenance fees and reducing patent life span.

12.3.1.1 Increase Maintenance Fee

In the US, maintenance fees on patents are paid in increasing amounts at periods 3½, 7½, and 11½ years after issue (Lemley 2001). Several economic researchers have argued for a higher and steeper maintenance fee structure. The idea is that with increasing maintenance fees, bad patents will be forfeited, and the likelihood that patents end up with trolls decrease (Bessen, Meurer 2008, Ayres, Parchomovsky 2007). Empirically, de Rassenfosse & van Pottelsberghe (2012) find that firms have significant price elasticity of demand for patents, and Love (2013) finds that trolls are the dominant

[86] Notice that there is still an issue in determining the added value by the individual components.
[87] Similar to the one proposed for SSO royalties

source of patent litigation in the final few years of the patent term. This indicates that increased fees would reduce the number of patents and litigations by trolls[88].

Patent fees are the lowest in history compared to income (Chien 2012) and would need to increase tenfold to match 1800 level. But given that maintenance fee increases are desirable, how should we go about setting these fees? Bessen and Meurer (2008) propose a quasi-independent organization (like federal reserves) that would be less affected by political pressure compared to the patent office. Increasing maintenance fees is a viable way of removing low quality patents without distorting innovation incentives. According to our analysis, such a change is likely to increase firm values.

12.3.1.2 Decrease Patent Lifespan

An alternative intervention to reduce the number of patents is to decrease their lifespan (Love 2013). A problem with this regulated approach compared to increasing fees, is that it does not leave room for firms to decide themselves whether it is worth paying for upholding a patent longer. Reducing patent length may in fact be harmful in industries where firms are dependent on reaping monopoly payoff over a long period to recoup expensive R&D costs (e.g. pharmaceuticals). On the other hand it might be fitting in a fast moving, cumulative industry where a first-mover advantage is sufficient to incentivize innovation.

12.3.2 Trolling

In this subsection we discuss solutions to many of the problems with patent trolling, discussed in section 3.3.2

12.3.2.1 Fee Shifting and Attorney Payment

Most attorney fee shifting statues are independently determined by the court, and not widely used (Chien 2012). Therefore regardless of outcome, the defendant bears the cost of his attorneys, which can be substantial[89]. This means that firms are incentivized to accept licensing settlements just below

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[88] This is a bit tricky though, as trolls are likely to view patents as real options that need to be exercised before expiration. In this perspective reducing the lifespan is likely to have limited effect on trolling.

[89] E.g. General Electric had ten legal representatives in a case over Picture Archiving and Communication Systems vs. Acacia (a patent troll) and eventually settled (Tucker 2011).

their expected cost of litigation (Lemley 2001). Furthermore the plaintiff can claim multiple firms at once, effectively pooling legal fees from several cases[90].

Mandatory attorney fee-shifting has often been proposed to reduce incentives for nuisance suits with weak patents (Hylton 1993, Chien 2012, Bessen, Meurer 2008). Despite the intuitive appeal, and a theoretical foundation by Rosenberg & Shavell (1985), critics point out that risk averse patent holders with credible but uncertain cases might be the real losers (Rhode 2004). Polinsky & Rubinfeld (1998) present a model where plaintiffs are actually encouraged to litigate weak patents when there is two-way fee shifting, in this case a fee-shifting policy would not help. Empirically researchers have not succeeded in isolating the effect of the two-way fee-shifting rule on nuisance suits (Pfennigstorf 1984, Chien 2012). The effect of introducing a two-way fee shifting is therefore inconclusive (Chien 2012).

The goal of fee shifting is to bring down nuisance suits and adjust incentives in favor of the defendant. With this in mind, we consider a one-way defendant-favorable fee shifting structure as proposed by Kieff (2009). Though not improving the case for patent holders with credible, uncertain cases; it might be a pragmatic way to level the playing field. Hylton (1993) finds that a one-way defendant-favorable fee-shifting structure is more efficient than a two-way fee shifting structure. Despite some good properties, one-way fee shifting lacks the property of “fairness” and therefore is somewhat a stopgap solution.

Chien (2012) notes that plaintiffs can circumvent a fee-shifting structure by using shell companies, isolated from the firm’s assets, in case they should loose. One way to deal with this is to require disclosure of ownership and corporate structure of parties with financial interest in the claim and make them bound by the fee shifting (Patent Fairness 2013). An alternative suggestion is to introduce collateral requirements in litigation cases.

A related issue is that attorneys can be paid with contingent-fees. This means that patent attorneys can approach patent owners and offer to litigate patents on behalf of the owner, only for a share of the royalty award or settlement. In this way trolling effectively becomes costless for firms[91]. Fee

[90] In the GE case (foodnote 89) another 13 firms were sued for infringing the same two patents, all eventually settled for undisclosed licensing fees (Tucker 2011).
[91] Disregarding potential retaliation.

shifting is likely to bring down this practice as either the company or the attorneys' assets will be at stake.

The pending *Innovation Act* modifies the attorney's fees statute to make fee shifting "the default rule" without forcing it. The idea is to discourage frivolous litigation, while not burdening legitimate litigation (Patent Fairness 2013). To us this seems to be a good solution, though other measures are needed to avoid usage of shell entities.

The extensive research on fee-shifting witness how heavy and expensive the American justice system is. Rhode (2004) suggests that the problem might not be excessive litigation, but systematic overcompensation of lawyers.

12.3.2.2 Continuation

It makes sense to have a system where firms can correct errors in their first application via a continuation. There are however substantial problems with the practice being used by a small set of patentees for rent extraction purposes (Lemley, Moore 2004). Allowing firms to withdraw a successful application and restart the prosecution, claiming a little bit extra (Lemley 2007), is almost an invitation to play the system rather than protecting innovations. Lemley & Moore (2004) present five potential solutions to further reduce the abusive use of continuations: (1) Capping the number of continuations to one; each filing offers several chances to persuade the examiner.[92] (2) Disallow broadening a patent in a continuation to ensure that a firm that does prior art search will know what is covered and will not be surprised by a submarine patent. (3) Publication after 18 months even if a patent is only applied for in US. This would reduce the uncertainty of submarine patents. (4) Limit liability of firms that started producing with the infringed technology before it became part of a continuation; this would stop firms matching their continuations to competitor products for the purpose of blocking (but is less restricting that point two). (5) Limiting the maximum time spend at prosecution of a patent, this would ensure that firms cannot trade years of patent coverage for a better chance at surprising a mature industry. It would also prevent efforts to wear down examiners at the PTO to an eventual grant (Allison et al. 2003).

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[92] The process at the PTO as a standard includes initial rejections, and allows applicants to argue their case before a "final" rejection (Lemley, Moore 2004) .

12.3.2.3 Vague Infringement Claims

Plaintiffs can make vague claims as to the content of an infringement (Patent Fairness 2013). It is reasonable to require that firms report how specifically they believe their patent is being infringed. Changing legislation to secure specific claims would make it more costly to initiate litigation, plaintiffs would have to familiarize themselves with the defendants' inventions, and mass suits[93] would occur less frequently. Lastly, eliminating vague claiming would stop trolls in filing suits hoping something pops up, "fishing" for an infringement. The pending Innovation Act reduces defendant discovery costs prior to courts interpretation of the claims (Patent Fairness 2013). This limits the cost of unjustified infringement, which is relevant due to cost asymmetries.[94] We believe delaying the discovery process until the actual claim has been identified, will increase the efficiency of the patent system.

12.3.2.5 Protect end Users from Claims

Trolling behavior also includes targeting customers. In fact companies such as supermarkets, restaurants, airlines and real estate agents that were traditionally spared are now being litigated (The Washington Post 2013). This is a dirty trick in the arsenal that could result significant negative effects of the patent system beyond complex industries.

12.3.2.6 Choice of Battlefield

When a plaintiff files an infringement suit any jurisdiction in the US can be chosen. This has led to a concentration of patent litigation in certain jurisdictions biased toward plaintiffs through written and tacit rules. Notably is Eastern District of Texas where plaintiffs win 88% of cases (versus 68% nationwide) (Williams 2006). The tendency towards suits in Eastern Texas is so profound that a whole industry of specialized plaintiff and defense lawyers has developed around it (Schwartz, Kesan 2012). There are (at least) three ways of dealing with this. (1) Remove the possibility of selecting jurisdiction. (2) Standardize interpretation across jurisdictions. (3) Decrease room for interpretation.

12.3.2.7 Self-help and Socially Acceptable Behavior

So far we have discussed how incentive structures can be used to direct behavior of firms, lawyers and other agents. An alternative approach is to change what is socially acceptable. Such changes in

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[93] Like in the GE case foodnote 89

[94] A small, lean troll have very low costs of retrieving information, but can force large costs on a technology company that may need to retrieve millions of pages from internal documents and emails (The Washington Post 2013).

behavior have been seen in regard to environmental- and human rights issues over the last decades. Similarly, socially legitimate usage of intellectual property rights could become a comparable differentiation parameter, and institutions should push toward “reasonable usage” of patent rights in order to change companies’ incentive structures.

12.4 Improving the Patent Office

In this section we discuss issues at the PTO. First, we explore how to strengthen incentives and capabilities at the PTO. Second, we explore the option of including third parties such as competitors in the prosecution of patent applications.

12.4.1 Retention and Incentives

Realizing the significance of the work done at the PTO it is important to strengthen the capabilities by devoting extra resources to training and hiring (Merrill, Levin & Myers 2004). Jaffe & Lerner (2011) notes that the PTO does not offer competitive salaries that would retain valuable examiners. Bonuses are based on number of cases completed, which does not incentivize senior examiners to spend time training younger (Merges 1999). That no rejection is ever final is also problematic, by rejecting an application examiners are effectively depriving themselves from bonuses, and applicants can bet on this moral hazard by asking for wide patents, eventually wearing out examiners (Merges 1999, Allison et al. 2003). Finally there is no follow up on eventual validity of patents that were issued.

In sum a review of the compensation package is needed. Salaries should be adjusted to retain experience in the office and bonus packages should reflect a broader spectrum of activities including time devoted to training, effort spend reviewing applications (rather than patents granted) and ex post validity of granted patents.

12.4.2 Third Party Inclusion

As we discussed in *Chapter 3* it is likely not efficient to make a prosecution process so thorough that only valid patents are granted, rather the aim should be rejecting applications where it is cost effective. The most costly patents for welfare are those that are used for litigation and holdup, these patents are overrepresented among patents with many claims, that use continuation filings[95], and relates to lots of prior art. Unfortunately these are also the patents that examiners are least incentivized to review thoroughly (Lemley, Moore 2004, Allison et al. 2003). Scholars have explored the option of involving third parties in reviewing prior art, these parties have a lot at stake and are likely the most informed on invalidity of a patent (Merges 1999). One way of involving competitors is through opposition; this is a common practice around the world, the idea is that competitors can present evidence as to the invalidity of a patent in its early life (Merges, Duffy 2011). The opposition system has proved much more potent than the American reexamination pendant[96], evidenced by higher incidence and more frequent revocation (Soobert 1998, Merges 1999). The recently enacted *America Invents Act* implemented a version of a post-grant opposition system (USPTO 2013) this is an improvement, though it is too soon to analyze the effect[97].

Other ways of involving firms could be to contract them in the research face for prior art, or have a sample of granted patents reviewed to determine an error rate that could be used to calculate bonuses at the PTO (Merges 1999).

12.5 The Right System

Throughout this paper we have discussed strengths, weaknesses, issues, modifications and remedies – all within the borders of today's intellectual property system. In this section we take one step back and discuss an "out of the box" approach: *ex post prize schemes with auctions*, to co-exist with the current patent system. Furthermore, we conclude the chapter by discussing issues related to the "one size fits all" patent policy.

12.5.1 Ex Post Prize Schemes with Auctions

Prizes have historically been widely used as "targeted prizes" posted ex ante by governments or sponsors (Scotchmer 2004). Compared to prizes (or subsidies), the patent system has several advantages: (1) Innovators (inventors) bear the risk. (2) Subsidies/prizes raise government taxes which

[95] Lemley, Moore(2004) reports that 23% are continuation patents, but among litigated patents the figure is 52%

[96] Simplified the difference between the two is that in the American system competitors can only ask examiners to review the grant, while in the (European) opposition system competitors may present evidence.

[97] For more information on post-grant opposition models, see e.g. (Carrier 2011)

distort the economy elsewhere. (3) Uncertainty of the social value of innovation might lead a prize system to over-/undercompensation and moral hazard (4) Decentralized decision process is much easier to handle as it self-regulates (Scotchmer 2004, Belleflamme, Peitz 2010). Furthermore, the "targeted prize" scheme does not fully operationalize creativity in the population, as only innovations with a prize might be undertaken, where at the patent system all (commercial) valuable innovations are likely to be undertaken. But what if prizes were given ex post? Say the government buys the patent right at market value after the patent has been granted in order to avoid underutilization? Wright (1983) shows, that such a prize system dominates the patent system, given that innovation value is observable, the problem is, it is not; inventors will have private information about the value of the invention (Rockett 2010). Kremer (1997) propose a similar model, where the sponsor does not need to know the private or social value of an innovation. This model is to co-exist with the patent system, first a patent is granted then the social planner can reward the patent holder by buying the patent through a second-price sealed bid auction[98]. To incentivize agents[99] to bid, the winner will with a small probability be granted the patent right, otherwise the innovation will be placed in the public domain, but in both cases the government pays the second-price with a mark-up to the inventor[100] (Kremer 1997, Rockett 2010). The system may break down if agents collude, e.g. patent holder bribes bidders to bid too high[101]. Conceptually, we find the idea of combining decentralized innovation decision with a centralized public buyout interesting, whether these prize schemes could improve the efficiency of the patent system we leave to future researchers to establish.

12.5.2 One Size Fits All

As presented, reviewed, analyzed and discussed throughout this paper, both theoretical and empirical research, including our own, indicate that the optimality of a patent system depends on a number of technology and industry specifics. Therefore it is often brought to question whether the "one size fits

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[98] In a second-price sealed auction each bidder submits a sealed bid. The highest bidder wins and pays the second-highest bid. In such an auction, it is a dominant strategy for the bidder to bid their true valuation of the good. For more information on auctions, see e.g. Easley & Kleinberg (2010).

[99] E.g. competititors

[100] The mark-up is to ensure that the patent holder agrees to sell; the model can still dominate the "normal patent system" because of deadweight loss reductions (Kremer 1997).

[101] For suggestions to avoid collusive behavior see Kramer (1997).

all” patent system is optimal (Scotchmer 2004). Differences in cash-flow timing, innovation pace, market structure and many more areas makes it almost inevitable that the system is suboptimal – at least in one setting.

On the other hand prominent researchers have called for “a simplification” of the patent system, limiting room for interpretation at the PTO, standardizing licensing agreements, and clearly defining borders (Jaffe, Lerner 2011, Bessen, Meurer 2008, Lemley, Shapiro 2013). Kieff (2009) puts it: “*When one size doesn't fit all, how could two do the trick?*” The point being that issues regarding speed, accuracy, political manipulation and uncertainty in prosecution and litigation are likely to increase with system complexity (Kieff 2009). These are viable points; we have argued that much of the patent thicket issue stems from heavy workload and lenient prosecution at the PTO and an uneven litigation processes.

A reasonable conclusion to the discussion is to continue to improve the patent system step by step without making drastic changes e.g. abolishing the patent system. Our interest has been in uncovering a particular weakness in the patent system, we chose a dataset of the most complex technologies (C) and a control dataset (B) that we thought likely to be unaffected by patents. In order to recommend drastic changes in current policies, one would have to weigh the negatives with positives, conducting a thorough research on the implications on other patent dependent industries (e.g. Pharma and Biotech). We believe the recently enacted *America Invent Act* and the pending *Innovation Act* are appropriate precautious improvements to the system.

We encourage further research on complex technologies (software), to establish whether intellectual property protection through patents is appropriate, or if alternatives such as secrecy, early-mover advantages, copyright and network effects are sufficient to encourage innovation on these markets (Belleflamme, Peitz 2010). This concludes our discussion on patent thickets, in the final chapter we conclude on our empirical study.

Chapter 13 Conclusion

The purpose of this thesis has been to examine the patent thicket problem. To answer our research question: *How does patenting affect firm value?* We studied firm- and industry patenting effects on market valuation of US firms in the period 1980-2004. We conclude that it is individually rational for US firms to patent, but they are on average negatively affected by patent thickets and fragmentation of intellectual property rights. Both firm- and industry effects are more pronounced in complex technologies, than in discrete technologies. Our results suggest that firms in complex industries are trapped in a prisoner's dilemma, that is, they would be better off collectively reducing patenting.

We broke our research question down into four sub-research questions (SRQ) and established empirically testable hypotheses to each SRQ.

To answer our first SRQ: *Do firms benefit from accumulating knowledge assets?* We established three hypotheses based on R&D stock, patent stock and forward citation stock respectively. We were able to confirm our hypotheses and conclude that firms benefit from accumulating knowledge assets.

To answer our second SRQ: *Do patent thickets affect firms negatively?* We established three hypotheses based on fragmentation, rival patenting in the operating space and rival patenting in the technology space respectively. We were able to confirm that fragmentation has a negative effect on market value, and that rival patenting in the operating space also affects firms negatively. The latter can alternatively be explained by a disadvantage on the product market, not attributed to patent thicket effects, why the result (on its own) is not a strong indicator of a patent thicket problem. We were not able to find any significant effect of rival patenting in the technology space for the full dataset. In conclusion we found evidence that patent thickets affect firms negatively through fragmentation of intellectual property rights.

To answer our third SRQ: *Are pernicious effects of patent thickets worse in complex industries?* We established four hypotheses related to complex and discrete industries, and tested these on both discrete- and complex industry datasets. We were able to confirm all four hypotheses[102] and found strong evidence of pernicious patent thicket effects in complex industries. Specifically we found that

[102] The fragmentation index was more significant in Model 5 & 6 in discrete industries.

fragmentation, rival patenting in the operating space, and rival patenting in the technology space all negatively affect market value in complex industries, where only fragmentation have a negative effect in discrete industries. Furthermore we found that firms in complex industries benefit relatively more from accumulating knowledge assets.

To answer our fourth SRQ: *Are firms trapped in a prisoner's dilemma?* We tested the effect of collectively reducing firm and industry patenting with one standard deviation on all three datasets. We found that firms in complex industries are trapped in a prisoner's dilemma situation, suggesting that improvements of the patent system are needed.

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List of Appendices

Appendix 1 An Introduction to OLS

Generally, the goal in empirical economics is to establish whether a change in one variable causes a change in another variable. We use the notion ceteris paribus – everything else equal, or "holding all other relevant factors fixed" (Wooldridge 2010). This notion is fundamental for econometric analysis. It is not enough to know whether two variables are correlated, we need to know whether a change in one variable causes a change in another. To accommodate this we use multiple regression analysis, where it is possible to explicit control for other factors that also affect the dependent variable (Wooldridge 2012).

In a MLR model with *K* independent variables, we wish to estimate the relationship:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + u \text{ , } u \sim N(0, \sigma^2)$$

The OLS method chooses parameters such that the sum of squared residuals is minimized:

$$Min_{\hat{\beta}} \sum_{i=1}^{n} (y_i - \hat{\beta}_0 - \hat{\beta}_1 x_{i1} - \hat{\beta}_2 x_{i2} - \cdots - \hat{\beta}_k x_{ik})^2$$

Using OLS, the notion of estimating the ceteris paribus effect (partial effect) of an independent variable on the dependent variable will only hold true if the model is correctly specified.

When using OLS the critical assumptions to judge your model by, are known as the Gauss-Markov assumptions (Wooldridge 2012):

Table 5.1: Gauss-Markov Assumptions

MLR.1 - Linear in Parameters	The true population model can be written as: $y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + u$ where $\beta_0, \beta_1, \ldots, \beta_k$ are unknown parameters of interest and u is an unobservable random error term.
MLR.2 - Random Sampling	We have a random sample of *n* observations, $\{(x_{i1}, x_{i2}, \ldots, x_{ik}, y_i): i = 1,2, \ldots, n\}$, following the population model (MLR.1).
MLR.3 - No Perfect Collinearity	None of the independent variables are constant, and none of the independent variables have an exact linear relationship.
MLR.4 - Zero Conditional Mean	The error term u, in the population model, is uncorrelated with each of the independent variables. That is, it has an expected value of zero given any values of the independent variables: $E(u \mid x_1, x_2, \ldots, x_k) = 0$
MLR.5 – Homoskedasticity	The variance of the error term u takes on the same value given any

value of the independent variables: $Var(u|x_1, x_2, \dots, x_k) = \sigma^2$

Under assumption MLR 1-4 the OLS estimator is unbiased, and under assumption MLR 1-5 the estimator is *the Best Linear Unbiased Estimator* (BLUE), where "best" means having the lowest variance compared to other unbiased, linear estimates (Wooldridge 2012).

Appendix 2 Descriptive Statistics, dataset B and C

2A Descriptive Statistics for Dataset B

Descriptive Statistics Dataset B (Discrete) 18.445 observations

Variable	*Mnemonic*	*Median*	*Mean*	*Std. Dev.*
Log(Tobin's Q)	ln_tobinq	-0,06	0,01	0,88
R&D stock/assets	xrd_at	0,00	0,10	0,77
Patent Stock / assets	sum_at_a	0,00	0,03	0,23
Citings stock / assets	hjtwt_at_a	0,00	0,42	3,05
Fragmentation	adj_frag_gind_a	0,71	0,66	0,20
6-digit industry patent count / assets	sum_at_dist3a_a	0,00	0,01	0,02
6-digit industry citings / assets	hjtwt_at_dist3a_a	0,03	0,15	0,26
4-digit industry patent count / assets	sum_at_dist4_a	0,00	0,01	0,01
4-digit industry citings / assets	hjtwt_at_dist4_a	0,01	0,12	0,19
Sales/assets	sale_at	1,52	1,72	2,44
EBIT/assets	ebit_at	0,08	-0,08	6,63
property plant equipment/assets	ppent_at	0,28	0,33	0,22
6-digit HHI	hhi_gind	552,1	861,4	737,0
6-digit Market Share	mshare_gind	0,17	1,45	4,63

Note: The sample is an unbalanced panel covering 2312 firms over the period 1980-2004. Dollar figures are 2005 values in millions.

2B Descriptive Statistics for Dataset C

Descriptive Statistics Dataset C (Complex) 24.651 observations

Variable	*Mnemonic*	*Median*	*Mean*	*Std. Dev.*
Log(Tobin's Q)	ln_tobinq	0,37	0,45	0,96
R&D stock/assets	xrd_at	0,27	0,52	1,30
Patent Stock / assets	sum_at_a	0,00	0,06	0,26
Citings stock / assets	hjtwt_at_a	0,00	1,36	5,24
Fragmentation	adj_frag_gind_a	0,79	0,76	0,17
6-digit industry patent count / assets	sum_at_dist3a_a	0,04	0,05	0,04
6-digit industry citings / assets	hjtwt_at_dist3a_a	0,81	0,96	0,83
4-digit industry patent count / assets	sum_at_dist4_a	0,05	0,04	0,03
4-digit industry citings / assets	hjtwt_at_dist4_a	0,89	0,85	0,51
Sales/assets	sale_at	0,98	1,10	1,54
EBIT/assets	ebit_at	0,03	-0,33	21,39
property plant equipment/assets	ppent_at	0,14	0,18	0,15
6-digit HHI	hhi_gind	1006,8	1303,6	1001,9
6-digit Market Share	mshare_gind	0,06	0,90	4,24

Note: The sample is an unbalanced panel covering 3171 firms over the period 1980-2004. Dollar figures are 2005 values in millions.

2C Correlations for Dataset B

	ln_tob~q	xrd_at	sum_at_a	hjtw~t_a	adj_fr~a	sum~3a_a	hjt~3a_a	sum_~4_a	hjtw~4_a	ebit_at	ppent_at	sale_at	mshare~d	hhi_gind
ln_tobinq	1													
xrd_at	0.1203	1												
sum_at_a	0.0886	0.0939	1											
hjtwt_at_a	0.1121	0.0797	0.6578	1										
adj_frag_g~a	0.0099	0.0442	0.0359	0.0599	1									
sum_at_~3a_a	0.0012	0.0612	0.1005	0.0808	-0.1463	1								
hjtwt_a~3a_a	0.0073	0.0587	0.0924	0.0813	-0.1292	0.9656	1							
sum_at_d~4_a	-0.0214	0.0406	0.1006	0.0713	0.1011	0.5740	0.5398	1						
hjtwt_at~4_a	0.0060	0.0439	0.0871	0.0723	0.1021	0.5107	0.5141	0.9343	1					
ebit_at	-0.0955	-0.0533	-0.0074	-0.0072	0.0091	-0.0325	-0.0234	-0.0158	-0.0065	1				
ppent_at	0.0013	-0.0763	-0.0576	-0.0693	0.0966	-0.2000	-0.1776	-0.2638	-0.2625	-0.0013	1			
sale_at	0.0040	-0.0179	-0.0256	-0.0357	-0.0869	-0.0654	-0.0709	-0.0638	-0.0634	-0.2105	-0.0243	1		
mshare_gind	0.0006	-0.0107	-0.0113	-0.0182	-0.0811	0.0419	0.0494	0.0651	0.0747	0.0088	-0.0164	-0.0317	1	
hhi_gind	0.0144	0.0381	0.0653	0.0458	-0.2403	0.5965	0.6184	0.4180	0.4387	-0.0090	-0.2300	-0.0511	0.2826	1

2D Correlations for Dataset C

	ln_tob~q	xrd_at	sum_at_a	hjtw~t_a	adj_fr~a	sum~3a_a	hjt~3a_a	sum_~4_a	hjtw~4_a	ebit_at	ppent_at	sale_at	mshare~d	hhi_gind
ln_tobinq	1													
xrd_at	0.1653	1												
sum_at_a	0.1025	0.2049	1											
hjtwt_at_a	0.1203	0.1436	0.6790	1										
adj_frag_g~a	0.0867	0.0637	0.0234	0.0271	1									
sum_at_~3a_a	-0.0706	-0.0302	0.1206	0.1316	0.0886	1								
hjtwt_a~3a_a	-0.0082	-0.0300	0.0755	0.1333	0.1013	0.8488	1							
sum_at_d~4_a	-0.0407	-0.0027	0.0120	0.0032	0.2100	-0.0562	-0.1361	1						
hjtwt_at~4_a	0.0192	-0.0219	-0.0140	0.0085	0.1478	-0.1366	-0.0752	0.8518	1					
ebit_at	-0.0669	-0.1326	-0.0040	-0.0022	-0.0052	0.0120	0.0115	0.0042	0.0070	1				
ppent_at	-0.1147	-0.0142	0.0343	0.0248	-0.1418	0.0850	0.0676	-0.1231	-0.1320	0.0053	1			
sale_at	-0.0146	0.1944	-0.0096	-0.0130	-0.0428	-0.0009	0.0037	0.0431	0.0438	-0.8461	-0.0162	1		
mshare_gind	-0.0666	-0.0464	-0.0043	-0.0088	-0.1521	0.0451	0.0280	-0.0577	-0.0642	0.0041	0.1505	-0.0090	1	
hhi_gind	-0.1422	-0.0732	0.0615	0.0628	-0.5729	0.2293	0.1016	-0.0387	-0.0387	0.0088	0.1619	0.0457	0.1382	1

Appendix 3 Deflation Index

From Index Mundi (2011):

Wholesale Price Index (2005 = 100).

Source: International Monetary Fund, International Financial Statistics and data files.

Year	Value
1980	57.06
1981	62.27
1982	63.52
1983	64.32
1984	65.85
1985	65.53
1986	63.64
1987	65.32
1988	67.94
1989	71.31
1990	73.85
1991	74.02
1992	74.45
1993	75.55
1994	76.52
1995	79.26
1996	81.12
1997	81.07
1998	79.06
1999	79.72
2000	84.32
2001	85.26
2002	83.30
2003	87.75
2004	93.18

Appendix 4 Global Industry Classification Standards (GICS)

S&P Indices (2008):

10	Energy	1010	Energy	101010	Energy Equipment & Services
				101020	Oil, Gas & Consumable Fuels
15	Materials	1510	Materials	151010	Chemicals
				151020	Construction Materials
				151030	Containers & Packaging
				151040	Metals & Mining
				151050	Paper & Forest Products
20	Industrials	2010	Capital Goods	201010	Aerospace & Defense
				201020	Building Products
				201030	Construction & Engineering
				201040	Electrical Equipment
				201050	Industrial Conglomerates
				201060	Machinery
				201070	Trading Companies & Distributors
		2020	Commercial & professional services	202010	Commercial Services & Supplies
				202020	Professional Services
		2030	Transportation	203010	Air Freight & Logistics
				203020	Airlines
				203030	Marine
				203040	Road & Rail
				203050	Transportation Infrastructure
25	Consumer Discretionary	2510	Automobiles & Components	251010	Auto Components
				251020	Automobiles
		2520	Consumer Durables & Apparel	252010	Household Durables
				252020	Leisure Equipment & Products
				252030	Textiles, Apparel & Luxury Goods
		2530	Consumer Services	253010	Hotels, Restaurants & Leisure
				253020	Diversified Consumer Services
		2540	Media	254010	Media
		2550	Retailing	255010	Distributors
				255020	Internet & Catalog Retail
				255030	Multiline Retail
				255040	Specialty Retail
30	Consumer Staples	3010	Food & Staples Retailing	301010	Food & Staples Retailing
		3020	Food, Beverage & Tobacco	302010	Beverages
				302020	Food Products
				302030	Tobacco
		3030	Household & Personal Products	303010	Household Products
				303020	Personal Products
35	Health care	3510	Healthcare Equipment & Services	351010	Health Care Equipment & Supplies
				351020	Health Care Providers & Services
				351030	Health Care Technology
		3520	Pharmaceuticals, Biotechnology & Life Sciences	352010	Biotechnology
				352020	Pharmaceuticals
				352030	Life Sciences Tools & Services
40	Financials	4010	Banks	401010	Commercial Banks
				401020	Thrifts & Mortgage Finance
		4020	Diversified Financials	402010	Diversified Financial Services
				402020	Consumer Finance
				402030	Capital Markets
		4030	Insurance	403010	Insurance
		4040	Real Estate	404010	Real Estate
				404020	Real Estate Investment Trusts (REITs)
				404030	Real Estate Management & Development
45	Information Technology	4510	Software & services	451010	Internet Software & Services
				451020	IT Services
				451030	Software

		4520	Technology hardware & Equipment	452010	Communications Equipment
				452020	Computers & Peripherals
				452030	Electronic Equipment & Components
				452040	Office Electronics
				452050	Semiconductor Equipment & Products
		4530	Semiconductors & Semiconductor equipment	453010	Semiconductors & Semiconductor Equipment
50	Telecommunication Services	5010	Telecommunication Services	501010	Diversified Telecom-munication Services
				501020	Wireless Telecom-munication Services
55	Utilities	5510	Utilities	551010	Electric Utilities
				551020	Gas Utilities
				551030	Multi-Utilities
				551040	Water Utilities
				551050	Independent Power Producers & Energy Traders

Appendix 5 Statistical Tests

5A Hausman Test

To test for the appropriateness of fixed effects, we conduct a Hausman test on model 8 and 9, comparing random- and fixed effect regressions (Wooldridge 2010). The statistical tests, strongly confirm that fixed effects are more appropriate.

Hausman model 8:

Test: Ho: difference in coefficients not systematic

chi2(37) = (b-B)'[(V_b-V_B)^(-1)](b-B)

= 3149.38

Prob>chi2 = 0.0000

(V_b-V_B is not positive definite)

Hausman model 9:

Test: Ho: difference in coefficients not systematic

chi2(38) = (b-B)'[(V_b-V_B)^(-1)](b-B)

= 3464.99

Prob>chi2 = 0.0000

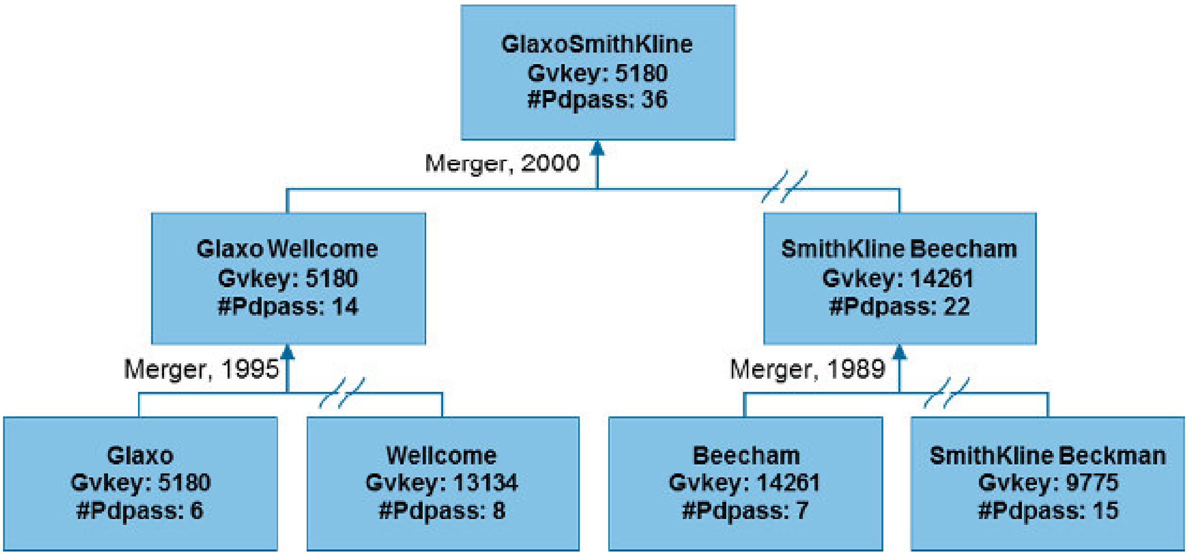
(V_b-V_B is not positive definite)

5B Prisoner's Dilemma, 10% Decrease from Mean

Prisoners Dilemma Results Based on 10% Decrease from Mean

Dataset	*Model*	*Coef.*	*Std. Err.*	*t*	*P>|t|*	*[95% Conf. Interval]*	
Full (A)	8	.0035187	.001824	1.93	0.054	-.0000567	.0070942
	9	-.0005205	.0013136	-0.40	0.692	-.0030954	.0020544
Discrete (B)	8	-.0046443	.0030646	-1.52	0.130	-.0106539	.0013653
	9	-.0040655	.0023804	-1.71	0.088	-.0087334	.0006024
Complex (C)	8	.0243625	.007685	3.17	0.002	.0092944	.0394306
	9	.0329862	.0062578	5.27	0.000	.0207165	.0452558

Appendix 6 Glaxo Consolidation Example



Name	*Gvkey*	*In dataset until*
Glaxo	5180	2004
Wellcome	13134	1994
Beecham	14261	1999
SmithKline Beckman	9775	1988

Note: Dataset ends in 2004

Appendix 7 Regression Results (Full Print)

7A Regression Results, Dataset A

	-1	-2	-3	-4	-5	-6	-7	-8	-9
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
xrd_at	0.0506***	0.0465***	0.0483***	0.0464***	0.0465***	0.0468***	0.0482***	0.0468***	0.0484***
	(0.00607)	(0.00615)	(0.00610)	(0.00615)	(0.00615)	(0.00613)	(0.00611)	(0.00613)	(0.00610)
ebit_at	-0.00151***	-0.00152***	-0.00151***	-0.00152***	-0.00153***	-0.00153***	-0.00152***	-0.00153***	-0.00153***
	(0.000251)	(0.000252)	(0.000251)	(0.000252)	(0.000252)	(0.000251)	(0.000251)	(0.000251)	(0.000251)
ppent_at	-0.463***	-0.468***	-0.468***	-0.469***	-0.472***	-0.466***	-0.469***	-0.466***	-0.468***
	(0.0524)	(0.0524)	(0.0524)	(0.0524)	(0.0523)	(0.0525)	(0.0524)	(0.0523)	(0.0522)
sale_at	0.00729*	0.00734*	0.00729*	0.00733*	0.00731*	0.00736*	0.00733*	0.00736*	0.00732*
	(0.00317)	(0.00315)	(0.00316)	(0.00315)	(0.00316)	(0.00316)	(0.00317)	(0.00316)	(0.00317)
mshare_gind	-0.00397	-0.00390	-0.00385	-0.00385	-0.00425	-0.00408	-0.00416	-0.00412	-0.00425
	(0.00276)	(0.00276)	(0.00276)	(0.00276)	(0.00278)	(0.00281)	(0.00278)	(0.00281)	(0.00279)
hhi_gind	-0.0000223*	-0.0000222**	-0.0000227**	-0.0000225**	-0.0000266**	-0.0000287**	-0.0000277**	-0.0000269**	-0.0000238**
	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000108)	(0.0000107)
0b.size	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1.size	0.0750***	0.0741***	0.0717***	0.0726***	0.0723***	0.0760***	0.0739***	0.0760***	0.0745***
	(0.0166)	(0.0166)	(0.0166)	(0.0166)	(0.0166)	(0.0166)	(0.0165)	(0.0166)	(0.0165)
2.size	0.141***	0.139***	0.135***	0.136***	0.136***	0.141***	0.138***	0.141***	0.138***
	(0.0272)	(0.0272)	(0.0272)	(0.0272)	(0.0272)	(0.0272)	(0.0271)	(0.0272)	(0.0271)
3.size	0.105*	0.0972*	0.0975*	0.0952*	0.0955*	0.0995*	0.0993*	0.0997*	0.0998*
	(0.0441)	(0.0442)	(0.0442)	(0.0442)	(0.0442)	(0.0442)	(0.0442)	(0.0442)	(0.0442)
emp_m_0_d_4	-0.0461*	-0.0455*	-0.0453*	-0.0452*	-0.0455*	-0.0455*	-0.0455*	-0.0452*	-0.0452*
	(0.0229)	(0.0229)	(0.0229)	(0.0229)	(0.0229)	(0.0229)	(0.0230)	(0.0229)	(0.0230)
1980b.fyear	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.0922***	-0.0927***	-0.0923***	-0.0926***	-0.0926***	-0.0926***	-0.0919***	-0.0928***	-0.0931***
	(0.0128)	(0.0128)	(0.0127)	(0.0128)	(0.0127)	(0.0127)	(0.0127)	(0.0127)	(0.0127)
1982.fyear	-0.0175	-0.0173	-0.0176	-0.0174	-0.0166	-0.0179	-0.0162	-0.0179	-0.0177
	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)
1983.fyear	0.168***	0.169***	0.169***	0.169***	0.171***	0.165***	0.170***	0.166***	0.170***
	(0.0176)	(0.0176)	(0.0176)	(0.0176)	(0.0175)	(0.0176)	(0.0175)	(0.0177)	(0.0175)
1984.fyear	-0.0469*	-0.0454*	-0.0464*	-0.0455*	-0.0441*	-0.0505**	-0.0441*	-0.0490**	-0.0440*
	(0.0187)	(0.0187)	(0.0187)	(0.0187)	(0.0187)	(0.0187)	(0.0186)	(0.0189)	(0.0186)
1985.fyear	0.0142	0.0161	0.0151	0.0161	0.0171	0.00572	0.0163	0.00820	0.0172
	(0.0197)	(0.0197)	(0.0197)	(0.0197)	(0.0197)	(0.0198)	(0.0196)	(0.0203)	(0.0197)
1986.fyear	0.0137	0.0157	0.0141	0.0154	0.0180	0.00212	0.0160	0.00579	0.0178
	(0.0210)	(0.0210)	(0.0209)	(0.0210)	(0.0209)	(0.0212)	(0.0209)	(0.0222)	(0.0209)
1987.fyear	-0.155***	-0.154***	-0.155***	-0.154***	-0.153***	-0.171***	-0.155***	-0.167***	-0.152***
	(0.0212)	(0.0212)	(0.0212)	(0.0212)	(0.0211)	(0.0216)	(0.0211)	(0.0230)	(0.0212)
1988.fyear	-0.199***	-0.197***	-0.199***	-0.198***	-0.194***	-0.213***	-0.195***	-0.207***	-0.192***
	(0.0219)	(0.0218)	(0.0218)	(0.0218)	(0.0219)	(0.0223)	(0.0218)	(0.0239)	(0.0219)
1989.fyear	-0.222***	-0.221***	-0.223***	-0.222***	-0.219***	-0.235***	-0.217***	-0.230***	-0.216***
	(0.0228)	(0.0228)	(0.0228)	(0.0228)	(0.0228)	(0.0229)	(0.0227)	(0.0242)	(0.0227)
1990.fyear	-0.408***	-0.407***	-0.409***	-0.407***	-0.405***	-0.420***	-0.403***	-0.416***	-0.402***
	(0.0239)	(0.0239)	(0.0239)	(0.0239)	(0.0239)	(0.0241)	(0.0239)	(0.0253)	(0.0239)

1991.fyear	-0.184***	-0.182***	-0.184***	-0.182***	-0.181***	-0.197***	-0.179***	-0.193***	-0.179***
	(0.0245)	(0.0245)	(0.0245)	(0.0245)	(0.0244)	(0.0246)	(0.0244)	(0.0258)	(0.0244)
1992.fyear	-0.138***	-0.135***	-0.137***	-0.136***	-0.136***	-0.154***	-0.135***	-0.150***	-0.134***
	(0.0238)	(0.0238)	(0.0238)	(0.0238)	(0.0237)	(0.0241)	(0.0237)	(0.0256)	(0.0237)
1993.fyear	-0.0587*	-0.0560*	-0.0584*	-0.0566*	-0.0555*	-0.0735**	-0.0532*	-0.0684**	-0.0528*
	(0.0236)	(0.0235)	(0.0235)	(0.0235)	(0.0235)	(0.0239)	(0.0234)	(0.0254)	(0.0235)
1994.fyear	-0.183***	-0.181***	-0.183***	-0.181***	-0.179***	-0.196***	-0.177***	-0.191***	-0.177***
	(0.0238)	(0.0237)	(0.0237)	(0.0237)	(0.0237)	(0.0241)	(0.0237)	(0.0255)	(0.0237)
1995.fyear	-0.0510*	-0.0490*	-0.0511*	-0.0496*	-0.0449+	-0.0568*	-0.0408+	-0.0530*	-0.0441+
	(0.0245)	(0.0245)	(0.0245)	(0.0245)	(0.0245)	(0.0247)	(0.0246)	(0.0256)	(0.0246)
1996.fyear	-0.0686**	-0.0666**	-0.0687**	-0.0672**	-0.0610*	-0.0693**	-0.0533*	-0.0663*	-0.0588*
	(0.0252)	(0.0251)	(0.0251)	(0.0251)	(0.0252)	(0.0253)	(0.0253)	(0.0259)	(0.0254)
1997.fyear	-0.0830**	-0.0811**	-0.0830**	-0.0817**	-0.0745**	-0.0783**	-0.0645*	-0.0763**	-0.0724**
	(0.0257)	(0.0256)	(0.0256)	(0.0256)	(0.0257)	(0.0257)	(0.0259)	(0.0260)	(0.0261)
1998.fyear	-0.239***	-0.237***	-0.239***	-0.237***	-0.231***	-0.236***	-0.223***	-0.233***	-0.228***
	(0.0268)	(0.0267)	(0.0267)	(0.0267)	(0.0268)	(0.0268)	(0.0269)	(0.0274)	(0.0269)
1999.fyear	0.000557	0.00172	0.00100	0.00164	0.00988	-0.000255	0.0125	0.00312	0.0116
	(0.0276)	(0.0276)	(0.0276)	(0.0276)	(0.0277)	(0.0278)	(0.0277)	(0.0285)	(0.0277)
2000.fyear	-0.370***	-0.369***	-0.368***	-0.368***	-0.363***	-0.379***	-0.366***	-0.374***	-0.361***
	(0.0284)	(0.0284)	(0.0284)	(0.0284)	(0.0284)	(0.0287)	(0.0284)	(0.0298)	(0.0285)
2001.fyear	-0.431***	-0.430***	-0.429***	-0.429***	-0.425***	-0.435***	-0.429***	-0.431***	-0.422***
	(0.0284)	(0.0283)	(0.0283)	(0.0283)	(0.0283)	(0.0284)	(0.0283)	(0.0291)	(0.0285)
2002.fyear	-0.683***	-0.682***	-0.680***	-0.680***	-0.676***	-0.689***	-0.685***	-0.684***	-0.672***
	(0.0287)	(0.0287)	(0.0287)	(0.0287)	(0.0286)	(0.0288)	(0.0288)	(0.0299)	(0.0293)
2003.fyear	-0.260***	-0.259***	-0.256***	-0.257***	-0.252***	-0.272***	-0.265***	-0.266***	-0.249***
	(0.0275)	(0.0275)	(0.0275)	(0.0275)	(0.0275)	(0.0278)	(0.0280)	(0.0295)	(0.0289)
2004.fyear	-0.246***	-0.243***	-0.240***	-0.241***	-0.237***	-0.268***	-0.256***	-0.260***	-0.235***
	(0.0279)	(0.0279)	(0.0279)	(0.0279)	(0.0279)	(0.0287)	(0.0288)	(0.0317)	(0.0302)
sum_at_a		0.0832***		0.0606*	0.0603*	0.0848***		0.0848***	
		(0.0218)		(0.0269)	(0.0269)	(0.0218)		(0.0218)	
hjtwt_at_a			0.00471***	0.00255	0.00258		0.00497***		0.00500***
			(0.00123)	(0.00157)	(0.00157)		(0.00124)		(0.00124)
adj_frag_g~a					-0.141**	-0.154***	-0.152**	-0.154***	-0.152**
					(0.0463)	(0.0467)	(0.0466)	(0.0465)	(0.0465)
sum_at_~3a_a						-1.648***		-1.657***	
						(0.405)		(0.405)	
hjtwt_a~3a_a							-0.0439**		-0.0492**
							(0.0160)		(0.0160)
sum_at_d~4_a								0.472	
								(0.715)	
sum_at~4_a_d								-0.222	
								(0.348)	
hjtwt_at~4_a									0.0611*
									(0.0250)
hjtwt_~4_a_d									-0.200
									(0.341)
_cons	0.538***	0.534***	0.536***	0.534***	0.643***	0.713***	0.674***	0.709***	0.657***
	(0.0293)	(0.0293)	(0.0293)	(0.0293)	(0.0446)	(0.0480)	(0.0461)	(0.0589)	(0.0523)
N	79284	79284	79284	79284	79284	79284	79284	79284	79284
R-sq	0.076	0.077	0.077	0.077	0.078	0.078	0.078	0.078	0.078
adj. R-sq	0.076	0.077	0.077	0.077	0.077	0.078	0.077	0.078	0.078
F	117.7	114.3	114.8	111.5	108.7	109.4	109.3	104.0	104.1

Standard errors in parentheses

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

7B Regression Results, Dataset B

	-1	-2	-3	-4	-5	-6	-7	-8	-9
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
xrd_at	0.0308**	0.0303**	0.0303**	0.0302**	0.0301**	0.0298**	0.0301**	0.0298**	0.0300**
	(0.00963)	(0.00963)	(0.00964)	(0.00964)	(0.00958)	(0.00969)	(0.00961)	(0.00969)	(0.00964)
ebit_at	-0.000554	-0.000551	-0.000548	-0.000548	-0.000573	-0.000611	-0.000632	-0.000609	-0.000638
	(0.000649)	(0.000649)	(0.000648)	(0.000648)	(0.000655)	(0.000665)	(0.000655)	(0.000665)	(0.000656)
ppent_at	-0.299**	-0.298**	-0.300**	-0.300**	-0.304**	-0.301**	-0.307**	-0.300**	-0.307**
	(0.0970)	(0.0968)	(0.0969)	(0.0968)	(0.0966)	(0.0966)	(0.0967)	(0.0966)	(0.0967)
sale_at	0.0168***	0.0168***	0.0168***	0.0168***	0.0167***	0.0167***	0.0167***	0.0168***	0.0167***
	(0.00181)	(0.00181)	(0.00180)	(0.00181)	(0.00190)	(0.00190)	(0.00191)	(0.00189)	(0.00190)
mshare_gind	0.00380	0.00382	0.00392	0.00391	0.00357	0.00189	0.00284	0.00192	0.00282
	(0.00600)	(0.00600)	(0.00598)	(0.00599)	(0.00588)	(0.00605)	(0.00595)	(0.00602)	(0.00593)
hhi_gind	0.0000414	0.0000418	0.0000408	0.0000410	0.0000464	0.0000716+	0.0000571	0.0000725+	0.0000576
	(0.0000379)	(0.0000379)	(0.0000379)	(0.0000379)	(0.0000376)	(0.0000388)	(0.0000376)	(0.0000389)	(0.0000375)
0b.size	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1.size	0.147**	0.147**	0.145**	0.145**	0.146**	0.146**	0.146**	0.145**	0.145**
	(0.0463)	(0.0463)	(0.0463)	(0.0463)	(0.0462)	(0.0462)	(0.0462)	(0.0465)	(0.0463)
2.size	0.175*	0.175*	0.173*	0.173*	0.177*	0.178*	0.176*	0.177*	0.174*
	(0.0831)	(0.0831)	(0.0831)	(0.0831)	(0.0828)	(0.0828)	(0.0827)	(0.0830)	(0.0826)
3.size	0.236+	0.232+	0.229+	0.229+	0.236+	0.238*	0.236+	0.237*	0.235+
	(0.120)	(0.120)	(0.121)	(0.121)	(0.120)	(0.120)	(0.120)	(0.120)	(0.120)
emp_m_0_d_4	-0.104*	-0.104*	-0.104*	-0.104*	-0.106*	-0.106*	-0.105*	-0.106*	-0.105*
	(0.0480)	(0.0480)	(0.0480)	(0.0480)	(0.0482)	(0.0482)	(0.0482)	(0.0482)	(0.0482)
1980b.fyear	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.0204	-0.0214	-0.0213	-0.0215	-0.0255	-0.0248	-0.0256	-0.0251	-0.0263
	(0.0202)	(0.0202)	(0.0202)	(0.0202)	(0.0203)	(0.0203)	(0.0203)	(0.0203)	(0.0203)
1982.fyear	0.0960***	0.0963***	0.0958***	0.0959***	0.0950***	0.0973***	0.0935***	0.0975***	0.0927***
	(0.0242)	(0.0242)	(0.0242)	(0.0242)	(0.0242)	(0.0243)	(0.0242)	(0.0243)	(0.0243)
1983.fyear	0.342***	0.342***	0.342***	0.342***	0.341***	0.349***	0.342***	0.351***	0.342***
	(0.0289)	(0.0289)	(0.0289)	(0.0289)	(0.0289)	(0.0292)	(0.0289)	(0.0297)	(0.0290)
1984.fyear	0.202***	0.203***	0.202***	0.203***	0.205***	0.219***	0.208***	0.221***	0.210***
	(0.0304)	(0.0304)	(0.0304)	(0.0304)	(0.0303)	(0.0309)	(0.0303)	(0.0321)	(0.0305)
1985.fyear	0.278***	0.279***	0.278***	0.278***	0.277***	0.292***	0.281***	0.296***	0.282***
	(0.0331)	(0.0331)	(0.0331)	(0.0331)	(0.0330)	(0.0340)	(0.0331)	(0.0355)	(0.0333)
1986.fyear	0.304***	0.305***	0.304***	0.304***	0.303***	0.325***	0.309***	0.329***	0.312***
	(0.0363)	(0.0363)	(0.0363)	(0.0363)	(0.0362)	(0.0381)	(0.0365)	(0.0404)	(0.0369)
1987.fyear	0.121**	0.122**	0.121**	0.121**	0.117**	0.141***	0.124**	0.146***	0.127**
	(0.0379)	(0.0378)	(0.0379)	(0.0378)	(0.0379)	(0.0399)	(0.0380)	(0.0429)	(0.0385)
1988.fyear	0.111**	0.112**	0.111**	0.111**	0.115**	0.139***	0.121**	0.143**	0.123**
	(0.0387)	(0.0387)	(0.0387)	(0.0387)	(0.0388)	(0.0408)	(0.0388)	(0.0436)	(0.0391)
1989.fyear	0.0713+	0.0722+	0.0714+	0.0717+	0.0662	0.0871*	0.0701+	0.0914*	0.0719+
	(0.0417)	(0.0416)	(0.0416)	(0.0416)	(0.0417)	(0.0430)	(0.0416)	(0.0452)	(0.0417)
1990.fyear	-0.165***	-0.164***	-0.165***	-0.164***	-0.172***	-0.155***	-0.170***	-0.151**	-0.169***
	(0.0449)	(0.0449)	(0.0449)	(0.0449)	(0.0451)	(0.0462)	(0.0450)	(0.0483)	(0.0451)
1991.fyear	0.0432	0.0443	0.0439	0.0441	0.0371	0.0505	0.0366	0.0540	0.0374
	(0.0479)	(0.0478)	(0.0478)	(0.0478)	(0.0477)	(0.0484)	(0.0477)	(0.0503)	(0.0478)
1992.fyear	0.176***	0.177***	0.177***	0.177***	0.160***	0.173***	0.159***	0.176***	0.160***
	(0.0449)	(0.0449)	(0.0449)	(0.0449)	(0.0448)	(0.0454)	(0.0448)	(0.0469)	(0.0448)
1993.fyear	0.253***	0.254***	0.253***	0.254***	0.241***	0.254***	0.239***	0.257***	0.239***
	(0.0433)	(0.0433)	(0.0433)	(0.0433)	(0.0434)	(0.0438)	(0.0434)	(0.0452)	(0.0434)
1994.fyear	0.0525	0.0537	0.0528	0.0532	0.0484	0.0593	0.0442	0.0625	0.0447
	(0.0446)	(0.0445)	(0.0445)	(0.0445)	(0.0445)	(0.0447)	(0.0447)	(0.0464)	(0.0447)

1995.fyear	0.0255	0.0267	0.0254	0.0258	0.0242	0.0341	0.0188	0.0368	0.0184
	(0.0471)	(0.0471)	(0.0471)	(0.0471)	(0.0470)	(0.0471)	(0.0473)	(0.0485)	(0.0473)
1996.fyear	0.0378	0.0388	0.0374	0.0378	0.0451	0.0499	0.0356	0.0519	0.0342
	(0.0478)	(0.0478)	(0.0478)	(0.0478)	(0.0478)	(0.0476)	(0.0487)	(0.0485)	(0.0488)
1997.fyear	0.0607	0.0616	0.0607	0.0610	0.0682	0.0702	0.0565	0.0717	0.0549
	(0.0491)	(0.0490)	(0.0491)	(0.0491)	(0.0490)	(0.0489)	(0.0504)	(0.0497)	(0.0506)
1998.fyear	-0.0235	-0.0225	-0.0236	-0.0232	-0.0116	-0.00758	-0.0216	-0.00557	-0.0221
	(0.0513)	(0.0513)	(0.0513)	(0.0513)	(0.0514)	(0.0513)	(0.0526)	(0.0523)	(0.0527)
1999.fyear	-0.0954+	-0.0946+	-0.0960+	-0.0956+	-0.0850	-0.0804	-0.0920+	-0.0784	-0.0916+
	(0.0522)	(0.0521)	(0.0521)	(0.0521)	(0.0522)	(0.0521)	(0.0531)	(0.0530)	(0.0531)
2000.fyear	-0.345***	-0.344***	-0.345***	-0.345***	-0.345***	-0.347***	-0.352***	-0.346***	-0.352***
	(0.0560)	(0.0560)	(0.0560)	(0.0560)	(0.0559)	(0.0558)	(0.0568)	(0.0561)	(0.0568)
2001.fyear	-0.289***	-0.288***	-0.289***	-0.288***	-0.291***	-0.301***	-0.298***	-0.300***	-0.297***
	(0.0554)	(0.0554)	(0.0554)	(0.0554)	(0.0554)	(0.0555)	(0.0561)	(0.0556)	(0.0560)
2002.fyear	-0.366***	-0.365***	-0.365***	-0.365***	-0.370***	-0.376***	-0.369***	-0.374***	-0.365***
	(0.0549)	(0.0549)	(0.0549)	(0.0549)	(0.0547)	(0.0546)	(0.0548)	(0.0550)	(0.0547)
2003.fyear	-0.106*	-0.105*	-0.104*	-0.104*	-0.111*	-0.113*	-0.104*	-0.111*	-0.0979+
	(0.0528)	(0.0528)	(0.0528)	(0.0528)	(0.0526)	(0.0525)	(0.0524)	(0.0533)	(0.0525)
2004.fyear	-0.0363	-0.0354	-0.0346	-0.0345	-0.0469	-0.0408	-0.0341	-0.0370	-0.0258
	(0.0533)	(0.0532)	(0.0532)	(0.0532)	(0.0530)	(0.0531)	(0.0528)	(0.0549)	(0.0535)
sum_at_a		0.0363		0.0123	0.0115	0.0359		0.0358	
		(0.0230)		(0.0290)	(0.0292)	(0.0230)		(0.0230)	
hjtwt_at_a			0.00467	0.00407	0.00429		0.00480		0.00478
			(0.00329)	(0.00387)	(0.00390)		(0.00329)		(0.00330)
adj_frag_g~a					-0.181**	-0.158*	-0.163*	-0.158*	-0.164*
					(0.0649)	(0.0652)	(0.0665)	(0.0650)	(0.0663)
sum_at_~3a_a						3.636*		3.531*	
						-1.771		-1.780	
hjtwt_a~3a_a							0.190+		0.175
							(0.109)		(0.110)
sum_at_d~4_a								1.006	
-2.720									
o.sum_~4_a_d								0	
								(.)	
hjtwt_at~4_a									0.104
									(0.170)
o.hjtw~4_a_d									0
									(.)
_cons	-0.0154	-0.0176	-0.0159	-0.0166	0.101	0.0191	0.0563	0.00772	0.0457
	(0.0613)	(0.0612)	(0.0612)	(0.0612)	(0.0730)	(0.0820)	(0.0772)	(0.0870)	(0.0794)
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N	18445	18445	18445	18445	18445	18445	18445	18445	18445
R-sq	0.080	0.080	0.080	0.080	0.081	0.082	0.081	0.082	0.082
adj. R-sq	0.078	0.078	0.078	0.078	0.079	0.080	0.080	0.080	0.080
F	27.10	26.39	26.39	25.69	24.83	24.88	24.76	24.32	24.14
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Standard err	ors in parentheses								
	p<0.05, **								
+ p<0.10, *	p<0.01,	*** p<0.001							

7C Regression Results, Dataset C

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	-1	-2	-3	-4	-5	-6	-7	-8	-9
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
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xrd_at	0.0555***	0.0514***	0.0529***	0.0512***	0.0514***	0.0516***	0.0534***	0.0516***	0.0538***

	(0.00952)	(0.00972)	(0.00955)	(0.00969)	(0.00969)	(0.00972)	(0.00956)	(0.00971)	(0.00957)
ebit_at	-0.00379***	-0.00373***	-0.00380***	-0.00375***	-0.00381***	-0.00378***	-0.00376***	-0.00382***	-0.00377***
	(0.000924)	(0.000924)	(0.000926)	(0.000926)	(0.000927)	(0.000924)	(0.000924)	(0.000925)	(0.000923)
ppent_at	-0.600***	-0.607***	-0.610***	-0.610***	-0.611***	-0.607***	-0.612***	-0.610***	-0.618***
	(0.117)	(0.117)	(0.117)	(0.117)	(0.117)	(0.117)	(0.117)	(0.116)	(0.116)
sale_at	-0.0323*	-0.0310*	-0.0324*	-0.0314*	-0.0323*	-0.0318*	-0.0313*	-0.0326*	-0.0317*
	(0.0152)	(0.0152)	(0.0153)	(0.0153)	(0.0153)	(0.0152)	(0.0152)	(0.0153)	(0.0152)
mshare_gind	-0.0116*	-0.0115*	-0.0114*	-0.0114*	-0.0121*	-0.0121*	-0.0117*	-0.0115*	-0.0109*
	(0.00505)	(0.00505)	(0.00505)	(0.00505)	(0.00508)	(0.00511)	(0.00520)	(0.00516)	(0.00519)
hhi_gind	-0.0000574**	-0.0000573***	-0.0000589***	-0.0000582***	-0.0000648***	-0.0000622***	-0.0000578***	-0.0000746***	-0.0000651***
	(0.0000186)	(0.0000186)	(0.0000185)	(0.0000185)	(0.0000190)	(0.0000191)	(0.0000191)	(0.0000200)	(0.0000193)
0b.size	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1.size	0.0767**	0.0754**	0.0720**	0.0732**	0.0728**	0.0755**	0.0745**	0.0744**	0.0730**
	(0.0257)	(0.0256)	(0.0256)	(0.0256)	(0.0256)	(0.0256)	(0.0255)	(0.0255)	(0.0255)
2.size	0.178***	0.173***	0.168***	0.169***	0.168***	0.172***	0.171***	0.168***	0.167***
	(0.0466)	(0.0466)	(0.0466)	(0.0466)	(0.0465)	(0.0464)	(0.0465)	(0.0462)	(0.0463)
3.size	0.217*	0.205*	0.205*	0.202*	0.200*	0.204*	0.206*	0.201*	0.203*
	(0.0961)	(0.0964)	(0.0961)	(0.0963)	(0.0961)	(0.0962)	(0.0960)	(0.0961)	(0.0958)
emp_m_0_d_4	-0.0381	-0.0366	-0.0362	-0.0360	-0.0360	-0.0363	-0.0347	-0.0377	-0.0345
	(0.0460)	(0.0460)	(0.0461)	(0.0460)	(0.0459)	(0.0459)	(0.0460)	(0.0459)	(0.0459)
1980b.fyear	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.152***	-0.152***	-0.153***	-0.153***	-0.148***	-0.146***	-0.141***	-0.133***	-0.121***
	(0.0330)	(0.0331)	(0.0331)	(0.0331)	(0.0330)	(0.0330)	(0.0331)	(0.0334)	(0.0335)
1982.fyear	-0.0358	-0.0364	-0.0362	-0.0364	-0.0281	-0.0270	-0.0195	-0.0181	0.00369
	(0.0381)	(0.0380)	(0.0381)	(0.0381)	(0.0381)	(0.0379)	(0.0380)	(0.0381)	(0.0384)
1983.fyear	0.109*	0.112**	0.110*	0.111**	0.123**	0.123**	0.128**	0.106*	0.135**
	(0.0429)	(0.0429)	(0.0429)	(0.0429)	(0.0431)	(0.0431)	(0.0429)	(0.0432)	(0.0430)
1984.fyear	-0.255***	-0.253***	-0.254***	-0.253***	-0.245***	-0.244***	-0.238***	-0.265***	-0.230***
	(0.0450)	(0.0450)	(0.0450)	(0.0450)	(0.0450)	(0.0449)	(0.0448)	(0.0450)	(0.0448)
1985.fyear	-0.248***	-0.245***	-0.246***	-0.245***	-0.235***	-0.237***	-0.231***	-0.275***	-0.235***
	(0.0458)	(0.0459)	(0.0459)	(0.0459)	(0.0460)	(0.0463)	(0.0459)	(0.0469)	(0.0458)
1986.fyear	-0.313***	-0.310***	-0.312***	-0.310***	-0.299***	-0.301***	-0.295***	-0.351***	-0.297***
	(0.0465)	(0.0465)	(0.0465)	(0.0465)	(0.0467)	(0.0472)	(0.0466)	(0.0484)	(0.0466)
1987.fyear	-0.508***	-0.505***	-0.507***	-0.506***	-0.494***	-0.496***	-0.487***	-0.558***	-0.491***
	(0.0480)	(0.0481)	(0.0481)	(0.0480)	(0.0484)	(0.0490)	(0.0483)	(0.0513)	(0.0483)
1988.fyear	-0.613***	-0.610***	-0.613***	-0.611***	-0.599***	-0.600***	-0.588***	-0.663***	-0.583***
	(0.0492)	(0.0492)	(0.0492)	(0.0492)	(0.0496)	(0.0498)	(0.0496)	(0.0522)	(0.0497)
1989.fyear	-0.660***	-0.659***	-0.661***	-0.660***	-0.647***	-0.646***	-0.622***	-0.682***	-0.580***
	(0.0510)	(0.0511)	(0.0510)	(0.0510)	(0.0516)	(0.0516)	(0.0521)	(0.0523)	(0.0533)
1990.fyear	-0.861***	-0.860***	-0.862***	-0.861***	-0.848***	-0.847***	-0.817***	-0.880***	-0.757***
	(0.0524)	(0.0525)	(0.0524)	(0.0524)	(0.0529)	(0.0528)	(0.0537)	(0.0535)	(0.0558)
1991.fyear	-0.645***	-0.643***	-0.645***	-0.643***	-0.633***	-0.632***	-0.595***	-0.660***	-0.517***
	(0.0524)	(0.0524)	(0.0523)	(0.0523)	(0.0525)	(0.0525)	(0.0540)	(0.0530)	(0.0572)
1992.fyear	-0.574***	-0.572***	-0.575***	-0.573***	-0.558***	-0.557***	-0.523***	-0.597***	-0.445***
	(0.0530)	(0.0530)	(0.0529)	(0.0529)	(0.0535)	(0.0535)	(0.0548)	(0.0549)	(0.0576)
1993.fyear	-0.444***	-0.441***	-0.444***	-0.443***	-0.427***	-0.426***	-0.388***	-0.464***	-0.296***
	(0.0537)	(0.0537)	(0.0537)	(0.0536)	(0.0543)	(0.0543)	(0.0557)	(0.0556)	(0.0589)
1994.fyear	-0.509***	-0.507***	-0.511***	-0.509***	-0.492***	-0.491***	-0.453***	-0.524***	-0.345***
	(0.0543)	(0.0543)	(0.0543)	(0.0542)	(0.0549)	(0.0550)	(0.0563)	(0.0559)	(0.0603)
1995.fyear	-0.309***	-0.306***	-0.310***	-0.308***	-0.287***	-0.285***	-0.241***	-0.288***	-0.0935
	(0.0560)	(0.0559)	(0.0559)	(0.0559)	(0.0569)	(0.0569)	(0.0588)	(0.0568)	(0.0655)
1996.fyear	-0.414***	-0.411***	-0.416***	-0.413***	-0.394***	-0.389***	-0.324***	-0.350***	-0.118
	(0.0595)	(0.0595)	(0.0595)	(0.0594)	(0.0602)	(0.0601)	(0.0636)	(0.0603)	(0.0749)
1997.fyear	-0.455***	-0.453***	-0.458***	-0.455***	-0.434***	-0.426***	-0.353***	-0.349***	-0.104
	(0.0603)	(0.0602)	(0.0603)	(0.0602)	(0.0611)	(0.0612)	(0.0651)	(0.0635)	(0.0811)

1998.fyear	-0.607***	-0.605***	-0.609***	-0.607***	-0.587***	-0.579***	-0.513***	-0.519***	-0.299***
	(0.0619)	(0.0619)	(0.0620)	(0.0619)	(0.0626)	(0.0628)	(0.0658)	(0.0638)	(0.0777)
1999.fyear	-0.0218	-0.0197	-0.0232	-0.0211	0.00528	0.0118	0.0607	0.0633	0.216**
	(0.0628)	(0.0628)	(0.0629)	(0.0628)	(0.0642)	(0.0644)	(0.0662)	(0.0650)	(0.0723)
2000.fyear	-0.763***	-0.761***	-0.763***	-0.762***	-0.739***	-0.734***	-0.704***	-0.722***	-0.630***
	(0.0651)	(0.0650)	(0.0651)	(0.0650)	(0.0658)	(0.0656)	(0.0661)	(0.0653)	(0.0667)
2001.fyear	-0.926***	-0.923***	-0.926***	-0.924***	-0.901***	-0.894***	-0.867***	-0.843***	-0.804***
	(0.0646)	(0.0646)	(0.0646)	(0.0646)	(0.0653)	(0.0656)	(0.0655)	(0.0661)	(0.0660)
2002.fyear	-1.264***	-1.263***	-1.262***	-1.263***	-1.239***	-1.233***	-1.219***	-1.207***	-1.221***
	(0.0643)	(0.0643)	(0.0643)	(0.0643)	(0.0649)	(0.0654)	(0.0648)	(0.0652)	(0.0646)
2003.fyear	-0.682***	-0.682***	-0.678***	-0.680***	-0.656***	-0.653***	-0.651***	-0.654***	-0.707***
	(0.0623)	(0.0623)	(0.0623)	(0.0623)	(0.0628)	(0.0631)	(0.0626)	(0.0630)	(0.0643)
2004.fyear	-0.745***	-0.742***	-0.739***	-0.740***	-0.717***	-0.718***	-0.730***	-0.769***	-0.838***
	(0.0627)	(0.0627)	(0.0627)	(0.0627)	(0.0631)	(0.0629)	(0.0634)	(0.0656)	(0.0685)
sum_at_a		0.126***		0.0880*	0.0874*	0.126***		0.127***	
		(0.0376)		(0.0429)	(0.0429)	(0.0378)		(0.0378)	
hjtwt_at_a			0.00601**	0.00335	0.00339		0.00637**		0.00638**
			(0.00198)	(0.00222)	(0.00222)		(0.00199)		(0.00201)
adj_frag_g~a					-0.186+	-0.188+	-0.215*	-0.241*	-0.265*
					(0.108)	(0.108)	(0.109)	(0.110)	(0.110)
sum_at_~3a_a						-0.325		-1.346+	
						(0.720)		(0.726)	
hjtwt_a~3a_a							-0.0748**		-0.136***
							(0.0235)		(0.0272)
sum_at_d~4_a								-4.598**	
-1.478									
sum_at~4_a_d								0.862***	
								(0.0903)	
hjtwt_at~4_a									-0.245***
									(0.0530)
hjtwt_~4_a_d									0.905***
									(0.0565)
_cons	1.146***	1.139***	1.146***	1.141***	1.275***	1.284***	1.325***	1.513***	1.483***
	(0.0691)	(0.0690)	(0.0690)	(0.0689)	(0.103)	(0.107)	(0.105)	(0.149)	(0.121)
N	24651	24651	24651	24651	24651	24651	24651	24651	24651
R-sq	0.167	0.168	0.168	0.169	0.169	0.169	0.170	0.170	0.172
adj. R-sq	0.166	0.167	0.167	0.167	0.168	0.167	0.168	0.169	0.170
F	158.2	152.0	153.6	148.3	144.3	143.9	147.4	.	.

Standard errors in parentheses

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

Appendix 8 Robustness Tests

8A Simple Fragmentation, Dataset A

	-1	-2	-3	-4	-5	-6
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
xrd_at	0.0467***	0.0466***	0.0469***	0.0484***	0.0483***	0.0486***
	(0.00613)	(0.00613)	(0.00613)	(0.00609)	(0.00609)	(0.00610)
sum_at_a	0.0848***	0.0848***	0.0850***			
	(0.0218)	(0.0218)	(0.0218)			
frag_claims	-0.130**			-0.125*		
	(0.0493)			(0.0494)		
sum_at_~3a_a	-1.656***	-1.613***	-1.660***			
	(0.406)	(0.405)	(0.405)			
sum_at_d~4_a	0.415	0.487	0.567			
	(0.716)	(0.715)	(0.715)			
ebit_at	-0.00152***	-0.00152***	-0.00153***	-0.00153***	-0.00153***	-0.00153***
	(0.000251)	(0.000251)	(0.000252)	(0.000250)	(0.000250)	(0.000252)
ppent_at	-0.465***	-0.464***	-0.468***	-0.467***	-0.467***	-0.470***
	(0.0523)	(0.0523)	(0.0522)	(0.0522)	(0.0522)	(0.0522)
sale_at	0.00737*	0.00737*	0.00737*	0.00733*	0.00732*	0.00732*
	(0.00316)	(0.00316)	(0.00317)	(0.00317)	(0.00316)	(0.00317)
mshare_gind	-0.00400	-0.00387	-0.00446	-0.00413	-0.00400	-0.00459
	(0.00280)	(0.00279)	(0.00282)	(0.00278)	(0.00277)	(0.00280)
hhi_gind	-0.0000269*	-0.0000241*	-0.0000283**	-0.0000235*	-0.0000211*	-0.0000253*
	(0.0000109)	(0.0000108)	(0.0000108)	(0.0000108)	(0.0000107)	(0.0000107)
sum_at~4_a_d	-0.222	-0.217	-0.220			
	(0.346)	(0.344)	(0.349)			
0b.size	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)
1.size	0.0762***	0.0762***	0.0756***	0.0747***	0.0746***	0.0740***
	(0.0166)	(0.0166)	(0.0166)	(0.0165)	(0.0165)	(0.0165)
2.size	0.142***	0.142***	0.141***	0.138***	0.138***	0.138***
	(0.0272)	(0.0272)	(0.0271)	(0.0271)	(0.0271)	(0.0271)
3.size	0.0996*	0.0998*	0.0990*	0.0997*	0.0999*	0.0990*
	(0.0442)	(0.0442)	(0.0442)	(0.0442)	(0.0442)	(0.0442)
emp_m_0_d_4	-0.0455*	-0.0448+	-0.0454*	-0.0455*	-0.0449+	-0.0454*
	(0.0229)	(0.0229)	(0.0229)	(0.0230)	(0.0230)	(0.0230)
1980b.fyear	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.0928***	-0.0931***	-0.0922***	-0.0930***	-0.0933***	-0.0925***
	(0.0127)	(0.0128)	(0.0127)	(0.0127)	(0.0128)	(0.0127)
1982.fyear	-0.0180	-0.0187	-0.0162	-0.0178	-0.0186	-0.0161
	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)
1983.fyear	0.165***	0.165***	0.168***	0.169***	0.169***	0.172***
	(0.0177)	(0.0177)	(0.0177)	(0.0175)	(0.0175)	(0.0175)
1984.fyear	-0.0503**	-0.0498**	-0.0458*	-0.0451*	-0.0451*	-0.0412*
	(0.0189)	(0.0189)	(0.0189)	(0.0186)	(0.0187)	(0.0187)
1985.fyear	0.00668	0.00764	0.0122	0.0160	0.0163	0.0207
	(0.0203)	(0.0204)	(0.0203)	(0.0197)	(0.0197)	(0.0197)
1986.fyear	0.00343	0.00465	0.0107	0.0158	0.0161	0.0220
	(0.0222)	(0.0222)	(0.0222)	(0.0209)	(0.0210)	(0.0210)
1987.fyear	-0.168***	-0.167***	-0.162***	-0.153***	-0.153***	-0.148***
	(0.0230)	(0.0230)	(0.0230)	(0.0212)	(0.0212)	(0.0212)
1988.fyear	-0.211***	-0.209***	-0.202***	-0.195***	-0.194***	-0.187***
	(0.0238)	(0.0239)	(0.0239)	(0.0218)	(0.0219)	(0.0219)
1989.fyear	-0.232***	-0.231***	-0.227***	-0.218***	-0.218***	-0.214***
	(0.0242)	(0.0242)	(0.0242)	(0.0227)	(0.0228)	(0.0227)
1990.fyear	-0.417***	-0.416***	-0.413***	-0.403***	-0.404***	-0.401***

	(0.0253)	(0.0253)	(0.0252)	(0.0239)	(0.0239)	(0.0239)
1991.fyear	-0.195***	-0.193***	-0.190***	-0.180***	-0.179***	-0.177***
	(0.0258)	(0.0259)	(0.0258)	(0.0244)	(0.0244)	(0.0244)
1992.fyear	-0.152***	-0.149***	-0.146***	-0.136***	-0.134***	-0.131***
	(0.0257)	(0.0257)	(0.0256)	(0.0237)	(0.0238)	(0.0237)
1993.fyear	-0.0713**	-0.0683**	-0.0637*	-0.0549*	-0.0534*	-0.0492*
	(0.0255)	(0.0255)	(0.0254)	(0.0235)	(0.0235)	(0.0235)
1994.fyear	-0.195***	-0.192***	-0.185***	-0.180***	-0.179***	-0.173***
	(0.0255)	(0.0256)	(0.0256)	(0.0237)	(0.0237)	(0.0237)
1995.fyear	-0.0557*	-0.0557*	-0.0463+	-0.0463+	-0.0474+	-0.0386
	(0.0255)	(0.0256)	(0.0256)	(0.0246)	(0.0246)	(0.0246)
1996.fyear	-0.0693**	-0.0703**	-0.0579*	-0.0613*	-0.0633*	-0.0517*
	(0.0259)	(0.0259)	(0.0260)	(0.0253)	(0.0253)	(0.0254)
1997.fyear	-0.0793**	-0.0806**	-0.0693**	-0.0750**	-0.0772**	-0.0667*
	(0.0260)	(0.0260)	(0.0261)	(0.0261)	(0.0260)	(0.0261)
1998.fyear	-0.236***	-0.238***	-0.225***	-0.230***	-0.233***	-0.221***
	(0.0274)	(0.0274)	(0.0275)	(0.0269)	(0.0268)	(0.0269)
1999.fyear	-0.000567	-0.00251	0.0143	0.00828	0.00564	0.0220
	(0.0285)	(0.0285)	(0.0287)	(0.0276)	(0.0276)	(0.0278)
2000.fyear	-0.378***	-0.377***	-0.363***	-0.365***	-0.365***	-0.351***
	(0.0298)	(0.0298)	(0.0299)	(0.0285)	(0.0285)	(0.0286)
2001.fyear	-0.435***	-0.434***	-0.421***	-0.426***	-0.425***	-0.412***
	(0.0291)	(0.0291)	(0.0292)	(0.0285)	(0.0285)	(0.0286)
2002.fyear	-0.688***	-0.687***	-0.675***	-0.676***	-0.675***	-0.662***
	(0.0299)	(0.0299)	(0.0299)	(0.0293)	(0.0293)	(0.0293)
2003.fyear	-0.270***	-0.269***	-0.256***	-0.252***	-0.252***	-0.239***
	(0.0295)	(0.0296)	(0.0296)	(0.0289)	(0.0289)	(0.0289)
2004.fyear	-0.263***	-0.261***	-0.251***	-0.238***	-0.237***	-0.227***
	(0.0317)	(0.0317)	(0.0317)	(0.0303)	(0.0303)	(0.0303)
frag_sum		-0.0652+			-0.0649+	
		(0.0337)			(0.0336)	
frag_citings			-0.229***			-0.227***
			(0.0466)			(0.0465)
hjtwt_at_a				0.00500***	0.00498***	0.00503***
				(0.00124)	(0.00124)	(0.00124)
hjtwt_a~3a_a				-0.0492**	-0.0479**	-0.0479**
				(0.0161)	(0.0160)	(0.0160)
hjtwt_at~4_a				0.0591*	0.0611*	0.0645**
				(0.0250)	(0.0250)	(0.0249)
hjtwt_~4_a_d				-0.199	-0.195	-0.198
				(0.338)	(0.337)	(0.341)
_cons	0.694***	0.639***	0.758***	0.639***	0.590***	0.707***
	(0.0612)	(0.0537)	(0.0581)	(0.0546)	(0.0467)	(0.0513)
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N	79284	79284	79284	79284	79284	79284
R-sq	0.078	0.078	0.079	0.078	0.078	0.079
adj. R-sq	0.078	0.078	0.078	0.077	0.077	0.078
F	104.1	103.8	104.5	104.2	103.9	104.6
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Standard err	ors in parentheses					
+ p<0.10, *	p<0.05, ** p<0.01,	*** p<0.001				

8B Simple Fragmentation, Dataset B & C

Dataset B: Discrete

Dataset C: Complex

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	-1	-2
	ln_tobinq	ln_tobinq
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xrd_at	0.0297**	0.0300**
	(0.00969)	(0.00963)
sum_at_a	0.0358	
	(0.0229)	
frag_citings	-0.150*	-0.151*
	(0.0586)	(0.0598)
sum_at_~3a_a	3.729*	
-1.776		
sum_at_d~4_a	1.069	
-2.725		
ebit_at	-0.000622	-0.000651
	(0.000669)	(0.000658)
ppent_at	-0.300**	-0.307**
	(0.0966)	(0.0967)
sale_at	0.0168***	0.0167***
	(0.00188)	(0.00189)
mshare_gind	0.00185	0.00281
	(0.00604)	(0.00596)
hhi_gind	0.0000728+	0.0000567
	(0.0000390)	(0.0000376)
o.sum_~4_a_d	0	
	(.)	
0b.size	0	0
	(.)	(.)
1.size	0.144**	0.144**
	(0.0464)	(0.0462)
2.size	0.176*	0.174*
	(0.0829)	(0.0826)
3.size	0.236+	0.234+
	(0.121)	(0.120)
emp_m_0_d_4	-0.106*	-0.104*
	(0.0482)	(0.0482)
1980b.fyear	0	0
	(.)	(.)
1981.fyear	-0.0246	-0.0256
	(0.0203)	(0.0203)
1982.fyear	0.0995***	0.0946***
	(0.0243)	(0.0243)
1983.fyear	0.354***	0.344***
	(0.0297)	(0.0289)
1984.fyear	0.225***	0.212***
	(0.0322)	(0.0306)
1985.fyear	0.301***	0.287***
	(0.0355)	(0.0333)
1986.fyear	0.334***	0.316***
	(0.0404)	(0.0369)
1987.fyear	0.151***	0.130***
	(0.0429)	(0.0384)
1988.fyear	0.146***	0.124**
	(0.0436)	(0.0391)
1989.fyear	0.0906*	0.0697+
	(0.0452)	(0.0417)
1990.fyear	-0.154**	-0.173***
	(0.0484)	(0.0452)
1991.fyear	0.0499	0.0323
	(0.0505)	(0.0479)
1992.fyear	0.178***	0.161***
	(0.0470)	(0.0449)
1993.fyear	0.257***	0.238***

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	-1	-2
	ln_tobinq	ln_tobinq
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xrd_at	0.0520***	0.0541***
	(0.00972)	(0.00957)
sum_at_a	0.127***	
	(0.0376)	
frag_citings	-0.343**	-0.339**
	(0.113)	(0.113)
sum_at_~3a_a	-1.460*	
	(0.726)	
sum_at_d~4_a	-4.638**	
-1.465		
ebit_at	-0.00384***	-0.00379***
	(0.000929)	(0.000926)
ppent_at	-0.613***	-0.622***
	(0.116)	(0.116)
sale_at	-0.0329*	-0.0319*
	(0.0153)	(0.0153)
mshare_gind	-0.0118*	-0.0111*
	(0.00514)	(0.00516)
hhi_gind	-0.0000741***	-0.0000641***
	(0.0000196)	(0.0000190)
sum_at~4_a_d	0.853***	
	(0.0902)	
0b.size	0	0
	(.)	(.)
1.size	0.0743**	0.0727**
	(0.0255)	(0.0255)
2.size	0.168***	0.166***
	(0.0462)	(0.0463)
3.size	0.200*	0.202*
	(0.0960)	(0.0958)
emp_m_0_d_4	-0.0375	-0.0343
	(0.0458)	(0.0459)
1980b.fyear	0	0
	(.)	(.)
1981.fyear	-0.129***	-0.118***
	(0.0334)	(0.0335)
1982.fyear	-0.0117	0.00767
	(0.0382)	(0.0384)
1983.fyear	0.115**	0.143***
	(0.0434)	(0.0432)
1984.fyear	-0.257***	-0.224***
	(0.0452)	(0.0450)
1985.fyear	-0.265***	-0.225***
	(0.0472)	(0.0461)
1986.fyear	-0.339***	-0.285***
	(0.0488)	(0.0471)
1987.fyear	-0.544***	-0.478***
	(0.0518)	(0.0489)
1988.fyear	-0.647***	-0.568***
	(0.0529)	(0.0505)
1989.fyear	-0.666***	-0.567***
	(0.0530)	(0.0538)
1990.fyear	-0.864***	-0.745***
	(0.0542)	(0.0563)
1991.fyear	-0.643***	-0.504***
	(0.0537)	(0.0577)
1992.fyear	-0.577***	-0.430***
	(0.0558)	(0.0584)
1993.fyear	-0.440***	-0.277***

	(0.0453)	(0.0435)
1994.fyear	0.0636	0.0449
	(0.0464)	(0.0447)
1995.fyear	0.0383	0.0191
	(0.0485)	(0.0473)
1996.fyear	0.0522	0.0338
	(0.0485)	(0.0487)
1997.fyear	0.0660	0.0484
	(0.0496)	(0.0503)
1998.fyear	-0.00661	-0.0242
	(0.0523)	(0.0526)
1999.fyear	-0.0757	-0.0900+
	(0.0531)	(0.0532)
2000.fyear	-0.342***	-0.348***
	(0.0562)	(0.0569)
2001.fyear	-0.295***	-0.292***
	(0.0556)	(0.0561)
2002.fyear	-0.370***	-0.362***
	(0.0550)	(0.0548)
2003.fyear	-0.107*	-0.0945+
	(0.0534)	(0.0525)
2004.fyear	-0.0348	-0.0247
	(0.0550)	(0.0535)
hjtwt_at_a		0.00474
		(0.00330)
hjtwt_a~3a_a		0.187+
		(0.109)
hjtwt_at~4_a		0.0837
		(0.170)
o.hjtw~4_a_d		0
		(.)
_cons	-0.00527	0.0338
	(0.0846)	(0.0758)
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N	18445	18445
R-sq	0.082	0.081
adj. R-sq	0.080	0.080
F	24.36	24.17
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Standard err	ors in parentheses	
+ p<0.10, *	p<0.05, ** p<0.01,	*** p<0.001

	(0.0568)	(0.0599)
1994.fyear	-0.498***	-0.325***
	(0.0573)	(0.0615)
1995.fyear	-0.258***	-0.0718
	(0.0585)	(0.0667)
1996.fyear	-0.316***	-0.0955
	(0.0620)	(0.0760)
1997.fyear	-0.311***	-0.0811
	(0.0655)	(0.0823)
1998.fyear	-0.486***	-0.278***
	(0.0654)	(0.0787)
1999.fyear	0.103	0.245***
	(0.0674)	(0.0741)
2000.fyear	-0.683***	-0.599***
	(0.0673)	(0.0687)
2001.fyear	-0.804***	-0.773***
	(0.0681)	(0.0679)
2002.fyear	-1.169***	-1.190***
	(0.0670)	(0.0665)
2003.fyear	-0.617***	-0.674***
	(0.0647)	(0.0660)
2004.fyear	-0.735***	-0.804***
	(0.0669)	(0.0699)
hjtwt_at_a		0.00641**
		(0.00201)
hjtwt_a~3a_a		-0.133***
		(0.0270)
hjtwt_at~4_a		-0.238***
		(0.0527)
hjtwt_~4_a_d		0.896***
		(0.0559)
_cons	1.575***	1.513***
	(0.145)	(0.116)
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N	24651	24651
R-sq	0.171	0.172
adj. R-sq	0.169	0.171
F	.	.
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Standard err	ors in parentheses	
+ p<0.10, *	p<0.05, ** p<0.01,	*** p<0.001

8C Unadjusted Fragmentation, Dataset A

	-1	-2	-3	-4	-5	-6	-7	-8	-9
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
xrd_at	0.0506***	0.0465***	0.0483***	0.0464***	0.0465***	0.0469***	0.0483***	0.0468***	0.0484***
	(0.00607)	(0.00615)	(0.00610)	(0.00615)	(0.00615)	(0.00613)	(0.00611)	(0.00613)	(0.00610)
ebit_at	-0.00151***	-0.00152***	-0.00151***	-0.00152***	-0.00153***	-0.00153***	-0.00152***	-0.00153***	-0.00153***
	(0.000251)	(0.000252)	(0.000251)	(0.000252)	(0.000252)	(0.000251)	(0.000252)	(0.000251)	(0.000251)
ppent_at	-0.463***	-0.468***	-0.468***	-0.469***	-0.472***	-0.467***	-0.469***	-0.466***	-0.469***
	(0.0524)	(0.0524)	(0.0524)	(0.0524)	(0.0523)	(0.0525)	(0.0524)	(0.0523)	(0.0522)
sale_at	0.00729*	0.00734*	0.00729*	0.00733*	0.00731*	0.00736*	0.00733*	0.00737*	0.00732*
	(0.00317)	(0.00315)	(0.00316)	(0.00315)	(0.00316)	(0.00316)	(0.00317)	(0.00316)	(0.00317)
mshare_gind	-0.00397	-0.00390	-0.00385	-0.00385	-0.00434	-0.00417	-0.00425	-0.00421	-0.00434

	(0.00276)	(0.00276)	(0.00276)	(0.00276)	(0.00279)	(0.00281)	(0.00279)	(0.00282)	(0.00279)
		-	-	-	-	-	-	-	
hhi_gind	-0.0000223*	0.0000222*	0.0000227*	0.0000225*	0.0000276**	0.0000298**	0.0000287**	0.0000280**	-0.0000248*
	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000109)	(0.0000107)
0b.size	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1.size	0.0750***	0.0741***	0.0717***	0.0726***	0.0723***	0.0759***	0.0738***	0.0760***	0.0745***
	(0.0166)	(0.0166)	(0.0166)	(0.0166)	(0.0166)	(0.0166)	(0.0165)	(0.0166)	(0.0165)
2.size	0.141***	0.139***	0.135***	0.136***	0.136***	0.141***	0.138***	0.141***	0.138***
	(0.0272)	(0.0272)	(0.0272)	(0.0272)	(0.0272)	(0.0272)	(0.0271)	(0.0272)	(0.0271)
3.size	0.105*	0.0972*	0.0975*	0.0952*	0.0950*	0.0990*	0.0988*	0.0992*	0.0993*
	(0.0441)	(0.0442)	(0.0442)	(0.0442)	(0.0442)	(0.0442)	(0.0442)	(0.0442)	(0.0442)
emp_m_0_d_4	-0.0461*	-0.0455*	-0.0453*	-0.0452*	-0.0458*	-0.0458*	-0.0459*	-0.0455*	-0.0455*
	(0.0229)	(0.0229)	(0.0229)	(0.0229)	(0.0229)	(0.0229)	(0.0230)	(0.0229)	(0.0230)
1980b.fyear	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.0922***	-0.0927***	-0.0923***	-0.0926***	-0.0926***	-0.0926***	-0.0919***	-0.0929***	-0.0931***
	(0.0128)	(0.0128)	(0.0127)	(0.0128)	(0.0127)	(0.0127)	(0.0127)	(0.0127)	(0.0127)
1982.fyear	-0.0175	-0.0173	-0.0176	-0.0174	-0.0164	-0.0177	-0.0160	-0.0178	-0.0175
	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)
1983.fyear	0.168***	0.169***	0.169***	0.169***	0.171***	0.165***	0.170***	0.166***	0.170***
	(0.0176)	(0.0176)	(0.0176)	(0.0176)	(0.0175)	(0.0176)	(0.0175)	(0.0177)	(0.0175)
1984.fyear	-0.0469*	-0.0454*	-0.0464*	-0.0455*	-0.0439*	-0.0504**	-0.0439*	-0.0489**	-0.0438*
	(0.0187)	(0.0187)	(0.0187)	(0.0187)	(0.0186)	(0.0187)	(0.0186)	(0.0189)	(0.0186)
1985.fyear	0.0142	0.0161	0.0151	0.0161	0.0171	0.00564	0.0164	0.00807	0.0173
	(0.0197)	(0.0197)	(0.0197)	(0.0197)	(0.0197)	(0.0198)	(0.0196)	(0.0203)	(0.0196)
1986.fyear	0.0137	0.0157	0.0141	0.0154	0.0179	0.00188	0.0159	0.00548	0.0177
	(0.0210)	(0.0210)	(0.0209)	(0.0210)	(0.0209)	(0.0212)	(0.0209)	(0.0222)	(0.0209)
1987.fyear	-0.155***	-0.154***	-0.155***	-0.154***	-0.152***	-0.171***	-0.154***	-0.167***	-0.152***
	(0.0212)	(0.0212)	(0.0212)	(0.0212)	(0.0211)	(0.0216)	(0.0211)	(0.0230)	(0.0212)
1988.fyear	-0.199***	-0.197***	-0.199***	-0.198***	-0.194***	-0.213***	-0.195***	-0.208***	-0.192***
	(0.0219)	(0.0218)	(0.0218)	(0.0218)	(0.0218)	(0.0223)	(0.0218)	(0.0239)	(0.0219)
1989.fyear	-0.222***	-0.221***	-0.223***	-0.222***	-0.219***	-0.235***	-0.217***	-0.230***	-0.216***
	(0.0228)	(0.0228)	(0.0228)	(0.0228)	(0.0228)	(0.0229)	(0.0227)	(0.0242)	(0.0227)
1990.fyear	-0.408***	-0.407***	-0.409***	-0.407***	-0.405***	-0.420***	-0.403***	-0.416***	-0.402***
	(0.0239)	(0.0239)	(0.0239)	(0.0239)	(0.0239)	(0.0240)	(0.0239)	(0.0253)	(0.0239)
1991.fyear	-0.184***	-0.182***	-0.184***	-0.182***	-0.182***	-0.198***	-0.179***	-0.193***	-0.179***
	(0.0245)	(0.0245)	(0.0245)	(0.0245)	(0.0244)	(0.0246)	(0.0244)	(0.0258)	(0.0244)
1992.fyear	-0.138***	-0.135***	-0.137***	-0.136***	-0.136***	-0.155***	-0.135***	-0.150***	-0.134***
	(0.0238)	(0.0238)	(0.0238)	(0.0238)	(0.0237)	(0.0241)	(0.0237)	(0.0256)	(0.0237)
1993.fyear	-0.0587*	-0.0560*	-0.0584*	-0.0566*	-0.0557*	-0.0740**	-0.0534*	-0.0690**	-0.0530*
	(0.0236)	(0.0235)	(0.0235)	(0.0235)	(0.0235)	(0.0239)	(0.0234)	(0.0254)	(0.0234)
1994.fyear	-0.183***	-0.181***	-0.183***	-0.181***	-0.179***	-0.197***	-0.177***	-0.192***	-0.178***
	(0.0238)	(0.0237)	(0.0237)	(0.0237)	(0.0237)	(0.0241)	(0.0237)	(0.0255)	(0.0237)
1995.fyear	-0.0510*	-0.0490*	-0.0511*	-0.0496*	-0.0441+	-0.0561*	-0.0399	-0.0523*	-0.0432+
	(0.0245)	(0.0245)	(0.0245)	(0.0245)	(0.0245)	(0.0247)	(0.0246)	(0.0256)	(0.0246)
1996.fyear	-0.0686**	-0.0666**	-0.0687**	-0.0672**	-0.0599*	-0.0682**	-0.0520*	-0.0652*	-0.0575*
	(0.0252)	(0.0251)	(0.0251)	(0.0251)	(0.0252)	(0.0253)	(0.0253)	(0.0259)	(0.0254)
1997.fyear	-0.0830**	-0.0811**	-0.0830**	-0.0817**	-0.0732**	-0.0770**	-0.0631*	-0.0750**	-0.0710**
	(0.0257)	(0.0256)	(0.0256)	(0.0256)	(0.0257)	(0.0257)	(0.0259)	(0.0260)	(0.0261)
1998.fyear	-0.239***	-0.237***	-0.239***	-0.237***	-0.229***	-0.235***	-0.222***	-0.232***	-0.226***
	(0.0268)	(0.0267)	(0.0267)	(0.0267)	(0.0268)	(0.0268)	(0.0269)	(0.0274)	(0.0269)
1999.fyear	0.000557	0.00172	0.00100	0.00164	0.0117	0.00159	0.0144	0.00490	0.0136
	(0.0276)	(0.0276)	(0.0276)	(0.0276)	(0.0277)	(0.0279)	(0.0277)	(0.0286)	(0.0277)
2000.fyear	-0.370***	-0.369***	-0.368***	-0.368***	-0.362***	-0.378***	-0.365***	-0.373***	-0.360***
	(0.0284)	(0.0284)	(0.0284)	(0.0284)	(0.0284)	(0.0287)	(0.0284)	(0.0298)	(0.0285)
2001.fyear	-0.431***	-0.430***	-0.429***	-0.429***	-0.424***	-0.434***	-0.428***	-0.430***	-0.421***
	(0.0284)	(0.0283)	(0.0283)	(0.0283)	(0.0283)	(0.0284)	(0.0283)	(0.0291)	(0.0285)
2002.fyear	-0.683***	-0.682***	-0.680***	-0.680***	-0.675***	-0.688***	-0.684***	-0.684***	-0.671***
	(0.0287)	(0.0287)	(0.0287)	(0.0287)	(0.0286)	(0.0288)	(0.0288)	(0.0299)	(0.0293)
2003.fyear	-0.260***	-0.259***	-0.256***	-0.257***	-0.251***	-0.271***	-0.265***	-0.265***	-0.248***
	(0.0275)	(0.0275)	(0.0275)	(0.0275)	(0.0275)	(0.0278)	(0.0280)	(0.0295)	(0.0289)
2004.fyear	-0.246***	-0.243***	-0.240***	-0.241***	-0.237***	-0.268***	-0.256***	-0.259***	-0.235***

	(0.0279)	(0.0279)	(0.0279)	(0.0279)	(0.0279)	(0.0287)	(0.0288)	(0.0317)	(0.0302)
sum_at_a		0.0832***		0.0606*	0.0603*	0.0849***		0.0849***	
		(0.0218)		(0.0269)	(0.0269)	(0.0218)		(0.0218)	
hjtwt_at_a			0.00471***	0.00255	0.00259		0.00498***		0.00501***
			(0.00123)	(0.00157)	(0.00158)		(0.00124)		(0.00124)
frag_gind_a					-0.174***	-0.188***	-0.185***	-0.189***	-0.185***
					(0.0513)	(0.0516)	(0.0516)	(0.0514)	(0.0514)
sum_at_~3a_a						-1.667***		-1.675***	
						(0.405)		(0.406)	
hjtwt_a~3a_a							-0.0443**		-0.0497**
							(0.0160)		(0.0160)
sum_at_d~4_a								0.464	
								(0.715)	
sum_at~4_a_d								-0.224	
								(0.351)	
hjtwt_at~4_a									0.0613*
									(0.0250)
hjtwt_~4_a_d									-0.201
									(0.343)
_cons	0.538***	0.534***	0.536***	0.534***	0.667***	0.740***	0.699***	0.736***	0.683***
	(0.0293)	(0.0293)	(0.0293)	(0.0293)	(0.0475)	(0.0508)	(0.0489)	(0.0613)	(0.0547)
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N	79284	79284	79284	79284	79284	79284	79284	79284	79284
R-sq	0.076	0.077	0.077	0.077	0.078	0.078	0.078	0.078	0.078
adj. R-sq	0.076	0.077	0.077	0.077	0.077	0.078	0.077	0.078	0.078
F	117.7	114.3	114.8	111.5	108.8	109.6	109.5	104.2	104.3
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Standard err	ors in parentheses								
	p<0.05, **								
+ p<0.10, *	p<0.01,	*** p<0.001							

8D Recursive Model Specification, Dataset A

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	-1	-2	-3	-4	-5	-6	-7	-8
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
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xrd_at	0.0506***	0.0508***	0.0512***	0.0513***	0.0515***	0.0512***	0.0515***	0.0513***
	(0.00607)	(0.00609)	(0.00609)	(0.00609)	(0.00606)	(0.00610)	(0.00606)	(0.00609)
		-	-	-		-	-	-
ebit_at	-0.00151***	0.00151***	0.00151***	0.00151***	-0.00151***	0.00151***	0.00151***	0.00152***
	(0.000251)	(0.000251)	(0.000252)	(0.000252)	(0.000251)	(0.000252)	(0.000250)	(0.000251)
ppent_at	-0.463***	-0.463***	-0.465***	-0.467***	-0.464***	-0.465***	-0.463***	-0.464***
	(0.0524)	(0.0524)	(0.0523)	(0.0523)	(0.0525)	(0.0524)	(0.0523)	(0.0522)
sale_at	0.00729*	0.00729*	0.00720*	0.00719*	0.00722*	0.00724*	0.00722*	0.00723*
	(0.00317)	(0.00317)	(0.00319)	(0.00320)	(0.00320)	(0.00320)	(0.00320)	(0.00320)
mshare_gind	-0.00397	-0.00397	-0.00359	-0.00399	-0.00377	-0.00388	-0.00381	-0.00396
	(0.00276)	(0.00277)	(0.00276)	(0.00278)	(0.00281)	(0.00279)	(0.00281)	(0.00279)
		-	-	-		-	-	-
hhi_gind	-0.0000223*	0.0000223*	0.0000224*	0.0000265*	-0.0000289**	0.0000274*	0.0000272*	0.0000238*
	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000108)	(0.0000107)
0b.size	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1.size	0.0750***	0.0749***	0.0685***	0.0684***	0.0705***	0.0709***	0.0705***	0.0715***
	(0.0166)	(0.0166)	(0.0166)	(0.0166)	(0.0166)	(0.0165)	(0.0166)	(0.0165)
2.size	0.141***	0.141***	0.133***	0.133***	0.135***	0.136***	0.135***	0.137***
	(0.0272)	(0.0272)	(0.0271)	(0.0271)	(0.0271)	(0.0270)	(0.0271)	(0.0270)
3.size	0.105*	0.105*	0.0951*	0.0956*	0.0976*	0.0974*	0.0979*	0.0980*
	(0.0441)	(0.0441)	(0.0440)	(0.0440)	(0.0441)	(0.0441)	(0.0441)	(0.0441)
emp_m_0_d_4	-0.0461*	-0.0464*	-0.0456*	-0.0458*	-0.0455*	-0.0457*	-0.0452*	-0.0454*
	(0.0229)	(0.0229)	(0.0229)	(0.0229)	(0.0229)	(0.0229)	(0.0229)	(0.0229)

1980b.fyear	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.0922***	-0.0921***	-0.0925***	-0.0925***	-0.0924***	-0.0920***	-0.0927***	-0.0931***
	(0.0128)	(0.0128)	(0.0128)	(0.0127)	(0.0127)	(0.0127)	(0.0127)	(0.0127)
1982.fyear	-0.0175	-0.0173	-0.0175	-0.0167	-0.0181	-0.0161	-0.0182	-0.0175
	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)
1983.fyear	0.168***	0.168***	0.167***	0.169***	0.163***	0.168***	0.164***	0.169***
	(0.0176)	(0.0176)	(0.0176)	(0.0176)	(0.0176)	(0.0175)	(0.0178)	(0.0176)
1984.fyear	-0.0469*	-0.0467*	-0.0482**	-0.0468*	-0.0533**	-0.0460*	-0.0520**	-0.0459*
	(0.0187)	(0.0187)	(0.0187)	(0.0187)	(0.0187)	(0.0187)	(0.0189)	(0.0187)
1985.fyear	0.0142	0.0144	0.0124	0.0134	0.00203	0.0134	0.00424	0.0143
	(0.0197)	(0.0197)	(0.0197)	(0.0197)	(0.0198)	(0.0197)	(0.0204)	(0.0197)
1986.fyear	0.0137	0.0139	0.0115	0.0140	-0.00204	0.0131	0.00127	0.0147
	(0.0210)	(0.0210)	(0.0209)	(0.0209)	(0.0213)	(0.0209)	(0.0222)	(0.0210)
1987.fyear	-0.155***	-0.155***	-0.158***	-0.157***	-0.175***	-0.158***	-0.171***	-0.155***
	(0.0212)	(0.0212)	(0.0212)	(0.0212)	(0.0217)	(0.0212)	(0.0231)	(0.0212)
1988.fyear	-0.199***	-0.199***	-0.202***	-0.198***	-0.217***	-0.198***	-0.212***	-0.195***
	(0.0219)	(0.0219)	(0.0219)	(0.0219)	(0.0223)	(0.0219)	(0.0240)	(0.0219)
1989.fyear	-0.222***	-0.222***	-0.225***	-0.222***	-0.238***	-0.219***	-0.234***	-0.218***
	(0.0228)	(0.0228)	(0.0228)	(0.0228)	(0.0230)	(0.0228)	(0.0243)	(0.0228)
1990.fyear	-0.408***	-0.408***	-0.411***	-0.409***	-0.424***	-0.405***	-0.420***	-0.405***
	(0.0239)	(0.0240)	(0.0240)	(0.0240)	(0.0241)	(0.0239)	(0.0254)	(0.0239)
1991.fyear	-0.184***	-0.184***	-0.187***	-0.186***	-0.202***	-0.182***	-0.198***	-0.182***
	(0.0245)	(0.0245)	(0.0245)	(0.0245)	(0.0246)	(0.0244)	(0.0259)	(0.0245)
1992.fyear	-0.138***	-0.138***	-0.140***	-0.141***	-0.159***	-0.138***	-0.155***	-0.137***
	(0.0238)	(0.0238)	(0.0239)	(0.0238)	(0.0241)	(0.0237)	(0.0257)	(0.0238)
1993.fyear	-0.0587*	-0.0587*	-0.0611**	-0.0601*	-0.0786**	-0.0560*	-0.0740**	-0.0556*
	(0.0236)	(0.0236)	(0.0236)	(0.0236)	(0.0240)	(0.0235)	(0.0256)	(0.0235)
1994.fyear	-0.183***	-0.183***	-0.185***	-0.183***	-0.201***	-0.179***	-0.196***	-0.179***
	(0.0238)	(0.0237)	(0.0238)	(0.0238)	(0.0242)	(0.0237)	(0.0257)	(0.0238)
1995.fyear	-0.0510*	-0.0511*	-0.0523*	-0.0478+	-0.0602*	-0.0421+	-0.0567*	-0.0450+
	(0.0245)	(0.0245)	(0.0246)	(0.0246)	(0.0248)	(0.0247)	(0.0257)	(0.0247)
1996.fyear	-0.0686**	-0.0687**	-0.0700**	-0.0640*	-0.0729**	-0.0544*	-0.0700**	-0.0593*
	(0.0252)	(0.0252)	(0.0253)	(0.0253)	(0.0254)	(0.0255)	(0.0261)	(0.0255)
1997.fyear	-0.0830**	-0.0830**	-0.0827**	-0.0756**	-0.0800**	-0.0638*	-0.0781**	-0.0710**
	(0.0257)	(0.0257)	(0.0258)	(0.0259)	(0.0258)	(0.0260)	(0.0262)	(0.0262)
1998.fyear	-0.239***	-0.239***	-0.236***	-0.230***	-0.236***	-0.221***	-0.233***	-0.225***
	(0.0268)	(0.0268)	(0.0269)	(0.0269)	(0.0270)	(0.0270)	(0.0276)	(0.0270)
1999.fyear	0.000557	0.000518	0.00545	0.0135	0.00333	0.0169	0.00645	0.0161
	(0.0276)	(0.0276)	(0.0277)	(0.0279)	(0.0280)	(0.0279)	(0.0287)	(0.0278)
2000.fyear	-0.370***	-0.370***	-0.362***	-0.357***	-0.371***	-0.359***	-0.367***	-0.355***
	(0.0284)	(0.0284)	(0.0286)	(0.0286)	(0.0288)	(0.0286)	(0.0300)	(0.0287)
2001.fyear	-0.431***	-0.431***	-0.419***	-0.415***	-0.424***	-0.419***	-0.420***	-0.413***
	(0.0284)	(0.0283)	(0.0285)	(0.0285)	(0.0286)	(0.0286)	(0.0293)	(0.0287)
2002.fyear	-0.683***	-0.683***	-0.668***	-0.664***	-0.676***	-0.674***	-0.671***	-0.662***
	(0.0287)	(0.0287)	(0.0289)	(0.0288)	(0.0290)	(0.0290)	(0.0301)	(0.0295)
2003.fyear	-0.260***	-0.260***	-0.243***	-0.239***	-0.256***	-0.254***	-0.251***	-0.239***
	(0.0275)	(0.0275)	(0.0277)	(0.0277)	(0.0280)	(0.0282)	(0.0298)	(0.0291)
2004.fyear	-0.246***	-0.246***	-0.228***	-0.224***	-0.252***	-0.244***	-0.245***	-0.226***
	(0.0279)	(0.0279)	(0.0281)	(0.0281)	(0.0289)	(0.0290)	(0.0319)	(0.0304)
sum_xrd_a		0.0000120	0.0000795	0.0000907	0.0000927	0.0000895	0.0000970	0.0000945
		(0.000476)	(0.000465)	(0.000468)	(0.000469)	(0.000468)	(0.000469)	(0.000467)
xrd_stock_d		0.0320	0.0275	0.0250	0.0242	0.0235	0.0243	0.0243
		(0.0648)	(0.0647)	(0.0647)	(0.0647)	(0.0647)	(0.0647)	(0.0647)
hjtwt_sum_a			0.00183***	0.00184***	0.00186***	0.00195***	0.00185***	0.00192***
			(0.000332)	(0.000331)	(0.000330)	(0.000326)	(0.000330)	(0.000326)
sum_stock_~d			0.0784***	0.0775***	0.0777***	0.0800***	0.0779***	0.0793***
			(0.0177)	(0.0176)	(0.0176)	(0.0176)	(0.0177)	(0.0176)
adj_frag_g~a				-0.140**	-0.153**	-0.150**	-0.153**	-0.151**
				(0.0463)	(0.0467)	(0.0466)	(0.0465)	(0.0465)
sum_at_~3a_a					-1.634***		-1.643***	
					(0.406)		(0.406)	
hjtwt_a~3a_a						-0.0467**		-0.0515**

						(0.0161)		(0.0161)
sum_at_d~4_a							0.428	
							(0.717)	
sum_at~4_a_d							-0.231	
							(0.346)	
hjtwt_at~4_a								0.0556*
								(0.0249)
hjtwt_~4_a_d								-0.210
								(0.338)
_cons	0.538***	0.531***	0.474***	0.582***	0.652***	0.612***	0.651***	0.598***
	(0.0293)	(0.0317)	(0.0341)	(0.0482)	(0.0515)	(0.0496)	(0.0622)	(0.0554)
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N	79284	79284	79284	79284	79284	79284	79284	79284
R-sq	0.076	0.076	0.077	0.078	0.079	0.078	0.079	0.079
adj. R-sq	0.076	0.076	0.077	0.077	0.078	0.078	0.078	0.078
F	117.7	111.2	106.2	103.6	102.1	101.7	97.45	97.22
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Standard err	ors in parentheses							
+ p<0.10, *	p<0.05, ** p<0.01,	*** p<0.001						

8E Recursive Model Specification, Dataset B

	-1	-2	-3	-4	-5	-6	-7	-8
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
xrd_at	0.0308**	0.0314**	0.0314**	0.0313**	0.0309**	0.0312**	0.0309**	0.0311**
	(0.00963)	(0.00976)	(0.00975)	(0.00969)	(0.00982)	(0.00973)	(0.00982)	(0.00975)
ebit_at	-0.000554	-0.000556	-0.000557	-0.000582	-0.000617	-0.000641	-0.000615	-0.000647
	(0.000649)	(0.000649)	(0.000650)	(0.000657)	(0.000666)	(0.000656)	(0.000666)	(0.000657)
ppent_at	-0.299**	-0.300**	-0.301**	-0.305**	-0.304**	-0.308**	-0.303**	-0.307**
	(0.0970)	(0.0973)	(0.0974)	(0.0972)	(0.0972)	(0.0972)	(0.0972)	(0.0972)
sale_at	0.0168***	0.0168***	0.0168***	0.0167***	0.0167***	0.0167***	0.0167***	0.0167***
	(0.00181)	(0.00181)	(0.00182)	(0.00191)	(0.00190)	(0.00192)	(0.00189)	(0.00192)
mshare_gind	0.00380	0.00387	0.00406	0.00374	0.00213	0.00298	0.00217	0.00296
	(0.00600)	(0.00600)	(0.00601)	(0.00589)	(0.00605)	(0.00597)	(0.00602)	(0.00595)
hhi_gind	0.0000414	0.0000402	0.0000398	0.0000451	0.0000698+	0.0000561	0.0000708+	0.0000566
	(0.0000379)	(0.0000378)	(0.0000378)	(0.0000375)	(0.0000388)	(0.0000375)	(0.0000389)	(0.0000374)
0b.size	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1.size	0.147**	0.148**	0.147**	0.148**	0.146**	0.148**	0.145**	0.147**
	(0.0463)	(0.0463)	(0.0463)	(0.0462)	(0.0461)	(0.0462)	(0.0464)	(0.0463)
2.size	0.175*	0.176*	0.175*	0.179*	0.178*	0.178*	0.176*	0.176*
	(0.0831)	(0.0821)	(0.0821)	(0.0818)	(0.0818)	(0.0818)	(0.0820)	(0.0816)
3.size	0.236+	0.237*	0.235+	0.242*	0.241*	0.241*	0.240*	0.241*
	(0.120)	(0.121)	(0.121)	(0.120)	(0.120)	(0.120)	(0.121)	(0.120)
emp_m_0_d_4	-0.104*	-0.104*	-0.104*	-0.106*	-0.107*	-0.106*	-0.107*	-0.105*
	(0.0480)	(0.0478)	(0.0478)	(0.0480)	(0.0480)	(0.0480)	(0.0480)	(0.0480)
1980b.fyear	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.0204	-0.0209	-0.0212	-0.0252	-0.0247	-0.0255	-0.0250	-0.0262
	(0.0202)	(0.0202)	(0.0201)	(0.0202)	(0.0202)	(0.0202)	(0.0202)	(0.0202)
1982.fyear	0.0960***	0.0960***	0.0960***	0.0951***	0.0970***	0.0937***	0.0973***	0.0929***
	(0.0242)	(0.0242)	(0.0242)	(0.0242)	(0.0243)	(0.0242)	(0.0243)	(0.0243)
1983.fyear	0.342***	0.342***	0.342***	0.341***	0.349***	0.342***	0.350***	0.342***
	(0.0289)	(0.0290)	(0.0290)	(0.0290)	(0.0293)	(0.0290)	(0.0298)	(0.0290)
1984.fyear	0.202***	0.202***	0.201***	0.204***	0.217***	0.207***	0.220***	0.208***
	(0.0304)	(0.0303)	(0.0303)	(0.0302)	(0.0309)	(0.0302)	(0.0320)	(0.0304)
1985.fyear	0.278***	0.278***	0.277***	0.276***	0.291***	0.280***	0.294***	0.281***
	(0.0331)	(0.0331)	(0.0331)	(0.0330)	(0.0340)	(0.0331)	(0.0355)	(0.0333)
1986.fyear	0.304***	0.304***	0.303***	0.302***	0.323***	0.308***	0.328***	0.311***

	(0.0363)	(0.0362)	(0.0363)	(0.0362)	(0.0382)	(0.0365)	(0.0404)	(0.0369)
1987.fyear	0.121**	0.121**	0.120**	0.116**	0.139***	0.123**	0.144***	0.126**
	(0.0379)	(0.0377)	(0.0378)	(0.0378)	(0.0398)	(0.0379)	(0.0428)	(0.0383)
1988.fyear	0.111**	0.110**	0.110**	0.114**	0.137***	0.120**	0.142**	0.122**
	(0.0387)	(0.0386)	(0.0387)	(0.0388)	(0.0408)	(0.0388)	(0.0436)	(0.0390)
1989.fyear	0.0713+	0.0709+	0.0709+	0.0651	0.0857*	0.0694+	0.0903*	0.0712+
	(0.0417)	(0.0416)	(0.0417)	(0.0417)	(0.0431)	(0.0416)	(0.0452)	(0.0417)
1990.fyear	-0.165***	-0.166***	-0.166***	-0.174***	-0.157***	-0.172***	-0.152**	-0.170***
	(0.0449)	(0.0449)	(0.0450)	(0.0452)	(0.0462)	(0.0451)	(0.0484)	(0.0452)
1991.fyear	0.0432	0.0422	0.0419	0.0346	0.0480	0.0344	0.0517	0.0353
	(0.0479)	(0.0478)	(0.0479)	(0.0478)	(0.0484)	(0.0478)	(0.0503)	(0.0478)
1992.fyear	0.176***	0.175***	0.175***	0.158***	0.170***	0.157***	0.174***	0.158***
	(0.0449)	(0.0448)	(0.0450)	(0.0449)	(0.0454)	(0.0449)	(0.0470)	(0.0449)
1993.fyear	0.253***	0.252***	0.252***	0.239***	0.252***	0.238***	0.255***	0.238***
	(0.0433)	(0.0432)	(0.0434)	(0.0434)	(0.0438)	(0.0435)	(0.0452)	(0.0435)
1994.fyear	0.0525	0.0507	0.0504	0.0453	0.0557	0.0415	0.0591	0.0420
	(0.0446)	(0.0444)	(0.0445)	(0.0444)	(0.0447)	(0.0447)	(0.0463)	(0.0447)
1995.fyear	0.0255	0.0241	0.0240	0.0220	0.0310	0.0170	0.0339	0.0167
	(0.0471)	(0.0469)	(0.0470)	(0.0469)	(0.0470)	(0.0473)	(0.0484)	(0.0473)
1996.fyear	0.0378	0.0360	0.0362	0.0431	0.0469	0.0340	0.0489	0.0327
	(0.0478)	(0.0476)	(0.0478)	(0.0478)	(0.0476)	(0.0487)	(0.0485)	(0.0489)
1997.fyear	0.0607	0.0589	0.0595	0.0662	0.0674	0.0548	0.0691	0.0533
	(0.0491)	(0.0489)	(0.0490)	(0.0490)	(0.0489)	(0.0505)	(0.0496)	(0.0507)
1998.fyear	-0.0235	-0.0254	-0.0247	-0.0135	-0.0103	-0.0232	-0.00811	-0.0236
	(0.0513)	(0.0512)	(0.0514)	(0.0515)	(0.0514)	(0.0528)	(0.0524)	(0.0529)
1999.fyear	-0.0954+	-0.0976+	-0.0964+	-0.0862+	-0.0827	-0.0929+	-0.0806	-0.0925+
	(0.0522)	(0.0521)	(0.0522)	(0.0523)	(0.0522)	(0.0533)	(0.0531)	(0.0532)
2000.fyear	-0.345***	-0.347***	-0.345***	-0.345***	-0.348***	-0.353***	-0.347***	-0.352***
	(0.0560)	(0.0558)	(0.0560)	(0.0559)	(0.0558)	(0.0569)	(0.0561)	(0.0569)
2001.fyear	-0.289***	-0.291***	-0.289***	-0.292***	-0.301***	-0.299***	-0.301***	-0.297***
	(0.0554)	(0.0554)	(0.0555)	(0.0554)	(0.0555)	(0.0562)	(0.0556)	(0.0561)
2002.fyear	-0.366***	-0.367***	-0.365***	-0.369***	-0.375***	-0.369***	-0.374***	-0.365***
	(0.0549)	(0.0550)	(0.0552)	(0.0550)	(0.0549)	(0.0551)	(0.0553)	(0.0549)
2003.fyear	-0.106*	-0.107*	-0.104+	-0.111*	-0.113*	-0.104*	-0.110*	-0.0980+
	(0.0528)	(0.0529)	(0.0531)	(0.0530)	(0.0529)	(0.0527)	(0.0536)	(0.0527)
2004.fyear	-0.0363	-0.0378	-0.0354	-0.0476	-0.0405	-0.0349	-0.0364	-0.0268
	(0.0533)	(0.0535)	(0.0536)	(0.0533)	(0.0535)	(0.0531)	(0.0551)	(0.0536)
sum_xrd_a		0.00284	0.00327	0.00332	0.00337	0.00330	0.00332	0.00322
		(0.00287)	(0.00303)	(0.00304)	(0.00309)	(0.00306)	(0.00305)	(0.00301)
xrd_stock_d		0.0983	0.0960	0.0977	0.102	0.0998	0.102	0.0982
		(0.145)	(0.145)	(0.144)	(0.144)	(0.144)	(0.144)	(0.144)
hjtwt_sum_a			0.000240	0.000386	0.000415	0.000333	0.000435	0.000330
			(0.000959)	(0.000963)	(0.000959)	(0.000965)	(0.000953)	(0.000967)
sum_stock_~d			0.0330	0.0332	0.0322	0.0312	0.0333	0.0317
			(0.0404)	(0.0404)	(0.0403)	(0.0404)	(0.0401)	(0.0404)
adj_frag_g~a				-0.181**	-0.159*	-0.163*	-0.158*	-0.164*
				(0.0649)	(0.0654)	(0.0665)	(0.0651)	(0.0664)
sum_at_~3a_a					3.697*		3.585*	
					-1.773		-1.781	
hjtwt_a~3a_a						0.191+		0.176
						(0.109)		(0.110)
sum_at_d~4_a							1.076	
-2.708								
o.sum_~4_a_d							0	
							(.)	
hjtwt_at~4_a								0.101
								(0.168)
o.hjtw~4_a_d								0
								(.)
_cons	-0.0154	-0.0647	-0.0883	0.0281	-0.0554	-0.0174	-0.0682	-0.0273
	(0.0613)	(0.0925)	(0.0952)	(0.107)	(0.115)	(0.113)	(0.119)	(0.117)
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N	18445	18445	18445	18445	18445	18445	18445	18445

R-sq	0.080	0.080	0.080	0.081	0.082	0.082	0.082	0.082
adj. R-sq	0.078	0.078	0.078	0.079	0.080	0.080	0.080	0.080
F	27.10	25.70	24.37	23.58	23.06	22.95	22.60	22.42
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Standard err	ors in parentheses							
+ p<0.10, *	p<0.05, ** p<0.01,	*** p<0.001						

8F Recursive Model Specification, Dataset C

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	-1	-2	-3	-4	-5	-6	-7	-8
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
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xrd_at	0.0555***	0.0558***	0.0562***	0.0563***	0.0563***	0.0568***	0.0563***	0.0571***
	(0.00952)	(0.00961)	(0.00961)	(0.00961)	(0.00961)	(0.00963)	(0.00960)	(0.00963)
ebit_at	-0.00379***	-0.00379***	-0.00384***	-0.00389***	-0.00389***	-0.00379***	-0.00393***	-0.00380***
	(0.000924)	(0.000929)	(0.000929)	(0.000930)	(0.000929)	(0.000927)	(0.000931)	(0.000926)
ppent_at	-0.600***	-0.600***	-0.604***	-0.604***	-0.604***	-0.605***	-0.606***	-0.611***
	(0.117)	(0.117)	(0.117)	(0.117)	(0.117)	(0.117)	(0.116)	(0.116)
sale_at	-0.0323*	-0.0323*	-0.0333*	-0.0341*	-0.0340*	-0.0322*	-0.0348*	-0.0324*
	(0.0152)	(0.0153)	(0.0153)	(0.0154)	(0.0153)	(0.0153)	(0.0154)	(0.0153)
mshare_gind	-0.0116*	-0.0114*	-0.0108*	-0.0115*	-0.0114*	-0.0111*	-0.0108*	-0.0102*
	(0.00505)	(0.00506)	(0.00504)	(0.00507)	(0.00511)	(0.00519)	(0.00515)	(0.00518)
hhi_gind	-0.0000574**	-0.0000578***	-0.0000575***	-0.0000640***	-0.0000624**	-0.0000564**	-0.0000747***	-0.0000638***
	(0.0000186)	(0.0000185)	(0.0000185)	(0.0000190)	(0.0000190)	(0.0000191)	(0.0000199)	(0.0000192)
0b.size	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1.size	0.0767**	0.0765**	0.0682**	0.0680**	0.0684**	0.0711**	0.0677**	0.0699**
	(0.0257)	(0.0257)	(0.0255)	(0.0254)	(0.0254)	(0.0254)	(0.0254)	(0.0253)
2.size	0.178***	0.176***	0.167***	0.165***	0.166***	0.170***	0.163***	0.166***
	(0.0466)	(0.0467)	(0.0462)	(0.0462)	(0.0460)	(0.0462)	(0.0458)	(0.0460)
3.size	0.217*	0.214*	0.202*	0.201*	0.202*	0.204*	0.200*	0.202*
	(0.0961)	(0.0960)	(0.0956)	(0.0954)	(0.0954)	(0.0956)	(0.0952)	(0.0954)
emp_m_0_d_4	-0.0381	-0.0379	-0.0351	-0.0351	-0.0348	-0.0335	-0.0361	-0.0332
	(0.0460)	(0.0460)	(0.0461)	(0.0460)	(0.0460)	(0.0460)	(0.0460)	(0.0459)
1980b.fyear	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.152***	-0.151***	-0.150***	-0.146***	-0.144***	-0.138***	-0.131***	-0.119***
	(0.0330)	(0.0330)	(0.0331)	(0.0330)	(0.0331)	(0.0330)	(0.0334)	(0.0334)
1982.fyear	-0.0358	-0.0353	-0.0347	-0.0267	-0.0255	-0.0184	-0.0167	0.00452
	(0.0381)	(0.0381)	(0.0382)	(0.0382)	(0.0381)	(0.0381)	(0.0383)	(0.0385)
1983.fyear	0.109*	0.111**	0.111**	0.122**	0.122**	0.128**	0.105*	0.135**
	(0.0429)	(0.0429)	(0.0429)	(0.0430)	(0.0430)	(0.0429)	(0.0432)	(0.0429)
1984.fyear	-0.255***	-0.253***	-0.252***	-0.244***	-0.244***	-0.235***	-0.264***	-0.228***
	(0.0450)	(0.0450)	(0.0449)	(0.0448)	(0.0448)	(0.0447)	(0.0449)	(0.0447)
1985.fyear	-0.248***	-0.245***	-0.246***	-0.236***	-0.237***	-0.231***	-0.275***	-0.234***
	(0.0458)	(0.0459)	(0.0457)	(0.0458)	(0.0461)	(0.0457)	(0.0468)	(0.0457)
1986.fyear	-0.313***	-0.309***	-0.310***	-0.299***	-0.301***	-0.293***	-0.351***	-0.295***
	(0.0465)	(0.0466)	(0.0464)	(0.0466)	(0.0470)	(0.0465)	(0.0483)	(0.0465)
1987.fyear	-0.508***	-0.504***	-0.507***	-0.495***	-0.498***	-0.488***	-0.558***	-0.491***
	(0.0480)	(0.0481)	(0.0480)	(0.0483)	(0.0489)	(0.0482)	(0.0512)	(0.0482)
1988.fyear	-0.613***	-0.609***	-0.613***	-0.601***	-0.603***	-0.588***	-0.665***	-0.584***
	(0.0492)	(0.0492)	(0.0491)	(0.0496)	(0.0498)	(0.0496)	(0.0522)	(0.0496)
1989.fyear	-0.660***	-0.656***	-0.658***	-0.645***	-0.645***	-0.620***	-0.682***	-0.579***
	(0.0510)	(0.0511)	(0.0509)	(0.0515)	(0.0515)	(0.0520)	(0.0523)	(0.0531)
1990.fyear	-0.861***	-0.856***	-0.861***	-0.848***	-0.847***	-0.816***	-0.880***	-0.757***
	(0.0524)	(0.0525)	(0.0524)	(0.0528)	(0.0528)	(0.0536)	(0.0535)	(0.0556)
1991.fyear	-0.645***	-0.641***	-0.644***	-0.633***	-0.633***	-0.595***	-0.661***	-0.518***

	(0.0524)	(0.0524)	(0.0523)	(0.0525)	(0.0524)	(0.0539)	(0.0530)	(0.0571)
1992.fyear	-0.574***	-0.569***	-0.573***	-0.558***	-0.559***	-0.523***	-0.598***	-0.446***
	(0.0530)	(0.0530)	(0.0528)	(0.0534)	(0.0534)	(0.0547)	(0.0548)	(0.0573)
1993.fyear	-0.444***	-0.440***	-0.444***	-0.428***	-0.429***	-0.389***	-0.467***	-0.297***
	(0.0537)	(0.0538)	(0.0536)	(0.0542)	(0.0543)	(0.0556)	(0.0556)	(0.0586)
1994.fyear	-0.509***	-0.505***	-0.509***	-0.493***	-0.493***	-0.453***	-0.526***	-0.345***
	(0.0543)	(0.0544)	(0.0543)	(0.0550)	(0.0550)	(0.0562)	(0.0560)	(0.0601)
1995.fyear	-0.309***	-0.305***	-0.307***	-0.287***	-0.287***	-0.240***	-0.289***	-0.0940
	(0.0560)	(0.0560)	(0.0560)	(0.0571)	(0.0570)	(0.0588)	(0.0569)	(0.0652)
1996.fyear	-0.414***	-0.410***	-0.414***	-0.395***	-0.392***	-0.325***	-0.354***	-0.121
	(0.0595)	(0.0595)	(0.0597)	(0.0606)	(0.0604)	(0.0637)	(0.0604)	(0.0746)
1997.fyear	-0.455***	-0.452***	-0.454***	-0.433***	-0.427***	-0.352***	-0.352***	-0.106
	(0.0603)	(0.0602)	(0.0604)	(0.0614)	(0.0614)	(0.0651)	(0.0635)	(0.0806)
1998.fyear	-0.607***	-0.603***	-0.600***	-0.581***	-0.575***	-0.506***	-0.517***	-0.294***
	(0.0619)	(0.0619)	(0.0622)	(0.0630)	(0.0631)	(0.0660)	(0.0639)	(0.0774)
1999.fyear	-0.0218	-0.0176	-0.0115	0.0138	0.0190	0.0699	0.0691	0.223**
	(0.0628)	(0.0628)	(0.0632)	(0.0646)	(0.0648)	(0.0665)	(0.0652)	(0.0721)
2000.fyear	-0.763***	-0.759***	-0.746***	-0.724***	-0.720***	-0.688***	-0.709***	-0.616***
	(0.0651)	(0.0650)	(0.0655)	(0.0664)	(0.0661)	(0.0666)	(0.0658)	(0.0670)
2001.fyear	-0.926***	-0.921***	-0.902***	-0.880***	-0.873***	-0.845***	-0.824***	-0.783***
	(0.0646)	(0.0646)	(0.0651)	(0.0659)	(0.0662)	(0.0660)	(0.0665)	(0.0664)
2002.fyear	-1.264***	-1.258***	-1.235***	-1.212***	-1.206***	-1.193***	-1.181***	-1.196***
	(0.0643)	(0.0643)	(0.0648)	(0.0655)	(0.0659)	(0.0653)	(0.0657)	(0.0652)
2003.fyear	-0.682***	-0.676***	-0.650***	-0.626***	-0.622***	-0.624***	-0.623***	-0.680***
	(0.0623)	(0.0623)	(0.0627)	(0.0633)	(0.0635)	(0.0632)	(0.0634)	(0.0649)
2004.fyear	-0.745***	-0.739***	-0.711***	-0.689***	-0.687***	-0.702***	-0.738***	-0.810***
	(0.0627)	(0.0627)	(0.0632)	(0.0637)	(0.0635)	(0.0639)	(0.0663)	(0.0692)
sum_xrd_a		0.0171*	0.0195*	0.0197*	0.0198*	0.0201*	0.0193*	0.0197*
		(0.00807)	(0.00829)	(0.00829)	(0.00829)	(0.00818)	(0.00822)	(0.00819)
xrd_stock_d		0.0355	0.0332	0.0250	0.0249	0.0239	0.0232	0.0103
		(0.132)	(0.131)	(0.132)	(0.132)	(0.132)	(0.132)	(0.130)
hjtwt_sum_a			0.00203***	0.00202***	0.00202***	0.00206***	0.00202***	0.00205***
			(0.000357)	(0.000358)	(0.000358)	(0.000355)	(0.000361)	(0.000357)
sum_stock_~d			0.0957**	0.0943**	0.0943**	0.0938**	0.0907**	0.0908**
			(0.0298)	(0.0297)	(0.0297)	(0.0297)	(0.0298)	(0.0297)
adj_frag_g~a				-0.181+	-0.184+	-0.208+	-0.236*	-0.258*
				(0.108)	(0.107)	(0.108)	(0.109)	(0.109)
sum_at_~3a_a					-0.319		-1.324+	
					(0.720)		(0.725)	
hjtwt_a~3a_a						-0.0734**		-0.134***
						(0.0235)		(0.0272)
sum_at_d~4_a							-4.535**	
-1.480								
sum_at~4_a_d							0.775***	
							(0.0932)	
hjtwt_at~4_a								-0.242***
								(0.0528)
hjtwt_~4_a_d								0.822***
								(0.0624)
_cons	1.146***	1.138***	1.062***	1.193***	1.205***	1.237***	1.441***	1.404***
	(0.0691)	(0.0691)	(0.0738)	(0.105)	(0.109)	(0.107)	(0.152)	(0.122)
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N	24651	24651	24651	24651	24651	24651	24651	24651
R-sq	0.167	0.168	0.170	0.170	0.170	0.171	0.171	0.173
adj. R-sq	0.166	0.166	0.168	0.169	0.169	0.169	0.170	0.171
F	158.2	149.4	143.2	139.5	136.1	138.0	.	.
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Standard err	ors in parentheses							
	p<0.05, **							
+ p<0.10, *	p<0.01,	*** p<0.001						

8G 20 Percent Stock Depreciation, Dataset A

	-1	-2	-3	-4	-5	-6	-7	-8
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
xrd_at	0.0555***	0.0558***	0.0562***	0.0563***	0.0563***	0.0568***	0.0563***	0.0571***
	(0.00952)	(0.00961)	(0.00961)	(0.00961)	(0.00961)	(0.00963)	(0.00960)	(0.00963)
ebit_at	-0.00379***	-0.00379***	-0.00384***	-0.00389***	-0.00389***	-0.00379***	-0.00393***	-0.00380***
	(0.000924)	(0.000929)	(0.000929)	(0.000930)	(0.000929)	(0.000927)	(0.000931)	(0.000926)
ppent_at	-0.600***	-0.600***	-0.604***	-0.604***	-0.604***	-0.605***	-0.606***	-0.611***
	(0.117)	(0.117)	(0.117)	(0.117)	(0.117)	(0.117)	(0.116)	(0.116)
sale_at	-0.0323*	-0.0323*	-0.0333*	-0.0341*	-0.0340*	-0.0322*	-0.0348*	-0.0324*
	(0.0152)	(0.0153)	(0.0153)	(0.0154)	(0.0153)	(0.0153)	(0.0154)	(0.0153)
mshare_gind	-0.0116*	-0.0114*	-0.0108*	-0.0115*	-0.0114*	-0.0111*	-0.0108*	-0.0102*
	(0.00505)	(0.00506)	(0.00504)	(0.00507)	(0.00511)	(0.00519)	(0.00515)	(0.00518)
hhi_gind	-0.0000574**	-0.0000578**	-0.0000575**	-0.0000640**	-0.0000624**	-0.0000564**	-0.0000747**	-0.0000638**
	(0.0000186)	(0.0000185)	(0.0000185)	(0.0000190)	(0.0000190)	(0.0000191)	(0.0000199)	(0.0000192)
0b.size	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1.size	0.0767**	0.0765**	0.0682**	0.0680**	0.0684**	0.0711**	0.0677**	0.0699**
	(0.0257)	(0.0257)	(0.0255)	(0.0254)	(0.0254)	(0.0254)	(0.0254)	(0.0253)
2.size	0.178***	0.176***	0.167***	0.165***	0.166***	0.170***	0.163***	0.166***
	(0.0466)	(0.0467)	(0.0462)	(0.0462)	(0.0460)	(0.0462)	(0.0458)	(0.0460)
3.size	0.217*	0.214*	0.202*	0.201*	0.202*	0.204*	0.200*	0.202*
	(0.0961)	(0.0960)	(0.0956)	(0.0954)	(0.0954)	(0.0956)	(0.0952)	(0.0954)
emp_m_0_d_4	-0.0381	-0.0379	-0.0351	-0.0351	-0.0348	-0.0335	-0.0361	-0.0332
	(0.0460)	(0.0460)	(0.0461)	(0.0460)	(0.0460)	(0.0460)	(0.0460)	(0.0459)
1980b.fyear	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.152***	-0.151***	-0.150***	-0.146***	-0.144***	-0.138***	-0.131***	-0.119***
	(0.0330)	(0.0330)	(0.0331)	(0.0330)	(0.0331)	(0.0330)	(0.0334)	(0.0334)
1982.fyear	-0.0358	-0.0353	-0.0347	-0.0267	-0.0255	-0.0184	-0.0167	0.00452
	(0.0381)	(0.0381)	(0.0382)	(0.0382)	(0.0381)	(0.0381)	(0.0383)	(0.0385)
1983.fyear	0.109*	0.111**	0.111**	0.122**	0.122**	0.128**	0.105*	0.135**
	(0.0429)	(0.0429)	(0.0429)	(0.0430)	(0.0430)	(0.0429)	(0.0432)	(0.0429)
1984.fyear	-0.255***	-0.253***	-0.252***	-0.244***	-0.244***	-0.235***	-0.264***	-0.228***
	(0.0450)	(0.0450)	(0.0449)	(0.0448)	(0.0448)	(0.0447)	(0.0449)	(0.0447)
1985.fyear	-0.248***	-0.245***	-0.246***	-0.236***	-0.237***	-0.231***	-0.275***	-0.234***
	(0.0458)	(0.0459)	(0.0457)	(0.0458)	(0.0461)	(0.0457)	(0.0468)	(0.0457)
1986.fyear	-0.313***	-0.309***	-0.310***	-0.299***	-0.301***	-0.293***	-0.351***	-0.295***
	(0.0465)	(0.0466)	(0.0464)	(0.0466)	(0.0470)	(0.0465)	(0.0483)	(0.0465)
1987.fyear	-0.508***	-0.504***	-0.507***	-0.495***	-0.498***	-0.488***	-0.558***	-0.491***
	(0.0480)	(0.0481)	(0.0480)	(0.0483)	(0.0489)	(0.0482)	(0.0512)	(0.0482)
1988.fyear	-0.613***	-0.609***	-0.613***	-0.601***	-0.603***	-0.588***	-0.665***	-0.584***
	(0.0492)	(0.0492)	(0.0491)	(0.0496)	(0.0498)	(0.0496)	(0.0522)	(0.0496)
1989.fyear	-0.660***	-0.656***	-0.658***	-0.645***	-0.645***	-0.620***	-0.682***	-0.579***
	(0.0510)	(0.0511)	(0.0509)	(0.0515)	(0.0515)	(0.0520)	(0.0523)	(0.0531)
1990.fyear	-0.861***	-0.856***	-0.861***	-0.848***	-0.847***	-0.816***	-0.880***	-0.757***
	(0.0524)	(0.0525)	(0.0524)	(0.0528)	(0.0528)	(0.0536)	(0.0535)	(0.0556)
1991.fyear	-0.645***	-0.641***	-0.644***	-0.633***	-0.633***	-0.595***	-0.661***	-0.518***
	(0.0524)	(0.0524)	(0.0523)	(0.0525)	(0.0524)	(0.0539)	(0.0530)	(0.0571)
1992.fyear	-0.574***	-0.569***	-0.573***	-0.558***	-0.559***	-0.523***	-0.598***	-0.446***
	(0.0530)	(0.0530)	(0.0528)	(0.0534)	(0.0534)	(0.0547)	(0.0548)	(0.0573)
1993.fyear	-0.444***	-0.440***	-0.444***	-0.428***	-0.429***	-0.389***	-0.467***	-0.297***
	(0.0537)	(0.0538)	(0.0536)	(0.0542)	(0.0543)	(0.0556)	(0.0556)	(0.0586)
1994.fyear	-0.509***	-0.505***	-0.509***	-0.493***	-0.493***	-0.453***	-0.526***	-0.345***
	(0.0543)	(0.0544)	(0.0543)	(0.0550)	(0.0550)	(0.0562)	(0.0560)	(0.0601)
1995.fyear	-0.309***	-0.305***	-0.307***	-0.287***	-0.287***	-0.240***	-0.289***	-0.0940
	(0.0560)	(0.0560)	(0.0560)	(0.0571)	(0.0570)	(0.0588)	(0.0569)	(0.0652)

1996.fyear	-0.414***	-0.410***	-0.414***	-0.395***	-0.392***	-0.325***	-0.354***	-0.121
	(0.0595)	(0.0595)	(0.0597)	(0.0606)	(0.0604)	(0.0637)	(0.0604)	(0.0746)
1997.fyear	-0.455***	-0.452***	-0.454***	-0.433***	-0.427***	-0.352***	-0.352***	-0.106
	(0.0603)	(0.0602)	(0.0604)	(0.0614)	(0.0614)	(0.0651)	(0.0635)	(0.0806)
1998.fyear	-0.607***	-0.603***	-0.600***	-0.581***	-0.575***	-0.506***	-0.517***	-0.294***
	(0.0619)	(0.0619)	(0.0622)	(0.0630)	(0.0631)	(0.0660)	(0.0639)	(0.0774)
1999.fyear	-0.0218	-0.0176	-0.0115	0.0138	0.0190	0.0699	0.0691	0.223**
	(0.0628)	(0.0628)	(0.0632)	(0.0646)	(0.0648)	(0.0665)	(0.0652)	(0.0721)
2000.fyear	-0.763***	-0.759***	-0.746***	-0.724***	-0.720***	-0.688***	-0.709***	-0.616***
	(0.0651)	(0.0650)	(0.0655)	(0.0664)	(0.0661)	(0.0666)	(0.0658)	(0.0670)
2001.fyear	-0.926***	-0.921***	-0.902***	-0.880***	-0.873***	-0.845***	-0.824***	-0.783***
	(0.0646)	(0.0646)	(0.0651)	(0.0659)	(0.0662)	(0.0660)	(0.0665)	(0.0664)
2002.fyear	-1.264***	-1.258***	-1.235***	-1.212***	-1.206***	-1.193***	-1.181***	-1.196***
	(0.0643)	(0.0643)	(0.0648)	(0.0655)	(0.0659)	(0.0653)	(0.0657)	(0.0652)
2003.fyear	-0.682***	-0.676***	-0.650***	-0.626***	-0.622***	-0.624***	-0.623***	-0.680***
	(0.0623)	(0.0623)	(0.0627)	(0.0633)	(0.0635)	(0.0632)	(0.0634)	(0.0649)
2004.fyear	-0.745***	-0.739***	-0.711***	-0.689***	-0.687***	-0.702***	-0.738***	-0.810***
	(0.0627)	(0.0627)	(0.0632)	(0.0637)	(0.0635)	(0.0639)	(0.0663)	(0.0692)
sum_xrd_a		0.0171*	0.0195*	0.0197*	0.0198*	0.0201*	0.0193*	0.0197*
		(0.00807)	(0.00829)	(0.00829)	(0.00829)	(0.00818)	(0.00822)	(0.00819)
xrd_stock_d		0.0355	0.0332	0.0250	0.0249	0.0239	0.0232	0.0103
		(0.132)	(0.131)	(0.132)	(0.132)	(0.132)	(0.132)	(0.130)
hjtwt_sum_a			0.00203***	0.00202***	0.00202***	0.00206***	0.00202***	0.00205***
			(0.000357)	(0.000358)	(0.000358)	(0.000355)	(0.000361)	(0.000357)
sum_stock_~d			0.0957**	0.0943**	0.0943**	0.0938**	0.0907**	0.0908**
			(0.0298)	(0.0297)	(0.0297)	(0.0297)	(0.0298)	(0.0297)
adj_frag_g~a				-0.181+	-0.184+	-0.208+	-0.236*	-0.258*
				(0.108)	(0.107)	(0.108)	(0.109)	(0.109)
sum_at_~3a_a					-0.319		-1.324+	
					(0.720)		(0.725)	
hjtwt_a~3a_a						-0.0734**		-0.134***
						(0.0235)		(0.0272)
sum_at_d~4_a							-4.535**	
-1.480								
sum_at~4_a_d							0.775***	
							(0.0932)	
hjtwt_at~4_a								-0.242***
								(0.0528)
hjtwt_~4_a_d								0.822***
								(0.0624)
_cons	1.146***	1.138***	1.062***	1.193***	1.205***	1.237***	1.441***	1.404***
	(0.0691)	(0.0691)	(0.0738)	(0.105)	(0.109)	(0.107)	(0.152)	(0.122)
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N	24651	24651	24651	24651	24651	24651	24651	24651
R-sq	0.167	0.168	0.170	0.170	0.170	0.171	0.171	0.173
adj. R-sq	0.166	0.166	0.168	0.169	0.169	0.169	0.170	0.171
F	158.2	149.4	143.2	139.5	136.1	138.0	.	.
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Standard err	ors in parentheses							
	p<0.05, **							
+ p<0.10, *	p<0.01,	*** p<0.001						

8H Lagged Independent Variables, Dataset A

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	-1	-2	-3	-4	-5	-6	-7	-8
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
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xrd_at	0.0555***	0.0558***	0.0562***	0.0563***	0.0563***	0.0568***	0.0563***	0.0571***
	(0.00952)	(0.00961)	(0.00961)	(0.00961)	(0.00961)	(0.00963)	(0.00960)	(0.00963)
ebit_at	-0.00379***	-0.00379***	-0.00384***	-0.00389***	-0.00389***	-0.00379***	-0.00393***	-0.00380***
	(0.000924)	(0.000929)	(0.000929)	(0.000930)	(0.000929)	(0.000927)	(0.000931)	(0.000926)
ppent_at	-0.600***	-0.600***	-0.604***	-0.604***	-0.604***	-0.605***	-0.606***	-0.611***

	(0.117)	(0.117)	(0.117)	(0.117)	(0.117)	(0.117)	(0.116)	(0.116)
sale_at	-0.0323*	-0.0323*	-0.0333*	-0.0341*	-0.0340*	-0.0322*	-0.0348*	-0.0324*
	(0.0152)	(0.0153)	(0.0153)	(0.0154)	(0.0153)	(0.0153)	(0.0154)	(0.0153)
mshare_gind	-0.0116*	-0.0114*	-0.0108*	-0.0115*	-0.0114*	-0.0111*	-0.0108*	-0.0102*
	(0.00505)	(0.00506)	(0.00504)	(0.00507)	(0.00511)	(0.00519)	(0.00515)	(0.00518)
hhi_gind	-0.0000574**	-0.0000578**	-0.0000575**	-0.0000640***	-0.0000624**	-0.0000564**	-0.0000747***	-0.0000638***
	(0.0000186)	(0.0000185)	(0.0000185)	(0.0000190)	(0.0000190)	(0.0000191)	(0.0000199)	(0.0000192)
0b.size	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1.size	0.0767**	0.0765**	0.0682**	0.0680**	0.0684**	0.0711**	0.0677**	0.0699**
	(0.0257)	(0.0257)	(0.0255)	(0.0254)	(0.0254)	(0.0254)	(0.0254)	(0.0253)
2.size	0.178***	0.176***	0.167***	0.165***	0.166***	0.170***	0.163***	0.166***
	(0.0466)	(0.0467)	(0.0462)	(0.0462)	(0.0460)	(0.0462)	(0.0458)	(0.0460)
3.size	0.217*	0.214*	0.202*	0.201*	0.202*	0.204*	0.200*	0.202*
	(0.0961)	(0.0960)	(0.0956)	(0.0954)	(0.0954)	(0.0956)	(0.0952)	(0.0954)
emp_m_0_d_4	-0.0381	-0.0379	-0.0351	-0.0351	-0.0348	-0.0335	-0.0361	-0.0332
	(0.0460)	(0.0460)	(0.0461)	(0.0460)	(0.0460)	(0.0460)	(0.0460)	(0.0459)
1980b.fyear	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.152***	-0.151***	-0.150***	-0.146***	-0.144***	-0.138***	-0.131***	-0.119***
	(0.0330)	(0.0330)	(0.0331)	(0.0330)	(0.0331)	(0.0330)	(0.0334)	(0.0334)
1982.fyear	-0.0358	-0.0353	-0.0347	-0.0267	-0.0255	-0.0184	-0.0167	0.00452
	(0.0381)	(0.0381)	(0.0382)	(0.0382)	(0.0381)	(0.0381)	(0.0383)	(0.0385)
1983.fyear	0.109*	0.111**	0.111**	0.122**	0.122**	0.128**	0.105*	0.135**
	(0.0429)	(0.0429)	(0.0429)	(0.0430)	(0.0430)	(0.0429)	(0.0432)	(0.0429)
1984.fyear	-0.255***	-0.253***	-0.252***	-0.244***	-0.244***	-0.235***	-0.264***	-0.228***
	(0.0450)	(0.0450)	(0.0449)	(0.0448)	(0.0448)	(0.0447)	(0.0449)	(0.0447)
1985.fyear	-0.248***	-0.245***	-0.246***	-0.236***	-0.237***	-0.231***	-0.275***	-0.234***
	(0.0458)	(0.0459)	(0.0457)	(0.0458)	(0.0461)	(0.0457)	(0.0468)	(0.0457)
1986.fyear	-0.313***	-0.309***	-0.310***	-0.299***	-0.301***	-0.293***	-0.351***	-0.295***
	(0.0465)	(0.0466)	(0.0464)	(0.0466)	(0.0470)	(0.0465)	(0.0483)	(0.0465)
1987.fyear	-0.508***	-0.504***	-0.507***	-0.495***	-0.498***	-0.488***	-0.558***	-0.491***
	(0.0480)	(0.0481)	(0.0480)	(0.0483)	(0.0489)	(0.0482)	(0.0512)	(0.0482)
1988.fyear	-0.613***	-0.609***	-0.613***	-0.601***	-0.603***	-0.588***	-0.665***	-0.584***
	(0.0492)	(0.0492)	(0.0491)	(0.0496)	(0.0498)	(0.0496)	(0.0522)	(0.0496)
1989.fyear	-0.660***	-0.656***	-0.658***	-0.645***	-0.645***	-0.620***	-0.682***	-0.579***
	(0.0510)	(0.0511)	(0.0509)	(0.0515)	(0.0515)	(0.0520)	(0.0523)	(0.0531)
1990.fyear	-0.861***	-0.856***	-0.861***	-0.848***	-0.847***	-0.816***	-0.880***	-0.757***
	(0.0524)	(0.0525)	(0.0524)	(0.0528)	(0.0528)	(0.0536)	(0.0535)	(0.0556)
1991.fyear	-0.645***	-0.641***	-0.644***	-0.633***	-0.633***	-0.595***	-0.661***	-0.518***
	(0.0524)	(0.0524)	(0.0523)	(0.0525)	(0.0524)	(0.0539)	(0.0530)	(0.0571)
1992.fyear	-0.574***	-0.569***	-0.573***	-0.558***	-0.559***	-0.523***	-0.598***	-0.446***
	(0.0530)	(0.0530)	(0.0528)	(0.0534)	(0.0534)	(0.0547)	(0.0548)	(0.0573)
1993.fyear	-0.444***	-0.440***	-0.444***	-0.428***	-0.429***	-0.389***	-0.467***	-0.297***
	(0.0537)	(0.0538)	(0.0536)	(0.0542)	(0.0543)	(0.0556)	(0.0556)	(0.0586)
1994.fyear	-0.509***	-0.505***	-0.509***	-0.493***	-0.493***	-0.453***	-0.526***	-0.345***
	(0.0543)	(0.0544)	(0.0543)	(0.0550)	(0.0550)	(0.0562)	(0.0560)	(0.0601)
1995.fyear	-0.309***	-0.305***	-0.307***	-0.287***	-0.287***	-0.240***	-0.289***	-0.0940
	(0.0560)	(0.0560)	(0.0560)	(0.0571)	(0.0570)	(0.0588)	(0.0569)	(0.0652)
1996.fyear	-0.414***	-0.410***	-0.414***	-0.395***	-0.392***	-0.325***	-0.354***	-0.121
	(0.0595)	(0.0595)	(0.0597)	(0.0606)	(0.0604)	(0.0637)	(0.0604)	(0.0746)
1997.fyear	-0.455***	-0.452***	-0.454***	-0.433***	-0.427***	-0.352***	-0.352***	-0.106
	(0.0603)	(0.0602)	(0.0604)	(0.0614)	(0.0614)	(0.0651)	(0.0635)	(0.0806)
1998.fyear	-0.607***	-0.603***	-0.600***	-0.581***	-0.575***	-0.506***	-0.517***	-0.294***
	(0.0619)	(0.0619)	(0.0622)	(0.0630)	(0.0631)	(0.0660)	(0.0639)	(0.0774)
1999.fyear	-0.0218	-0.0176	-0.0115	0.0138	0.0190	0.0699	0.0691	0.223**
	(0.0628)	(0.0628)	(0.0632)	(0.0646)	(0.0648)	(0.0665)	(0.0652)	(0.0721)
2000.fyear	-0.763***	-0.759***	-0.746***	-0.724***	-0.720***	-0.688***	-0.709***	-0.616***
	(0.0651)	(0.0650)	(0.0655)	(0.0664)	(0.0661)	(0.0666)	(0.0658)	(0.0670)
2001.fyear	-0.926***	-0.921***	-0.902***	-0.880***	-0.873***	-0.845***	-0.824***	-0.783***

	(0.0646)	(0.0646)	(0.0651)	(0.0659)	(0.0662)	(0.0660)	(0.0665)	(0.0664)
2002.fyear	-1.264***	-1.258***	-1.235***	-1.212***	-1.206***	-1.193***	-1.181***	-1.196***
	(0.0643)	(0.0643)	(0.0648)	(0.0655)	(0.0659)	(0.0653)	(0.0657)	(0.0652)
2003.fyear	-0.682***	-0.676***	-0.650***	-0.626***	-0.622***	-0.624***	-0.623***	-0.680***
	(0.0623)	(0.0623)	(0.0627)	(0.0633)	(0.0635)	(0.0632)	(0.0634)	(0.0649)
2004.fyear	-0.745***	-0.739***	-0.711***	-0.689***	-0.687***	-0.702***	-0.738***	-0.810***
	(0.0627)	(0.0627)	(0.0632)	(0.0637)	(0.0635)	(0.0639)	(0.0663)	(0.0692)
sum_xrd_a		0.0171*	0.0195*	0.0197*	0.0198*	0.0201*	0.0193*	0.0197*
		(0.00807)	(0.00829)	(0.00829)	(0.00829)	(0.00818)	(0.00822)	(0.00819)
xrd_stock_d		0.0355	0.0332	0.0250	0.0249	0.0239	0.0232	0.0103
		(0.132)	(0.131)	(0.132)	(0.132)	(0.132)	(0.132)	(0.130)
hjtwt_sum_a			0.00203***	0.00202***	0.00202***	0.00206***	0.00202***	0.00205***
			(0.000357)	(0.000358)	(0.000358)	(0.000355)	(0.000361)	(0.000357)
sum_stock_~d			0.0957**	0.0943**	0.0943**	0.0938**	0.0907**	0.0908**
			(0.0298)	(0.0297)	(0.0297)	(0.0297)	(0.0298)	(0.0297)
adj_frag_g~a				-0.181+	-0.184+	-0.208+	-0.236*	-0.258*
				(0.108)	(0.107)	(0.108)	(0.109)	(0.109)
sum_at_~3a_a					-0.319		-1.324+	
					(0.720)		(0.725)	
hjtwt_a~3a_a						-0.0734**		-0.134***
						(0.0235)		(0.0272)
sum_at_d~4_a							-4.535**	
-1.480								
sum_at~4_a_d							0.775***	
							(0.0932)	
hjtwt_at~4_a								-0.242***
								(0.0528)
hjtwt_~4_a_d								0.822***
								(0.0624)
_cons	1.146***	1.138***	1.062***	1.193***	1.205***	1.237***	1.441***	1.404***
	(0.0691)	(0.0691)	(0.0738)	(0.105)	(0.109)	(0.107)	(0.152)	(0.122)
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N	24651	24651	24651	24651	24651	24651	24651	24651
R-sq	0.167	0.168	0.170	0.170	0.170	0.171	0.171	0.173
adj. R-sq	0.166	0.166	0.168	0.169	0.169	0.169	0.170	0.171
F	158.2	149.4	143.2	139.5	136.1	138.0	.	.
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Standard err	ors in parentheses							
	p<0.05, **							
+ p<0.10, *	p<0.01,	*** p<0.001						

8I Lagged Independent Variables, Dataset B

	-1	-2	-3	-4	-5	-6	-7	-8	-9
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
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L.xrd_at	0.0171+	0.0168+	0.0165+	0.0167+	0.0166+	0.0164+	0.0161+	0.0180+	0.0161+
	(0.00916)	(0.00914)	(0.00916)	(0.00914)	(0.00915)	(0.00918)	(0.00916)	(0.00991)	(0.00914)
L.ebit_at	0.00872	0.00872	0.00878	0.00878	0.00858	0.00841	0.00840	0.00486	0.00839
	(0.00601)	(0.00601)	(0.00599)	(0.00600)	(0.00600)	(0.00599)	(0.00601)	(0.00392)	(0.00601)
L.ppent_at	-0.227*	-0.227*	-0.230*	-0.230*	-0.232*	-0.227*	-0.235*	-0.226*	-0.235*
	(0.102)	(0.102)	(0.102)	(0.102)	(0.102)	(0.102)	(0.102)	(0.102)	(0.102)
L.sale_at	0.0436**	0.0435**	0.0436**	0.0437**	0.0423*	0.0421*	0.0418*		0.0416*
	(0.0165)	(0.0165)	(0.0165)	(0.0165)	(0.0166)	(0.0166)	(0.0166)		(0.0166)
sale_at								0.0203***	
								(0.00151)	
L.mshare_g~d	0.000623	0.000656	0.000812	0.000806	0.000572	-0.00115	-0.000600	-0.000993	-0.000586
	(0.00550)	(0.00550)	(0.00548)	(0.00548)	(0.00538)	(0.00557)	(0.00548)	(0.00554)	(0.00551)

L.hhi_gind	0.0000708+	0.0000709+	0.0000698+	0.0000695+	0.0000748+	0.000100*	0.0000926*	0.0000988*	0.0000918*
	(0.0000390)	(0.0000390)	(0.0000389)	(0.0000390)	(0.0000387)	(0.0000404)	(0.0000383)	(0.0000409)	(0.0000384)
0bL.size	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1L.size	0.227***	0.226***	0.224***	0.225***	0.225***	0.225***	0.224***	0.227***	0.225***
	(0.0451)	(0.0451)	(0.0452)	(0.0452)	(0.0451)	(0.0450)	(0.0450)	(0.0452)	(0.0451)
2L.size	0.386***	0.386***	0.383***	0.383***	0.385***	0.387***	0.384***	0.385***	0.385***
	(0.0845)	(0.0844)	(0.0844)	(0.0844)	(0.0843)	(0.0843)	(0.0842)	(0.0845)	(0.0841)
3L.size	0.617***	0.615***	0.608***	0.609***	0.613***	0.618***	0.612***	0.612***	0.612***
	(0.145)	(0.145)	(0.145)	(0.146)	(0.146)	(0.146)	(0.145)	(0.146)	(0.145)
L.emp_m_0_~4	0.0372	0.0375	0.0376	0.0374	0.0357	0.0344	0.0361	0.0312	0.0358
	(0.0489)	(0.0489)	(0.0489)	(0.0489)	(0.0491)	(0.0492)	(0.0490)	(0.0486)	(0.0490)
1981b.fyear	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1982.fyear	0.111***	0.112***	0.111***	0.111***	0.109***	0.110***	0.108***	0.112***	0.109***
	(0.0212)	(0.0212)	(0.0212)	(0.0212)	(0.0212)	(0.0212)	(0.0213)	(0.0211)	(0.0212)
1983.fyear	0.314***	0.314***	0.314***	0.313***	0.313***	0.316***	0.312***	0.316***	0.312***
	(0.0267)	(0.0266)	(0.0266)	(0.0266)	(0.0266)	(0.0266)	(0.0267)	(0.0266)	(0.0266)
1984.fyear	0.218***	0.219***	0.218***	0.218***	0.217***	0.226***	0.219***	0.223***	0.219***
	(0.0304)	(0.0303)	(0.0304)	(0.0303)	(0.0303)	(0.0305)	(0.0304)	(0.0314)	(0.0305)
1985.fyear	0.302***	0.302***	0.302***	0.301***	0.303***	0.316***	0.308***	0.313***	0.308***
	(0.0343)	(0.0342)	(0.0343)	(0.0343)	(0.0343)	(0.0348)	(0.0343)	(0.0364)	(0.0345)
1986.fyear	0.320***	0.321***	0.321***	0.320***	0.319***	0.335***	0.326***	0.329***	0.325***
	(0.0366)	(0.0365)	(0.0366)	(0.0365)	(0.0365)	(0.0373)	(0.0366)	(0.0391)	(0.0368)
1987.fyear	0.167***	0.167***	0.166***	0.166***	0.165***	0.186***	0.174***	0.177***	0.172***
	(0.0397)	(0.0395)	(0.0396)	(0.0395)	(0.0395)	(0.0411)	(0.0397)	(0.0443)	(0.0402)
1988.fyear	0.161***	0.162***	0.161***	0.160***	0.157***	0.180***	0.167***	0.173***	0.165***
	(0.0403)	(0.0402)	(0.0403)	(0.0403)	(0.0402)	(0.0421)	(0.0404)	(0.0456)	(0.0409)
1989.fyear	0.147***	0.148***	0.147***	0.146***	0.149***	0.171***	0.157***	0.164***	0.155***
	(0.0430)	(0.0429)	(0.0430)	(0.0429)	(0.0431)	(0.0448)	(0.0431)	(0.0482)	(0.0434)
1990.fyear	-0.0907*	-0.0899+	-0.0905*	-0.0912*	-0.0946*	-0.0750	-0.0887+	-0.0815	-0.0900+
	(0.0459)	(0.0459)	(0.0459)	(0.0459)	(0.0459)	(0.0471)	(0.0457)	(0.0504)	(0.0459)
1991.fyear	0.0789	0.0798+	0.0796+	0.0790	0.0738	0.0898+	0.0768	0.0842	0.0758
	(0.0484)	(0.0482)	(0.0483)	(0.0483)	(0.0482)	(0.0490)	(0.0481)	(0.0519)	(0.0483)
1992.fyear	0.204***	0.205***	0.205***	0.204***	0.199***	0.212***	0.199***	0.196***	0.199***
	(0.0471)	(0.0470)	(0.0471)	(0.0470)	(0.0469)	(0.0474)	(0.0469)	(0.0491)	(0.0469)
1993.fyear	0.291***	0.292***	0.292***	0.291***	0.279***	0.291***	0.279***	0.284***	0.278***
	(0.0451)	(0.0450)	(0.0451)	(0.0450)	(0.0450)	(0.0456)	(0.0452)	(0.0476)	(0.0452)
1994.fyear	0.108*	0.109*	0.108*	0.107*	0.0988*	0.112*	0.0969*	0.103*	0.0969*
	(0.0459)	(0.0458)	(0.0459)	(0.0458)	(0.0458)	(0.0462)	(0.0460)	(0.0482)	(0.0460)
1995.fyear	0.0916+	0.0926+	0.0920+	0.0912+	0.0881+	0.0990*	0.0836+	0.0902+	0.0834+
	(0.0481)	(0.0480)	(0.0481)	(0.0480)	(0.0479)	(0.0481)	(0.0483)	(0.0502)	(0.0483)
1996.fyear	0.0919+	0.0928+	0.0915+	0.0907+	0.0898+	0.100*	0.0840+	0.0930+	0.0844+
	(0.0494)	(0.0493)	(0.0494)	(0.0493)	(0.0492)	(0.0492)	(0.0498)	(0.0510)	(0.0498)
1997.fyear	0.166**	0.166**	0.165**	0.165**	0.170***	0.175***	0.158**	0.170**	0.160**
	(0.0508)	(0.0507)	(0.0508)	(0.0507)	(0.0508)	(0.0508)	(0.0521)	(0.0520)	(0.0521)
1998.fyear	0.0877	0.0885+	0.0876	0.0869	0.0922+	0.0954+	0.0783	0.0896+	0.0797
	(0.0535)	(0.0534)	(0.0534)	(0.0534)	(0.0535)	(0.0534)	(0.0553)	(0.0544)	(0.0555)
1999.fyear	0.00459	0.00532	0.00417	0.00352	0.0116	0.0165	-0.000422	0.00969	0.000199
	(0.0543)	(0.0543)	(0.0543)	(0.0542)	(0.0545)	(0.0544)	(0.0561)	(0.0557)	(0.0562)
2000.fyear	-0.223***	-0.222***	-0.223***	-0.224***	-0.217***	-0.211***	-0.224***	-0.218***	-0.224***
	(0.0579)	(0.0578)	(0.0578)	(0.0578)	(0.0580)	(0.0579)	(0.0590)	(0.0589)	(0.0590)
2001.fyear	-0.147*	-0.147*	-0.147*	-0.148*	-0.147*	-0.149**	-0.157**	-0.152**	-0.157**
	(0.0578)	(0.0578)	(0.0578)	(0.0578)	(0.0577)	(0.0577)	(0.0587)	(0.0578)	(0.0587)
2002.fyear	-0.239***	-0.239***	-0.239***	-0.239***	-0.240***	-0.249***	-0.249***	-0.255***	-0.250***
	(0.0570)	(0.0570)	(0.0570)	(0.0570)	(0.0568)	(0.0569)	(0.0577)	(0.0568)	(0.0577)
2003.fyear	0.0174	0.0180	0.0186	0.0183	0.0152	0.00989	0.0165	0.00539	0.0140
	(0.0550)	(0.0549)	(0.0550)	(0.0549)	(0.0547)	(0.0547)	(0.0548)	(0.0549)	(0.0549)
2004.fyear	0.0843	0.0849	0.0860	0.0857	0.0813	0.0793	0.0903+	0.0732	0.0861
	(0.0549)	(0.0549)	(0.0549)	(0.0549)	(0.0546)	(0.0545)	(0.0545)	(0.0555)	(0.0553)

L.sum_at_a		0.0360		-0.0299	-0.0306	0.0347		0.0364	
		(0.0893)		(0.109)	(0.109)	(0.0894)		(0.0879)	
L.hjtwt_at_a			0.00675	0.00750	0.00763		0.00682		0.00685
			(0.00601)	(0.00675)	(0.00672)		(0.00596)		(0.00595)
L.adj_frag~a					-0.120+	-0.100	-0.0992	-0.109+	-0.0992
					(0.0655)	(0.0657)	(0.0669)	(0.0651)	(0.0669)
L.sum_a~3a_a						3.269+		3.377+	
						-1.853		-1.852	
L.hjtwt~3a_a							0.249*		0.254*
							(0.117)		(0.118)
L.sum_at~4_a								-0.993	
-2.997									
oL.sum~4_a_d								0	
								(.)	
L.hjtwt_~4_a									-0.0668
									(0.172)
oL.hjt~4_a_d									0
									(.)
_cons	-0.245***	-0.247***	-0.246***	-0.245***	-0.166*	-0.243**	-0.228**	-0.187*	-0.219*
	(0.0692)	(0.0692)	(0.0692)	(0.0692)	(0.0807)	(0.0897)	(0.0840)	(0.0935)	(0.0869)
N	15858	15858	15858	15858	15858	15858	15858	15858	15858
R-sq	0.071	0.071	0.071	0.071	0.072	0.072	0.072	0.077	0.072
adj. R-sq	0.069	0.069	0.069	0.069	0.070	0.070	0.070	0.075	0.070
F	20.41	19.84	19.83	19.29	18.94	18.97	18.91	30.18	18.40
Standard err	ors in parentheses								
	p<0.05, **								
+ p<0.10, *	p<0.01,	*** p<0.001							

8J Lagged Independent Variables, Dataset C

	-1	-2	-3	-4	-5	-6	-7	-8	-9
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
L.xrd_at	0.0765***	0.0695***	0.0696***	0.0680***	0.0683***	0.0700***	0.0698***	0.0698***	0.0699***
	(0.0176)	(0.0168)	(0.0171)	(0.0169)	(0.0169)	(0.0169)	(0.0171)	(0.0152)	(0.0173)
L.ebit_at	0.0137	0.0144	0.0145	0.0146	0.0145	0.0144	0.0144	0.0102	0.0138
	(0.0274)	(0.0267)	(0.0268)	(0.0266)	(0.0268)	(0.0269)	(0.0270)	(0.0252)	(0.0273)
L.ppent_at	-0.234*	-0.250*	-0.248*	-0.252*	-0.253*	-0.251*	-0.249*	-0.255*	-0.254*
	(0.117)	(0.116)	(0.116)	(0.116)	(0.116)	(0.116)	(0.116)	(0.116)	(0.115)
L.sale_at	0.0152	0.0155	0.0140	0.0145	0.0136	0.0145	0.0130		0.0123
	(0.0212)	(0.0211)	(0.0212)	(0.0212)	(0.0212)	(0.0212)	(0.0212)		(0.0212)
sale_at								0.0263	
								(0.0166)	
L.mshare_g~d	-0.0167**	-0.0164**	-0.0164**	-0.0164**	-0.0168**	-0.0171**	-0.0169**	-0.0161**	-0.0157**
	(0.00528)	(0.00525)	(0.00527)	(0.00526)	(0.00530)	(0.00524)	(0.00530)	(0.00532)	(0.00531)
L.hhi_gind	-0.0000397*	- 0.0000402 *	- 0.0000418 *	- 0.0000415 *	- 0.0000466 *	- 0.0000488 *	- 0.0000471 *	- 0.0000673** *	- 0.0000553* *
	(0.0000185)	(0.000018 5)	(0.000018 4)	(0.000018 4)	(0.000019 1)	(0.000019 2)	(0.000019 1)	(0.0000201)	(0.0000194)
0bL.size	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1L.size	0.235***	0.233***	0.228***	0.229***	0.229***	0.231***	0.228***	0.230***	0.226***
	(0.0279)	(0.0278)	(0.0278)	(0.0278)	(0.0278)	(0.0278)	(0.0278)	(0.0278)	(0.0277)

2L.size	0.548***	0.542***	0.536***	0.536***	0.535***	0.539***	0.534***	0.533***	0.529***
	(0.0490)	(0.0489)	(0.0490)	(0.0490)	(0.0489)	(0.0487)	(0.0488)	(0.0483)	(0.0487)
3L.size	0.820***	0.802***	0.808***	0.802***	0.802***	0.799***	0.807***	0.795***	0.804***
	(0.114)	(0.115)	(0.114)	(0.115)	(0.115)	(0.115)	(0.114)	(0.114)	(0.115)
L.emp_m_0_~4	0.00550	0.00669	0.00669	0.00695	0.00714	0.00615	0.00684	0.00374	0.00756
	(0.0458)	(0.0459)	(0.0460)	(0.0460)	(0.0459)	(0.0458)	(0.0459)	(0.0460)	(0.0459)
1981b.fyear	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1982.fyear	0.102**	0.101**	0.103***	0.102**	0.105***	0.102***	0.106***	0.122***	0.128***
	(0.0310)	(0.0309)	(0.0311)	(0.0310)	(0.0310)	(0.0309)	(0.0310)	(0.0312)	(0.0312)
1983.fyear	0.257***	0.256***	0.257***	0.256***	0.262***	0.259***	0.263***	0.274***	0.289***
	(0.0342)	(0.0342)	(0.0342)	(0.0342)	(0.0342)	(0.0341)	(0.0342)	(0.0342)	(0.0345)
1984.fyear	-0.0315	-0.0293	-0.0308	-0.0299	-0.0213	-0.0202	-0.0223	-0.0514	-0.0153
	(0.0394)	(0.0395)	(0.0395)	(0.0395)	(0.0398)	(0.0399)	(0.0398)	(0.0400)	(0.0396)
1985.fyear	-0.0646	-0.0619	-0.0633	-0.0623	-0.0566	-0.0562	-0.0578	-0.0897*	-0.0493
	(0.0421)	(0.0422)	(0.0422)	(0.0422)	(0.0422)	(0.0423)	(0.0421)	(0.0426)	(0.0419)
1986.fyear	-0.124**	-0.120**	-0.121**	-0.120**	-0.113**	-0.110*	-0.114**	-0.170***	-0.118**
	(0.0427)	(0.0427)	(0.0427)	(0.0427)	(0.0429)	(0.0433)	(0.0429)	(0.0445)	(0.0428)
1987.fyear	-0.285***	-0.282***	-0.284***	-0.283***	-0.275***	-0.270***	-0.277***	-0.349***	-0.279***
	(0.0448)	(0.0448)	(0.0448)	(0.0448)	(0.0450)	(0.0458)	(0.0450)	(0.0478)	(0.0449)
1988.fyear	-0.395***	-0.390***	-0.393***	-0.391***	-0.383***	-0.377***	-0.385***	-0.476***	-0.389***
	(0.0459)	(0.0459)	(0.0460)	(0.0460)	(0.0464)	(0.0472)	(0.0464)	(0.0505)	(0.0463)
1989.fyear	-0.424***	-0.420***	-0.422***	-0.421***	-0.412***	-0.407***	-0.414***	-0.509***	-0.408***
	(0.0490)	(0.0490)	(0.0490)	(0.0489)	(0.0497)	(0.0502)	(0.0498)	(0.0539)	(0.0497)
1990.fyear	-0.654***	-0.653***	-0.655***	-0.655***	-0.645***	-0.644***	-0.646***	-0.705***	-0.597***
	(0.0511)	(0.0511)	(0.0510)	(0.0510)	(0.0517)	(0.0518)	(0.0523)	(0.0534)	(0.0531)
1991.fyear	-0.441***	-0.440***	-0.441***	-0.441***	-0.431***	-0.431***	-0.433***	-0.485***	-0.361***
	(0.0518)	(0.0518)	(0.0518)	(0.0518)	(0.0524)	(0.0525)	(0.0537)	(0.0538)	(0.0553)
1992.fyear	-0.372***	-0.369***	-0.371***	-0.369***	-0.362***	-0.363***	-0.364***	-0.410***	-0.272***
	(0.0518)	(0.0518)	(0.0518)	(0.0517)	(0.0521)	(0.0522)	(0.0540)	(0.0535)	(0.0564)
1993.fyear	-0.232***	-0.229***	-0.233***	-0.231***	-0.220***	-0.217***	-0.223***	-0.282***	-0.131*
	(0.0522)	(0.0521)	(0.0521)	(0.0520)	(0.0527)	(0.0530)	(0.0544)	(0.0548)	(0.0568)
1994.fyear	-0.275***	-0.271***	-0.275***	-0.273***	-0.262***	-0.259***	-0.265***	-0.322***	-0.156**
	(0.0529)	(0.0527)	(0.0528)	(0.0527)	(0.0534)	(0.0536)	(0.0553)	(0.0554)	(0.0586)
1995.fyear	-0.0672	-0.0634	-0.0692	-0.0667	-0.0546	-0.0495	-0.0582	-0.105+	0.0684
	(0.0535)	(0.0534)	(0.0535)	(0.0534)	(0.0541)	(0.0544)	(0.0557)	(0.0559)	(0.0597)
1996.fyear	-0.143*	-0.139*	-0.144*	-0.142*	-0.127*	-0.125*	-0.131*	-0.132*	0.0427
	(0.0564)	(0.0563)	(0.0564)	(0.0562)	(0.0572)	(0.0572)	(0.0594)	(0.0571)	(0.0665)
1997.fyear	-0.176**	-0.172**	-0.177**	-0.175**	-0.161**	-0.166**	-0.166**	-0.108+	0.0756
	(0.0589)	(0.0588)	(0.0589)	(0.0588)	(0.0594)	(0.0591)	(0.0631)	(0.0592)	(0.0752)
1998.fyear	-0.323***	-0.320***	-0.325***	-0.323***	-0.307***	-0.316***	-0.312***	-0.199**	-0.0215
	(0.0609)	(0.0608)	(0.0609)	(0.0608)	(0.0616)	(0.0616)	(0.0662)	(0.0644)	(0.0836)
1999.fyear	0.151*	0.154*	0.150*	0.152*	0.165**	0.155*	0.161*	0.248***	0.412***
	(0.0623)	(0.0622)	(0.0623)	(0.0622)	(0.0626)	(0.0634)	(0.0675)	(0.0651)	(0.0807)
2000.fyear	-0.412***	-0.410***	-0.413***	-0.412***	-0.393***	-0.402***	-0.396***	-0.321***	-0.213**
	(0.0632)	(0.0630)	(0.0632)	(0.0631)	(0.0640)	(0.0642)	(0.0665)	(0.0650)	(0.0729)
2001.fyear	-0.512***	-0.508***	-0.510***	-0.509***	-0.493***	-0.501***	-0.495***	-0.484***	-0.408***
	(0.0640)	(0.0639)	(0.0640)	(0.0639)	(0.0644)	(0.0642)	(0.0650)	(0.0635)	(0.0655)
2002.fyear	-0.866***	-0.864***	-0.864***	-0.863***	-0.847***	-0.862***	-0.848***	-0.784***	-0.773***
	(0.0639)	(0.0637)	(0.0638)	(0.0637)	(0.0642)	(0.0648)	(0.0648)	(0.0653)	(0.0651)
2003.fyear	-0.302***	-0.302***	-0.297***	-0.298***	-0.281***	-0.299***	-0.280***	-0.256***	-0.281***
	(0.0620)	(0.0619)	(0.0619)	(0.0619)	(0.0623)	(0.0632)	(0.0623)	(0.0628)	(0.0621)
2004.fyear	-0.365***	-0.363***	-0.358***	-0.359***	-0.341***	-0.356***	-0.340***	-0.356***	-0.404***
	(0.0616)	(0.0614)	(0.0615)	(0.0615)	(0.0619)	(0.0623)	(0.0619)	(0.0618)	(0.0639)
L.sum_at_a		0.199***		0.0996	0.0995	0.198***		0.199***	
		(0.0535)		(0.0626)	(0.0626)	(0.0532)		(0.0532)	
L.hjtwt_at_a			0.00933***	0.00671*	0.00674*		0.00935***		0.00927***
			(0.00232)	(0.00264)	(0.00264)		(0.00232)		(0.00234)
L.adj_frag~a					-0.138	-0.133	-0.138	-0.203+	-0.192+
					(0.109)	(0.108)	(0.109)	(0.110)	(0.110)
L.sum_a~3a_a						0.639		-1.052	

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
						(0.740)		(0.762)	
L.hjtwt~3a_a							0.00207		-0.0681*
							(0.0260)		(0.0291)
L.sum_at~4_a								-7.202***	
-1.631									
L.sum_~4_a_d								0.397***	
								(0.100)	
L.hjtwt_~4_a									-0.288***
									(0.0593)
L.hjtw~4_a_d									0.542***
									(0.0645)
_cons	0.578***	0.570***	0.577***	0.574***	0.674***	0.646***	0.676***	1.076***	0.905***
	(0.0713)	(0.0711)	(0.0712)	(0.0711)	(0.106)	(0.110)	(0.108)	(0.159)	(0.127)
N	21089	21089	21089	21089	21089	21089	21089	21089	21089
R-sq	0.162	0.164	0.164	0.164	0.165	0.164	0.164	0.167	0.167
adj. R-sq	0.161	0.162	0.163	0.163	0.163	0.163	0.163	0.165	0.165
F	73.06	71.26	71.38	69.50	67.82	67.52	67.67	.	.

Standard errors in parentheses

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

8K Polynomial Specification, Dataset A

	-1	-2	-3	-4	-5	-6	-7	-8	-9
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
xrd_at	-0.155***	-0.173***	-0.169***	-0.175***	-0.173***	-0.166***	-0.168***	-0.167***	-0.167***
	(0.0290)	(0.0295)	(0.0295)	(0.0296)	(0.0295)	(0.0294)	(0.0295)	(0.0294)	(0.0295)
xrd_at2	0.0550***	0.0564***	0.0568***	0.0569***	0.0564***	0.0550***	0.0563***	0.0551***	0.0562***
	(0.00700)	(0.00698)	(0.00701)	(0.00700)	(0.00700)	(0.00697)	(0.00700)	(0.00697)	(0.00700)
xrd_at3	-0.00409***	-0.00414***	-0.00418***	-0.00417***	-0.00414***	-0.00405***	-0.00415***	-0.00406***	-0.00414***
	(0.000555)	(0.000553)	(0.000555)	(0.000554)	(0.000554)	(0.000551)	(0.000554)	(0.000551)	(0.000554)
xrd_at4	0.000113***	0.000114***	0.000115***	0.000114***	0.000114***	0.000111***	0.000114***	0.000112***	0.000114***
	(0.0000164)	(0.0000163)	(0.0000164)	(0.0000163)	(0.0000163)	(0.0000162)	(0.0000163)	(0.0000162)	(0.0000163)
xrd_at5	-0.00000103***	-0.00000104***	-0.00000105***	-0.00000105***	-0.00000104***	-0.00000102***	-0.00000104***	-0.00000102***	-0.00000104***
	(0.0000001 59)	(0.0000001 57)	(0.0000001 58)	(0.0000001 58)	(0.0000001 5	8) (0.0000001	57) (0.000000	158) (0.00000	0157) (0.00000015 8)
ebit_at	-0.00141***	-0.00142***	-0.00141***	-0.00142***	-0.00142***	-0.00143***	-0.00142***	-0.00143***	-0.00143***
	(0.000261)	(0.000261)	(0.000260)	(0.000260)	(0.000261)	(0.000260)	(0.000260)	(0.000259)	(0.000260)
ppent_at	-0.432***	-0.436***	-0.434***	-0.435***	-0.438***	-0.436***	-0.434***	-0.435***	-0.434***
	(0.0529)	(0.0530)	(0.0529)	(0.0529)	(0.0529)	(0.0530)	(0.0529)	(0.0528)	(0.0527)
sale_at	0.00764*	0.00779*	0.00771*	0.00778*	0.00776*	0.00778*	0.00775*	0.00779*	0.00774*
	(0.00321)	(0.00317)	(0.00319)	(0.00317)	(0.00318)	(0.00318)	(0.00320)	(0.00318)	(0.00320)
mshare_gind	-0.00435	-0.00425	-0.00424	-0.00422	-0.00458+	-0.00440	-0.00451	-0.00445	-0.00459+
	(0.00277)	(0.00276)	(0.00276)	(0.00276)	(0.00278)	(0.00280)	(0.00279)	(0.00281)	(0.00279)
hhi_gind	-0.0000210*	-0.0000212*	-0.0000215*	-0.0000213*	-0.0000250*	-0.0000271*	-0.0000261*	-0.0000251*	-0.0000223*

	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000106)	(0.0000107)	(0.0000106)	(0.0000108)	(0.0000107)
0b.size	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1.size	0.0868***	0.0864***	0.0841***	0.0851***	0.0848***	0.0876***	0.0862***	0.0877***	0.0867***
	(0.0167)	(0.0167)	(0.0166)	(0.0167)	(0.0166)	(0.0166)	(0.0165)	(0.0166)	(0.0166)
2.size	0.165***	0.164***	0.160***	0.162***	0.161***	0.165***	0.162***	0.165***	0.163***
	(0.0273)	(0.0273)	(0.0273)	(0.0273)	(0.0273)	(0.0273)	(0.0272)	(0.0273)	(0.0272)
3.size	0.129**	0.125**	0.124**	0.123**	0.123**	0.125**	0.125**	0.126**	0.126**
	(0.0444)	(0.0444)	(0.0445)	(0.0444)	(0.0444)	(0.0445)	(0.0445)	(0.0445)	(0.0445)
emp_m_0_d_4	-0.0504*	-0.0490*	-0.0496*	-0.0490*	-0.0492*	-0.0489*	-0.0497*	-0.0485*	-0.0494*
	(0.0229)	(0.0229)	(0.0229)	(0.0229)	(0.0229)	(0.0229)	(0.0230)	(0.0229)	(0.0230)
1980b.fyear	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.0924***	-0.0922***	-0.0927***	-0.0924***	-0.0924***	-0.0921***	-0.0922***	-0.0924***	-0.0934***
	(0.0127)	(0.0127)	(0.0127)	(0.0127)	(0.0127)	(0.0127)	(0.0127)	(0.0127)	(0.0127)
1982.fyear	-0.0171	-0.0167	-0.0172	-0.0169	-0.0161	-0.0172	-0.0159	-0.0173	-0.0174
	(0.0155)	(0.0155)	(0.0155)	(0.0154)	(0.0154)	(0.0154)	(0.0154)	(0.0154)	(0.0154)
1983.fyear	0.168***	0.169***	0.168***	0.169***	0.171***	0.165***	0.169***	0.166***	0.170***
	(0.0175)	(0.0175)	(0.0175)	(0.0175)	(0.0175)	(0.0175)	(0.0175)	(0.0177)	(0.0175)
1984.fyear	-0.0450*	-0.0428*	-0.0443*	-0.0431*	-0.0418*	-0.0475*	-0.0422*	-0.0458*	-0.0422*
	(0.0187)	(0.0186)	(0.0186)	(0.0186)	(0.0186)	(0.0187)	(0.0186)	(0.0189)	(0.0186)
1985.fyear	0.0183	0.0215	0.0197	0.0212	0.0221	0.0118	0.0208	0.0146	0.0215
	(0.0196)	(0.0196)	(0.0196)	(0.0196)	(0.0196)	(0.0198)	(0.0196)	(0.0203)	(0.0196)
1986.fyear	0.0176	0.0207	0.0183	0.0202	0.0225	0.00822	0.0200	0.0124	0.0216
	(0.0209)	(0.0209)	(0.0209)	(0.0209)	(0.0208)	(0.0212)	(0.0208)	(0.0221)	(0.0209)
1987.fyear	-0.151***	-0.148***	-0.150***	-0.148***	-0.147***	-0.164***	-0.150***	-0.159***	-0.148***
	(0.0211)	(0.0211)	(0.0211)	(0.0211)	(0.0211)	(0.0216)	(0.0211)	(0.0229)	(0.0211)
1988.fyear	-0.192***	-0.189***	-0.192***	-0.190***	-0.186***	-0.203***	-0.188***	-0.198***	-0.185***
	(0.0218)	(0.0218)	(0.0217)	(0.0218)	(0.0218)	(0.0222)	(0.0217)	(0.0238)	(0.0218)
1989.fyear	-0.214***	-0.211***	-0.214***	-0.212***	-0.210***	-0.224***	-0.208***	-0.219***	-0.208***
	(0.0227)	(0.0227)	(0.0227)	(0.0227)	(0.0227)	(0.0229)	(0.0226)	(0.0241)	(0.0226)
1990.fyear	-0.397***	-0.394***	-0.397***	-0.395***	-0.393***	-0.407***	-0.391***	-0.402***	-0.391***
	(0.0238)	(0.0238)	(0.0238)	(0.0238)	(0.0238)	(0.0240)	(0.0238)	(0.0252)	(0.0238)
1991.fyear	-0.175***	-0.171***	-0.174***	-0.172***	-0.171***	-0.185***	-0.169***	-0.180***	-0.169***
	(0.0243)	(0.0243)	(0.0243)	(0.0243)	(0.0243)	(0.0245)	(0.0242)	(0.0257)	(0.0243)
1992.fyear	-0.130***	-0.125***	-0.128***	-0.126***	-0.126***	-0.143***	-0.126***	-0.137***	-0.125***
	(0.0237)	(0.0237)	(0.0237)	(0.0237)	(0.0236)	(0.0239)	(0.0236)	(0.0255)	(0.0236)
1993.fyear	-0.0496*	-0.0452+	-0.0487*	-0.0460*	-0.0451+	-0.0614**	-0.0437+	-0.0557*	-0.0433+
	(0.0235)	(0.0234)	(0.0234)	(0.0234)	(0.0234)	(0.0238)	(0.0233)	(0.0253)	(0.0234)
1994.fyear	-0.173***	-0.169***	-0.173***	-0.170***	-0.168***	-0.183***	-0.167***	-0.178***	-0.167***
	(0.0237)	(0.0237)	(0.0237)	(0.0236)	(0.0236)	(0.0241)	(0.0237)	(0.0255)	(0.0237)
1995.fyear	-0.0419+	-0.0385	-0.0413+	-0.0392	-0.0351	-0.0460+	-0.0316	-0.0417	-0.0348
	(0.0245)	(0.0244)	(0.0244)	(0.0244)	(0.0245)	(0.0246)	(0.0245)	(0.0255)	(0.0246)
1996.fyear	-0.0596*	-0.0561*	-0.0590*	-0.0568*	-0.0514*	-0.0590*	-0.0443+	-0.0555*	-0.0496+
	(0.0251)	(0.0251)	(0.0251)	(0.0250)	(0.0251)	(0.0252)	(0.0253)	(0.0259)	(0.0254)
1997.fyear	-0.0705**	-0.0670**	-0.0696**	-0.0676**	-0.0612*	-0.0650*	-0.0519*	-0.0627*	-0.0594*
	(0.0257)	(0.0256)	(0.0256)	(0.0256)	(0.0257)	(0.0257)	(0.0260)	(0.0260)	(0.0261)
1998.fyear	-0.225***	-0.222***	-0.224***	-0.222***	-0.216***	-0.222***	-0.209***	-0.218***	-0.213***
	(0.0268)	(0.0267)	(0.0267)	(0.0267)	(0.0268)	(0.0268)	(0.0269)	(0.0274)	(0.0269)
1999.fyear	0.0137	0.0162	0.0153	0.0163	0.0236	0.0138	0.0259	0.0176	0.0250
	(0.0277)	(0.0276)	(0.0276)	(0.0276)	(0.0277)	(0.0279)	(0.0278)	(0.0286)	(0.0277)
2000.fyear	-0.357***	-0.354***	-0.354***	-0.353***	-0.349***	-0.363***	-0.352***	-0.358***	-0.348***
	(0.0284)	(0.0284)	(0.0284)	(0.0284)	(0.0284)	(0.0287)	(0.0284)	(0.0298)	(0.0285)
2001.fyear	-0.412***	-0.408***	-0.408***	-0.407***	-0.404***	-0.414***	-0.409***	-0.410***	-0.402***
	(0.0283)	(0.0283)	(0.0283)	(0.0283)	(0.0283)	(0.0284)	(0.0283)	(0.0291)	(0.0285)
2002.fyear	-0.661***	-0.657***	-0.655***	-0.655***	-0.651***	-0.665***	-0.661***	-0.659***	-0.649***
	(0.0287)	(0.0287)	(0.0287)	(0.0287)	(0.0287)	(0.0288)	(0.0289)	(0.0299)	(0.0293)
2003.fyear	-0.238***	-0.233***	-0.230***	-0.231***	-0.227***	-0.246***	-0.241***	-0.239***	-0.225***
	(0.0277)	(0.0276)	(0.0276)	(0.0276)	(0.0277)	(0.0280)	(0.0281)	(0.0297)	(0.0289)
2004.fyear	-0.223***	-0.217***	-0.214***	-0.214***	-0.212***	-0.241***	-0.231***	-0.231***	-0.211***
	(0.0281)	(0.0281)	(0.0281)	(0.0281)	(0.0281)	(0.0289)	(0.0289)	(0.0318)	(0.0303)

sum_at_a		0.140***		0.0991*	0.0984*	0.143***		0.143***	
		(0.0356)		(0.0466)	(0.0466)	(0.0357)		(0.0358)	
sum_at_a2		-0.00544**		-0.00374+	-0.00370	-0.00561**		-0.00561**	
		(0.00202)		(0.00227)	(0.00227)	(0.00203)		(0.00203)	
hjtwt_at_a			0.00556***	0.00282	0.00284+		0.00581***		0.00583***
			(0.00126)	(0.00172)	(0.00172)		(0.00127)		(0.00127)
adj_frag_g~a					-0.128**	-0.140**	-0.138**	-0.140**	-0.139**
					(0.0459)	(0.0463)	(0.0462)	(0.0461)	(0.0461)
sum_at_~3a_a						-1.507***		-1.516***	
						(0.405)		(0.406)	
hjtwt_a~3a_a							-0.0438**		-0.0489**
							(0.0161)		(0.0161)
sum_at_d~4_a								0.529	
								(0.712)	
sum_at~4_a_d								-0.241	
								(0.346)	
hjtwt_at~4_a									0.0582*
									(0.0249)
hjtwt_~4_a_d									-0.226
									(0.338)
_cons	0.553***	0.547***	0.550***	0.548***	0.646***	0.710***	0.678***	0.705***	0.664***
	(0.0292)	(0.0292)	(0.0292)	(0.0292)	(0.0442)	(0.0475)	(0.0457)	(0.0585)	(0.0520)
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N	79284	79284	79284	79284	79284	79284	79284	79284	79284
R-sq	0.080	0.081	0.081	0.081	0.081	0.082	0.081	0.082	0.082
adj. R-sq	0.079	0.080	0.080	0.081	0.081	0.081	0.081	0.081	0.081
F	107.6	102.6	105.6	100.6	98.32	98.78	101.0	94.50	96.67
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Standard errors in parentheses
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

8L Without Deflation, Dataset A

	-1	-2	-3	-4	-5	-6	-7	-8	-9
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
xrd_at	0.0511***	0.0471***	0.0488***	0.0470***	0.0472***	0.0473***	0.0486***	0.0474***	0.0490***
	(0.00637)	(0.00647)	(0.00640)	(0.00646)	(0.00646)	(0.00645)	(0.00642)	(0.00645)	(0.00640)
ebit_at	-0.00151***	-0.00152***	-0.00151***	-0.00152***	-0.00153***	-0.00152***	-0.00152***	-0.00152***	-0.00153***
	(0.000254)	(0.000254)	(0.000253)	(0.000254)	(0.000254)	(0.000254)	(0.000254)	(0.000253)	(0.000253)
ppent_at	-0.466***	-0.471***	-0.471***	-0.472***	-0.475***	-0.467***	-0.470***	-0.468***	-0.470***
	(0.0525)	(0.0525)	(0.0525)	(0.0525)	(0.0525)	(0.0527)	(0.0525)	(0.0525)	(0.0523)
sale_at	0.00728*	0.00734*	0.00729*	0.00733*	0.00732*	0.00738*	0.00734*	0.00742*	0.00735*
	(0.00316)	(0.00314)	(0.00315)	(0.00314)	(0.00315)	(0.00315)	(0.00316)	(0.00314)	(0.00316)
mshare_gind	-0.00398	-0.00389	-0.00384	-0.00384	-0.00424	-0.00414	-0.00418	-0.00421	-0.00424
	(0.00276)	(0.00276)	(0.00276)	(0.00276)	(0.00278)	(0.00277)	(0.00277)	(0.00278)	(0.00277)
hhi_gind	-0.0000218*	-0.0000219*	-0.0000224*	-0.0000222*	-0.0000263*	-0.0000271*	-0.0000269*	-0.0000215*	-0.0000225*
	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000107)	(0.0000108)	(0.0000107)
0b.size	0	0	0	0	0	0	0	0	0

	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1.size	0.0751***	0.0737***	0.0716***	0.0721***	0.0719***	0.0761***	0.0742***	0.0762***	0.0748***
	(0.0166)	(0.0166)	(0.0166)	(0.0166)	(0.0166)	(0.0166)	(0.0165)	(0.0166)	(0.0165)
2.size	0.141***	0.138***	0.134***	0.135***	0.135***	0.141***	0.138***	0.141***	0.138***
	(0.0273)	(0.0272)	(0.0273)	(0.0273)	(0.0273)	(0.0273)	(0.0272)	(0.0273)	(0.0272)
3.size	0.104*	0.0962*	0.0958*	0.0940*	0.0943*	0.0996*	0.0985*	0.0993*	0.0988*
	(0.0442)	(0.0442)	(0.0442)	(0.0442)	(0.0442)	(0.0443)	(0.0443)	(0.0443)	(0.0442)
emp_m_0_d_4	-0.0460*	-0.0455*	-0.0454*	-0.0453*	-0.0455*	-0.0456*	-0.0457*	-0.0449+	-0.0452*
	(0.0229)	(0.0229)	(0.0229)	(0.0229)	(0.0229)	(0.0229)	(0.0230)	(0.0229)	(0.0230)
1980b.fyear	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.0917***	-0.0908***	-0.0916***	-0.0910***	-0.0910***	-0.0963***	-0.0928***	-0.0925***	-0.0921***
	(0.0128)	(0.0128)	(0.0128)	(0.0128)	(0.0128)	(0.0128)	(0.0127)	(0.0129)	(0.0127)
1982.fyear	-0.0171	-0.0160	-0.0170	-0.0163	-0.0155	-0.0238	-0.0177	-0.0176	-0.0167
	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0156)	(0.0155)	(0.0158)	(0.0155)
1983.fyear	0.167***	0.169***	0.168***	0.169***	0.171***	0.156***	0.167***	0.168***	0.171***
	(0.0176)	(0.0176)	(0.0176)	(0.0176)	(0.0176)	(0.0179)	(0.0176)	(0.0186)	(0.0177)
1984.fyear	-0.0463*	-0.0441*	-0.0458*	-0.0445*	-0.0430*	-0.0592**	-0.0463*	-0.0449*	-0.0419*
	(0.0187)	(0.0187)	(0.0187)	(0.0187)	(0.0187)	(0.0191)	(0.0187)	(0.0200)	(0.0188)
1985.fyear	0.0149	0.0180	0.0161	0.0177	0.0187	-0.00302	0.0146	0.0149	0.0201
	(0.0198)	(0.0198)	(0.0197)	(0.0198)	(0.0197)	(0.0204)	(0.0197)	(0.0218)	(0.0198)
1986.fyear	0.0147	0.0175	0.0152	0.0169	0.0195	-0.00615	0.0147	0.0152	0.0205
	(0.0210)	(0.0210)	(0.0210)	(0.0210)	(0.0210)	(0.0219)	(0.0210)	(0.0237)	(0.0211)
1987.fyear	-0.156***	-0.153***	-0.156***	-0.154***	-0.153***	-0.182***	-0.158***	-0.157***	-0.150***
	(0.0212)	(0.0212)	(0.0212)	(0.0212)	(0.0212)	(0.0224)	(0.0212)	(0.0251)	(0.0215)
1988.fyear	-0.198***	-0.195***	-0.198***	-0.196***	-0.192***	-0.224***	-0.198***	-0.195***	-0.188***
	(0.0219)	(0.0219)	(0.0219)	(0.0219)	(0.0219)	(0.0233)	(0.0219)	(0.0264)	(0.0222)
1989.fyear	-0.221***	-0.219***	-0.221***	-0.219***	-0.217***	-0.248***	-0.221***	-0.219***	-0.212***
	(0.0228)	(0.0228)	(0.0228)	(0.0228)	(0.0228)	(0.0238)	(0.0228)	(0.0268)	(0.0230)
1990.fyear	-0.407***	-0.404***	-0.406***	-0.405***	-0.402***	-0.434***	-0.406***	-0.405***	-0.398***
	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0239)	(0.0250)	(0.0239)	(0.0280)	(0.0241)
1991.fyear	-0.185***	-0.181***	-0.183***	-0.181***	-0.180***	-0.214***	-0.184***	-0.184***	-0.176***
	(0.0245)	(0.0245)	(0.0245)	(0.0245)	(0.0245)	(0.0255)	(0.0244)	(0.0286)	(0.0246)
1992.fyear	-0.138***	-0.134***	-0.136***	-0.134***	-0.134***	-0.170***	-0.140***	-0.139***	-0.130***
	(0.0239)	(0.0238)	(0.0238)	(0.0238)	(0.0238)	(0.0252)	(0.0237)	(0.0287)	(0.0240)
1993.fyear	-0.0590*	-0.0549*	-0.0581*	-0.0556*	-0.0545*	-0.0908***	-0.0591*	-0.0585*	-0.0501*
	(0.0236)	(0.0236)	(0.0235)	(0.0236)	(0.0235)	(0.0251)	(0.0235)	(0.0287)	(0.0237)
1994.fyear	-0.183***	-0.179***	-0.182***	-0.180***	-0.177***	-0.213***	-0.183***	-0.181***	-0.174***
	(0.0238)	(0.0237)	(0.0237)	(0.0237)	(0.0237)	(0.0253)	(0.0237)	(0.0289)	(0.0239)
1995.fyear	-0.0502*	-0.0467+	-0.0496*	-0.0474+	-0.0427+	-0.0751**	-0.0468+	-0.0459	-0.0412+
	(0.0245)	(0.0245)	(0.0245)	(0.0245)	(0.0245)	(0.0257)	(0.0245)	(0.0287)	(0.0246)
1996.fyear	-0.0679**	-0.0642*	-0.0668**	-0.0647*	-0.0585*	-0.0887***	-0.0595*	-0.0611*	-0.0558*
	(0.0252)	(0.0252)	(0.0252)	(0.0251)	(0.0252)	(0.0264)	(0.0252)	(0.0291)	(0.0252)
1997.fyear	-0.0823**	-0.0789**	-0.0815**	-0.0795**	-0.0722**	-0.0980***	-0.0711**	-0.0738*	-0.0704**
	(0.0257)	(0.0257)	(0.0257)	(0.0257)	(0.0258)	(0.0266)	(0.0257)	(0.0288)	(0.0257)
1998.fyear	-0.238***	-0.236***	-0.238***	-0.236***	-0.229***	-0.255***	-0.230***	-0.229***	-0.226***
	(0.0268)	(0.0268)	(0.0267)	(0.0267)	(0.0268)	(0.0277)	(0.0268)	(0.0301)	(0.0268)
1999.fyear	0.000487	0.00326	0.00177	0.00312	0.0115	-0.0197	0.00563	0.00805	0.0144
	(0.0276)	(0.0276)	(0.0276)	(0.0276)	(0.0277)	(0.0288)	(0.0277)	(0.0314)	(0.0279)
2000.fyear	-0.369***	-0.366***	-0.366***	-0.365***	-0.360***	-0.399***	-0.373***	-0.365***	-0.355***
	(0.0285)	(0.0285)	(0.0284)	(0.0285)	(0.0285)	(0.0299)	(0.0287)	(0.0334)	(0.0293)
2001.fyear	-0.430***	-0.427***	-0.426***	-0.426***	-0.421***	-0.456***	-0.436***	-0.425***	-0.416***
	(0.0284)	(0.0284)	(0.0284)	(0.0284)	(0.0284)	(0.0295)	(0.0287)	(0.0325)	(0.0294)
2002.fyear	-0.682***	-0.679***	-0.677***	-0.677***	-0.673***	-0.710***	-0.691***	-0.676***	-0.665***
	(0.0287)	(0.0287)	(0.0287)	(0.0287)	(0.0287)	(0.0299)	(0.0293)	(0.0332)	(0.0304)
2003.fyear	-0.259***	-0.256***	-0.253***	-0.253***	-0.249***	-0.294***	-0.272***	-0.254***	-0.240***
	(0.0275)	(0.0275)	(0.0275)	(0.0275)	(0.0275)	(0.0293)	(0.0287)	(0.0338)	(0.0305)
2004.fyear	-0.243***	-0.239***	-0.236***	-0.236***	-0.233***	-0.289***	-0.261***	-0.242***	-0.225***
	(0.0280)	(0.0280)	(0.0280)	(0.0280)	(0.0279)	(0.0307)	(0.0296)	(0.0367)	(0.0321)
sum_at_a		0.0714***		0.0489+	0.0487+	0.0733***		0.0731***	
		(0.0203)		(0.0260)	(0.0260)	(0.0203)		(0.0203)	
hjtwt_at_a			0.00410**	0.00236	0.00237		0.00436***		0.00436**

			*						*
			(0.00114)	(0.00148)	(0.00148)		(0.00114)		(0.00114)
adj_frag_g~a					-0.143**	-0.157***	-0.155***	-0.155***	-0.154***
					(0.0463)	(0.0467)	(0.0466)	(0.0465)	(0.0465)
sum_at_~3a_a						-1.268***		-1.275***	
						(0.299)		(0.299)	
hjtwt_a~3a_a							-0.0354**		-0.0396**
							(0.0121)		(0.0121)
sum_at_d~4_a								1.209*	
								(0.512)	
sum_at~4_a_d								-0.186	
								(0.354)	
hjtwt_at~4_a									0.0594**
									(0.0194)
hjtwt_~4_a_d									-0.192
									(0.343)
_cons	0.537***	0.532***	0.534***	0.532***	0.642***	0.729***	0.681***	0.668***	0.647***
	(0.0293)	(0.0293)	(0.0293)	(0.0293)	(0.0446)	(0.0494)	(0.0467)	(0.0622)	(0.0537)
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N	79219	79219	79219	79219	79219	79219	79219	79219	79219
R-sq	0.076	0.077	0.077	0.077	0.077	0.078	0.077	0.078	0.078
adj. R-sq	0.076	0.076	0.076	0.076	0.077	0.077	0.077	0.078	0.077
F	117.0	113.5	113.9	110.6	107.8	108.5	108.4	103.3	103.4
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Standard errors in parentheses
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

8M Without Control Variables, Dataset A

	-1	-2	-3	-4	-5	-6	-7	-8	-9
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
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xrd_at	0.0518***	0.0476***	0.0492***	0.0474***	0.0475***	0.0479***	0.0491***	0.0479***	0.0494***
	(0.00604)	(0.00615)	(0.00608)	(0.00615)	(0.00615)	(0.00613)	(0.00609)	(0.00613)	(0.00608)
1980b.fyear	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.0905***	-0.0910***	-0.0907***	-0.0910***	-0.0908***	-0.0906***	-0.0900***	-0.0912***	-0.0916***
	(0.0128)	(0.0128)	(0.0128)	(0.0128)	(0.0128)	(0.0128)	(0.0128)	(0.0128)	(0.0128)
1982.fyear	-0.0210	-0.0209	-0.0213	-0.0212	-0.0201	-0.0209	-0.0196	-0.0211	-0.0215
	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)
1983.fyear	0.173***	0.174***	0.173***	0.174***	0.176***	0.170***	0.175***	0.172***	0.175***
	(0.0177)	(0.0176)	(0.0176)	(0.0176)	(0.0176)	(0.0177)	(0.0176)	(0.0177)	(0.0176)
1984.fyear	-0.0450*	-0.0438*	-0.0446*	-0.0439*	-0.0419*	-0.0476*	-0.0416*	-0.0450*	-0.0422*
	(0.0187)	(0.0187)	(0.0187)	(0.0187)	(0.0187)	(0.0187)	(0.0187)	(0.0189)	(0.0187)
1985.fyear	0.0128	0.0145	0.0137	0.0145	0.0160	0.00543	0.0156	0.00990	0.0160
	(0.0197)	(0.0197)	(0.0197)	(0.0197)	(0.0197)	(0.0199)	(0.0197)	(0.0202)	(0.0197)
1986.fyear	0.0161	0.0178	0.0164	0.0174	0.0202	0.00525	0.0187	0.0120	0.0201
	(0.0209)	(0.0209)	(0.0209)	(0.0209)	(0.0209)	(0.0213)	(0.0209)	(0.0220)	(0.0209)
1987.fyear	-0.149***	-0.148***	-0.149***	-0.148***	-0.146***	-0.164***	-0.148***	-0.156***	-0.146***
	(0.0211)	(0.0211)	(0.0211)	(0.0211)	(0.0211)	(0.0216)	(0.0211)	(0.0227)	(0.0211)
1988.fyear	-0.195***	-0.193***	-0.195***	-0.194***	-0.190***	-0.208***	-0.191***	-0.199***	-0.188***
	(0.0219)	(0.0218)	(0.0218)	(0.0218)	(0.0219)	(0.0223)	(0.0218)	(0.0237)	(0.0219)
1989.fyear	-0.215***	-0.213***	-0.215***	-0.214***	-0.211***	-0.226***	-0.210***	-0.218***	-0.209***
	(0.0228)	(0.0228)	(0.0228)	(0.0228)	(0.0228)	(0.0230)	(0.0227)	(0.0240)	(0.0227)

1990.fyear	-0.402***	-0.401***	-0.403***	-0.402***	-0.399***	-0.414***	-0.397***	-0.406***	-0.397***
	(0.0239)	(0.0238)	(0.0238)	(0.0238)	(0.0238)	(0.0240)	(0.0238)	(0.0250)	(0.0238)
1991.fyear	-0.174***	-0.172***	-0.174***	-0.173***	-0.171***	-0.186***	-0.168***	-0.178***	-0.169***
	(0.0245)	(0.0244)	(0.0244)	(0.0244)	(0.0244)	(0.0246)	(0.0244)	(0.0256)	(0.0244)
1992.fyear	-0.124***	-0.122***	-0.123***	-0.122***	-0.121***	-0.139***	-0.120***	-0.130***	-0.120***
	(0.0238)	(0.0238)	(0.0238)	(0.0238)	(0.0237)	(0.0241)	(0.0237)	(0.0254)	(0.0237)
1993.fyear	-0.0438+	-0.0413+	-0.0434+	-0.0418+	-0.0399+	-0.0569*	-0.0375	-0.0481+	-0.0381
	(0.0234)	(0.0234)	(0.0234)	(0.0234)	(0.0234)	(0.0238)	(0.0233)	(0.0251)	(0.0233)
1994.fyear	-0.169***	-0.166***	-0.169***	-0.167***	-0.164***	-0.180***	-0.162***	-0.172***	-0.164***
	(0.0235)	(0.0234)	(0.0235)	(0.0234)	(0.0235)	(0.0239)	(0.0235)	(0.0250)	(0.0235)
1995.fyear	-0.0338	-0.0320	-0.0337	-0.0325	-0.0271	-0.0380	-0.0230	-0.0324	-0.0285
	(0.0241)	(0.0240)	(0.0240)	(0.0240)	(0.0241)	(0.0243)	(0.0242)	(0.0249)	(0.0242)
1996.fyear	-0.0484*	-0.0465+	-0.0482*	-0.0470+	-0.0401	-0.0473+	-0.0325	-0.0435+	-0.0409+
	(0.0245)	(0.0245)	(0.0245)	(0.0244)	(0.0246)	(0.0247)	(0.0247)	(0.0251)	(0.0248)
1997.fyear	-0.0636*	-0.0619*	-0.0632*	-0.0622*	-0.0543*	-0.0571*	-0.0446+	-0.0555*	-0.0559*
	(0.0248)	(0.0248)	(0.0248)	(0.0248)	(0.0250)	(0.0250)	(0.0252)	(0.0251)	(0.0254)
1998.fyear	-0.221***	-0.220***	-0.221***	-0.220***	-0.212***	-0.217***	-0.205***	-0.213***	-0.212***
	(0.0259)	(0.0259)	(0.0259)	(0.0259)	(0.0261)	(0.0261)	(0.0261)	(0.0264)	(0.0262)
1999.fyear	0.0220	0.0231	0.0229	0.0233	0.0320	0.0229	0.0349	0.0270	0.0313
	(0.0270)	(0.0270)	(0.0270)	(0.0270)	(0.0272)	(0.0273)	(0.0272)	(0.0278)	(0.0272)
2000.fyear	-0.349***	-0.348***	-0.347***	-0.347***	-0.340***	-0.355***	-0.343***	-0.349***	-0.340***
	(0.0276)	(0.0276)	(0.0276)	(0.0276)	(0.0277)	(0.0279)	(0.0276)	(0.0287)	(0.0277)
2001.fyear	-0.410***	-0.409***	-0.407***	-0.407***	-0.402***	-0.411***	-0.405***	-0.406***	-0.401***
	(0.0275)	(0.0275)	(0.0274)	(0.0274)	(0.0275)	(0.0276)	(0.0275)	(0.0280)	(0.0276)
2002.fyear	-0.659***	-0.657***	-0.655***	-0.655***	-0.650***	-0.662***	-0.658***	-0.656***	-0.646***
	(0.0279)	(0.0279)	(0.0278)	(0.0278)	(0.0279)	(0.0280)	(0.0281)	(0.0288)	(0.0284)
2003.fyear	-0.231***	-0.230***	-0.226***	-0.227***	-0.221***	-0.240***	-0.233***	-0.231***	-0.217***
	(0.0268)	(0.0268)	(0.0268)	(0.0268)	(0.0268)	(0.0272)	(0.0274)	(0.0285)	(0.0281)
2004.fyear	-0.213***	-0.210***	-0.206***	-0.207***	-0.202***	-0.232***	-0.219***	-0.218***	-0.199***
	(0.0272)	(0.0272)	(0.0272)	(0.0272)	(0.0272)	(0.0280)	(0.0282)	(0.0304)	(0.0294)
sum_at_a		0.0801***		0.0547*	0.0546*	0.0817***		0.0818***	
		(0.0211)		(0.0262)	(0.0262)	(0.0212)		(0.0212)	
hjtwt_at_a			0.00480***	0.00286+	0.00287+		0.00504***		0.00509***
			(0.00122)	(0.00156)	(0.00156)		(0.00123)		(0.00123)
adj_frag_g~a					-0.112*	-0.123**	-0.121**	-0.124**	-0.123**
					(0.0459)	(0.0463)	(0.0462)	(0.0462)	(0.0462)
sum_at_~3a_a						-1.604***		-1.614***	
						(0.405)		(0.406)	
hjtwt_a~3a_a							-0.0407*		-0.0465**
							(0.0159)		(0.0159)
sum_at_d~4_a								0.885	
								(0.706)	
hjtwt_at~4_a									0.0677**
									(0.0249)
_cons	0.426***	0.421***	0.420***	0.419***	0.499***	0.568***	0.528***	0.542***	0.504***
	(0.0198)	(0.0198)	(0.0198)	(0.0198)	(0.0385)	(0.0424)	(0.0403)	(0.0480)	(0.0418)
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N	79284	79284	79284	79284	79284	79284	79284	79284	79284
R-sq	0.069	0.069	0.069	0.070	0.070	0.070	0.070	0.071	0.070
adj. R-sq	0.068	0.069	0.069	0.069	0.070	0.070	0.070	0.070	0.070
F	149.6	143.9	144.6	139.2	134.4	134.9	134.8	130.3	130.4
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Standard errors	in parentheses								
+ p<0.10, * p<0	.05, ** p<0.01,	*** p<0.001							

8N Without R&D Stock, Dataset A

	-1	-2	-3	-4	-5	-6	-7	-8	-9
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
ebit_at	-0.00170***	-0.00170***	-0.00170***	-0.00169***	-0.00170***	-0.00170***	-0.00170***	-0.00170***	-0.00171***
	(0.000341)	(0.000332)	(0.000334)	(0.000331)	(0.000331)	(0.000331)	(0.000335)	(0.000331)	(0.000334)
ppent_at	-0.417***	-0.429***	-0.427***	-0.431***	-0.433***	-0.427***	-0.427***	-0.427***	-0.426***
	(0.0522)	(0.0523)	(0.0522)	(0.0522)	(0.0522)	(0.0524)	(0.0522)	(0.0522)	(0.0521)
sale_at	0.00861**	0.00853**	0.00853**	0.00851**	0.00850**	0.00856**	0.00857**	0.00856**	0.00857**
	(0.00310)	(0.00308)	(0.00308)	(0.00307)	(0.00307)	(0.00308)	(0.00309)	(0.00308)	(0.00309)
mshare_gind	-0.00417	-0.00404	-0.00401	-0.00400	-0.00439	-0.00422	-0.00430	-0.00427	-0.00439
	(0.00277)	(0.00276)	(0.00276)	(0.00276)	(0.00278)	(0.00281)	(0.00279)	(0.00281)	(0.00279)
hhi_gind	-0.0000218*	-0.0000218*	-0.0000224*	-0.0000220*	-0.0000260*	-0.0000281**	-0.0000273*	-0.0000263*	-0.0000236*
	(0.0000108)	(0.0000108)	(0.0000108)	(0.0000108)	(0.0000107)	(0.0000108)	(0.0000108)	(0.0000109)	(0.0000108)
0b.size	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1.size	0.0830***	0.0808***	0.0782***	0.0791***	0.0789***	0.0827***	0.0805***	0.0828***	0.0811***
	(0.0167)	(0.0166)	(0.0166)	(0.0166)	(0.0166)	(0.0166)	(0.0165)	(0.0166)	(0.0165)
2.size	0.169***	0.162***	0.159***	0.159***	0.159***	0.165***	0.161***	0.165***	0.162***
	(0.0274)	(0.0274)	(0.0274)	(0.0274)	(0.0274)	(0.0274)	(0.0273)	(0.0274)	(0.0273)
3.size	0.191***	0.169***	0.175***	0.167***	0.167***	0.172***	0.177***	0.172***	0.178***
	(0.0454)	(0.0454)	(0.0454)	(0.0454)	(0.0454)	(0.0454)	(0.0455)	(0.0454)	(0.0455)
emp_m_0_d_4	-0.0419+	-0.0414+	-0.0411+	-0.0412+	-0.0414+	-0.0414+	-0.0413+	-0.0411+	-0.0410+
	(0.0231)	(0.0230)	(0.0231)	(0.0230)	(0.0230)	(0.0231)	(0.0231)	(0.0230)	(0.0231)
1980b.fyear	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.0922***	-0.0929***	-0.0924***	-0.0928***	-0.0928***	-0.0928***	-0.0919***	-0.0931***	-0.0931***
	(0.0128)	(0.0128)	(0.0128)	(0.0128)	(0.0128)	(0.0128)	(0.0127)	(0.0128)	(0.0128)
1982.fyear	-0.0179	-0.0175	-0.0180	-0.0177	-0.0169	-0.0181	-0.0166	-0.0182	-0.0180
	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)	(0.0155)
1983.fyear	0.167***	0.168***	0.168***	0.168***	0.170***	0.164***	0.169***	0.165***	0.169***
	(0.0176)	(0.0176)	(0.0176)	(0.0176)	(0.0175)	(0.0176)	(0.0175)	(0.0177)	(0.0175)
1984.fyear	-0.0471*	-0.0450*	-0.0464*	-0.0451*	-0.0437*	-0.0500**	-0.0441*	-0.0485*	-0.0441*
	(0.0187)	(0.0187)	(0.0187)	(0.0187)	(0.0187)	(0.0187)	(0.0186)	(0.0189)	(0.0187)
1985.fyear	0.0144	0.0172	0.0157	0.0172	0.0181	0.00697	0.0169	0.00946	0.0177
	(0.0197)	(0.0197)	(0.0197)	(0.0197)	(0.0197)	(0.0198)	(0.0196)	(0.0203)	(0.0196)
1986.fyear	0.0133	0.0161	0.0139	0.0158	0.0184	0.00282	0.0157	0.00653	0.0173
	(0.0210)	(0.0209)	(0.0209)	(0.0209)	(0.0209)	(0.0213)	(0.0209)	(0.0222)	(0.0209)
1987.fyear	-0.155***	-0.153***	-0.155***	-0.153***	-0.152***	-0.170***	-0.155***	-0.165***	-0.152***
	(0.0212)	(0.0212)	(0.0212)	(0.0212)	(0.0211)	(0.0216)	(0.0211)	(0.0230)	(0.0212)
1988.fyear	-0.198***	-0.196***	-0.198***	-0.197***	-0.193***	-0.211***	-0.194***	-0.206***	-0.192***
	(0.0218)	(0.0218)	(0.0218)	(0.0218)	(0.0218)	(0.0223)	(0.0218)	(0.0239)	(0.0219)
1989.fyear	-0.220***	-0.218***	-0.221***	-0.219***	-0.217***	-0.232***	-0.215***	-0.227***	-0.214***
	(0.0228)	(0.0228)	(0.0227)	(0.0228)	(0.0227)	(0.0229)	(0.0227)	(0.0242)	(0.0227)
1990.fyear	-0.405***	-0.403***	-0.406***	-0.404***	-0.402***	-0.416***	-0.400***	-0.412***	-0.400***
	(0.0239)	(0.0239)	(0.0239)	(0.0239)	(0.0239)	(0.0240)	(0.0238)	(0.0253)	(0.0239)
1991.fyear	-0.182***	-0.179***	-0.182***	-0.180***	-0.179***	-0.194***	-0.177***	-0.190***	-0.176***
	(0.0245)	(0.0244)	(0.0244)	(0.0244)	(0.0244)	(0.0246)	(0.0243)	(0.0258)	(0.0244)
1992.fyear	-0.137***	-0.134***	-0.136***	-0.134***	-0.134***	-0.152***	-0.133***	-0.147***	-0.133***
	(0.0238)	(0.0238)	(0.0238)	(0.0238)	(0.0237)	(0.0240)	(0.0236)	(0.0256)	(0.0237)
1993.fyear	-0.0572*	-0.0536*	-0.0569*	-0.0542*	-0.0531*	-0.0707**	-0.0515*	-0.0656**	-0.0511*
	(0.0235)	(0.0235)	(0.0235)	(0.0235)	(0.0235)	(0.0239)	(0.0234)	(0.0254)	(0.0234)
1994.fyear	-0.180***	-0.177***	-0.180***	-0.177***	-0.175***	-0.192***	-0.174***	-0.187***	-0.174***

	(0.0237)	(0.0237)	(0.0237)	(0.0237)	(0.0236)	(0.0241)	(0.0236)	(0.0255)	(0.0237)
1995.fyear	-0.0477+	-0.0452+	-0.0480*	-0.0459+	-0.0413+	-0.0529*	-0.0376	-0.0490+	-0.0406+
	(0.0245)	(0.0244)	(0.0244)	(0.0244)	(0.0245)	(0.0246)	(0.0245)	(0.0255)	(0.0245)
1996.fyear	-0.0654**	-0.0629*	-0.0657**	-0.0635*	-0.0575*	-0.0656**	-0.0499*	-0.0625*	-0.0550*
	(0.0251)	(0.0251)	(0.0251)	(0.0251)	(0.0252)	(0.0253)	(0.0253)	(0.0259)	(0.0253)
1997.fyear	-0.0782**	-0.0761**	-0.0785**	-0.0767**	-0.0697**	-0.0733**	-0.0596*	-0.0712**	-0.0670*
	(0.0256)	(0.0256)	(0.0256)	(0.0256)	(0.0257)	(0.0257)	(0.0259)	(0.0260)	(0.0260)
1998.fyear	-0.229***	-0.228***	-0.230***	-0.229***	-0.222***	-0.227***	-0.214***	-0.224***	-0.218***
	(0.0267)	(0.0267)	(0.0267)	(0.0267)	(0.0267)	(0.0268)	(0.0268)	(0.0274)	(0.0268)
1999.fyear	0.00753	0.00836	0.00769	0.00826	0.0163	0.00640	0.0191	0.00982	0.0184
	(0.0276)	(0.0276)	(0.0275)	(0.0275)	(0.0277)	(0.0278)	(0.0277)	(0.0285)	(0.0277)
2000.fyear	-0.364***	-0.363***	-0.362***	-0.362***	-0.357***	-0.372***	-0.359***	-0.367***	-0.355***
	(0.0284)	(0.0284)	(0.0284)	(0.0284)	(0.0284)	(0.0287)	(0.0284)	(0.0298)	(0.0285)
2001.fyear	-0.419***	-0.418***	-0.416***	-0.417***	-0.413***	-0.423***	-0.417***	-0.419***	-0.411***
	(0.0283)	(0.0283)	(0.0283)	(0.0283)	(0.0283)	(0.0284)	(0.0283)	(0.0291)	(0.0285)
2002.fyear	-0.665***	-0.665***	-0.662***	-0.664***	-0.659***	-0.673***	-0.668***	-0.668***	-0.656***
	(0.0286)	(0.0286)	(0.0285)	(0.0285)	(0.0285)	(0.0287)	(0.0287)	(0.0298)	(0.0292)
2003.fyear	-0.243***	-0.243***	-0.238***	-0.241***	-0.236***	-0.256***	-0.249***	-0.250***	-0.233***
	(0.0275)	(0.0274)	(0.0274)	(0.0274)	(0.0274)	(0.0277)	(0.0279)	(0.0295)	(0.0288)
2004.fyear	-0.229***	-0.227***	-0.222***	-0.225***	-0.221***	-0.251***	-0.239***	-0.243***	-0.220***
	(0.0279)	(0.0279)	(0.0279)	(0.0279)	(0.0278)	(0.0287)	(0.0287)	(0.0317)	(0.0302)
sum_at_a		0.118***		0.0935**	0.0933**	0.120***		0.120***	
		(0.0238)		(0.0297)	(0.0297)	(0.0239)		(0.0239)	
hjtwt_at_a			0.00620***	0.00278+	0.00281+		0.00647***		0.00650***
			(0.00125)	(0.00163)	(0.00163)		(0.00126)		(0.00126)
adj_frag_g~a					-0.138**	-0.151**	-0.149**	-0.151**	-0.149**
					(0.0467)	(0.0470)	(0.0470)	(0.0469)	(0.0469)
sum_at_~3a_a						-1.621***		-1.630***	
						(0.406)		(0.407)	
hjtwt_a~3a_a							-0.0461**		-0.0511**
							(0.0161)		(0.0161)
sum_at_d~4_a								0.478	
								(0.715)	
sum_at~4_a_d								-0.237	
								(0.349)	
hjtwt_at~4_a									0.0570*
									(0.0250)
hjtwt_~4_a_d									-0.220
									(0.341)
_cons	0.528***	0.524***	0.526***	0.524***	0.630***	0.699***	0.663***	0.696***	0.649***
	(0.0294)	(0.0293)	(0.0293)	(0.0293)	(0.0447)	(0.0481)	(0.0463)	(0.0591)	(0.0525)
N	79284	79284	79284	79284	79284	79284	79284	79284	79284
R-sq	0.072	0.074	0.073	0.074	0.074	0.075	0.074	0.075	0.074
adj. R-sq	0.072	0.073	0.073	0.073	0.074	0.074	0.073	0.074	0.074
F	116.0	112.8	113.3	110.0	107.1	107.7	107.7	102.2	102.4

Standard errors in parentheses
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

80 Without R&D Stock, Dataset B

	-1	-2	-3	-4	-5	-6	-7	-8	-9
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq

			-	-	-	-	-	-	-
ebit_at	-0.000673	-0.000667	-0.000664	-0.000663	-0.000688	-0.000726	-0.000748	-0.000724	-0.000754
	(0.000690)	(0.000689)	(0.000688)	(0.000688)	(0.000695)	(0.000705)	(0.000694)	(0.000705)	(0.000695)
ppent_at	-0.303**	-0.302**	-0.305**	-0.304**	-0.308**	-0.305**	-0.311**	-0.304**	-0.311**
	(0.0964)	(0.0963)	(0.0964)	(0.0963)	(0.0961)	(0.0961)	(0.0962)	(0.0960)	(0.0962)
sale_at	0.0167***	0.0167***	0.0167***	0.0167***	0.0167***	0.0167***	0.0166***	0.0167***	0.0166***
	(0.00176)	(0.00176)	(0.00175)	(0.00175)	(0.00185)	(0.00185)	(0.00185)	(0.00184)	(0.00185)
mshare_gind	0.00386	0.00388	0.00398	0.00397	0.00363	0.00191	0.00289	0.00194	0.00288
	(0.00600)	(0.00599)	(0.00598)	(0.00598)	(0.00587)	(0.00605)	(0.00595)	(0.00602)	(0.00592)
hhi_gind	0.0000409	0.0000415	0.0000403	0.0000406	0.0000460	0.0000717+	0.0000567	0.0000725+	0.0000572
	(0.0000379)	(0.0000379)	(0.0000379)	(0.0000379)	(0.0000375)	(0.0000388)	(0.0000376)	(0.0000389)	(0.0000375)
0b.size	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1.size	0.149**	0.148**	0.147**	0.147**	0.148**	0.147**	0.147**	0.147**	0.146**
	(0.0464)	(0.0464)	(0.0464)	(0.0463)	(0.0463)	(0.0462)	(0.0462)	(0.0465)	(0.0463)
2.size	0.181*	0.181*	0.179*	0.179*	0.183*	0.184*	0.182*	0.183*	0.180*
	(0.0833)	(0.0832)	(0.0833)	(0.0833)	(0.0830)	(0.0830)	(0.0829)	(0.0831)	(0.0827)
3.size	0.273*	0.268*	0.266*	0.265*	0.271*	0.273*	0.272*	0.273*	0.271*
	(0.124)	(0.124)	(0.124)	(0.124)	(0.124)	(0.124)	(0.124)	(0.124)	(0.124)
emp_m_0_d_4	-0.101*	-0.100*	-0.100*	-0.100*	-0.102*	-0.103*	-0.102*	-0.103*	-0.101*
	(0.0480)	(0.0480)	(0.0480)	(0.0480)	(0.0482)	(0.0482)	(0.0482)	(0.0482)	(0.0482)
1980b.fyear	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.0200	-0.0212	-0.0210	-0.0213	-0.0253	-0.0246	-0.0254	-0.0249	-0.0261
	(0.0202)	(0.0202)	(0.0202)	(0.0202)	(0.0203)	(0.0203)	(0.0203)	(0.0203)	(0.0203)
1982.fyear	0.0961***	0.0964***	0.0959***	0.0960***	0.0951***	0.0975***	0.0936***	0.0977***	0.0927***
	(0.0242)	(0.0242)	(0.0242)	(0.0242)	(0.0242)	(0.0243)	(0.0242)	(0.0243)	(0.0243)
1983.fyear	0.342***	0.342***	0.342***	0.342***	0.341***	0.349***	0.342***	0.351***	0.342***
	(0.0289)	(0.0289)	(0.0289)	(0.0289)	(0.0289)	(0.0292)	(0.0289)	(0.0297)	(0.0290)
1984.fyear	0.202***	0.203***	0.202***	0.203***	0.206***	0.219***	0.208***	0.222***	0.210***
	(0.0304)	(0.0303)	(0.0304)	(0.0304)	(0.0303)	(0.0309)	(0.0303)	(0.0321)	(0.0305)
1985.fyear	0.277***	0.279***	0.278***	0.278***	0.277***	0.293***	0.281***	0.295***	0.282***
	(0.0331)	(0.0331)	(0.0331)	(0.0331)	(0.0330)	(0.0339)	(0.0331)	(0.0355)	(0.0333)
1986.fyear	0.304***	0.305***	0.304***	0.304***	0.303***	0.325***	0.309***	0.329***	0.312***
	(0.0362)	(0.0362)	(0.0362)	(0.0362)	(0.0362)	(0.0381)	(0.0364)	(0.0404)	(0.0369)
1987.fyear	0.121**	0.122**	0.121**	0.121**	0.117**	0.141***	0.124**	0.146***	0.127***
	(0.0378)	(0.0378)	(0.0378)	(0.0378)	(0.0378)	(0.0398)	(0.0379)	(0.0428)	(0.0384)
1988.fyear	0.111**	0.112**	0.111**	0.111**	0.115**	0.139***	0.121**	0.144**	0.123**
	(0.0387)	(0.0386)	(0.0387)	(0.0387)	(0.0387)	(0.0407)	(0.0388)	(0.0436)	(0.0391)
1989.fyear	0.0710+	0.0720+	0.0711+	0.0715+	0.0660	0.0873*	0.0698+	0.0913*	0.0717+
	(0.0416)	(0.0416)	(0.0416)	(0.0416)	(0.0416)	(0.0430)	(0.0416)	(0.0452)	(0.0417)
1990.fyear	-0.165***	-0.164***	-0.165***	-0.164***	-0.172***	-0.155***	-0.170***	-0.151**	-0.169***
	(0.0449)	(0.0449)	(0.0449)	(0.0449)	(0.0451)	(0.0461)	(0.0450)	(0.0483)	(0.0451)
1991.fyear	0.0431	0.0443	0.0438	0.0441	0.0371	0.0508	0.0365	0.0540	0.0373
	(0.0478)	(0.0478)	(0.0478)	(0.0478)	(0.0477)	(0.0483)	(0.0477)	(0.0502)	(0.0477)
1992.fyear	0.176***	0.177***	0.176***	0.177***	0.160***	0.173***	0.159***	0.176***	0.159***
	(0.0449)	(0.0449)	(0.0448)	(0.0449)	(0.0448)	(0.0454)	(0.0448)	(0.0469)	(0.0448)
1993.fyear	0.252***	0.254***	0.252***	0.253***	0.240***	0.254***	0.238***	0.256***	0.238***
	(0.0433)	(0.0432)	(0.0433)	(0.0433)	(0.0433)	(0.0437)	(0.0434)	(0.0452)	(0.0434)
1994.fyear	0.0520	0.0533	0.0523	0.0528	0.0480	0.0592	0.0437	0.0621	0.0441
	(0.0445)	(0.0445)	(0.0445)	(0.0445)	(0.0444)	(0.0447)	(0.0447)	(0.0463)	(0.0447)
1995.fyear	0.0250	0.0263	0.0248	0.0254	0.0237	0.0338	0.0182	0.0363	0.0178
	(0.0471)	(0.0470)	(0.0470)	(0.0470)	(0.0470)	(0.0470)	(0.0473)	(0.0484)	(0.0473)
1996.fyear	0.0380	0.0392	0.0376	0.0381	0.0454	0.0504	0.0357	0.0522	0.0344
	(0.0477)	(0.0477)	(0.0477)	(0.0477)	(0.0477)	(0.0476)	(0.0486)	(0.0485)	(0.0487)
1997.fyear	0.0603	0.0614	0.0603	0.0607	0.0679	0.0699	0.0560	0.0714	0.0544
	(0.0490)	(0.0490)	(0.0490)	(0.0490)	(0.0490)	(0.0488)	(0.0504)	(0.0496)	(0.0505)
1998.fyear	-0.0240	-0.0229	-0.0241	-0.0236	-0.0120	-0.00788	-0.0222	-0.00603	-0.0227
	(0.0513)	(0.0512)	(0.0513)	(0.0513)	(0.0514)	(0.0512)	(0.0526)	(0.0523)	(0.0527)
1999.fyear	-0.0964+	-0.0954+	-0.0969+	-0.0964+	-0.0858	-0.0811	-0.0930+	-0.0793	-0.0926+

	(0.0521)	(0.0521)	(0.0521)	(0.0521)	(0.0522)	(0.0520)	(0.0531)	(0.0530)	(0.0530)
2000.fyear	-0.345***	-0.344***	-0.345***	-0.344***	-0.344***	-0.347***	-0.352***	-0.346***	-0.352***
	(0.0560)	(0.0560)	(0.0560)	(0.0560)	(0.0559)	(0.0558)	(0.0568)	(0.0561)	(0.0568)
2001.fyear	-0.287***	-0.286***	-0.287***	-0.286***	-0.289***	-0.299***	-0.296***	-0.298***	-0.295***
	(0.0554)	(0.0554)	(0.0554)	(0.0554)	(0.0553)	(0.0555)	(0.0561)	(0.0556)	(0.0560)
2002.fyear	-0.364***	-0.363***	-0.363***	-0.363***	-0.368***	-0.374***	-0.368***	-0.373***	-0.364***
	(0.0549)	(0.0549)	(0.0549)	(0.0549)	(0.0547)	(0.0546)	(0.0547)	(0.0549)	(0.0547)
2003.fyear	-0.104*	-0.103+	-0.103+	-0.103+	-0.110*	-0.112*	-0.103*	-0.110*	-0.0965+
	(0.0528)	(0.0528)	(0.0528)	(0.0528)	(0.0526)	(0.0525)	(0.0524)	(0.0533)	(0.0524)
2004.fyear	-0.0353	-0.0343	-0.0335	-0.0334	-0.0458	-0.0396	-0.0329	-0.0361	-0.0245
	(0.0532)	(0.0532)	(0.0532)	(0.0532)	(0.0530)	(0.0531)	(0.0528)	(0.0548)	(0.0535)
sum_at_a		0.0411+		0.0163	0.0155	0.0405+		0.0404+	
		(0.0227)		(0.0283)	(0.0285)	(0.0227)		(0.0227)	
hjtwt_at_a			0.00499	0.00418	0.00441		0.00511		0.00509
			(0.00327)	(0.00383)	(0.00386)		(0.00327)		(0.00328)
adj_frag_g~a					-0.181**	-0.158*	-0.164*	-0.158*	-0.165*
					(0.0649)	(0.0653)	(0.0665)	(0.0650)	(0.0663)
sum_at_~3a_a						3.708*		3.611*	
						-1.770		-1.780	
hjtwt_a~3a_a							0.192+		0.176
							(0.109)		(0.110)
sum_at_d~4_a								0.929	
-2.720									
o.sum_~4_a_d								0	
								(.)	
hjtwt_at~4_a									0.106
									(0.170)
o.hjtw~4_a_d									0
									(.)
_cons	-0.0122	-0.0148	-0.0129	-0.0138	0.104	0.0205	0.0592	0.00997	0.0484
	(0.0611)	(0.0611)	(0.0611)	(0.0611)	(0.0728)	(0.0819)	(0.0770)	(0.0870)	(0.0793)
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N	18445	18445	18445	18445	18445	18445	18445	18445	18445
R-sq	0.079	0.079	0.079	0.079	0.080	0.081	0.081	0.081	0.081
adj. R-sq	0.077	0.077	0.077	0.077	0.078	0.079	0.079	0.079	0.079
F	28.13	27.38	27.38	26.64	25.68	25.72	25.59	25.12	24.94
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Standard err	ors in parentheses								
	p<0.05, **								
+ p<0.10, *	p<0.01,	*** p<0.001							

8P Without R&D Stock, Dataset C

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	-1	-2	-3	-4	-5	-6	-7	-8	-9
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
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ebit_at	-0.00252**	-0.00256**	-0.00261**	-0.00259**	-0.00264**	-0.00260**	-0.00255**	-0.00264**	-0.00256**
	(0.000955)	(0.000952)	(0.000951)	(0.000951)	(0.000949)	(0.000949)	(0.000949)	(0.000949)	(0.000947)
ppent_at	-0.517***	-0.534***	-0.535***	-0.539***	-0.539***	-0.535***	-0.535***	-0.537***	-0.542***
	(0.117)	(0.116)	(0.117)	(0.116)	(0.116)	(0.116)	(0.116)	(0.116)	(0.116)
sale_at	-0.00740	-0.00805	-0.00894	-0.00863	-0.00936	-0.00871	-0.00769	-0.00951	-0.00786
	(0.0155)	(0.0154)	(0.0154)	(0.0154)	(0.0154)	(0.0154)	(0.0154)	(0.0154)	(0.0153)
mshare_gind	-0.0121*	-0.0119*	-0.0119*	-0.0118*	-0.0125*	-0.0125*	-0.0121*	-0.0119*	-0.0113*
	(0.00505)	(0.00504)	(0.00505)	(0.00504)	(0.00508)	(0.00512)	(0.00520)	(0.00516)	(0.00519)
		-	-	-	-	-	-	-	-
hhi_gind	-0.0000530**	0.0000533	0.0000552	0.0000543	0.0000606	0.0000577	0.0000540	0.0000701*	0.0000612

		**	**	**	**	**	**	**	**
	(0.0000187)	(0.0000186)	(0.0000186)	(0.0000186)	(0.0000191)	(0.0000192)	(0.0000192)	(0.0000201)	(0.0000194)
0b.size	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1.size	0.0913***	0.0881***	0.0845**	0.0856***	0.0852***	0.0883***	0.0870***	0.0873***	0.0856***
	(0.0258)	(0.0257)	(0.0257)	(0.0257)	(0.0257)	(0.0256)	(0.0256)	(0.0256)	(0.0255)
2.size	0.229***	0.218***	0.214***	0.214***	0.212***	0.217***	0.217***	0.214***	0.214***
	(0.0474)	(0.0473)	(0.0473)	(0.0474)	(0.0473)	(0.0471)	(0.0472)	(0.0470)	(0.0471)
3.size	0.362***	0.332**	0.339***	0.328**	0.327**	0.331**	0.340***	0.329**	0.339***
	(0.101)	(0.101)	(0.101)	(0.101)	(0.101)	(0.101)	(0.101)	(0.101)	(0.101)
emp_m_0_d _4	-0.0432	-0.0407	-0.0406	-0.0400	-0.0401	-0.0404	-0.0391	-0.0418	-0.0389
	(0.0463)	(0.0463)	(0.0464)	(0.0463)	(0.0462)	(0.0462)	(0.0464)	(0.0462)	(0.0463)
1980b.fyear	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.150***	-0.151***	-0.151***	-0.151***	-0.146***	-0.144***	-0.139***	-0.131***	-0.120***
	(0.0329)	(0.0330)	(0.0330)	(0.0330)	(0.0330)	(0.0330)	(0.0330)	(0.0334)	(0.0334)
1982.fyear	-0.0334	-0.0344	-0.0340	-0.0344	-0.0265	-0.0252	-0.0179	-0.0163	0.00494
	(0.0380)	(0.0380)	(0.0380)	(0.0380)	(0.0380)	(0.0379)	(0.0380)	(0.0381)	(0.0383)
1983.fyear	0.116**	0.118**	0.116**	0.118**	0.129**	0.129**	0.134**	0.112**	0.141**
	(0.0428)	(0.0429)	(0.0428)	(0.0429)	(0.0431)	(0.0431)	(0.0429)	(0.0432)	(0.0430)
1984.fyear	-0.248***	-0.246***	-0.248***	-0.246***	-0.238***	-0.238***	-0.232***	-0.258***	-0.224***
	(0.0449)	(0.0451)	(0.0450)	(0.0451)	(0.0450)	(0.0450)	(0.0449)	(0.0451)	(0.0449)
1985.fyear	-0.241***	-0.238***	-0.239***	-0.238***	-0.228***	-0.230***	-0.224***	-0.268***	-0.228***
	(0.0458)	(0.0459)	(0.0458)	(0.0459)	(0.0460)	(0.0463)	(0.0459)	(0.0470)	(0.0459)
1986.fyear	-0.306***	-0.303***	-0.306***	-0.304***	-0.293***	-0.295***	-0.290***	-0.345***	-0.291***
	(0.0464)	(0.0465)	(0.0465)	(0.0465)	(0.0467)	(0.0472)	(0.0466)	(0.0484)	(0.0466)
1987.fyear	-0.500***	-0.498***	-0.500***	-0.498***	-0.487***	-0.489***	-0.481***	-0.551***	-0.484***
	(0.0479)	(0.0480)	(0.0479)	(0.0479)	(0.0483)	(0.0489)	(0.0482)	(0.0512)	(0.0482)
1988.fyear	-0.606***	-0.603***	-0.607***	-0.604***	-0.593***	-0.594***	-0.582***	-0.657***	-0.577***
	(0.0490)	(0.0490)	(0.0490)	(0.0490)	(0.0495)	(0.0497)	(0.0495)	(0.0520)	(0.0496)
1989.fyear	-0.653***	-0.652***	-0.655***	-0.653***	-0.641***	-0.640***	-0.617***	-0.676***	-0.575***
	(0.0509)	(0.0509)	(0.0509)	(0.0509)	(0.0515)	(0.0515)	(0.0520)	(0.0522)	(0.0532)
1990.fyear	-0.852***	-0.853***	-0.855***	-0.854***	-0.841***	-0.839***	-0.810***	-0.873***	-0.751***
	(0.0524)	(0.0525)	(0.0525)	(0.0525)	(0.0529)	(0.0529)	(0.0538)	(0.0536)	(0.0559)
1991.fyear	-0.634***	-0.633***	-0.634***	-0.633***	-0.623***	-0.622***	-0.586***	-0.650***	-0.509***
	(0.0522)	(0.0522)	(0.0522)	(0.0522)	(0.0524)	(0.0523)	(0.0539)	(0.0529)	(0.0571)
1992.fyear	-0.564***	-0.563***	-0.566***	-0.564***	-0.549***	-0.549***	-0.516***	-0.589***	-0.439***
	(0.0528)	(0.0528)	(0.0528)	(0.0528)	(0.0534)	(0.0534)	(0.0547)	(0.0547)	(0.0574)
1993.fyear	-0.432***	-0.430***	-0.434***	-0.431***	-0.416***	-0.415***	-0.379***	-0.454***	-0.288***
	(0.0536)	(0.0536)	(0.0535)	(0.0535)	(0.0542)	(0.0543)	(0.0556)	(0.0555)	(0.0588)
1994.fyear	-0.498***	-0.496***	-0.501***	-0.498***	-0.482***	-0.481***	-0.445***	-0.513***	-0.338***
	(0.0541)	(0.0541)	(0.0541)	(0.0540)	(0.0547)	(0.0548)	(0.0561)	(0.0557)	(0.0602)
1995.fyear	-0.297***	-0.295***	-0.299***	-0.297***	-0.277***	-0.275***	-0.233***	-0.277***	-0.0876
	(0.0557)	(0.0557)	(0.0557)	(0.0557)	(0.0568)	(0.0567)	(0.0587)	(0.0566)	(0.0654)
1996.fyear	-0.398***	-0.396***	-0.401***	-0.398***	-0.380***	-0.374***	-0.313***	-0.335***	-0.110
	(0.0593)	(0.0593)	(0.0593)	(0.0592)	(0.0600)	(0.0599)	(0.0634)	(0.0601)	(0.0748)
1997.fyear	-0.435***	-0.434***	-0.440***	-0.437***	-0.416***	-0.407***	-0.338***	-0.330***	-0.0934
	(0.0599)	(0.0599)	(0.0600)	(0.0599)	(0.0608)	(0.0608)	(0.0648)	(0.0632)	(0.0810)
1998.fyear	-0.580***	-0.580***	-0.585***	-0.582***	-0.563***	-0.554***	-0.491***	-0.494***	-0.280***
	(0.0616)	(0.0617)	(0.0617)	(0.0616)	(0.0623)	(0.0625)	(0.0655)	(0.0635)	(0.0776)
1999.fyear	0.00163	0.00218	-0.00150	0.000521	0.0259	0.0334	0.0799	0.0849	0.233**
	(0.0627)	(0.0627)	(0.0627)	(0.0627)	(0.0641)	(0.0642)	(0.0661)	(0.0649)	(0.0722)
2000.fyear	-0.735***	-0.734***	-0.737***	-0.735***	-0.713***	-0.708***	-0.679***	-0.696***	-0.606***
	(0.0648)	(0.0649)	(0.0649)	(0.0649)	(0.0656)	(0.0654)	(0.0659)	(0.0651)	(0.0665)
2001.fyear	-0.888***	-0.889***	-0.890***	-0.890***	-0.868***	-0.859***	-0.833***	-0.809***	-0.771***
	(0.0644)	(0.0644)	(0.0644)	(0.0644)	(0.0650)	(0.0654)	(0.0651)	(0.0659)	(0.0656)
2002.fyear	-1.219***	-1.223***	-1.219***	-1.222***	-1.199***	-1.192***	-1.177***	-1.166***	-1.179***
	(0.0636)	(0.0637)	(0.0637)	(0.0638)	(0.0642)	(0.0648)	(0.0640)	(0.0646)	(0.0639)
2003.fyear	-0.635***	-0.640***	-0.634***	-0.638***	-0.615***	-0.611***	-0.607***	-0.612***	-0.662***
	(0.0618)	(0.0618)	(0.0618)	(0.0618)	(0.0622)	(0.0625)	(0.0620)	(0.0624)	(0.0637)
2004.fyear	-0.702***	-0.702***	-0.697***	-0.699***	-0.677***	-0.678***	-0.688***	-0.729***	-0.793***

	(0.0622)	(0.0623)	(0.0622)	(0.0623)	(0.0626)	(0.0624)	(0.0628)	(0.0651)	(0.0681)
sum_at_a		0.169***		0.127**	0.126**	0.169***		0.170***	
		(0.0374)		(0.0425)	(0.0425)	(0.0376)		(0.0379)	
hjtwt_at_a			0.00760***	0.00370	0.00375+		0.00796***		0.00799***
			(0.00202)	(0.00227)	(0.00227)		(0.00202)		(0.00204)
adj_frag_g~a					-0.179	-0.181	-0.207+	-0.234*	-0.256*
					(0.111)	(0.111)	(0.112)	(0.112)	(0.113)
sum_at_~3a_a						-0.369		-1.389+	
						(0.721)		(0.728)	
hjtwt_a~3a_a							-0.0726**		-0.133***
							(0.0236)		(0.0273)
sum_at_d~4_a								-4.596**	
-1.480									
sum_at~4_a_d								0.842***	
								(0.0903)	
hjtwt_at~4_a									-0.240***
									(0.0531)
hjtwt_~4_a_d									0.881***
									(0.0566)
_cons	1.094***	1.090***	1.097***	1.092***	1.220***	1.231***	1.269***	1.462***	1.425***
	(0.0687)	(0.0687)	(0.0687)	(0.0686)	(0.104)	(0.108)	(0.106)	(0.150)	(0.122)
N	24651	24651	24651	24651	24651	24651	24651	24651	24651
R-sq	0.162	0.164	0.163	0.164	0.164	0.164	0.165	0.165	0.167
adj. R-sq	0.161	0.163	0.162	0.163	0.163	0.163	0.163	0.164	0.165
F	88.87	87.47	87.26	85.30	83.15	82.99	83.13	.	.

Standard errors in parentheses
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

8Q Alternative Tobin's Q, Dataset A

	-1	-2	-3	-4	-5	-6	-7	-8	-9
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
xrd_at	0.0905***	0.0856***	0.0874***	0.0854***	0.0856***	0.0860***	0.0875***	0.0860***	0.0876***
	(0.00605)	(0.00598)	(0.00598)	(0.00597)	(0.00598)	(0.00598)	(0.00598)	(0.00598)	(0.00598)
ebit_at	-0.00112***	-0.00114***	-0.00113***	-0.00114***	-0.00115***	-0.00115***	-0.00114***	-0.00115***	-0.00115***
	(0.000303)	(0.000304)	(0.000302)	(0.000302)	(0.000301)	(0.000302)	(0.000301)	(0.000302)	(0.000301)
ppent_at	-0.000367	-0.00595	-0.00733	-0.00839	-0.0108	-0.00502	-0.00828	-0.00633	-0.00964
	(0.0565)	(0.0566)	(0.0566)	(0.0566)	(0.0565)	(0.0565)	(0.0565)	(0.0566)	(0.0565)
sale_at	0.0158***	0.0159***	0.0158***	0.0159***	0.0159***	0.0159***	0.0159***	0.0159***	0.0159***
	(0.00371)	(0.00369)	(0.00367)	(0.00367)	(0.00362)	(0.00365)	(0.00365)	(0.00366)	(0.00366)
mshare_gind	-0.00232	-0.00224	-0.00218	-0.00218	-0.00296	-0.00296	-0.00296	-0.00296	-0.00302
	(0.00269)	(0.00269)	(0.00269)	(0.00269)	(0.00272)	(0.00273)	(0.00272)	(0.00273)	(0.00272)
hhi_gind	-0.0000277+	-0.0000276+	-0.0000283*	-0.0000280*	-0.0000387**	-0.0000399**	-0.0000397**	-0.0000397**	-0.0000379**
	(0.0000142)	(0.0000142)	(0.0000142)	(0.0000142)	(0.0000142)	(0.0000142)	(0.0000142)	(0.0000143)	(0.0000142)
0b.size	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)

1.size	0.176***	0.175***	0.172***	0.173***	0.172***	0.176***	0.173***	0.176***	0.173***
	(0.0211)	(0.0211)	(0.0211)	(0.0211)	(0.0211)	(0.0211)	(0.0211)	(0.0211)	(0.0211)
2.size	0.384***	0.380***	0.374***	0.376***	0.374***	0.381***	0.375***	0.381***	0.375***
	(0.0337)	(0.0337)	(0.0338)	(0.0338)	(0.0338)	(0.0338)	(0.0337)	(0.0338)	(0.0337)
3.size	0.519***	0.506***	0.506***	0.502***	0.502***	0.507***	0.507***	0.506***	0.507***
	(0.0558)	(0.0559)	(0.0558)	(0.0558)	(0.0558)	(0.0559)	(0.0558)	(0.0559)	(0.0558)
emp_m_0_d_4	0.0423	0.0435	0.0437	0.0440	0.0420	0.0420	0.0419	0.0420	0.0419
	(0.0269)	(0.0269)	(0.0269)	(0.0269)	(0.0269)	(0.0269)	(0.0269)	(0.0269)	(0.0269)
1980b.fyear	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.123***	-0.124***	-0.123***	-0.123***	-0.124***	-0.125***	-0.124***	-0.124***	-0.124***
	(0.0221)	(0.0221)	(0.0221)	(0.0221)	(0.0220)	(0.0220)	(0.0220)	(0.0220)	(0.0220)
1982.fyear	0.0337	0.0339	0.0334	0.0336	0.0357	0.0349	0.0360	0.0350	0.0353
	(0.0254)	(0.0254)	(0.0254)	(0.0254)	(0.0254)	(0.0254)	(0.0254)	(0.0254)	(0.0254)
1983.fyear	0.308***	0.309***	0.309***	0.309***	0.312***	0.307***	0.311***	0.307***	0.311***
	(0.0273)	(0.0273)	(0.0273)	(0.0273)	(0.0272)	(0.0272)	(0.0272)	(0.0274)	(0.0272)
1984.fyear	0.0258	0.0276	0.0264	0.0273	0.0290	0.0240	0.0287	0.0240	0.0289
	(0.0293)	(0.0293)	(0.0293)	(0.0293)	(0.0292)	(0.0292)	(0.0292)	(0.0294)	(0.0292)
1985.fyear	0.127***	0.129***	0.128***	0.129***	0.130***	0.121***	0.129***	0.120***	0.130***
	(0.0302)	(0.0302)	(0.0302)	(0.0302)	(0.0301)	(0.0302)	(0.0301)	(0.0308)	(0.0301)
1986.fyear	0.141***	0.144***	0.142***	0.143***	0.146***	0.133***	0.144***	0.132***	0.145***
	(0.0316)	(0.0315)	(0.0315)	(0.0315)	(0.0314)	(0.0317)	(0.0314)	(0.0327)	(0.0315)
1987.fyear	-0.0841**	-0.0821*	-0.0842**	-0.0829*	-0.0828*	-0.0978**	-0.0849**	-0.0985**	-0.0836**
	(0.0324)	(0.0324)	(0.0324)	(0.0324)	(0.0323)	(0.0327)	(0.0323)	(0.0341)	(0.0323)
1988.fyear	-0.102**	-0.100**	-0.103**	-0.101**	-0.0970**	-0.110***	-0.0980**	-0.111**	-0.0972**
	(0.0331)	(0.0331)	(0.0330)	(0.0330)	(0.0330)	(0.0332)	(0.0330)	(0.0345)	(0.0330)
1989.fyear	-0.102**	-0.100**	-0.103**	-0.101**	-0.0990**	-0.110**	-0.0977**	-0.111**	-0.0980**
	(0.0339)	(0.0339)	(0.0338)	(0.0338)	(0.0337)	(0.0338)	(0.0337)	(0.0348)	(0.0338)
1990.fyear	-0.284***	-0.282***	-0.285***	-0.284***	-0.283***	-0.294***	-0.281***	-0.294***	-0.282***
	(0.0353)	(0.0353)	(0.0353)	(0.0353)	(0.0352)	(0.0352)	(0.0352)	(0.0362)	(0.0352)
1991.fyear	0.0126	0.0152	0.0131	0.0146	0.0151	0.00344	0.0169	0.00278	0.0163
	(0.0354)	(0.0353)	(0.0353)	(0.0353)	(0.0352)	(0.0353)	(0.0352)	(0.0363)	(0.0352)
1992.fyear	0.0488	0.0523	0.0501	0.0519	0.0488	0.0363	0.0508	0.0357	0.0498
	(0.0353)	(0.0353)	(0.0352)	(0.0352)	(0.0350)	(0.0352)	(0.0351)	(0.0365)	(0.0350)
1993.fyear	0.142***	0.146***	0.143***	0.145***	0.145***	0.133***	0.147***	0.132***	0.146***
	(0.0343)	(0.0342)	(0.0342)	(0.0342)	(0.0341)	(0.0342)	(0.0342)	(0.0354)	(0.0342)
1994.fyear	-0.00778	-0.00470	-0.00794	-0.00587	-0.00376	-0.0150	-0.00136	-0.0159	-0.00304
	(0.0345)	(0.0344)	(0.0344)	(0.0344)	(0.0343)	(0.0345)	(0.0344)	(0.0357)	(0.0344)
1995.fyear	0.173***	0.175***	0.172***	0.174***	0.182***	0.174***	0.186***	0.174***	0.183***
	(0.0348)	(0.0347)	(0.0347)	(0.0347)	(0.0347)	(0.0347)	(0.0349)	(0.0354)	(0.0349)
1996.fyear	0.153***	0.156***	0.153***	0.155***	0.166***	0.161***	0.173***	0.161***	0.169***
	(0.0352)	(0.0352)	(0.0352)	(0.0351)	(0.0352)	(0.0352)	(0.0356)	(0.0356)	(0.0357)
1997.fyear	0.147***	0.149***	0.147***	0.148***	0.161***	0.160***	0.170***	0.160***	0.165***
	(0.0356)	(0.0356)	(0.0356)	(0.0356)	(0.0356)	(0.0356)	(0.0362)	(0.0358)	(0.0364)
1998.fyear	-0.0240	-0.0222	-0.0243	-0.0230	-0.0114	-0.0142	-0.00519	-0.0149	-0.00848
	(0.0368)	(0.0368)	(0.0368)	(0.0368)	(0.0368)	(0.0368)	(0.0371)	(0.0372)	(0.0372)
1999.fyear	0.274***	0.275***	0.274***	0.275***	0.289***	0.282***	0.292***	0.282***	0.290***
	(0.0376)	(0.0376)	(0.0375)	(0.0375)	(0.0376)	(0.0377)	(0.0377)	(0.0382)	(0.0377)
2000.fyear	-0.0706+	-0.0691+	-0.0682+	-0.0681+	-0.0601	-0.0721+	-0.0616	-0.0731+	-0.0605
	(0.0380)	(0.0379)	(0.0379)	(0.0379)	(0.0379)	(0.0380)	(0.0378)	(0.0391)	(0.0379)
2001.fyear	-0.133***	-0.131***	-0.130***	-0.130***	-0.124**	-0.132***	-0.127***	-0.133***	-0.125**
	(0.0382)	(0.0382)	(0.0381)	(0.0381)	(0.0381)	(0.0381)	(0.0380)	(0.0386)	(0.0382)
2002.fyear	-0.420***	-0.419***	-0.416***	-0.417***	-0.411***	-0.422***	-0.417***	-0.423***	-0.413***
	(0.0383)	(0.0383)	(0.0383)	(0.0383)	(0.0382)	(0.0382)	(0.0382)	(0.0392)	(0.0387)
2003.fyear	0.0349	0.0364	0.0409	0.0396	0.0467	0.0300	0.0374	0.0288	0.0435
	(0.0369)	(0.0369)	(0.0369)	(0.0369)	(0.0368)	(0.0370)	(0.0370)	(0.0387)	(0.0380)
2004.fyear	0.0539	0.0568	0.0615+	0.0606	0.0649+	0.0393	0.0515	0.0376	0.0592
	(0.0371)	(0.0371)	(0.0371)	(0.0371)	(0.0370)	(0.0375)	(0.0374)	(0.0406)	(0.0389)
sum_at_a		0.100***		0.0656*	0.0651*	0.102***		0.102***	
		(0.0230)		(0.0266)	(0.0266)	(0.0230)		(0.0230)	
hjtwt_at_a			0.00626***	0.00393*	0.00399*		0.00648***		0.00649***

			(0.00133)	(0.00158)	(0.00158)		(0.00134)		(0.00134)
adj_frag_g~a					-0.304***	-0.318***	-0.315***	-0.317***	-0.313***
					(0.0594)	(0.0599)	(0.0599)	(0.0600)	(0.0600)
sum_at_~3a_a						-1.291**		-1.282**	
						(0.490)		(0.488)	
hjtwt_a~3a_a							-0.0324+		-0.0343+
							(0.0189)		(0.0190)
sum_at_d~4_a								-0.0773	
								(0.905)	
sum_at~4_a_d								0.357	
								(0.457)	
hjtwt_at~4_a									0.0248
									(0.0294)
hjtwt_~4_a_d									0.383
									(0.457)
_cons	-0.0783*	-0.0830*	-0.0811*	-0.0831*	0.158**	0.217***	0.185**	0.198*	0.149*
	(0.0392)	(0.0391)	(0.0391)	(0.0391)	(0.0597)	(0.0639)	(0.0615)	(0.0785)	(0.0695)
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N	73518	73518	73518	73518	73518	73518	73518	73518	73518
R-sq	0.064	0.064	0.064	0.064	0.066	0.066	0.065	0.066	0.066
adj. R-sq	0.063	0.064	0.064	0.064	0.065	0.065	0.065	0.065	0.065
F	96.13	94.48	95.61	93.08	91.31	90.53	91.39	86.12	86.94
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Standard err	ors in parentheses								
	p<0.05, **								
+ p<0.10, *	p<0.01,	*** p<0.001							

8R Alternative Tobin's Q, Dataset B

	-1	-2	-3	-4	-5	-6	-7	-8	-9
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
xrd_at	0.0868***	0.0857***	0.0858***	0.0855***	0.0855***	0.0853***	0.0857***	0.0853***	0.0856***
	(0.00960)	(0.00916)	(0.00921)	(0.00909)	(0.00909)	(0.00916)	(0.00913)	(0.00915)	(0.00914)
ebit_at	-0.000112	-0.000106	-0.000100	-0.0000994	-0.000139	-0.000182	-0.000209	-0.000183	-0.000216
	(0.000682)	(0.000682)	(0.000679)	(0.000680)	(0.000687)	(0.000699)	(0.000687)	(0.000698)	(0.000688)
ppent_at	0.205+	0.208+	0.202+	0.204+	0.202+	0.207+	0.197+	0.207+	0.197+
	(0.112)	(0.111)	(0.111)	(0.111)	(0.111)	(0.111)	(0.111)	(0.111)	(0.111)
sale_at	0.0214***	0.0214***	0.0214***	0.0214***	0.0214***	0.0214***	0.0213***	0.0214***	0.0213***
	(0.00349)	(0.00348)	(0.00350)	(0.00350)	(0.00332)	(0.00332)	(0.00332)	(0.00331)	(0.00333)
mshare_gind	0.00103	0.00107	0.00126	0.00123	0.000713	-0.000935	-0.0000856	-0.000928	-0.000195
	(0.00588)	(0.00588)	(0.00586)	(0.00587)	(0.00583)	(0.00589)	(0.00585)	(0.00589)	(0.00582)
hhi_gind	0.0000199	0.0000211	0.0000189	0.0000197	0.0000305	0.0000579	0.0000451	0.0000576	0.0000459
	(0.0000468)	(0.0000468)	(0.0000467)	(0.0000468)	(0.0000461)	(0.0000461)	(0.0000460)	(0.0000464)	(0.0000459)
0b.size	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1.size	0.206***	0.205***	0.201***	0.201***	0.203***	0.203***	0.202***	0.204***	0.201***
	(0.0548)	(0.0548)	(0.0548)	(0.0548)	(0.0547)	(0.0548)	(0.0548)	(0.0553)	(0.0549)
2.size	0.320**	0.319**	0.314**	0.315**	0.321**	0.324**	0.319**	0.324**	0.317**
	(0.0986)	(0.0985)	(0.0983)	(0.0983)	(0.0981)	(0.0984)	(0.0980)	(0.0984)	(0.0980)
3.size	0.439**	0.427**	0.425**	0.422**	0.431**	0.435**	0.433**	0.436**	0.432**
	(0.138)	(0.138)	(0.138)	(0.138)	(0.137)	(0.138)	(0.138)	(0.138)	(0.137)
emp_m_0_d_	0.0156	0.0165	0.0161	0.0164	0.0121	0.0117	0.0127	0.0117	0.0131

4									
	(0.0533)	(0.0533)	(0.0533)	(0.0533)	(0.0535)	(0.0536)	(0.0536)	(0.0536)	(0.0536)
1980b.fyear	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	0.00304	0.000294	0.00100	0.000133	-0.00573	-0.00581	-0.00571	-0.00574	-0.00643
	(0.0377)	(0.0378)	(0.0377)	(0.0378)	(0.0378)	(0.0377)	(0.0377)	(0.0378)	(0.0377)
1982.fyear	0.243***	0.244***	0.242***	0.243***	0.243***	0.245***	0.241***	0.245***	0.240***
	(0.0432)	(0.0432)	(0.0432)	(0.0431)	(0.0431)	(0.0431)	(0.0431)	(0.0432)	(0.0431)
1983.fyear	0.580***	0.581***	0.579***	0.580***	0.581***	0.589***	0.581***	0.589***	0.582***
	(0.0478)	(0.0477)	(0.0477)	(0.0477)	(0.0477)	(0.0480)	(0.0477)	(0.0482)	(0.0477)
1984.fyear	0.402***	0.404***	0.402***	0.403***	0.410***	0.424***	0.413***	0.423***	0.414***
	(0.0519)	(0.0519)	(0.0519)	(0.0519)	(0.0519)	(0.0524)	(0.0520)	(0.0531)	(0.0520)
1985.fyear	0.527***	0.530***	0.528***	0.529***	0.531***	0.546***	0.534***	0.545***	0.535***
	(0.0529)	(0.0529)	(0.0529)	(0.0529)	(0.0528)	(0.0535)	(0.0529)	(0.0541)	(0.0529)
1986.fyear	0.600***	0.602***	0.599***	0.600***	0.602***	0.624***	0.608***	0.623***	0.611***
	(0.0558)	(0.0558)	(0.0558)	(0.0558)	(0.0557)	(0.0572)	(0.0560)	(0.0584)	(0.0562)
1987.fyear	0.376***	0.377***	0.375***	0.376***	0.370***	0.395***	0.377***	0.393***	0.380***
	(0.0560)	(0.0560)	(0.0560)	(0.0560)	(0.0558)	(0.0575)	(0.0561)	(0.0588)	(0.0563)
1988.fyear	0.409***	0.411***	0.408***	0.409***	0.413***	0.435***	0.417***	0.435***	0.419***
	(0.0575)	(0.0575)	(0.0574)	(0.0574)	(0.0575)	(0.0589)	(0.0576)	(0.0598)	(0.0575)
1989.fyear	0.378***	0.380***	0.378***	0.379***	0.371***	0.391***	0.373***	0.390***	0.375***
	(0.0599)	(0.0599)	(0.0599)	(0.0599)	(0.0595)	(0.0606)	(0.0595)	(0.0608)	(0.0594)
1990.fyear	0.180**	0.182**	0.181**	0.182**	0.167**	0.183**	0.167**	0.183**	0.169**
	(0.0616)	(0.0616)	(0.0616)	(0.0616)	(0.0612)	(0.0619)	(0.0611)	(0.0625)	(0.0611)
1991.fyear	0.465***	0.467***	0.466***	0.467***	0.455***	0.467***	0.452***	0.466***	0.453***
	(0.0633)	(0.0632)	(0.0632)	(0.0632)	(0.0626)	(0.0630)	(0.0625)	(0.0639)	(0.0624)
1992.fyear	0.542***	0.545***	0.543***	0.544***	0.518***	0.529***	0.515***	0.529***	0.516***
	(0.0628)	(0.0628)	(0.0628)	(0.0628)	(0.0618)	(0.0622)	(0.0617)	(0.0627)	(0.0617)
1993.fyear	0.602***	0.605***	0.603***	0.604***	0.588***	0.600***	0.583***	0.599***	0.584***
	(0.0612)	(0.0611)	(0.0611)	(0.0611)	(0.0604)	(0.0606)	(0.0604)	(0.0612)	(0.0604)
1994.fyear	0.393***	0.396***	0.394***	0.395***	0.391***	0.401***	0.384***	0.400***	0.385***
	(0.0614)	(0.0613)	(0.0613)	(0.0613)	(0.0609)	(0.0611)	(0.0610)	(0.0620)	(0.0609)
1995.fyear	0.348***	0.351***	0.348***	0.349***	0.351***	0.359***	0.342***	0.358***	0.342***
	(0.0636)	(0.0636)	(0.0636)	(0.0636)	(0.0633)	(0.0632)	(0.0634)	(0.0640)	(0.0634)
1996.fyear	0.394***	0.396***	0.393***	0.394***	0.409***	0.412***	0.395***	0.412***	0.394***
	(0.0640)	(0.0639)	(0.0639)	(0.0639)	(0.0641)	(0.0639)	(0.0649)	(0.0644)	(0.0651)
1997.fyear	0.421***	0.423***	0.421***	0.422***	0.438***	0.437***	0.421***	0.437***	0.420***
	(0.0653)	(0.0652)	(0.0652)	(0.0652)	(0.0654)	(0.0651)	(0.0665)	(0.0655)	(0.0668)
1998.fyear	0.349***	0.352***	0.349***	0.350***	0.373***	0.375***	0.359***	0.374***	0.358***
	(0.0671)	(0.0670)	(0.0670)	(0.0670)	(0.0676)	(0.0673)	(0.0687)	(0.0681)	(0.0688)
1999.fyear	0.253***	0.255***	0.252***	0.253***	0.274***	0.276***	0.263***	0.275***	0.263***
	(0.0687)	(0.0686)	(0.0686)	(0.0686)	(0.0689)	(0.0687)	(0.0696)	(0.0693)	(0.0696)
2000.fyear	0.0797	0.0814	0.0797	0.0805	0.0852	0.0785	0.0729	0.0783	0.0732
	(0.0707)	(0.0706)	(0.0706)	(0.0706)	(0.0705)	(0.0703)	(0.0714)	(0.0705)	(0.0714)
2001.fyear	0.149*	0.150*	0.149*	0.150*	0.147*	0.131+	0.136+	0.131+	0.137+
	(0.0707)	(0.0706)	(0.0706)	(0.0706)	(0.0703)	(0.0705)	(0.0712)	(0.0704)	(0.0711)
2002.fyear	0.0194	0.0211	0.0211	0.0216	0.0164	0.00323	0.0135	0.00321	0.0173
	(0.0711)	(0.0711)	(0.0710)	(0.0710)	(0.0706)	(0.0704)	(0.0707)	(0.0704)	(0.0705)
2003.fyear	0.300***	0.302***	0.303***	0.304***	0.296***	0.286***	0.301***	0.286***	0.307***
	(0.0692)	(0.0692)	(0.0692)	(0.0692)	(0.0687)	(0.0685)	(0.0687)	(0.0689)	(0.0686)
2004.fyear	0.388***	0.390***	0.391***	0.392***	0.375***	0.373***	0.387***	0.373***	0.395***
	(0.0682)	(0.0681)	(0.0681)	(0.0681)	(0.0675)	(0.0672)	(0.0675)	(0.0688)	(0.0682)
sum_at_a		0.0827**		0.0389	0.0388	0.0828**		0.0829**	
		(0.0261)		(0.0237)	(0.0239)	(0.0257)		(0.0257)	
hjtwt_at_a			0.00941**	0.00745+	0.00767+		0.00954**		0.00951**
			(0.00337)	(0.00389)	(0.00391)		(0.00336)		(0.00337)
adj_frag_g~a					-0.283***	-0.260***	-0.262**	-0.261***	-0.262**
					(0.0790)	(0.0784)	(0.0803)	(0.0780)	(0.0803)
sum_at_~3a_a						3.720+		3.735+	
						-1.965		-1.972	
hjtwt_a~3a_a							0.223		0.210
							(0.142)		(0.143)
sum_at_d~4_a								-0.204	

-3.342									
o.sum_~4_a_d								0	
								(.)	
hjtwt_at~4_a									0.105
									(0.185)
o.hjtw~4_a_d									0
									(.)
_cons	-0.744***	-0.750***	-0.746***	-0.748***	-0.572***	-0.658***	-0.626***	-0.655***	-0.638***
	(0.0793)	(0.0791)	(0.0791)	(0.0792)	(0.0908)	(0.0963)	(0.0962)	(0.102)	(0.0991)
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N	17270	17270	17270	17270	17270	17270	17270	17270	17270
R-sq	0.065	0.066	0.066	0.066	0.068	0.069	0.069	0.069	0.069
adj. R-sq	0.063	0.064	0.064	0.064	0.066	0.067	0.067	0.067	0.067
F	21.81	21.53	21.46	21.08	20.81	20.77	20.68	20.38	20.12
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Standard err	ors in parentheses								
+ p<0.10, *	p<0.05, ** p<0.01,	*** p<0.001							

8S Alternative Tobin's Q, Dataset C

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	-1	-2	-3	-4	-5	-6	-7	-8	-9
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
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xrd_at	0.0793***	0.0758***	0.0764***	0.0755***	0.0757***	0.0761***	0.0767***	0.0762***	0.0770***
	(0.00960)	(0.00969)	(0.00957)	(0.00967)	(0.00969)	(0.00971)	(0.00959)	(0.00970)	(0.00962)
ebit_at	0.00227*	0.00233*	0.00225*	0.00228*	0.00221*	0.00225*	0.00220*	0.00219*	0.00219*
	(0.00108)	(0.00108)	(0.00108)	(0.00108)	(0.00108)	(0.00108)	(0.00108)	(0.00108)	(0.00108)
ppent_at	-0.111	-0.117	-0.123	-0.123	-0.123	-0.117	-0.123	-0.119	-0.128
	(0.123)	(0.123)	(0.123)	(0.123)	(0.122)	(0.122)	(0.122)	(0.122)	(0.122)
sale_at	0.0701***	0.0712***	0.0699***	0.0704***	0.0694***	0.0701***	0.0693***	0.0690***	0.0690***
	(0.0178)	(0.0179)	(0.0178)	(0.0179)	(0.0178)	(0.0178)	(0.0178)	(0.0178)	(0.0179)
mshare_gind	-0.00982+	-0.00974+	-0.00963+	-0.00963+	-0.0104*	-0.0106*	-0.0104*	-0.0102*	-0.0102*
	(0.00523)	(0.00523)	(0.00523)	(0.00523)	(0.00517)	(0.00518)	(0.00515)	(0.00507)	(0.00498)
hhi_gind	-0.0000532*	-0.0000529*	-0.0000547*	-0.0000543*	-0.0000622**	-0.0000636**	-0.0000613**	-0.0000677**	-0.0000601**
	(0.0000218)	(0.0000218)	(0.0000218)	(0.0000217)	(0.0000226)	(0.0000227)	(0.0000227)	(0.0000228)	(0.0000227)
0b.size	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1.size	0.197***	0.196***	0.191***	0.192***	0.192***	0.195***	0.192***	0.194***	0.190***
	(0.0316)	(0.0316)	(0.0315)	(0.0315)	(0.0315)	(0.0316)	(0.0315)	(0.0316)	(0.0316)
2.size	0.502***	0.498***	0.491***	0.492***	0.489***	0.495***	0.490***	0.491***	0.487***
	(0.0537)	(0.0537)	(0.0538)	(0.0538)	(0.0538)	(0.0536)	(0.0537)	(0.0535)	(0.0537)
3.size	0.775***	0.763***	0.760***	0.758***	0.756***	0.760***	0.758***	0.757***	0.756***
	(0.108)	(0.108)	(0.108)	(0.108)	(0.108)	(0.108)	(0.108)	(0.108)	(0.108)
emp_m_0_d_4	0.0403	0.0416	0.0423	0.0425	0.0428	0.0413	0.0429	0.0403	0.0434
	(0.0503)	(0.0504)	(0.0504)	(0.0504)	(0.0503)	(0.0503)	(0.0503)	(0.0504)	(0.0503)
1980b.fyear	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.275***	-0.275***	-0.276***	-0.276***	-0.270***	-0.272***	-0.269***	-0.257***	-0.252***
	(0.0511)	(0.0511)	(0.0512)	(0.0512)	(0.0511)	(0.0515)	(0.0513)	(0.0516)	(0.0515)
1982.fyear	-0.0322	-0.0327	-0.0326	-0.0327	-0.0228	-0.0254	-0.0208	-0.00927	0.00235
	(0.0539)	(0.0539)	(0.0539)	(0.0539)	(0.0539)	(0.0541)	(0.0541)	(0.0543)	(0.0544)

1983.fyear	0.173**	0.175**	0.173**	0.174**	0.189**	0.189**	0.189**	0.177**	0.200***
	(0.0581)	(0.0581)	(0.0581)	(0.0581)	(0.0584)	(0.0584)	(0.0585)	(0.0586)	(0.0586)
1984.fyear	-0.308***	-0.306***	-0.308***	-0.307***	-0.297***	-0.297***	-0.296***	-0.309***	-0.282***
	(0.0626)	(0.0627)	(0.0627)	(0.0627)	(0.0626)	(0.0627)	(0.0629)	(0.0628)	(0.0630)
1985.fyear	-0.301***	-0.298***	-0.299***	-0.298***	-0.286***	-0.284***	-0.286***	-0.323***	-0.287***
	(0.0636)	(0.0637)	(0.0637)	(0.0637)	(0.0639)	(0.0639)	(0.0641)	(0.0655)	(0.0640)
1986.fyear	-0.415***	-0.413***	-0.415***	-0.414***	-0.401***	-0.396***	-0.400***	-0.447***	-0.399***
	(0.0647)	(0.0648)	(0.0647)	(0.0647)	(0.0651)	(0.0652)	(0.0653)	(0.0673)	(0.0653)
1987.fyear	-0.663***	-0.661***	-0.663***	-0.662***	-0.648***	-0.643***	-0.647***	-0.704***	-0.646***
	(0.0669)	(0.0670)	(0.0670)	(0.0670)	(0.0676)	(0.0677)	(0.0679)	(0.0708)	(0.0680)
1988.fyear	-0.765***	-0.762***	-0.765***	-0.763***	-0.750***	-0.746***	-0.748***	-0.792***	-0.730***
	(0.0684)	(0.0685)	(0.0684)	(0.0684)	(0.0690)	(0.0689)	(0.0699)	(0.0709)	(0.0702)
1989.fyear	-0.774***	-0.773***	-0.775***	-0.775***	-0.759***	-0.759***	-0.755***	-0.771***	-0.702***
	(0.0694)	(0.0695)	(0.0694)	(0.0694)	(0.0702)	(0.0705)	(0.0722)	(0.0708)	(0.0738)
1990.fyear	-1.009***	-1.009***	-1.011***	-1.011***	-0.996***	-0.995***	-0.990***	-1.011***	-0.929***
	(0.0725)	(0.0726)	(0.0725)	(0.0725)	(0.0733)	(0.0736)	(0.0759)	(0.0741)	(0.0777)
1991.fyear	-0.712***	-0.711***	-0.712***	-0.711***	-0.700***	-0.701***	-0.693***	-0.716***	-0.620***
	(0.0712)	(0.0713)	(0.0712)	(0.0712)	(0.0717)	(0.0722)	(0.0750)	(0.0726)	(0.0776)
1992.fyear	-0.624***	-0.622***	-0.625***	-0.624***	-0.610***	-0.611***	-0.601***	-0.616***	-0.504***
	(0.0751)	(0.0751)	(0.0750)	(0.0750)	(0.0756)	(0.0764)	(0.0806)	(0.0766)	(0.0847)
1993.fyear	-0.417***	-0.415***	-0.418***	-0.417***	-0.402***	-0.402***	-0.393***	-0.408***	-0.286***
	(0.0719)	(0.0719)	(0.0718)	(0.0718)	(0.0725)	(0.0731)	(0.0778)	(0.0733)	(0.0831)
1994.fyear	-0.492***	-0.491***	-0.495***	-0.494***	-0.477***	-0.476***	-0.468***	-0.479***	-0.351***
	(0.0731)	(0.0731)	(0.0730)	(0.0730)	(0.0736)	(0.0741)	(0.0788)	(0.0741)	(0.0856)
1995.fyear	-0.223**	-0.220**	-0.224**	-0.223**	-0.201**	-0.202**	-0.191*	-0.174*	-0.0436
	(0.0739)	(0.0740)	(0.0739)	(0.0738)	(0.0749)	(0.0756)	(0.0813)	(0.0756)	(0.0912)
1996.fyear	-0.354***	-0.351***	-0.356***	-0.354***	-0.334***	-0.340***	-0.320***	-0.271***	-0.129
	(0.0761)	(0.0761)	(0.0761)	(0.0760)	(0.0768)	(0.0790)	(0.0864)	(0.0810)	(0.102)
1997.fyear	-0.402***	-0.400***	-0.405***	-0.404***	-0.380***	-0.390***	-0.364***	-0.280**	-0.139
	(0.0763)	(0.0764)	(0.0764)	(0.0763)	(0.0774)	(0.0815)	(0.0894)	(0.0874)	(0.111)
1998.fyear	-0.572***	-0.571***	-0.575***	-0.574***	-0.552***	-0.563***	-0.538***	-0.477***	-0.346**
	(0.0785)	(0.0786)	(0.0786)	(0.0785)	(0.0794)	(0.0834)	(0.0891)	(0.0867)	(0.105)
1999.fyear	0.152+	0.154+	0.151+	0.152+	0.181*	0.172*	0.192*	0.246**	0.334***
	(0.0791)	(0.0792)	(0.0792)	(0.0792)	(0.0807)	(0.0835)	(0.0869)	(0.0858)	(0.0957)
2000.fyear	-0.603***	-0.601***	-0.603***	-0.602***	-0.577***	-0.584***	-0.570***	-0.553***	-0.495***
	(0.0811)	(0.0811)	(0.0811)	(0.0811)	(0.0821)	(0.0839)	(0.0851)	(0.0835)	(0.0869)
2001.fyear	-0.776***	-0.774***	-0.776***	-0.775***	-0.750***	-0.763***	-0.743***	-0.689***	-0.675***
	(0.0811)	(0.0812)	(0.0812)	(0.0812)	(0.0818)	(0.0859)	(0.0849)	(0.0877)	(0.0866)
2002.fyear	-1.163***	-1.163***	-1.161***	-1.161***	-1.135***	-1.149***	-1.130***	-1.102***	-1.115***
	(0.0811)	(0.0812)	(0.0811)	(0.0812)	(0.0819)	(0.0854)	(0.0831)	(0.0857)	(0.0829)
2003.fyear	-0.524***	-0.524***	-0.520***	-0.521***	-0.494***	-0.507***	-0.491***	-0.490***	-0.520***
	(0.0782)	(0.0783)	(0.0782)	(0.0783)	(0.0791)	(0.0816)	(0.0793)	(0.0813)	(0.0800)
2004.fyear	-0.590***	-0.587***	-0.583***	-0.583***	-0.558***	-0.566***	-0.560***	-0.600***	-0.630***
	(0.0783)	(0.0784)	(0.0784)	(0.0785)	(0.0791)	(0.0796)	(0.0788)	(0.0813)	(0.0824)
sum_at_a		0.110**		0.0498	0.0490	0.109**		0.110**	
		(0.0410)		(0.0478)	(0.0477)	(0.0408)		(0.0408)	
hjtwt_at_a			0.00683**	0.00533*	0.00539*		0.00693**		0.00695**
			(0.00211)	(0.00240)	(0.00240)		(0.00212)		(0.00214)
adj_frag_g~a					-0.211+	-0.200	-0.220+	-0.264*	-0.273*
					(0.121)	(0.122)	(0.124)	(0.125)	(0.125)
sum_at_~3a_a						0.603		-0.613	
						(0.928)		(0.932)	
hjtwt_a~3a_a							-0.0138		-0.0679*
							(0.0304)		(0.0337)
sum_at_d~4_a								-4.539**	
-1.743									
sum_at~4_a_d								0.879***	
								(0.111)	
hjtwt_at~4_a									-0.178**
									(0.0584)
hjtwt_~4_a_d									1.003***
									(0.0621)
_cons	0.543***	0.537***	0.543***	0.540***	0.692***	0.661***	0.706***	0.888***	0.792***

	(0.0835)	(0.0836)	(0.0836)	(0.0835)	(0.121)	(0.127)	(0.123)	(0.178)	(0.140)
N	23424	23424	23424	23424	23424	23424	23424	23424	23424
R-sq	0.139	0.140	0.140	0.140	0.140	0.140	0.140	0.141	0.141
adj. R-sq	0.138	0.138	0.139	0.139	0.139	0.139	0.139	0.139	0.140
F	112.1	108.5	110.0	106.7	104.3	103.0	104.5	.	.

Standard errors in parentheses
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

8T Only patenting Firms, Dataset A

	-1	-2	-3	-4	-5	-6	-7	-8	-9
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
xrd_at	0.0532***	0.0436***	0.0488***	0.0438***	0.0440***	0.0437***	0.0480***	0.0436***	0.0483***
	(0.0111)	(0.0116)	(0.0113)	(0.0115)	(0.0115)	(0.0115)	(0.0113)	(0.0115)	(0.0113)
ebit_at	0.00343	0.00651	0.00756	0.00798	0.00803	0.00578	0.00675	0.00592	0.00687
	(0.0294)	(0.0305)	(0.0302)	(0.0306)	(0.0306)	(0.0304)	(0.0303)	(0.0304)	(0.0303)
ppent_at	-0.501***	-0.502***	-0.505***	-0.504***	-0.508***	-0.501***	-0.506***	-0.499***	-0.504***
	(0.0737)	(0.0738)	(0.0738)	(0.0738)	(0.0736)	(0.0739)	(0.0736)	(0.0731)	(0.0730)
sale_at	0.00528***	0.00537***	0.00523***	0.00532***	0.00533***	0.00542***	0.00531***	0.00542***	0.00528***
	(0.000937)	(0.000962)	(0.000964)	(0.000970)	(0.000969)	(0.000958)	(0.000958)	(0.000959)	(0.000960)
mshare_gind	-0.000896	-0.000848	-0.000792	-0.000803	-0.00107	-0.000670	-0.000835	-0.000714	-0.000868
	(0.00219)	(0.00219)	(0.00218)	(0.00218)	(0.00221)	(0.00226)	(0.00222)	(0.00226)	(0.00223)
hhi_gind	0.00000278	0.00000306	0.00000252	0.00000284	-0.00000666	-0.0000132	-0.0000119	-0.0000115	-0.00000974
	(0.0000139)	(0.0000139)	(0.0000139)	(0.0000139)	(0.0000143)	(0.0000144)	(0.0000143)	(0.0000146)	(0.0000144)
0b.size	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1.size	0.0652**	0.0644**	0.0601**	0.0618**	0.0605**	0.0662**	0.0633**	0.0665**	0.0642**
	(0.0221)	(0.0220)	(0.0220)	(0.0220)	(0.0220)	(0.0220)	(0.0218)	(0.0220)	(0.0219)
2.size	0.150***	0.148***	0.139***	0.142***	0.141***	0.149***	0.144***	0.150***	0.144***
	(0.0401)	(0.0401)	(0.0402)	(0.0402)	(0.0402)	(0.0401)	(0.0399)	(0.0401)	(0.0400)
3.size	0.105	0.0844	0.0892	0.0812	0.0800	0.0854	0.0929	0.0858	0.0929
	(0.0728)	(0.0730)	(0.0731)	(0.0731)	(0.0730)	(0.0730)	(0.0732)	(0.0730)	(0.0732)
emp_m_0_d_4	-0.0225	-0.0209	-0.0206	-0.0203	-0.0208	-0.0201	-0.0212	-0.0198	-0.0213
	(0.0341)	(0.0340)	(0.0341)	(0.0341)	(0.0341)	(0.0341)	(0.0343)	(0.0341)	(0.0343)
1980b.fyear	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.0784***	-0.0793***	-0.0787***	-0.0792***	-0.0788***	-0.0785***	-0.0776***	-0.0789***	-0.0786***
	(0.0145)	(0.0145)	(0.0145)	(0.0145)	(0.0145)	(0.0145)	(0.0144)	(0.0145)	(0.0145)
1982.fyear	0.00486	0.00515	0.00479	0.00502	0.00619	0.00629	0.00733	0.00602	0.00588
	(0.0177)	(0.0177)	(0.0177)	(0.0177)	(0.0177)	(0.0177)	(0.0177)	(0.0177)	(0.0178)
1983.fyear	0.187***	0.189***	0.189***	0.189***	0.191***	0.185***	0.190***	0.186***	0.190***
	(0.0202)	(0.0201)	(0.0201)	(0.0201)	(0.0201)	(0.0201)	(0.0201)	(0.0202)	(0.0201)
1984.fyear	-0.0273	-0.0249	-0.0263	-0.0250	-0.0243	-0.0315	-0.0242	-0.0301	-0.0249
	(0.0213)	(0.0213)	(0.0213)	(0.0213)	(0.0212)	(0.0213)	(0.0212)	(0.0215)	(0.0212)
1985.fyear	0.0224	0.0255	0.0241	0.0255	0.0263	0.0129	0.0261	0.0154	0.0259
	(0.0225)	(0.0224)	(0.0224)	(0.0224)	(0.0224)	(0.0225)	(0.0223)	(0.0231)	(0.0223)
1986.fyear	0.00462	0.00768	0.00537	0.00725	0.00912	-0.00986	0.00671	-0.00603	0.00702

	(0.0241)	(0.0241)	(0.0241)	(0.0241)	(0.0241)	(0.0245)	(0.0240)	(0.0257)	(0.0240)
1987.fyear	-0.145***	-0.142***	-0.144***	-0.143***	-0.141***	-0.163***	-0.143***	-0.158***	-0.142***
	(0.0244)	(0.0244)	(0.0243)	(0.0243)	(0.0243)	(0.0249)	(0.0242)	(0.0267)	(0.0243)
1988.fyear	-0.191***	-0.188***	-0.191***	-0.189***	-0.186***	-0.208***	-0.187***	-0.202***	-0.185***
	(0.0253)	(0.0253)	(0.0253)	(0.0253)	(0.0252)	(0.0259)	(0.0252)	(0.0281)	(0.0252)
1989.fyear	-0.193***	-0.191***	-0.194***	-0.192***	-0.189***	-0.208***	-0.186***	-0.203***	-0.186***
	(0.0265)	(0.0265)	(0.0264)	(0.0264)	(0.0264)	(0.0267)	(0.0263)	(0.0286)	(0.0263)
1990.fyear	-0.356***	-0.353***	-0.357***	-0.354***	-0.352***	-0.371***	-0.348***	-0.365***	-0.348***
	(0.0275)	(0.0274)	(0.0274)	(0.0274)	(0.0274)	(0.0277)	(0.0273)	(0.0295)	(0.0273)
1991.fyear	-0.116***	-0.112***	-0.115***	-0.113***	-0.111***	-0.131***	-0.107***	-0.126***	-0.107***
	(0.0276)	(0.0275)	(0.0275)	(0.0275)	(0.0274)	(0.0278)	(0.0273)	(0.0297)	(0.0273)
1992.fyear	-0.114***	-0.110***	-0.113***	-0.110***	-0.108***	-0.131***	-0.106***	-0.125***	-0.104***
	(0.0269)	(0.0268)	(0.0268)	(0.0268)	(0.0267)	(0.0273)	(0.0266)	(0.0299)	(0.0267)
1993.fyear	-0.0247	-0.0202	-0.0240	-0.0211	-0.0187	-0.0408	-0.0148	-0.0344	-0.0138
	(0.0268)	(0.0268)	(0.0268)	(0.0268)	(0.0267)	(0.0273)	(0.0266)	(0.0299)	(0.0266)
1994.fyear	-0.124***	-0.120***	-0.124***	-0.121***	-0.118***	-0.139***	-0.115***	-0.133***	-0.114***
	(0.0271)	(0.0270)	(0.0270)	(0.0270)	(0.0269)	(0.0275)	(0.0269)	(0.0299)	(0.0269)
1995.fyear	0.0414	0.0448	0.0412	0.0437	0.0478+	0.0341	0.0544+	0.0391	0.0525+
	(0.0278)	(0.0277)	(0.0277)	(0.0277)	(0.0277)	(0.0279)	(0.0278)	(0.0294)	(0.0277)
1996.fyear	0.0132	0.0164	0.0128	0.0153	0.0189	0.00874	0.0298	0.0130	0.0261
	(0.0287)	(0.0286)	(0.0286)	(0.0286)	(0.0286)	(0.0287)	(0.0287)	(0.0300)	(0.0287)
1997.fyear	0.0274	0.0304	0.0272	0.0295	0.0343	0.0308	0.0490+	0.0338	0.0434
	(0.0291)	(0.0291)	(0.0291)	(0.0291)	(0.0291)	(0.0291)	(0.0293)	(0.0297)	(0.0294)
1998.fyear	-0.140***	-0.137***	-0.140***	-0.138***	-0.134***	-0.141***	-0.124***	-0.137***	-0.128***
	(0.0309)	(0.0308)	(0.0308)	(0.0308)	(0.0308)	(0.0308)	(0.0308)	(0.0319)	(0.0308)
1999.fyear	0.132***	0.134***	0.133***	0.134***	0.139***	0.126***	0.141***	0.130***	0.141***
	(0.0322)	(0.0321)	(0.0321)	(0.0321)	(0.0321)	(0.0323)	(0.0321)	(0.0335)	(0.0320)
2000.fyear	-0.195***	-0.193***	-0.192***	-0.192***	-0.190***	-0.212***	-0.197***	-0.206***	-0.193***
	(0.0331)	(0.0330)	(0.0330)	(0.0330)	(0.0329)	(0.0333)	(0.0330)	(0.0352)	(0.0331)
2001.fyear	-0.284***	-0.282***	-0.281***	-0.281***	-0.280***	-0.295***	-0.289***	-0.290***	-0.284***
	(0.0328)	(0.0328)	(0.0327)	(0.0327)	(0.0327)	(0.0328)	(0.0328)	(0.0341)	(0.0331)
2002.fyear	-0.618***	-0.616***	-0.613***	-0.613***	-0.612***	-0.631***	-0.628***	-0.625***	-0.619***
	(0.0335)	(0.0334)	(0.0334)	(0.0334)	(0.0333)	(0.0335)	(0.0338)	(0.0353)	(0.0345)
2003.fyear	-0.172***	-0.170***	-0.165***	-0.166***	-0.164***	-0.191***	-0.187***	-0.184***	-0.174***
	(0.0316)	(0.0316)	(0.0315)	(0.0315)	(0.0315)	(0.0320)	(0.0324)	(0.0347)	(0.0338)
2004.fyear	-0.186***	-0.181***	-0.177***	-0.177***	-0.177***	-0.217***	-0.207***	-0.207***	-0.191***
	(0.0325)	(0.0325)	(0.0325)	(0.0325)	(0.0324)	(0.0336)	(0.0340)	(0.0379)	(0.0362)
sum_at_a		0.0870***		0.0627*	0.0624*	0.0888***		0.0889***	
		(0.0236)		(0.0281)	(0.0280)	(0.0236)		(0.0236)	
hjtwt_at_a			0.00490***	0.00277+	0.00281+		0.00518***		0.00520***
			(0.00130)	(0.00161)	(0.00161)		(0.00131)		(0.00131)
adj_frag_g~a					-0.186*	-0.218*	-0.217*	-0.219**	-0.218**
					(0.0835)	(0.0849)	(0.0844)	(0.0844)	(0.0840)
sum_at_~3a_a						-1.627***		-1.642***	
						(0.409)		(0.409)	
hjtwt_a~3a_a							-0.0520**		-0.0548***
							(0.0162)		(0.0162)
sum_at_d~4_a								0.452	
								(0.744)	
sum_at~4_a_d								-0.298	
								(0.399)	
hjtwt_at~4_a									0.0404
									(0.0273)
hjtwt_~4_a_d									-0.285
									(0.387)
_cons	0.525***	0.517***	0.520***	0.516***	0.679***	0.794***	0.750***	0.791***	0.742***
	(0.0376)	(0.0376)	(0.0375)	(0.0375)	(0.0797)	(0.0854)	(0.0824)	(0.0951)	(0.0874)
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N	45963	45963	45963	45963	45963	45963	45963	45963	45963
R-sq	0.081	0.082	0.082	0.083	0.083	0.084	0.083	0.084	0.084
adj. R-sq	0.080	0.082	0.081	0.082	0.082	0.083	0.083	0.083	0.083

F	88.21	85.42	86.17	83.56	81.41	82.60	82.80	78.55	78.80

Standard errors in parentheses
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

8U Drop Small Industries, Dataset A

	-1	-2	-3	-4	-5	-6	-7	-8	-9
	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq	ln_tobinq
xrd_at	0.0489***	0.0451***	0.0467***	0.0450***	0.0452***	0.0455***	0.0466***	0.0455***	0.0469***
	(0.00630)	(0.00638)	(0.00633)	(0.00638)	(0.00637)	(0.00636)	(0.00634)	(0.00636)	(0.00633)
ebit_at	-0.00150***	-0.00152***	-0.00151***	-0.00152***	-0.00152***	-0.00152***	-0.00152***	-0.00152***	-0.00153***
	(0.000245)	(0.000246)	(0.000245)	(0.000245)	(0.000246)	(0.000245)	(0.000245)	(0.000245)	(0.000244)
ppent_at	-0.468***	-0.473***	-0.473***	-0.475***	-0.477***	-0.472***	-0.474***	-0.473***	-0.475***
	(0.0530)	(0.0530)	(0.0530)	(0.0530)	(0.0530)	(0.0532)	(0.0530)	(0.0532)	(0.0531)
sale_at	0.00721*	0.00725*	0.00721*	0.00724*	0.00722*	0.00727*	0.00724*	0.00728*	0.00725*
	(0.00312)	(0.00310)	(0.00311)	(0.00310)	(0.00311)	(0.00311)	(0.00312)	(0.00311)	(0.00312)
mshare_gind	-0.00267	-0.00258	-0.00255	-0.00254	-0.00308	-0.00292	-0.00301	-0.00297	-0.00311
	(0.00284)	(0.00284)	(0.00284)	(0.00284)	(0.00287)	(0.00290)	(0.00287)	(0.00290)	(0.00288)
hhi_gind	-0.0000218+	-0.0000220+	-0.0000224+	-0.0000223+	-0.0000270*	-0.0000292*	-0.0000280*	-0.0000264*	-0.0000230*
	(0.0000116)	(0.0000116)	(0.0000115)	(0.0000115)	(0.0000116)	(0.0000116)	(0.0000116)	(0.0000118)	(0.0000117)
0b.size	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1.size	0.0691***	0.0682***	0.0658***	0.0665***	0.0662***	0.0700***	0.0678***	0.0700***	0.0684***
	(0.0170)	(0.0169)	(0.0169)	(0.0169)	(0.0169)	(0.0169)	(0.0168)	(0.0169)	(0.0169)
2.size	0.142***	0.140***	0.136***	0.137***	0.136***	0.142***	0.138***	0.142***	0.138***
	(0.0279)	(0.0279)	(0.0279)	(0.0279)	(0.0279)	(0.0279)	(0.0278)	(0.0279)	(0.0278)
3.size	0.124**	0.117*	0.117*	0.115*	0.114*	0.119*	0.118*	0.118*	0.118*
	(0.0461)	(0.0462)	(0.0462)	(0.0462)	(0.0462)	(0.0463)	(0.0463)	(0.0463)	(0.0462)
emp_m_0_d_4	-0.0311	-0.0306	-0.0303	-0.0303	-0.0312	-0.0312	-0.0312	-0.0310	-0.0310
	(0.0236)	(0.0236)	(0.0236)	(0.0236)	(0.0236)	(0.0236)	(0.0236)	(0.0236)	(0.0237)
1980b.fyear	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1981.fyear	-0.0884***	-0.0889***	-0.0885***	-0.0888***	-0.0888***	-0.0888***	-0.0880***	-0.0891***	-0.0894***
	(0.0130)	(0.0130)	(0.0130)	(0.0130)	(0.0130)	(0.0130)	(0.0130)	(0.0130)	(0.0130)
1982.fyear	-0.0167	-0.0164	-0.0167	-0.0165	-0.0154	-0.0167	-0.0151	-0.0165	-0.0166
	(0.0159)	(0.0159)	(0.0158)	(0.0158)	(0.0158)	(0.0158)	(0.0158)	(0.0158)	(0.0158)
1983.fyear	0.178***	0.179***	0.179***	0.180***	0.182***	0.175***	0.181***	0.178***	0.181***
	(0.0179)	(0.0179)	(0.0179)	(0.0179)	(0.0179)	(0.0179)	(0.0179)	(0.0180)	(0.0179)
1984.fyear	-0.0349+	-0.0335+	-0.0344+	-0.0336+	-0.0321+	-0.0386*	-0.0321+	-0.0359+	-0.0317+
	(0.0190)	(0.0190)	(0.0190)	(0.0189)	(0.0189)	(0.0190)	(0.0189)	(0.0192)	(0.0189)
1985.fyear	0.0204	0.0224	0.0214	0.0223	0.0233	0.0118	0.0226	0.0158	0.0239
	(0.0200)	(0.0200)	(0.0200)	(0.0200)	(0.0200)	(0.0201)	(0.0199)	(0.0206)	(0.0199)
1986.fyear	0.0169	0.0188	0.0174	0.0185	0.0215	0.00553	0.0198	0.0112	0.0220
	(0.0212)	(0.0212)	(0.0212)	(0.0212)	(0.0212)	(0.0215)	(0.0212)	(0.0225)	(0.0212)
1987.fyear	-0.150***	-0.148***	-0.150***	-0.149***	-0.147***	-0.166***	-0.149***	-0.159***	-0.146***
	(0.0214)	(0.0214)	(0.0214)	(0.0214)	(0.0214)	(0.0219)	(0.0213)	(0.0233)	(0.0214)
1988.fyear	-0.196***	-0.194***	-0.196***	-0.195***	-0.191***	-0.209***	-0.192***	-0.202***	-0.188***
	(0.0221)	(0.0221)	(0.0221)	(0.0221)	(0.0221)	(0.0226)	(0.0221)	(0.0242)	(0.0221)

1989.fyear	-0.221***	-0.219***	-0.221***	-0.220***	-0.217***	-0.233***	-0.216***	-0.226***	-0.214***
	(0.0231)	(0.0231)	(0.0231)	(0.0231)	(0.0231)	(0.0232)	(0.0230)	(0.0245)	(0.0230)
1990.fyear	-0.406***	-0.405***	-0.407***	-0.406***	-0.403***	-0.418***	-0.401***	-0.412***	-0.401***
	(0.0243)	(0.0243)	(0.0243)	(0.0243)	(0.0242)	(0.0244)	(0.0242)	(0.0256)	(0.0242)
1991.fyear	-0.178***	-0.175***	-0.177***	-0.176***	-0.175***	-0.191***	-0.172***	-0.184***	-0.172***
	(0.0248)	(0.0248)	(0.0247)	(0.0248)	(0.0247)	(0.0249)	(0.0247)	(0.0261)	(0.0247)
1992.fyear	-0.136***	-0.134***	-0.135***	-0.134***	-0.134***	-0.153***	-0.133***	-0.146***	-0.132***
	(0.0242)	(0.0241)	(0.0241)	(0.0241)	(0.0241)	(0.0244)	(0.0240)	(0.0260)	(0.0240)
1993.fyear	-0.0587*	-0.0560*	-0.0583*	-0.0566*	-0.0551*	-0.0732**	-0.0530*	-0.0659*	-0.0527*
	(0.0239)	(0.0238)	(0.0238)	(0.0238)	(0.0238)	(0.0242)	(0.0237)	(0.0258)	(0.0237)
1994.fyear	-0.181***	-0.179***	-0.181***	-0.179***	-0.176***	-0.194***	-0.175***	-0.186***	-0.175***
	(0.0241)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0244)	(0.0240)	(0.0259)	(0.0240)
1995.fyear	-0.0436+	-0.0417+	-0.0436+	-0.0423+	-0.0364	-0.0482+	-0.0324	-0.0427+	-0.0366
	(0.0248)	(0.0248)	(0.0248)	(0.0247)	(0.0248)	(0.0249)	(0.0248)	(0.0258)	(0.0249)
1996.fyear	-0.0627*	-0.0608*	-0.0627*	-0.0614*	-0.0538*	-0.0620*	-0.0463+	-0.0577*	-0.0532*
	(0.0255)	(0.0255)	(0.0255)	(0.0254)	(0.0255)	(0.0256)	(0.0257)	(0.0263)	(0.0257)
1997.fyear	-0.0804**	-0.0787**	-0.0805**	-0.0793**	-0.0707**	-0.0742**	-0.0611*	-0.0715**	-0.0708**
	(0.0260)	(0.0260)	(0.0260)	(0.0260)	(0.0260)	(0.0260)	(0.0263)	(0.0264)	(0.0265)
1998.fyear	-0.242***	-0.241***	-0.242***	-0.241***	-0.233***	-0.239***	-0.226***	-0.235***	-0.232***
	(0.0271)	(0.0271)	(0.0271)	(0.0271)	(0.0271)	(0.0271)	(0.0272)	(0.0278)	(0.0273)
1999.fyear	-0.00223	-0.00117	-0.00172	-0.00120	0.00836	-0.00170	0.0110	0.00291	0.00965
	(0.0279)	(0.0279)	(0.0279)	(0.0279)	(0.0280)	(0.0281)	(0.0280)	(0.0289)	(0.0280)
2000.fyear	-0.361***	-0.360***	-0.360***	-0.360***	-0.354***	-0.369***	-0.356***	-0.363***	-0.351***
	(0.0288)	(0.0288)	(0.0288)	(0.0288)	(0.0287)	(0.0290)	(0.0287)	(0.0302)	(0.0289)
2001.fyear	-0.423***	-0.421***	-0.420***	-0.420***	-0.416***	-0.426***	-0.420***	-0.421***	-0.412***
	(0.0287)	(0.0287)	(0.0287)	(0.0287)	(0.0286)	(0.0287)	(0.0287)	(0.0295)	(0.0288)
2002.fyear	-0.680***	-0.679***	-0.677***	-0.678***	-0.673***	-0.686***	-0.681***	-0.680***	-0.667***
	(0.0291)	(0.0290)	(0.0290)	(0.0290)	(0.0290)	(0.0291)	(0.0292)	(0.0303)	(0.0297)
2003.fyear	-0.248***	-0.247***	-0.244***	-0.245***	-0.239***	-0.260***	-0.252***	-0.251***	-0.233***
	(0.0277)	(0.0277)	(0.0277)	(0.0277)	(0.0276)	(0.0280)	(0.0281)	(0.0299)	(0.0291)
2004.fyear	-0.235***	-0.233***	-0.230***	-0.230***	-0.227***	-0.258***	-0.244***	-0.246***	-0.220***
	(0.0281)	(0.0281)	(0.0281)	(0.0281)	(0.0280)	(0.0289)	(0.0289)	(0.0321)	(0.0305)
sum_at_a		0.0805***		0.0558+	0.0556+	0.0823***		0.0824***	
		(0.0238)		(0.0292)	(0.0292)	(0.0239)		(0.0239)	
hjtwt_at_a			0.00459***	0.00267+	0.00269+		0.00483***		0.00487***
			(0.00125)	(0.00162)	(0.00162)		(0.00126)		(0.00126)
adj_frag_g~a					-0.177***	-0.193***	-0.189***	-0.193***	-0.189***
					(0.0512)	(0.0515)	(0.0515)	(0.0515)	(0.0514)
sum_at_~3a_a						-1.625***		-1.633***	
						(0.407)		(0.407)	
hjtwt_a~3a_a							-0.0402*		-0.0455**
							(0.0161)		(0.0161)
sum_at_d~4_a								0.670	
								(0.724)	
sum_at~4_a_d								0.949***	
								(0.0527)	
hjtwt_at~4_a									0.0701**
									(0.0252)
hjtwt_~4_a_d									0.900***
									(0.0352)
_cons	0.533***	0.530***	0.531***	0.530***	0.668***	0.742***	0.699***	0.673***	0.622***
	(0.0297)	(0.0297)	(0.0297)	(0.0297)	(0.0487)	(0.0522)	(0.0503)	(0.0598)	(0.0524)
N	76238	76238	76238	76238	76238	76238	76238	76238	76238
R-sq	0.077	0.077	0.077	0.078	0.078	0.079	0.078	0.079	0.079
adj. R-sq	0.076	0.077	0.077	0.077	0.078	0.078	0.078	0.078	0.078
F	115.0	111.6	112.2	108.9	106.4	107.1	107.0	.	.

Standard errors in parentheses
+ $p<0.10$, * $p<0.05$ ** $p<0.01$ *** $p<0.001$