ABSTRACT

Title of Document: POKES, PRODS, AND PUSHES: INFORMATION AVAILABILITY AND DECISION MAKING IN AMBIGUOUS ENVIRONMENTS

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In this dissertation I investigate how changes in the availability of information influences decision making in inherently ambiguous environments. As the Internet has not only fostered connectivity, but also catalyzed information generation on an unprecedented scale, my objective is to revisit the concept of information availability and salience in the digital age. I conduct my empirical analysis in the contexts of entrepreneurship and healthcare, which are significant both theoretically as well as in terms of economic and public welfare. In essay one, I examine how rising perceptions of fashion, viz., increased media coverage and herding, influence the willingness of venture capitalists to fund non-co-located entrepreneurs. This essay contributes to extant theory on entrepreneur-VC co-location by identifying the effect that social trends, as opposed to factors

which are native only to the focal entrepreneur, can have on the willingness to venture capitalists to fund non-co-located entrepreneurs. In essay two, I explore the interplay between the broadcast and social media, as well as the ability of these media to incentivize firm formation on the part of nascent entrepreneurs. Applying the lens of agenda setting theory I demonstrate that the social media will moderate the impact of the broadcast media when entrepreneurs and financiers seek to found and fund new ventures. This study augments existing literature by considering not only the intensity of non-novel information, but also how participation will impact decision making. The third essay investigates a persistent puzzle in the medical literature: how different physicians react to medical guideline release (i.e. the release of new and novel information) which call into question the efficacy of long standing treatment options. Situating this essay within two theoretical tensions in the literature, the trade-off between agility and routines and the debate between costless and costly information assimilation, I find that while physicians are discerning in their reaction to new information their reactions are not quick, creating significant public welfare deficits. Moreover, I find that physician characteristics, such as tenure, board certification, and freelancer status, significantly moderate physician response to new guidelines. Taken together these essays contribute to the literature on Information Systems and Strategic Management by augmenting understanding of the construct of information availability, and how it affects decision makers in ambiguous environments.

POKES, PRODS, AND PUSHES: INFORMATION AVAILABILITY AND DECISION MAKING IN AMBIGUOUS ENVIRONMENTS

By

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Dedication

For Allan N. Greenwood and William G. Fennell
Two remarkable men who taught me remarkably different things

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CHAPTER 1: OVERVIEW

"Between the birth of the world and 2003, there were five exabytes of information created. We [now] create five exabytes every two days. See why it's so painful to operate in information markets?" - *Eric Schmidt, CEO, Google*

Precipitated by the unprecedented increase in interconnectivity afforded by the internet, business has undergone a striking transformation in the past two decades (Malone et al. 1987). Unsurprisingly, a substantial body of research has examined a variety of changes wrought by the Internet, such as the demise of the print newspaper industry (Greer and Mensing 2006), the ability of firms to outsource large portions of their operations (Gopal et al. 2002), and the recent digital transformation of healthcare (Agarwal et al. 2010). In this dissertation I focus on a significant phenomenon that is a direct outcome of the connectivity afforded by the Internet: the explosion in the availability of information and its influence on strategic decision making in inherently ambiguous environments. While investigations of information availability are not new, and have a rich tradition in both the psychology (Tversky and Kahneman 1973) and management (Pollock et al. 2008) literatures, a key recent distinctive characteristic is the sheer volume of information available to decision makers. The remarkable increase in the quantity and variety of information today, simply by virtue of its scale, necessitates fresh conceptualizations of information availability and salience. The broad objective of this dissertation, therefore, is to revisit the concept of information availability, and determine how individuals react to the information emanating from their environment in the digital age.

This dissertation is comprised of three distinct studies, each focused on a different actor facing a strategic decision, and a different form of information availability. The unifying theme that binds the essays is that the focus is on the decision maker's response, in the presence of Knightian uncertainty (1921), to increases in the availability of information. In this chapter, I discuss the broad themes in the literature associated with information availability as well as its influence on decision making under uncertainty that inform my work.

1.1 Information Availability

Extant literature in the disciplines of sociology, psychology, and management provides two broad perspectives on how the availability of information will influence decision making under uncertainty. First, research suggests that decisions may be influenced as a result of the legitimacy associated with information, through tacit or explicit endorsement by the information provider (DiMaggio and Powell 1983). Second, invocation of the availability heuristic due to the increased salience of the topic at hand (Tversky and Kahneman 1973) can influence the degree to which the information will affect the decision maker's judgment.

The perspective of increased legitimacy suggests that, when information providers increase their discussion of topics, acting in a concordant manner will increase the legitimacy of the firm or decision maker (DiMaggio and Powell 1983). Theoretically, this can occur for many reasons (Abrahamson 1996, Deephouse 1996, Pollock and Rindova 2003, Stuart et al. 1999), and both the practitioner press and academic literatures are rife with anecdotal examples of this

behavior. Consider, for illustrative purposes, the internet boom of the late 1990s and early 2000s (Gompers and Lerner 1999) or the disk drive boom of the 1980s (Agarwal et al. 2004). While it was patently evident at that time that market entry was associated with staggering profitability, the economic rationale for such beliefs had not been clearly established (Baskerville and Myers 2009). One is forced to ask the question, therefore: why did herding, on such a monumental scale, occur? The answer many scholars have proposed, viz. Abrahamson (1997) and Gompers (1996), is that increased discussion and rhetoric surrounding topics, increases their perceived valuation. This increased perceived value, however, is temporary and often uncorrelated with the underlying quality of the investment (Gompers and Lerner 2000) leading to inevitable, and sometimes cataclysmic, market corrections when the underlying values of investments are uncovered, and severe market penalties for those who attempted to capitalize on the behavior of the herd (Abrahamson and Rosenkopf 1993, Low and Abrahamson 1997).

An alternative to the mechanism of legitimacy is one of increased salience, which has an equally deep tradition in the field of social psychology. Scholars in this line of work have argued that increases in the salience of various topics, stimulated by information release, causes decision makers to invoke the availability heuristic (Tversky and Kahneman 1973) thereby biasing their estimates of the probability of an event occurring. As with the discussion of legitimacy, anecdotal evidence of the effects of increased salience exists in the academic literature and in the popular press. During the fall of 2002, for example, John Allen Muhammad (more commonly known as the Beltway Sniper), and

accomplice Lee Malvo, killed 11 people in the greater Washington DC Metro area over a three week period. The events, while tragic, had a much greater effect on individual behavior than expected as a result of the explosion of media coverage (Schmid 2005, Sunstein 2003). DC residents began ducking behind their vehicles while at filling stations, cancelling school recesses, and weaving though the parking lots of malls and shopping centers not only in Washington but also hundreds of miles away (AssociatedPress 2002). The impetus for this change in behavior was the drastic increase in the salience of gun violence during the time of the attacks. As a result, individuals began to ignore the actual probability of being a victim of an attack (Tversky and Kahneman 1973) not recognizing that it was far more dangerous to perform standard tasks (such as driving an automobile) during the same period. Further examples of the adverse consequences of information salience include national aversion to drinking water after then President Carter declared a public health emergency in Love Canal, NY (Kuran and Sunstein 1999), public aversion to air travel after the attacks of September 11th (Schmid 2005), and others. Examples need not be negative however. Berkshire Hathaway, the conglomerate American holding company, often receives temporary increases in stock price when actress Anne Hathaway receives large amounts of media attention (Crabtree 2011).

1.2 Dissertation Overview

Against the backdrop of the drastic effects that increases in information can have on decision making, the objective of this dissertation is to investigate the phenomenon of information availability as it relates to decision making under

uncertainty within a business context. While the theoretical underpinnings of this work are not new, I augment prior work by considering the impact of information availability in the digital age, where explosions of information are not only commonplace, but occur with regularity. Moreover, while the theoretical phenomena discussed above are well-established in the experimental, theoretical, and analytical literature, limited academic work has been devoted to moving these concepts into large scale, secondary data contexts. The cumulative economic effects of these increases in information, therefore, have been relatively understudied; notably in contexts where the agent is required to make real time trade-offs when making decisions.

In the first study, I investigate how changes in the amount of extant discussion on various IT industrial sectors will influence the decision making of venture capitalists, as well as their willingness to overcome co-location barriers during the funding process. While the literature on VC decision making has explicated the importance of co-location during the funding process (Gompers and Lerner 1999), citing its ability to create knowledge spill-overs (Alcácer and Chung 2007) and grant the VC access to tacit information through overlapping social networks (Sorenson and Stuart 2001), limited attention has been devoted to examining methodologies by which the co-location constraint can be overcome. In this study I argue that the increases in media rhetoric (Abrahamson 1997) and herding behavior (Gompers and Lerner 2000) will increase the venture capitalist's perceived value of entrepreneurs operating in "fashionable" market spaces (Abrahamson 1996). I further augment this line of reasoning by demonstrating

that this increased perceived valuation has a negative moderating effect the importance of co-location, i.e. the increase in fashion influences VCs operating in non-co-located contexts to a much greater degree than those in co-located contexts. This essay contributes to extant theory on entrepreneur-VC co-location by identifying the effect that social trends, as opposed to factors which are native only to the focal entrepreneur, can have on the willingness to venture capitalists to fund non-co-located entrepreneurs.

In the second study, I investigate how dramatic increases in discussion can impact the willingness of IT entrepreneurs to found firms. The second essay builds on and augments the first study by considering not simply the increase in the amount of discourse, but also the source of the discourse. Adopting a lens of agenda setting theory (McCombs and Shaw 1972) I argue that increases in the discussion of industries within the broadcast media (i.e. newspapers) will increase the salience of topics in the mind of entrepreneurs. I find, however, that the unidirectional effect of the broadcast media is insufficient to incentivize action on the part of the entrepreneur. Rather, results indicate that increases in broadcast media coverage stimulate increases in social media discussion, and that the social media mediates the relationship between the increases in broadcast media coverage and firm founding. This essay makes three contributions to the extant literature. First, while the effect of the traditional print media has been well explored in business contexts (Pfarrer et al. 2010, Pollock and Rindova 2003, Pollock et al. 2008), the effect of the newly created social media has received limited attention. Second, while the influence media has on decision making later

on in a firm's life-cycle has been well explored, the focus of this essay is on the very formation of *de novo* enterprises. Third, and importantly, this essay is the first empirical investigation of the interplay between broadcast and social media. While extant literature has investigated many questions about these two media independently, how these two media work in conjunction to influence decision making is a question which to date has yet to be investigated.

In the third study, I investigate how novel information, through medical guideline release, changes the behavior of physician decision makers. Building upon the unifying theme of information availability, the essay is distinctive from the first two studies in that it considers not simply the volume of information, but also its novelty. Situating this essay within two theoretical tensions in the literature, i.e. the trade-off between agility (Mitchell 1989, 1991) and routines (Nelson and Winter 1982) and the debate between costless (Muth 1961) and costly (Reyna and Brainerd 1991) information assimilation, I pose the following questions: What is the nature and speed of physician response to information shocks in the form of a new medical guideline? Are physicians discerning in their application of medical guidelines? And, is physician response moderated by physician characteristic? To investigate these questions I make use of an exogenous shock to extant medical knowledge, the release of an updated guideline for the utilization of coronary stents by the American Heart Association and the American College of Cardiology. Results are four-fold and shed significant light on the theoretical tensions which motivate the study. First, I find evidence of incumbent inertia. While physicians do react to medical guidelines

their response is not swift, creating significant public welfare deficits. Second, results indicate that physicians are discerning in their reaction to guideline release, suggesting that information assimilation in intensive environments is not necessarily costly for expert decision makers. Third, results indicate that more highly trained physicians, i.e. those who are board certified in cardiology, react faster to guideline release. Moreover, findings indicate that board certified physicians of longer tenure react even faster than the marginal board certified physician, indicating that experience and training are key assets which influence the speed with which new information is incorporated into decision making rubrics. Fourth, and finally, results indicate that physicians with superior financial incentives not to respond do not appear to be swayed by them. In sum, these finding significantly augment the extant work on expert decision making under uncertainty by exploring the nature and speed of physician response to new information. Moreover, this work underscores the public welfare implications which result from the unwillingness of decision makers to respond to new information in a medical context.

1.3 Concluding Remarks

This dissertation is motivated by the need to extend theoretical and practical understanding of the effects of the remarkable increase in information availability we are witnessing in the digital age on decision making. While prior research has studied the effect of changes in the amount of information on decision making, a key contribution of my work is to extend empirical work beyond the laboratory context to the analysis of large scale secondary data sets.

By reexamining prior findings in two distinct contexts, entrepreneurship and healthcare, where uncertainty is the norm rather than the exception, I am able not only to examine the real time trade-offs which decision makers must make when reacting to newly available information, but also economically quantify the effects from a public welfare perspective. The dissertation offers novel insights into the relationship between information availability and decision making, while simultaneously highlighting the need for further work. There are robust opportunities for future work to study how the source, format, veracity, tenor, and plausibility of information affect decision making in uncertain environments.

CHAPTER 2: O' FASHION WHERE ART THOU: OVERCOMING VENTURE CAPITALIST CO-LOCATION BARRIERS

ABSTRACT

The benefit co-location provides to nascent entrepreneurs has been an important research topic in the management and entrepreneurship literatures for many years. However, relatively little scholarly work has been done examining how venture capitalists may be influenced to fund non-co-located entrepreneurs. In this work we examine how broader social trends in the form of fashions, which are not specific to the entrepreneur, may influence venture capitalists to cross geographic boundaries when making investments. Using a matched sample methodology, our results suggest that the influence of increased fashionability, in the form of media coverage and herding, is significantly stronger for venture capitalists considering funding non-co-located, as opposed to co-located, entrepreneurs. Theoretical and practical implications are discussed within.

2.1 Introduction

How does entrepreneur location influence the decision making of venture capitalists? To date, the intersection of geography and entrepreneurship has been an important topic in the strategic management, entrepreneurship, and economics literatures (Agarwal et al. 2007, Agarwal and Gort 1996, Bresnahan et al. 2001, Klepper 2007, Porter 2000). Moreover, a persistent finding of this work is that *de novo* entrepreneurial entrants are far more likely to receive venture capital (VC) financing if they are co-located with their financiers (Gompers and Lerner 1999, Sorenson and Stuart 2001). Extant literature espouses many benefits which

emanate from co-location, for both the VC, e.g. overlapping social networks (Sorenson and Stuart 2001) and decreased monitoring costs (Gorman and Sahlman 1989), and the entrepreneur, e.g. knowledge spillovers (Alcácer and Chung 2007), high quality managers (Bresnahan et al. 2001), and access to skilled labor (Porter 2000). However, significant empirical evidence of the willingness of VCs to fund remotely located entrepreneurs exists, in spite of the benefits offered by co-location.

Sorenson and Stuart (2001) pose one method by which this non-co-located funding can occur: co-location by one of the members of the VC's investment syndicate. Their argument, at root, is that the co-location of a member of the syndicate team allows the entire syndicate to acquire information about the focal entrepreneur at greatly reduced cost. This is accomplished through the creation of information conduits, i.e. *pipes* (Podolny 2001), between the entrepreneur and the other members of the syndicate. Once the pipe has been created, information about the entrepreneur can be captured easily by the co-located member of the syndicate, and then disseminated to the remainder of the investment team.

Although this explanation of non-co-located funding sheds light on individual social dynamics and how the VC may exploit his social network to increase his geographic investment footprint, what has yet to be considered is the effect of environmental level social factors, such as fads, fashions, and social trends, on the funding decisions of VCs in non-co-located contexts. More simply, although studies have shown the willingness of VCs to overlook geographic funding barriers by leveraging their social network (Sorenson and Stuart 2001),

the objective of this work is to understand how environmental level social cues, such as fashion, may influence the VC's decision to invest in remotely located entrepreneurs.

Abrahamson's (1996) seminal work on fashion defines it as "a relatively transitory collective belief, disseminated by management fashion setters, that a management technique leads to rational management progress." While originally conceptualized to describe the dissemination of management styles, the fashions literature has since been applied to perceptions of technology (Baskerville and Myers 2009), organizational design (Benders and Van Veen 2001), and even the rise of industries (Low and Abrahamson 1997). Furthermore, the investigation of fashion in multiple industrial contexts has suggested that the perception of technologies, industries, or industrial sectors as "fashionable" imbues them with both increased legitimacy and perceived value (Abrahamson 1991, 1996). Accepting the importance of co-location in the VC funding context (Gompers and Lerner 1999, Gorman and Sahlman 1989, Sorenson and Stuart 2001), we argue that when VCs perceive different technological spaces as more fashionable, it will increase their propensity to fund non-co-located entrepreneurs operating within those technological spaces. The reason for this is that the increase in the perception of the fashionability of the entrepreneur's industrial sector will increase the perceived return from the focal entrepreneur, thereby making the VC more willing to shoulder the costs associated with non-co-located funding (Gorman and Sahlman 1989).

Our empirical investigation considers two dimensions of the fashionability construct that have received limited attention within the specific context of VC funding decisions – *herding* (Abrahamson and Rosenkopf 1993, Low and Abrahamson 1997) and *media attention* (Abrahamson 1997, Benders and Van Veen 2001). Media coverage can influence decision makers by increasing the perceived legitimacy of the topics they cover (Pfarrer et al. 2010, Pollock and Rindova 2003, Pollock et al. 2008), thereby leading to a perception of increased quality, and by extension, profitability. In our context, we argue that industrial sectors which experience large increases in media discourse will appear more fashionable. This increased fashionability, in turn, will cause VCs to believe in the viability of the entrepreneurial ventures operating in such sectors. Moreover, we consider the effect of herding, which has also been a consistent theme in the fashion literature (Abrahamson and Rosenkopf 1993, Low and Abrahamson 1997). Although rhetoric development, i.e. media, is essential for fashion dissemination, action is equally important (Abrahamson 1996) to avoid the appearance of cheap talk. Prior literature in VC financing has often demonstrated the effect which herding behavior can have on funding (Gompers and Lerner 2000, Gompers 1994). We seek to augment this research by showing that, in the face of uncertainty, VCs are influenced by the previous funding decisions made by other VCs. However, we take this reasoning further by arguing that such herding behavior, on a specific technology sector, will also increase the probability of VCs investing in non-co-located entrepreneurs.

We conduct our empirical analysis using data from several sources on first-round funding of new technology-based ventures. The data on co-location and VC funding is taken from the VentureXpert dataset which provides detailed information on VC deals and funded entrepreneurs in the US over the last thirty years (Sorenson and Stuart 2001). This dataset is then augmented with information from eleven national newspapers by assessing the frequency of media reports on the technological sector of the entrepreneur in the years preceding the funding decision. Our analysis is then conducted using the matched sample methodology described by Sorenson and Stuart (2001). Results suggest that increased fashionability is associated with an increased probability of receiving first round VC financing. Moreover, results suggest that non-co-located entrepreneurs receive significantly greater benefits, compared with co-located entrepreneurs, when perceptions of the fashionability of their technological sectors rise.

Theoretically, this work expands the locus of theory pertaining to co-location in entrepreneurship and VC research. To wit, the current view of why location matters in VC decision-making is predicated on the structure of the VC's syndicate and networks (Sorenson and Stuart 2001), as well as the coordination costs associated with distance (Gorman and Sahlman 1989, Porter 2000). However, this research has yet to address the influence that social trends can have on the decision to forego the benefits of co-location in an attempt to capitalize on high potential investment opportunities. Thus, our work augments existing theory

by considering the impact of environmental level perceptions of fashion on VC decision making

2.2 Theory and Hypotheses

2.2.1 Co-Location in Entrepreneurship

As discussed previously, co-location is a strong determinant of funding in the context of VC financing, with many benefits accruing to both the entrepreneur, and the venture capitalist (VC) (Gompers and Lerner 1999). From the perspective of the VC, co-location offers two specific benefits: reduction in the cost to establish *ex ante* entrepreneur quality (Sorenson and Stuart 2001) and reduction in the *ex post* costs associated with monitoring and managing the ongoing relationship with the entrepreneur (Gorman and Sahlman 1989). The entrepreneur, in contrast, gains access to knowledge spillovers (Alcácer and Chung 2007), high quality managers (Bresnahan et al. 2001), and skilled labor (Porter 2000).

Extant literature has explored many aspects of the reasons that VCs prefer funding co-located entrepreneurs. Before making funding decisions VCs must gather copious amounts of information about the entrepreneur in order to estimate her *ex ante* quality and potential financial return (Gompers and Lerner 1999). When entrepreneurs are co-located with their prospective financiers this is much easier. Not only does co-location decrease the costs of face to face interaction, thereby decreasing the cost to acquire tacit signals about the entrepreneur, but the intermingling of co-located social networks (Sorenson and Stuart 2001) both

decreases the costs of acquiring additional information about the entrepreneur, and can provide legitimizing signals of quality (Stuart et al. 1999). After the funding relationship is established the VC also receives benefits through co-location: namely that monitoring costs of managing the relationship *ex post* are much lower (Gorman and Sahlman 1989), thereby mitigating problems relating to moral hazard. Furthermore, the literature indicates that VCs find it easier to deploy key assets, such as managers, financial and accounting specialists, and financial underwriters (in the event of an IPO) when the entrepreneur is local (Gompers and Lerner 1999).

For their part, entrepreneurs respond to this strong co-location preference by either locating their venture within VC hotbeds (e.g. Silicon Valley, New York, Boston) or by targeting local VCs where funding odds are more favorable. As would be expected, location within VC hotbeds offers many benefits to the entrepreneur above and beyond the increased probability of funding reception; benefits which are discussed in depth by the agglomeration literature (Bresnahan et al. 2001, Porter 2000). These benefits fall primarily along two lines. First, by locating their firms within these economies, entrepreneurs increase their access to highly skilled labor and managers (Bresnahan et al. 2001). As highly technical human capital is often transferrable across firm boundaries (Grubel and Scott 1966), this offers the entrepreneur the ability to acquire skilled personnel in both in the short and long term. Second, the entrepreneur has the opportunity to benefit from knowledge spillovers should she locate in a VC hotbed (Porter 2000). As the generation of large amounts of knowledge and intellectual property is common in

VC hotbeds, the entrepreneur located within these economies can, potentially, access valuable knowledge spillovers which will increase the quality of her firm (Alcácer and Chung 2007). Given these benefits to both the VC and entrepreneur we propose the following as a baseline hypothesis:

H1: VC-Entrepreneur co-location will be associated with an increased probability of first round funding reception.

2.2.2 Managerial and Technical Fashions

Fashions are not simply trivial occurrences which appear casually over time (Abrahamson 1991). Instead they serve as important demonstrators of legitimacy (DiMaggio and Powell 1983) for organizations by providing resolutions to important economic, managerial, and technical problems (Abrahamson 1996). As this impression of technological or economic superiority spreads within the economy, stakeholders respond by demanding the adoption of fashionable practices and technologies, resulting in even greater legitimacy being attached to those practices (Abrahamson 1991). Moreover, as the public perception of the fashionability of a given technology increases, discourse regarding the technology is stimulated in the public and private domain (Abrahamson 1996, Abrahamson and Fairchild 1999), contributing to what Swanson and Ramiller (1997) refer to as the *organizing vision* of the technology. The authors assert that, as a technology becomes more fashionable, managers will discuss it more and increase their own understanding of it (Abrahamson and Fairchild 1999, Ramiller and Swanson 2003, Swanson and Ramiller 1997). This discourse, in turn, leads to increased knowledge dissemination and resource availability, making it easier for managers to access market information.

More simply, the critical argument regarding fashionability, and its effect on managerial and individual behavior, relies on the perception that fashionable practices or technologies offer significant benefits to adopters, even if true evidence of these benefits is currently lacking (Abrahamson and Rosenkopf 1993). From the perspective of the VC, increases in the perception of the fashionability of the entrepreneur's technological space will have two effects on the funding decision: increases in the legitimacy of the technological space the entrepreneur is operating in (Abrahamson 1996) and increased information availability about the entrepreneur's technological space (Ramiller and Swanson 2003, Swanson and Ramiller 1997).

Increases in legitimacy stemming from changes in the perceived fashionability of different technological spaces will, in turn, increase the perceived quality of the entrepreneurs operating in those fashionable technological market spaces (Abrahamson 1996). More simply, as entrepreneurs who are operating in highly fashionable markets are imbued with increased legitimacy, they will appear to be more attractive investments targets for VCs, all else equal. The reason for this increased attractiveness is two-fold. First, fashions are believed to provide answers to important managerial and technological problems (Abrahamson 1991). The investment in fashionable markets, therefore, should increase the projected financial return to the VC (Abrahamson and Rosenkopf 1993). Second, it is likely that financial stakeholders within the organization (or third party investors) will demand that the VC operate within

these markets, because of the increased legitimacy the VC will also receive (Abrahamson 1996).

From the perspective of information availability, the increase in fashion will increase the amount of information available to the VC regarding a focal technological market, thereby decreasing the cost to acquire information (Abrahamson 1997). Increases in fashion stimulate increased discourse and rhetoric about the focal technology (Abrahamson 1996, Abrahamson and Fairchild 1999, Benders and Van Veen 2001). This increased discourse, in turn, offers two benefits to the VC. First, by virtue of the increased discourse extant understanding of the technology will increase (Swanson and Ramiller 1997). Second, and more importantly, when discourse in the public and private domain is high, it will decrease the cost to acquire information (Pfarrer et al. 2010, Pollock and Rindova 2003, Pollock et al. 2008); significantly reducing the necessary investment the VC must make in terms of both time and capital.

Examples of the effect of fashions on investment behavior are common in both the academic literature and the popular press. These extend from the classic examples of disk drive manufacture in the l980s (Agarwal et al. 2004, Gompers 1994) to the Internet Boom of the late 1990s (Gompers and Lerner 1999). In each of these cases, the perception of the fashionability of the technology had strong effects on the willingness of both individual and institutional actors to invest in such technologies. Technologies such as enterprise resource plans (ERP), for example, went through periods when they were considered to be extremely useful to firms, leading to their adoption even when their value to the firm had not been

established clearly (Baskerville and Myers 2009), and strong arguments against the viability of these technologies existed (Hendricks et al. 2007). The current trend in "Green" IT or social media technologies is evidence of the ongoing influence of technologies that are considered fashionable. Pervasive wisdom suggests that firms and decision-makers are likely to believe there is value in these technologies, even though they are still nascent or have not yet established a clear payoff for their early adopters.

In sum, the literature regarding fashion suggests that increases in perceptions of fashionability will lead to both increased legitimacy (DiMaggio and Powell 1983), as well as economic value (Abrahamson 1996). Therefore, we propose:

H2: Increases in the perceived fashionability of the entrepreneur will be associated with an increased probability of first round funding reception.

2.2.3 Fashionability and the Co-Location Problem

While the previous section argues for the main effect of fashionability on funding decisions, we assert that changing fashionability also has an indirect effect on VC funding decisions. Recall that our arguments about fashion suggest that decision-makers perceive fashionable objects or technologies as being more valuable, *ceteris paribus*. However, the focal question of this study relates to how increases in the fashionability of a technological space may induce the VC to relax the co-location preference, and significantly increase the odds of funding non-co-located entrepreneurs operating within that technological space. Extant literature suggests three mechanisms by which this, non-co-located funding decisions, may occur.

The first mechanism suggests that when certain technology classes are perceived as more fashionable, new ventures that are associated with such technologies will receive greater visibility and attention (Abrahamson and Rosenkopf 1993, Deephouse 2000, Pollock and Rindova 2003), regardless of where they are located. As enhanced fashionability brings with it an associated increase in legitimacy (Abrahamson 1996), the VC is more likely to be aware of, and take note of, these new ventures (Kirsch et al. 2009), even if they are outside the VC's traditional geographical preference. Consider, for illustrative purposes, the recent increase in the perceived fashionability of "Green" IT. As perceptions of the fashionability of Green IT rises, VCs will be more aware and cognizant of the actions Green IT firms take, even if they are not located in the VC's economic area, i.e. the VC will increase the radius of their search for potential funding targets. This benefit of a widened search radius will likely not help firms that do not have the benefits of increased fashionability, as they will not receive the attention from the VC which comes with the associated increase in fashionability. This mechanism suggests that as fashionability increases, all else equal, VCs will search out these firms actively and the odds of receiving funding from a non-co-located VC will increase.

The second mechanism suggests a bias that may be induced within the VC's decision-making process. Prior work in availability and salience (Kuran and Sunstein 1999, Tversky and Kahneman 1973) suggests that as recollection of certain events or subjects increases, decision-makers systematically make errors in judgment regarding the true probability of those events occurring. If this is true,

the increases in rhetoric associated with increases in fashion (Abrahamson 1997) will have a disproportionately higher effect of for non-co-located entrepreneurs. The reason for this asymmetric effect is as follows. It is well established that VCs realize that *ex post* costs associated with managing non-co-located entrepreneurs is higher compared to managing co-located entrepreneurs (Gompers and Lerner 1999, Gorman and Sahlman 1989). However, if increases in the fashionability of certain technologies enhances their perceived value (Abrahamson 1996), it is also possible that fashionability will systematically reduce the recognition of the costs associated with investing in that technological space. This would imply that the cost estimates by the VCs will be biased; leading to the perceived value of such fashionable new ventures being systematically higher, and the perceived cost of managing the non-co-located relationship being systematically lower. Moreover, even if the VC only believes that fashionable entrepreneurs possesses a higher probability of payoff, and that the size of this financial return will be larger, a simple cost benefit analysis suggests that the VC will be more likely to shoulder the costs associated with funding a non-co-located entrepreneur. Therefore, if fashion both increases the salience of entrepreneurial technologies, and biases the perception of payoff associated with those technologies, we would expect to see that increased fashionability has a disproportionately higher effect on non-co-located VC decision making, thereby leading to higher odds of funding.

The third mechanism is based on simple supply and demand associated with an increased perception of value of a specific technology. As certain technologies come into fashion, and are seen as more legitimate and valuable to

the VC community, there will likely be excess demand to fund such new ventures locally. When the local market for such investments is saturated, VCs who perceive value in these technology spaces will likely look elsewhere for opportunities. Therefore, if fashionability leads to local market saturation, VCs will be more likely to fund entrepreneurs who are in the fashionable technology space, but who are not co-located geographically. While it may be argued that VCs would prefer to not fund any firms in that technology space if local markets are saturated, extant literature suggests that VCs face pressure from their own investors and their peer VCs to invest in specific areas (Gompers 1996) at different points in time. Because of this increased pressure, it is likely that the odds of non-co-located funding ties will increase.

Given these three mechanisms: increased visibility and attention, biased decision making on the part of the VC, and an excess demand for entrepreneurs operating within the fashionable technological space; we propose the following,

H3: Fashionability will negatively moderate the relationship between co-location and probability of first round funding reception.

2.3 Data and Methodology

2.3.1 Measuring Fashion

Our empirical analysis considers two artifacts the fashionability construct which have been used extensively in the extant literature, but received limited attention within the context of VC financing: *herding* (Abrahamson and Rosenkopf 1993, Low and Abrahamson 1997) and *media attention* (Abrahamson 1997, Benders and Van Veen 2001). As is common in behavioral decision making

research (Smith and Von Winterfeldt 2004), the direct measurement of the latent fashion construct is difficult. We therefore employ these two proxies, which are reflective of the fashion, in order to ensure a clean operationalization of the construct.

With respect to media coverage, the creation of rhetoric is vital for both the creation of perceptions of fashion, and the dissemination of perceptions fashion, across the population (Abrahamson 1997). While the seminal literature on fashion relied on the "pro-innovation bias" of decision makers for this dissemination (Abrahamson 1991) more recent literature has viewed the media and trade press as a vehicle as well (Benders and Van Veen 2001). Prior literature related to the effect of media on decision making supports this view (Pfarrer et al. 2010, Pollock and Rindova 2003, Pollock et al. 2008). Not only does media increase the visibility of firms (Zavyalova et al. 2012) and accelerate the dissemination of information across the population (Pollock et al. 2008), it has the added advantage of not only increasing the legitimacy of technologies (Pollock and Rindova 2003) but providing tacit endorsement for the technology by virtue of writing about it (Deephouse 2000); endorsements which are of vital importance in the VC financing process (Stuart et al. 1999).

In a related vein, herding, situations where individuals "follow the crowd," has also been a consistent theme in the fashion literature (Abrahamson and Rosenkopf 1993, Low and Abrahamson 1997). Although rhetoric development, i.e. media, is essential for management dissemination, action is equally important (Abrahamson 1996) to avoid the appearance of cheap talk. Prior literature in VC

financing has often demonstrated the effect herding behavior can have on funding (Gompers and Lerner 2000, Gompers 1994); as VCs have little tolerance for maverick behavior (Gompers 1996) and are influenced by the actions of other VCs in their social networks (Sorenson and Stuart 2001, 2008).

2.3.2 Data

We draw on several resources to test our hypotheses. Information on VC funding decisions is derived from round level data in the VentureXpert dataset.

We augment these data with information from eleven newspapers in order to determine the amount of media coverage each industry sub-sector is receiving[1]. In order to gauge media attention we use two national newspapers (*USA Today* and *The Wall Street Journal*) to ensure that we capture discussion of different industries within both the business press and the popular press. Owing to the fact that perceptions of fashion can be concentrated geographically we augment the data from the national press with media coverage from within the VC's economic zone[2]. We use nine major newspapers to accomplish this: *The Boston Herald, The New York Times, The Chicago Tribune, The Minneapolis Star Tribune, The Washington Post, The Atlanta Journal Constitution, The Austin American Statesman, The Denver Post,* and *The San Jose Mercury News*. In each case these are the largest, i.e. highest circulation, newspapers in the economic zone with the exception of the *San Jose Mercury News* (which is substituted for the *Los Angeles*

[1] Our media variable is captured at the company industry subclass level 3 (ISC3). ISC3 is a distinction which is made within the VentureXpert dataset to cleanly delineate between different subsectors of the IT industry.
[2] Economic zone is defined here using the US Census Bureau's Economic Census demarcations

Times due to the importance of Silicon Valley to the emergence of the VC industry over the past three decades).

We apply several restrictions in our sample to facilitate analysis. First, we only use entrepreneurs based in the United States as the notion of co-location, as well as the operationalization of media coverage, is more clearly defined in the US. Second, we only include first-round funding in our analysis to mitigate the effects of confounding conditions from continued VC-entrepreneur interactions over subsequent funding rounds. Although our arguments are possibly valid for multiple funding rounds, the most apparent effect of changes in perceptions of fashion will be visible during first-round funding. Finally, we look at only technology entrepreneurs (Information Technology) as this category accounts for the majority of VC investments in the last three decades (Gompers and Lerner, 1999) and allows for clear measurement of herding and media coverage.

The unit of analysis for this investigation will be the VC – entrepreneur dyad. The reason for this is as follows. Although entrepreneurs are often be funded by groups of VCs in each round, each VC firm, in effect, makes independent decisions regarding the form and amount of investments. Our dataset comprises, therefore, 19,859 distinct entrepreneur-VC dyads for first-round funding between 1985 and 2006, consisting of 11,946 entrepreneurs funded by 2464 VCs.

2.3.3 Matched Sample Methodology

As the data from VentureXpert provides only information on realized ties between entrepreneurs and VCs, we create a matched sample, following Sorenson

and Stuart's (2001) methodology, which contains a set of funding relationships that could have occurred, but were *not* realized. In each year, we match VCs which have funded an entrepreneur with every other entrepreneur, in the same industry, who was not funded by the focal VC but was funded by another VC. We effectively assume that the focal VC chose to *not* fund those entrepreneurs who were funded by other VCs. As entrepreneurs tend to contact many potential VCs, and are funded by few (Kirsch et al. 2009), this assumption is not unreasonable (Sorenson and Stuart 2001). In effect, we match on year of funding, specific technology space, and the evidence of funding by the focal VC to another entrepreneur in that year. The specific technology space is denoted by matching on the industry subclass two (ISC2). ISCs are annotations within VentureXpert that provide increasing levels of granularity regarding the specific industry or technological domain each entrepreneur operates in. ISC2 is the second most granular and includes 69 different classifications. This methodology offers us three distinct benefits. First, it ensures that the focal VC has capital to fund entrepreneurs (as it has elected to fund *someone*). Second, it guarantees that the VC is open to funding an entrepreneur in the specific technology space of the focal entrepreneur, as it has funded an entrepreneur in that space. Third, it ensures that each entrepreneur meets a minimum threshold of quality, at the time of funding reception, as each one has received funding from *at least one* VC. Following Breslow and Day (1980) we enforce a 1:1 ratio of unrealized ties to every realized tie. The final dataset consists of a total of 19,850 unrealized

matches (9 items not possessing suitable matches). Summary statistics are available in Table 2.1.

2.3.4 Variable Definitions

Dependent Variable: The dependent variable for our analysis is the dichotomous indicator of funding reception, *funded*. *Funded* is set to 1 if the funding relationship between the focal entrepreneur and focal VC was realized and funding occurred.

Independent Variables: The first independent variable of interest is the dichotomous indicator of VC-entrepreneur *Co-Location*. Co-location of the entrepreneur-VC dyad is determined using the zip code information for both parties provided in VentureXpert dataset. We first map the entrepreneur and VC zip codes to the 176 economic areas (EA) in the US provided by the Bureau of Economic Analysis (Alcácer and Chung 2007). As each EA encompasses several zip codes, we use the United States Postal Service dataset which provides the most central zip code for each EA. We then match the zip code of the entrepreneur and the VC to the most central zip code in each EA using a Haversine formula (Gellert et al. 1989). The Haversine method uses the latitude and longitude associated with each zip code and the central zip code for the EA. If the EAs for both the entrepreneur and VC match, *Co-Location* is coded as 1, else the variable is coded as 0.

The second independent variable of interest, *Herding*, is measured as the total observed investment in the focal entrepreneur's ISC2 by all VCs over the two year period immediately preceding the focal funding decision, normalized by

total spending on all IT categories by all VCs in VentureXpert. Even though individual decisions on funding for a specific ISC2 are hard to observe, the overall trends of realized investments in the technologies associated with the ISC2, relative to overall VC spending, are visible to the community. Our measure, therefore, captures the extent to which observed funding is directed to the ISC2 of the focal entrepreneur in the two-year period prior to funding, as a percentage of total IT-specific funding. In alternative analyses, we normalized ISC2-specific funding by total spending across *all* categories as well as total spending within the focal VC's EA; the results are consistent and are available from the authors upon request. This variable is operationalized as a percentage (0-100).

The third independent variable of interest, *Media*, is measured as the change in media coverage for the focal entrepreneur's ISC3 within the VC's economic zone. We use the VC's economic zone because we are studying how changes in proximal media coverage influence VC decision making. Our operationalization of the *Media* variable is as follows. First, we use the number of articles from the two national media outlets, *The Wall Street Journal* and *USA Today*, to establish the amount of media coverage which every VC is exposed to in time *t* for industry *i*. We then supplement this measure of media discourse by adding the coverage of the newspaper which is associated with the VC's economic zone. Finally, we operationalize the media coverage as the change in the change in the number of articles from these three periodicals in industry *i* between time periods *t-2* and *t-1*. This variable is scaled to the change in 1000s of articles to increase interpretability of the results and is lagged by one time period

to preclude the possibility of reverse causality. We use a difference measure, which captures the relative change in discourse, as opposed to a growth metric or a simple article count, for two reasons. First, extant literature has demonstrated that extensive discussion of topics in the media causes decision makers to be desensitized to the media ubiquity by taking it "for granted" (Pollock et al. 2008). Second, as we want to capture large increases or decreases in the media coverage, operationalizations like a growth metric, which has a natural infimum of negative one, are unsuitable. We note here that as media coverage is overwhelmingly positive, with the exception of political coverage, media tenor is likely a non-issue (Pollock and Rindova 2003)[3].

Controls: We control for several other variables in our analysis of VC funding decisions. Our first variable, *Herfindahl*, controls for the diversification strategy of the VC. This variable is operationalized as a Herfindahl Index of the ISC2 categories representing new ventures the VC has invested in over the five years previous to the funding decision. Two more control variables, *VC Concentration* and *Entre Concentration*, provide a measure of the concentration of entrepreneurial and VC activity in the respective locations of the focal VC and focal entrepreneur. These variables are operationalized as the total number of distinct VCs or entrepreneurs either receiving or providing funding in the focal EA by year. Third, we include controls for measure the age of the VC firm (*firm age*) and the net investment of the VC (*firm size*) during the time that it has been actively investing. Fourth, we control for the recent spending activity

[3] Due to the scope of our media inquiry we are unable to download each article to ensure positivity. However, results from a randomly sampled group of 20,000 articles supports the assertion that media coverage is positive. Results of this analysis is available upon request.

(*PrevSpending*) of the VC. This variable is operationalized as the total amount of money the focal VC has invested over the previous three years. Fifth, to account for heterogeneity in entrepreneur quality we include two controls. First, the novelty of the entrepreneur's intellectual property at the time of funding reception (*Patent Originality*), which is calculated using Hall et al's (2001) inverted Herfindahl index. Second, the log of the age of the entrepreneurial firm (*ln(EntreAge)*), which is calculated by subtracting the year of the new venture's founding date from the date of the first round of funding reception.

Our final control, *syndicate co-location*, is a measure of the extent to which members of the VC's syndicate are co-located with the focal entrepreneur. This measure is included to capture the ability of the VC to gather information about the focal entrepreneur through his syndicate (Sorenson and Stuart, 2001). The operationalization of this variable is as follows. We first measure the level of affiliation between the focal VC and all the investment partners within the VC's funding syndicate by counting the number of times the member of the syndicate *j* has co-funded an entrepreneur with the focal VC (*cofunding*). We then determine which of these syndicate partners are co-located with the focal entrepreneur ($colocation_j$). Our measure of syndicate co-location is then calculated with the following equation: $\sum_1^j cofunding_{ij} * colocation_j$ This measure estimates the relative influence that a syndicate member has on the focal VC and weights that influence by whether that syndicate member is co-located with the focal entrepreneur. If no member of the VC's syndicate is co-located with the entrepreneur, this variable is 0. If some members of the syndicate are co-located

with the entrepreneur, the influence of the syndicate members is weighted by their influence as determined by the extent of previous co-funding. In the case of non-realized ties, we estimate this measure by assuming that the focal VC joins the existing syndicate that has funded the entrepreneur and perform the same analysis as above, thereby including the actual funding VCs into the focal VC's syndicate. In the case of unrealized ties, this measure may not accurately capture the true effect as we assume that only the focal VC joins the new syndicate, without considering his or her true syndicate (Sorenson and Stuart, 2001) – this is a data limitation. Finally, we include a set of ISC2 and year fixed effects to capture time invariant industry heterogeneity and year-specific heterogeneity.

2.3.5 Empirical Strategy

The primary regression analysis used is a logistic regression with funding as the dependent variable. The three research variables of interest, *Co-Location, Herding,* and *Media*, are introduced as determinants of the probability of funding using the following equation:

$$\begin{aligned} Probability\ (Funded = 1) \\ &= \beta_1 CoLocation + \beta_2 Herding\ + \beta_3 Media \\ &+\ M_1{}'Entrepreneur\ Controls + M_2{}'VC\ Controls \\ &+\ M_3{}'Area\ Controls + \varepsilon \end{aligned}$$

where M_1, M_2, and M_3, are the vector of coefficients associated with the indicated controls. As we are investigating how VCs react to increases in fashionability, and whether or not entrepreneurs receive greater marginal benefit from increases in fashions when they are non-co-located, we individually interact *Herding* and *Media* with *Co-Location*. Results of these regressions are available in Table 2.2.

One concern which emerges from these initial estimations is that individual level VC preference in decision making may be driving the effect. This presents two logistical challenges. The first is that a fixed effect model is computationally intensive when using non-linear estimators. The second is that, due to the non-linear nature of the estimator, interpreting the coefficients is difficult (Ai and Norton 2003). We therefore re-estimate our model using a fixed effect linear probability model (LPM). While a non-linear estimator is preferable in situations with a dichotomous dependent variable, LPMs offer the benefit of increasing the interpretability of the interaction terms while decreasing the computational demands which make non-linear estimators with fixed effects infeasible. Results of these regressions are available in Table 2.3. Moreover, to preserve consistency with Sorenson and Stuart's (2001) original methodology, we re-execute our matching process using a 1:5 ratio of realized to unrealized ties. This is done to ensure that our change in the ratio of realized to unrealized ties has not influenced the outcome of the regressions. Results of these regressions are available in Table 2.4[4].

The final concern is the homogeneity which is introduced into the independent variables of interest, *herding* and *media* attention, as a result of the stringency of the match. To explain, because we match on the ISC2 each possible counterfactual for the focal funding decision has, by definition, very similar values for herding and media attention. The concern, therefore, is that while the

[4] While a conditional logit is traditionally used in choice models its usage is inappropriate here because the set of choices is heterogeneous across decision sets and there are thousands of possible entrepreneurs to choose from. Practically speaking, using a conditional logit would create a single fixed effect for each entrepreneur, which, together with the VC fixed effect, would perfectly predict the model for each entrepreneur funded by only one VC.

specificity of the match does allow us to study how fashion influences VC funding decisions differently in co-located and non-co-located contexts, it does limit our ability to interpret the direct effects of the model, which are not constructed dyadically. To resolve this concern we replicate our 1:1 match, however, we do not constrain the counterfactuals to be in the same ISC2 as the focal entrepreneur. Result of these regressions are available in Table 2.5.

2.4 Results

We first consider the results from the baseline model shown in Table 2.2. Consistent with prior work, as the diversification of the VC and the previous spending of the VC increase there is an associated increase in the probability of the entrepreneur receiving first round funding. Moreover, as the concentration of entrepreneurs increases, the size of the VC increases, and as the age of the focal VC increases, the probability of funding reception decreases.

When considering our proposed hypotheses an equally interesting story emerges. First, as evidenced by the *Co-Location* coefficient there is a strong and significant correlation between co-location with the focal VC and first round funding reception (providing support for H1). Second, as indicated by the coefficients of *Herding* and *Media*, there is a strong and significant correlation between increases in perception of fashion and first round funding reception (providing support for H2). Third, as witnessed by Column 2 and Column 4 in Table 2.2, the interaction term between *Herding* and *Co-Location* is negative and significant indicating that increases in herding influence the VC funding decision to a much greater degree when the entrepreneur is non-co-located. Moreover, as

shown by Column 3 and Column 4 in Table 2.2, the interaction term between *Media* and *Co-Location* exhibits the same behavior, indicating that VC's are more strongly influenced by *Media* in the case of non-co-located entrepreneurs as well. Furthermore, the direct effect coefficients for *Media* and *Herding* are larger than the coefficients for their respective interaction terms. This suggests that any entrepreneur operating in a technological space experiencing an increase in fashion will garner benefits from the increase in fashion; however this benefit is less for co-located entrepreneurs (indicating support for H3).

The results of the 1:5 match (Table 2.4), as well as the linear probability model estimates (Table 2.3), suggest the same results. In each case the coefficients for *Co-Location, Herding,* and *Media* change are positive and significant (indicating support for H1 and H2)[5]. Moreover, in both sets of regressions the interaction terms are negative and significant indicating a moderating relationship between the variables. Finally, the coefficient of the interaction terms are smaller than the coefficients of the direct effects, indicating that the benefits of *Herding* and *Media* coverage appear for all entrepreneurs, albeit at a significantly slower rate for co-located entrepreneurs. These findings indicate further support for H3.

Our utilization of the linear probability model also assists in the interpretation of the results of the interactions. First, we see that the statistical results from these estimations (Table 2.3) corroborate our previous findings by suggesting that *Co-Location, Herding,* and *Media* are all significantly correlated

[5] The smaller coefficients for the 1:5 match are expected due to the mechanical relationship between the successes (realized funding ties) and failures (non realized funding) within the data.

with first round funding reception. Moreover, the coefficients of the interaction terms between our fashion variables and co-location are negative, significant, and smaller that their respective direct effects (indicating the moderating relationship proposed by H3). Utilization of the LPM also allows us to show our results graphically to assist in interpretation. We use the LPM estimates, as opposed to the logit or probit estimates, because of the aforementioned issues with the interpretation of nonlinear interactions (Ai and Norton 2003). We note here that the predicted probability of funding reception remains consistently within the acceptable range of [0..1] when the independent variables are constrained to their observed values, thereby avoiding one of the major empirical concerns associated with LPMs[6].

Referencing Figures 2.1 and 2.2 we see further support for H1, H2, and H3. In both figures the y-axis indicates the predicted probability of the entrepreneur receiving first round funding from the focal VC. The x-axis represents the manipulation of the quantity of media coverage and herding, respectively, which the VC is subjected to. In both figures we see, as expected, that entrepreneurs who are co-located with their focal VC far more likely to receive first round funding, *ceteris paribus* (providing support for H1). Furthermore, we see that there are increasing returns to our fashion variables in both figures (indicating support for H2). Finally, we see that the slope of the non-co-located line is significantly steeper, indicating that increases in fashion are far more influential when VCs are considering funding non-co-located entrepreneurs

[6] Each model has been estimated using Huber-White standard errors to manage the heteroskedasticity concerns associated with linear probability models.

(indicating support for H3). Extending these graphical representations we next chart the marginal increase in the probability of funding the entrepreneur receives from increases in herding or media coverage (Figures 2.3 and 2.4). In these figures the y-axis is the marginal increase in the probability of funding reception and the x-axis is the change in the independent variable of interest. As we can see from these figures, the marginal benefit of increasing media coverage, and herding, translate into significantly higher increases in the marginal probability of funding for non-co-located entrepreneurs, as compared to co-located entrepreneurs.

Finally, given the concerns with interpreting the direct effects in the constrained model we consider the direct effects of the logistic regression when the match is not constrained to match on the ISC2 variable (Table 2.5). As with our previous regressions, the results are very similar, indicating support for all three hypothesized relationships; as evidenced by the significant and positive coefficient of *Co-Location* (H1), the significant and positive coefficients of *Herding* and *Media* coverage (H2), and the negative and significant coefficients of the interactions of *Herding* and *Media* coverage with *Co-Location* (H3).

2.5 Discussion and Conclusion

The objective of this study is to determine how VCs react to changes to the perception of fashionability in various industries and technologies, and how that reaction can increase the probability of non-co-located funding. Empirically, we investigate this question by modeling how changes to two aspects of fashionability, herding and media attention, may influence VCs to invest in non-

co-located entrepreneurs. Recognizing the benefits which co-location provides, we argue that increases in the perception of fashionability will cause the VC to be more likely to invest in remotely located entrepreneurs through three possible mechanisms. First, increases in perceptions of fashion will increase the awareness of entrepreneurs in the fashionable technological space by the VC funding community. Second, entrepreneurial firms operating in fashionable technological spaces will appear more legitimate, valuable, and, potentially, profitable (Abrahamson 1996, Low and Abrahamson 1997). Thus, the perceived increase in value will increase the willingness of VCs to take on the additional risk, monitoring, and coordination costs associated with funding a non-co-located entrepreneur. Third, and finally, the increase in perception of value which fashion confers upon entrepreneurs in the fashionable technological space will deplete the local supply of unfunded entrepreneurs who operate in that technological market space, causing VCs to expand their search radius. While the empirical methodology we employ does not allow us to identify which of these mechanisms will dominate the other two, all three mechanisms suggest that as technological sectors receive the benefits of enhanced fashionability, the relative odds of a non-co-located entrepreneur receiving first-stage funding from a VC will increase significantly. Findings indicate not only that increases in the perceptions of the fashionability, through herding and media coverage, are associated with an increased likelihood of the entrepreneur receiving first round VC funding, but the influence of fashion is far greater for VCs who are considering funding non-co-located entrepreneurs.

Theoretically, our work augments the existing knowledge of fashion by considering how benefits accrue to different agents in a decision making environment. While extant literature has considered many aspects of the fashion construct, including identification (Abrahamson 1996), dissemination (Abrahamson 1997), adoption (Abrahamson 1991), and even the evolution of industries (Low and Abrahamson 1997), one thing that has yet to be considered is to whom the benefits of fashion accrue, and at what rate. In this work we find that the benefits of fashion accumulate faster for those entrepreneurs who are more difficult to gather information about. However, the alternate case, where the benefits of fashion accrue to co-located entrepreneurs, thereby exacerbating the desire of VCs to fund these firms, is equally plausible. In this respect, we explore the boundary conditions of fashion by identifying which agents within a social system will garner the most benefit.

Our work similarly augments extant theory pertaining to location in entrepreneurship. While much has been written on the phenomenon of co-location in the VC funding context, extant literature has underscored the importance of co-location, as opposed to investigating methods by which decision makers will chose to look beyond the physical constraints it places upon them. Examples of this emphasis are common in the literature, ranging from Sorenson and Stuart's (2001) discussion of VC syndicates to the coordination costs discussed by Gorman and Sahlman (1989). We expand upon this work, therefore, not only by exploring the social trends which can significantly influence the decision of VCs

to make funding decisions, but by demonstrating how geographical barriers to funding may be overcome by exploiting these trends.

From a policy perspective this work offers insights into how VCs can be incentivized to discard their traditional co-location constraints and fund across geographic boundaries. One consistent concern for policy makers at the federal, state, and municipal levels is the incentivization of entrepreneurial activity within their political jurisdictions (because of the job creation benefits which are associated with small business). However, the acquisition of capital for such entrepreneurs is often a pressing concern which can stunt the emergence of new ventures, or cause entrepreneurs re-locate, leaving the policy maker with depleted stocks of both human and non-human resources. Our work suggests a partial solution to such problems.

Consider, for illustrative purposes, the state of New Mexico's recent efforts to incentivize entrepreneurial growth (Barrett 2008). New Mexico is unique in that it is home to both Sandia National Laboratories as well as the Los Alamos National Research Laboratory. However, the state is not known for its entrepreneurship activity, nor is it known as a VC hotbed. This has limited the extent to which new ventures start and thrive in the state by decreasing the necessary cash flow which is available to the nascent entrepreneur at early stages. In order to remedy this concern the state has recently been working with VC firms to increase the level of investments in local entrepreneurship, specifically around the research labs. The program, dubbed Springboard, has been set in motion to increase the level of localized capital available to small businesses in New

Mexico in the hope of creating a new high technology hub in the greater Santa Fe area. Our results have direct implications for policy-makers within the state who wish to increase participation from VCs in New Mexico. Not only can the state leverage its own connections in the media to increase discussion, which will incentivize VCs to invest in local entrepreneurs, it can also offer tax subsidies and other forms of support to firms operating within "hot" technological areas, i.e. industries which VCs are herding towards.

Second, our results on fashion suggest that there may be greater value in focusing on emerging technologies and products for local entrepreneurs rather than existing technologies. Our analysis suggests that it is not the level of discourse but the growth in discourse that is important. Therefore, entrepreneurs in New Mexico looking for VC funding will have greater success with VCs from other areas if they are operating in technological spaces that are experiencing a sudden spurt in fashionability. Entrepreneurs in more stable technological contexts may not be able to garner such benefits as VC funding from out of state may be harder to come by, all else equal.

Several important managerial implications also emerge from our work, which primarily serve the entrepreneur. Namely, the entrepreneur should strongly consider relocating her firm to a VC hotbed (The 128 Corridor in Boston, New York City, or Sand Hill Rd in Northern California) if her products are not sufficiently fashionable to garner media attention. Moreover, if the entrepreneur is operating in a technological space which has already seen much VC and media attention, and that attention has since subsided, she should also consider

relocating to a VC hotbed. More to the point, the notion of fashionability may not have, as of yet, entered entrepreneurial decision-making calculus. Studies show that entrepreneurs tend to think of risk and opportunity in very personal terms without regard to the environment (Sarasvathy et al. 1998). We suggest that the shrewd entrepreneur might find it worthwhile to balance supply side opportunities (such as those presented by New Mexico) with funding opportunities from non-co-located VCs by considering the impact of fashion.

This study is subject to certain limitations which offer many opportunities for future research. First, while we conjecture about the value of the "right" location decision for the entrepreneur, our dataset is limited in terms of visibility into the other processes that an entrepreneur may adopt to find funding. Second, the structure of the VentureXpert database does not provide information about the entrepreneurs that were not funded by any VC. While this does offer the benefit of each entrepreneur meeting the minimum quality threshold to receive VC funding, thereby increasing the precision of our attempts to measure the marginal effects of fashion in co-located and non-co-located contexts by limiting the variation in *ex ante* entrepreneur quality, it is clearly a limitation in the data. Third, we operationalize media attention using eleven mainstream periodicals in the US; however, media attention and herding, are still proxies for fashionability. Further exploration of other artifacts of fashion, beyond media attention and herding, is certainly warranted. Fourth, our analysis considers co-location at an abstract level, given the data available. We do not account for other factors that may influence the co-location constraint, such as the VC firm having multiple

offices, one of which may be near the entrepreneur's location. We only account for the VC's main office location. In most cases this is not a problem as most VCs have few branch offices. However, our measure of co-location is simplistic and the results must be evaluated with these caveats in mind. Finally, we offer one cautionary note regarding the direct effects within the model. While we have performed multiple permutations of the Sorenson and Stuart (2001) matching process to limit the potential downside of this methodology, we urge further research into the effects of fashion, through herding, media attention, and other artifacts, which can more precisely identify the effect of fashion increases on the decisions of entrepreneurs and VCs.

In conclusion, we investigate how increases in the fashionability of various industries will influence the behavior of venture capital financiers. Starting with the well-established fact that location matters in the context of VC funding (Sorenson and Stuart 2001) we argue that increases in fashionability will induce VCs, on the margin, to fund entrepreneurs who are located remotely. Empirically, we consider two potential operationalizations of the fashion construct: increased rhetoric through media coverage (Abrahamson 1996) and herding by VCs (Low and Abrahamson 1997). Results suggest that VCs who are considering funding entrepreneurs who are non-co-located are influenced to a much greater extent than VCs who are considering co-located entrepreneurs. Moreover, while results further suggest that the *ex ante* probability of funding is higher for co-located entrepreneurs, there are many reasons why entrepreneurs may choose to locate themselves away from VC hotbeds. These include, but are

not limited to, the availability of local resources, access to markets, or favorable regulatory environments. In such situations, we argue that the focal entrepreneur can exploit the social aspects of the market, such as fashionability, to receive VC funding in lieu of relocating, when relocation will put the entrepreneur at a future strategic disadvantage.

CHAPTER 3: "TIGERBLOOD:" BROADCAST MEDIA, SOCIAL MEDIA, AND FIRM FOUNDING

ABSTRACT

In this paper, we study the impact of increases in media coverage from two sources, the broadcast and social media, on firm founding rates in the context of technology-based entrepreneurship. Adopting a lens of Agenda Setting Theory we argue that increases in the broadcast media will stimulate discussion in the social media. We go on to argue that increases in the social media, which allows decision makers to participate in the discourse, will increase firm founding rates. We test these hypotheses on entrepreneurship data obtained from VentureXpert, augmented with social media data from the three largest blogging platforms, and broadcast media data from newspaper articles collected through the Internet between 1996 and 2006. Our empirical results, which use the exogenous variation in media coverage resulting from natural disasters as an instrument, provide evidence for the effect of increased media coverage on entrepreneurial firm founding rates. Our work here is the first, to our knowledge, to directly show the interplay between the social and broadcast media in influencing entrepreneurial decisions and also provides evidence on how social media plays an increasingly important role in the economy.

3.1 Introduction

How does media discourse affect entrepreneurial decision-making? The extant literature on media espouses two mechanisms for this effect. On one hand, media is known to legitimize topics (Pollock and Rindova 2003), thereby

conferring superior reputation (Deephouse 2000, Pfarrer et al. 2010) upon the recipients of the coverage. Conversely, increases in media have also been shown to cause biased decision making by increasing the availability of ideas for recall (Pollock et al. 2008, Sunstein 2003). In this paper, we investigate how a change in the level of media discourse will influence the decision of entrepreneurs to form firms. More specifically, we expand the locus of investigation within this literature stream to determine how discourse, in the traditional *broadcast media,* defined as the one-directional print media, and *social media,* on specific technologies, interacts to affect the decision of entrepreneurs to form firms in the discussed technological space.

We augment the existing literature in media by focusing attention on two specific factors that have not yet been addressed. First, while the effect of the traditional print media on decision making has been explored rigorously in the extant literature (Pfarrer et al. 2010, Pollock and Rindova 2003, Pollock et al. 2008, Zavyalova et al. 2012), the effect of the new, and burgeoning, social media has been largely ignored. Second, while most of this work has studied decisions or outcomes that are further along in a firm's evolution, e.g. IPO prices (Pollock and Rindova 2003), we focus on the founding decision itself, thereby arguing for the role of media in the genesis of entrepreneurial start-ups. To theorize on how social media may augment the effect of the broadcast media in the context of firm founding, we adopt a lens of *Agenda-Setting Theory.*

Beginning with the work by McCombs and Shaw (1972) and Cohen (1963), agenda setting theory describes how the news media influences readers by

exerting “influence [over] our perceptions of what are the most important news issues of the day” (McCombs 2004). One major finding of this research is that while the media is adept at influencing *what people think about,* it has substantially less effect in influencing *what people think about those topics* (Cohen 1963). The reason for this is that individuals must participate in their own “informal” discourse (Erbring et al. 1980) before acting upon new information.

Defining broadcast media as traditional outlets of print media we argue that broadcast media coverage of various technologies will increase the availability and legitimacy of those topics (Iyengar et al. 1982), thereby stimulating discussion of the technologies in the social media. The social media, which is participatory by nature, will then provide a location for informal and participative communication, which facilitates the translation of salience into opinion and action (Erbring et al. 1980). More simply, while broadcast media sets the public agenda by increasing the salience of various ideas in the public sphere (Berger 2001, Cook et al. 1983, McCombs 2004, McCombs and Shaw 1972), social media, through participation, will drive observable decisions made by entrepreneurs, thereby mediating the relationship between broadcast media and firm founding (Erbring et al. 1980).

We test the logic described above in the context of firm founding by technology entrepreneurs using the VentureXpert dataset which has been used extensively in the extant literature (Hallen 2008, Sorenson and Stuart 2001). We augment this dataset using media coverage from eleven major newspapers within the United States as well as the three major English speaking blogging services

(*Typepad, Blogger,* and *Wordpress*). Results indicate that increases in media coverage have a strong effect on the firm founding rate, and that social media mediates the relationship between the broadcast media and firm founding. Owing to the fact that we explore a mediating relationship in large, secondary data context, we explore our results both econometrically, where we employ an instrumental variable approach by exploiting the exogenous variation resulting from natural disasters, and psychometrically, where we expand upon the Baron and Kenny (1986) framework by using Sobel tests. In each case the mediating relationship is consistent.

Before proceeding to our theory and empirical investigation we make one caveat. We situate the reasoning for our finding by arguing for what Thaler and Sunstein (2008) identify as a "nudge" effect. Research in entrepreneurship has shown that entrepreneurs tend to identify technological opportunities which are related to their own experience or knowledge endowments (Shane 2000, Shane and Venkataraman 2000). We argue that, after an entrepreneur has identified an opportunity, that there is an interim period where entrepreneurs are unsure as to whether or not the market conditions are sufficient to make the exploitation of that opportunity profitable. A significant increase in media discourse on the relevant technology will "nudge" the marginal entrepreneur into founding her firm. Thus, our view of media discourse is not predicated on acquisition of new

information or knowledge that may accrue to the entrepreneur from the media; indeed, in high-tech environments, this is highly unlikely[7].

The remainder of the manuscript is laid out as follows. First, we discuss the extant literature on media coverage in the context of decision making and provide a review of the relevant literature on firm founding. Second, we present our hypotheses regarding firm founding as well as our hypotheses regarding the nature of the mediation between the broadcast and social media in the firm founding decisions of technology entrepreneurs. Third, we discuss the data construction process and describe the various methodologies we use to empirically test our hypotheses. Finally, we provide a discussion of our findings, outlining both theoretical and practical implications, and conclude with a discussion of possible future research.

3.2 Theory and Hypotheses

3.2.1 Media and Decision Making

The effect of information availability, and its impact on perceptions of salience, has a long standing tradition in the literature on decision making and has been recognized as an important factor which can affect the judgment of decision makers. First recognized in Tversky and Kahneman's (1973) seminal work on judgment under uncertainty, many researchers have identified the impact of increased information availability on the judgment tasks that precede critical decision making (Heath and Tversky 1991, Kuran and Sunstein 1999, Pollock et

[7] Similarly, it is unlikely that entrepreneurs will *en masse* start new firms in technologies that see significant discourse increases; this would nullify the value of any specific knowledge, experience, and asset-specific skills that are rare and necessary for technology entrepreneurship.

al. 2008). Since that time, the literature relating to the effect information availability has on managerial decision-making has divided into two research streams. In the first stream, following the original work of Tversky and Kahneman (1973, 1974), researchers have argued that increases in availability leads to biases in decision making due to the invocation of the *availability heuristic* (Heath and Tversky 1991, Kuran and Sunstein 1999, Pollock et al. 2008). In the second stream, researchers have argued that increased availability of information is a *legitimizing* force which signals the superior quality of certain ideas (Abrahamson 1991, 1996, Deephouse 2000, Pollock and Rindova 2003). We describe each of these arguments below.

The first stream of research surrounding the salience of information regarding a subject (be it firm, technology, or industry) argues that as the amount of discourse on the subject increases, individuals lose their ability to form accurate judgments regarding the subject. This leads to a systematic bias in judgment, manifesting as an inaccurate estimation of the risks associated with events related to the subject (Heath and Tversky 1991). The reason for this inability is the invocation of the *availability heuristic* (Tversky and Kahneman 1973, 1974). When this heuristic is invoked, decision makers begin to create a causal linkage between "the probability of an event [and] the ease with which instances or occurrences can be brought to mind (Tversky & Kahneman, 1974, p. 1127)", thereby leading to bias. This original finding has sparked a host of research in experimental psychology (Carroll 1978, Pachur et al. 2012), finance (Kliger and Kudryavtsev 2010), marketing (Folkes 1988), and strategic

management (Pollock et al. 2008) where, in each context, evidence shows that individuals tie the salience of events surrounding them to the probability of those events occurring. Increasing salience can be a function of many factors that have been studied in the literature, such as prior experience or exposure to the subject at hand (Fox 2006), strategically manipulated information (Tversky and Kahneman 1973), and, most relevant to our analysis, increased media attention (Eisenman 1993, Sunstein 2003). Due to the media's role as the primary source of information to the general public (Entman 1989), the media has a significant role in raising the level of salience through increasing availability of information on certain subjects. Therefore, it follows that an industry setting or event receiving considerable media attention, by virtue of increased availability, is likely to introduce biases when decision-makers are required to make probability judgments (Perry 2003). Indeed, some existing work studying the effects of media on judgments has identified exactly these cumulative patterns (Frost et al. 1997, Pollock et al. 2008, Riddle 2010).

Alternatively, researchers have also treated increased media coverage of key events or firms as a *legitimizer* of both ideas and firms (Deephouse 2000, Pollock and Rindova 2003). Take, for example, Abrahamson's (1996) seminal work on management fashion. In this research, he asserts that the development of rhetorics, and stimulating an increase of public discourse, is essential not only for managerial "trend setters" to maintain their status but also to provoke the adoption of new management fashions (Abrahamson 1991, Abrahamson and Fairchild 1999). An important assumption of this work is, however, that adopters of the

new management fashion must believe that the new trend leads to "rational management progress" and is superior to contemporary methodologies. Much of the business literature on media similarly supports this view. Researchers have argued that increased attention granted by the media can influence investor behavior towards stock purchase at IPO (Pollock and Rindova 2003) and grant the firm celebrity status which will buffer the firm against the penalties of sub-par earnings announcements (Pfarrer et al. 2010). At a more methodological level, the use of print media as a proxy measure of management fashion, and the implied legitimacy of certain events or firms, has significant support (Baskerville and Myers 2009, Benders and Van Veen 2001). The underlying assumption here is that increased discourse identifies the underlying appeal of the topic to a wider audience, thereby providing evidence of benefits it may provide. Thus, increase media coverage of certain firms or industries could be seen as legitimizing information, which then incentivizes appropriate action on the part of the decision-maker.

While these two mechanisms explaining the effect of increased media attention may appear at odds, one arguing that decision making is normative (legitimacy) (Abrahamson 1991),while the other arguing for the presence of bias (availability) (Tversky and Kahneman 1973), the direction of influence by the media on decision-making appears to be in the same direction in either theoretical viewpoint. In the presence of increased information availability in the media, individuals will likely display decisions that appear to be driven by the assumption that the ideas discussed in the media are superior or present better

odds. In the specific context that we model, firm founding, both theoretical arguments point towards the positive influence of media coverage on the rate of firm founding. We next discuss research on firm founding to ground the influence of media in this literature before proposing specific hypotheses.

3.2.2 The Entrepreneur's Decision: Firm Founding

Research on firm formation has focused on two separate questions of interest in the economics and entrepreneurship literatures. The first question of interest revolves around market conditions that attract entrepreneurial activity. Entry and exit patterns of entrepreneurs in an industry have been tied to the presence of competition and congestion (Delacroix et al. 1989); entrepreneurs tend to seek out environments which are either "munificent or sparse" (Dubini 1989) and represent a unique set of risks and opportunities for the average entrepreneur (Klepper and Graddy 1990). The agglomeration phenomenon is also studied in this line of research; entrepreneurs tend to locate their new ventures in select regions in order to utilize market-related resources and capabilities that also tend to be geographically concentrated (Audretsch et al. 2005). Agglomeration allows entrepreneurs to leverage knowledge spillovers that are local and specific to certain regions and also increases their ability to acquire customers, skilled managers and labor (Bresnahan et al. 2001).

The second stream of research, which is more pertinent to our theorizing, is based on understanding the characteristics of the entrepreneur and the decision-making process that precedes the actual firm founding. Research has found that personal experiences affect the probability of firm founding (Shane and Khurana

2003), and that experience has a strong hand in enabling entrepreneurs to identify opportunities in the marketplace (Shane 2001, 2001). It has similarly been argued that a unique set of resources, within the entrepreneurial community, allows them to identify and respond to opportunities through entrepreneurial activity (Alvarez and Busenitz 2001). However, as Grégoire et al. (2010) note, the process of opportunity recognition includes both the recognition of the technological opportunity, as well as the identification of market readiness. Therefore, while entrepreneurial discovery or creation of technological opportunities is likely driven by unique entrepreneurial skill-sets (Alvarez and Barney, 2007), the actual founding of the firm is an outcome of the effectuation process (Sarasvathy 2001), which requires the entrepreneur to subjectively evaluate the market's receptivity to such technological opportunities (Foss et al. 2008).

This subjective judgment of markets is an integral part the identification of, and the decision to act on, entrepreneurial opportunities (Foss et al. 2008). Because of this, the idiosyncratic perception, by the entrepreneur, of the market-technology dyad will play a large role in the decision of the entrepreneur to act on perceived market opportunities (Grégoire et al. 2010). This idiosyncratic perception is important for two reasons. The first is that the identification of entrepreneurial opportunities is often treated as a black box in the literature (Alvarez and Busenitz 2001), i.e. entrepreneurial opportunities are treated as if they *are* opportunities or they *are not*, with little credence paid to the perspective of the individual making that judgment. This is important because, during the decision to enter the market, the onus is not simply on the entrepreneur to

"discover" or "create" opportunities (Alvarez and Barney 2007), it is both to identify the technological gap which is unmet by the market, as well as judge the opportune moment to exploit that gap. The second is that "an opportunity is neither solely about a new technology nor solely about a current market situation (Grégoire and Shepherd 2012)." Nor is an opportunity simply the perception of what assets an entrepreneur possesses within their venture and believes they can possess in the future (Haynie et al. 2009). An entrepreneurial opportunity is the mix of both the technological gap and the market situation which will allow the exploitation of that gap. If, as Shane (2003) suggests, that the market situation requires judgments (Foss et al. 2008), which are idiosyncratic to the entrepreneur (Grégoire and Shepherd 2012, Shane 2003), then it is reasonable to believe that these judgments will be subject to the same biases and heuristics which affect other forms of decision making, such as the influence wielded by media (McCombs 2004).

We therefore hypothesize that entrepreneurs will be influenced by the presence of increased media coverage in the industries they wish to enter because of the media's ability to influence decision making through the twin pathways of salience or legitimacy described before. Either of the two theoretical mechanisms described above will influence the entrepreneur, on the margin, to incorporate their firm as a result of a dramatic increase in media attention devoted to their specific technology or industry, all else being equal. On one hand, a drastic increase in the salience of the entrepreneur's technological space biases downward the entrepreneur's perceived probability of failure (Tversky and

Kahneman 1974), making it likely that she will found the firm. Alternatively, the increased perception of market legitimacy and fashionability through media will, on the margin, induce more entrepreneurs with the technological "means" to actually found the firm. Therefore, we propose the following for both broadcast and social media as a baseline:

H1: Increases in media coverage will be associated with an increased firm founding rate for industries affected by the media coverage, all else equal.

3.2.3 Social Media: The Agenda Setting Process

While Hypothesis 1 provides a framework for evaluating the impact of media on firm founding it does not allow us to differentiate between broadcast media, print media in this case, and the emerging world of social media. While broadcast media has been studied in the literature, the advent of social media technologies in the 1990s has allowed a new form of discourse that is not limited by region, professional role, or nationality. Moreover, the advent of social media and Web 2.0 technology has the ability to foster *participation*. To consider how social media may influence firm founding and how structural properties of these media may affect decision making we adopt the lens of Agenda Setting to theorize on how social and broadcast media may affect entrepreneurial firm founding differently.

As noted in Cohen's (1963) seminal work, agenda setting theory addresses the ability of the media to "influence the salience of topics on the public agenda" (McCombs and Reynolds 2002). In essence, this theory argues that the relative importance of topics, as dictated by coverage devoted to that topic in print, influences the salience of those topics in the mind of the general public. The

theory finds that there is a strong, and causal (Iyengar et al. 1982), relationship between what is covered in the news media and the perceived importance of that event or phenomenon by the public (Berger 2001, Cook et al. 1983, McCombs and Shaw 1972). However, discussion of topics in the news media has a limited ability to influence decision making; instead, these discussions only influence the salience of those topics (Cook et al. 1983, Erbring et al. 1980). This is because "an interpretation of the news [is] not [created] by individual intuition but by "social reality testing". Informal communication with others is essential to help people make sense of news media content, and thus plays a critical role in shaping public perceptions of issue salience" (Erbring et al 1980, pg 41). In other words, while it is necessary for the media to address a topic for it to become salient for the reader, as the media is the major conduit through which people gather their information on public affairs (Entman 1989), that alone has limited influence on decision making. Instead, individuals must have the option to participate in the discourse for changes in observable decision making to occur (Erbring et al. 1980).

If these arguments from agenda setting are accurate, then the literature on the effect of media on decision making is likely incomplete and only offers a partial picture of the effect media may have on decision making. While media portrayals of topics increase salience in the mind of the entrepreneur, that alone would be insufficient to incentivize actual firm founding as an intermediate step, participation, must occur before the entrepreneur takes action. Ample anecdotal evidence exists for the attractions of the option to participate in the creation of

discourse in contemporary print and social media. While many traditional print outlets exist for news and commentary, The Huffington Post has become one of the leading outlets for news and commentary[8]. The Economist writes that the Huffington Post is "designed for the wired generation's short attention spans and addiction to social media; it has managed recently to increase its "stickiness", the number of stories each visitor reads. And it mixes both hard and frothy news (much of it rewritten from other sources, though an increasing amount is original) with *generous dollops of opinion by guest bloggers*." Thus, while the Wall Street Journal and USA Today still retain leadership amongst traditional print media, bloggers and social media appear to retain some vital influence on decision-making.

If participation in discussion with members of the individual's peer and social network (also referred to as "informal communication") is indeed critical, as argued by Erbring et al. (1980), in inducing action on the part of the decision-maker, then the effect of the broadcast media may be limited here. Social media, which is participatory by nature, will serve to resolve this lack of "sense of community" (McCombs and Shaw 1993) between the general public and the broadcast media by facilitating the informal communication which is necessary. As blogs, and other forms of social media, are often effective indicators of public opinion (O'Connor et al. 2010) and valuable repositories of information, we assert that discourse in social media will provide the option to participate to the entrepreneur, who may use these means to enter into informal discussions with

[8] http://www.economist.com/node/21550262

other members of the entrepreneurial community. A significant increase in discourse on social media will not only provide increased salience, but when viewed through the lens of agenda setting, will have a higher chance of eliciting action on the part of the entrepreneur, i.e. firm founding.

This raises the question of the relationship between social and broadcast media. Does the broadcast media set the agenda for discussion on the social media? We argue that broadcast media introduces and sets the agenda in the public sphere by increasing the salience of certain topics and events (Iyengar et al. 1982), which then form the seeds for discussion and debate in the social media world. As mentioned above, the Huffington Post typically picks up articles from mainstream media outlets and republishes these, alongside blogs and commentary by readers. This multi-stage process therefore results in a mediating relationship between the broadcast media and the founding decision by the entrepreneur. The broadcast media sets the agenda for discussion within the social media, which in turn, affects the entrepreneur's observable firm founding decision through the availability of participatory discussion. Therefore we propose:

H2: Social Media Coverage will mediate the relationship between the broadcast media coverage and firm founding rate for industries affected by the media coverage, all else equal.

3.3 Methodology

3.3.1 Data Collection and Coding

We conduct our empirical analysis of the proposed hypotheses using a dataset derived from the VentureXpert dataset provided by Thompson Reuters. VentureXpert has been used frequently in prior academic research on

entrepreneurship (Hallen 2008, Sorenson and Stuart 2001, 2008). We identify the sample for our analysis after applying three restrictions on the data. First, we consider only entrepreneurial firms founded between 1996 and 2006 to ensure the presence of social media, in our case the presence of blogs, during this time period. Second, we include only entrepreneurial firms based in the United States. As we measure broadcast media discourse using national US newspapers, and social media discourse using blogging services initiated in the US, the ability to measure changes in media coverage cleanly is much easier with American firms. Finally, we use only Information Technology (IT) entrepreneurs in our analysis to mitigate the problems associated with variable clock-speed times entrepreneurs in different industries are faced with (Mendelson and Pillai 1998). Consistent with the extant literature (Hallen 2008, Sorenson and Stuart 2001) we define IT entrepreneurs as those who have been classified part of the "Information Technology" industry classification within the VentureXpert dataset.

While VentureXpert provides information on when entrepreneurial firms were founded, our theoretical arguments are based the extent of media discussion of various technologies around the country. As such, we need to consider the number of firms founded in a certain geographical area in a certain time-period. We therefore divide the firms founded into both the nine Economic Census Zones ascribed by the Census Bureau and six-month time-periods between 1996 and 2006. Moreover, to increase the granularity of our investigation, we dissect the IT industry into the 304 IT sub-segments defined by VentureXpert in order to ensure we are measuring media discourse specific to the focal entrepreneur; a selection

of these industry classifications are provided in Table 3.8. We use these industry subclasses in measuring discourse. Our final sample consists of 54,720 observations tracking the number of entrepreneurial firms, by six month periods, in each of 9 Economic Census zones, across 304 IT subclasses in the period 1996-2006. The dependent variable, *Num_Founded,* is the number of entrepreneurial firms founded in Economic Zone *k* as part of Industry *i* during period *j*. The summary statistics for the sample are provided in Table 3.3.

3.3.2 Media Change Measurement

Our first independent variable is the level of discourse that a technology subclass receives in the broadcast media during the time-period preceding the founding of the firm. While media is clearly a broad construct and can include many different sources, such as television, print, and film, we focus here on discourse from the newspaper print media for two reasons. First, there is a cumulative tradition within the strategy literature that has used newspaper-based print media as measures of legitimacy and fashion (Benders and Van Veen 2001, Pollock et al. 2008, Sunstein 2003). Second, the journalism literature recognizes the primacy of newspapers in agenda-setting, allowing us to remain consistent with this literature as well (McCombs 1981). Our measurement of broadcast media, therefore, uses the number of newspaper articles that discuss the specific technology subclass described above in six-month time-periods, captured through the use of a web-scraping tool. We use six-month periods to increase the granularity of our analysis while allowing enough time to pass between observations such that discourse levels may change.

We use newspaper articles from two primary print outlets to provide our baseline measure broadcast media: *The Wall Street Journal* (WSJ) and *USA Today* (USAT). We do this for two reasons. First, these periodicals are the most widely distributed daily periodicals in the world (with a current daily circulation of 2.06mm and 1.83mm respectively). Second, using these two periodicals allows us to measure discourse within both the business and popular presses thereby increasing the scope of our measurement. As geographic proximity is also a key concern when measuring salience, we augment this measure of broadcast discourse by also including discourse from a newspaper in the focal entrepreneur's economic zone. A full listing of the economic zones and the newspapers used in each of these zones is available Table 3.1[9].

Measuring discourse on social media for the time period we study is easier. We use a web-scraping tool to determine the number of blog posts that discuss the technology subclass in question on three major English-speaking blogging services – *WordPress* (Word), *TypePad* (Type) and *Blogger*. Cumulatively, these three blogging platforms accounted for over 66% of personal blogging at the end of our analysis period in 2007 (Palatnik 2007). Our web-scraping tool measures both the usage of the technology in the main blog post as well as comments that follow by individual readers. The reason for this is that total discourse, i.e. both the post and the reaction to that post, is the desired objective of our measurement of social media. It is worth noting that due to the

[9] While most regional newspapers are the largest in the respective economic zone (e.g. *The Chicago Tribune, The New York Times*) we substitute newspapers salient to IT entrepreneurship (e.g. *San Jose Mercury News*) where appropriate.

explosion of blogging during the period of study, the scale of this measure is vastly greater than that of broadcast media, as seen in Table 3.3.

Our operationalization of the social and broadcast media (henceforth *Broadcast Media* and *Social Media*) is based on changes in the amount discourse, regarding an IT industry sub-segment, over time. Moreover, we lag both variables to preclude reverse causality. Therefore, if the firm was founded in time period *j,* change in discourse is measured in the industry subclass *i* of the firm between time periods *j-2* and *j-1.* The broadcast media here includes the two national newspapers and the newspaper specific to economic zone *k.* This same operationalization is used to measure the change in social media after substituting the number of blog posts for the number of articles. We use a difference measure for these variables because prior work argues that high level of media ubiquity causes individuals to take the level of discourse "for granted" (Pollock et al. 2008). As individuals become desensitized to information when they are consistently subjected to it (Gerbner and Gross 1976), the usage of a simple article count provides potentially misleading information. Other possible measures, such as a growth metric, which is bounded at negative one, are unsuitable as we must capture both large increases, and decreases, in discourse.

One potential concern in our operationalization of broadcast and social media, which only captures the number of articles, pertains to the tone of the articles included in the measure. Would firm founding be differently affected if the bulk of the articles actually disparaged the technology subclass in question? This raises the issue of tone of media coverage. The majority opinion in

journalism is that news media coverage is overwhelmingly positive (Mark 2006, Pollock and Rindova 2003), with the exception of political coverage, and should not be of concern. To ensure that this is true, we randomly gathered approximately 20,000 articles from the sample of articles that contributed to the article count from LexisNexis and analyzed their tone using the Linguistic Inquiry Word Count (LIWC) (Pennebaker et al. 2007) tool which has been used extensively in the literature. This tool provides an index of the positivity and negativity of each article. We then randomly sampled 1000 articles at a time from the corpus of approximately 20,000 articles and repeated this procedure (with replacement) 10,000 times. For each draw, we then calculated the mean tone indices, giving us a simulated sample of 10,000 draws of the mean of means. The mean positivity we obtain is 2.23 while the mean negativity is 0.73, with a difference of means T-test highly significant. This simple test reinforces the conventional wisdom from the journalism literature and allows us to rely on salience using article counts.

3.3.3 Controls

Broadly speaking, the controls for this investigation fall into two basic classifications: economic factors native to the geographic area and social factors shown to influence firm founding rates. To include these controls we augment the VentureXpert dataset with information from three other sources. First, we use the US Census Bureau's Small Area Income and Poverty Estimates (SAIPE) dataset, which allows us to control for time varying economic conditions. Second, we use the US Census Bureau's County Business Partners (CBP) dataset which provides

information on IT firms, as defined by NAICS code, in the different geographic regions of the US. Finally, we use the NBER Patenting dataset to account for the differing rates of technological progress (i.e. technological regimes) in industries across time.

Drawing from the SAIPE data, we include controls for *Poverty*, to control for the number of people living in poverty in the economic zone in which the entrepreneurial firm is founded (Armington and Acs 2002), the median income (*Median*) to control for the wealth of the economic zone, and the population of the economic zone (Bruno and Tyebjee 1982, Saxenian 1994). Utilizing the CBP data, we include controls for the number of people in the economic zone currently working in the IT industry (*Employment*) (Saxenian 1994) and the number of IT firms based in the economic zone (*NumFirms*) which are already operating (Saxenian 1994). We classify IT firms in this context as those which are operating in IT based NAICS codes in economic zone *k* at time *j*. From VentureXpert, we control for access to venture capital by measuring the amount of capital invested by VCs in industry *i* within economic zone *k* (*VC Capital*) and the number of VC funding decisions (*VC Investments)* within industry *i*, economic zone *k*, and period *j* (Bruno and Tyebjee 1982). Finally, using the NBER patenting dataset, we control for regime changes within the technology of the focal entrepreneur, we control for the cumulative number of patents which have been granted to entrepreneurs, in industry *i*, in the two years prior to the focal time-period (Shane 2001).

3.4 Data Analysis

As our dependent variable is a count (i.e. the number of firms founded in *i,j,k*) we use a conditional fixed effect Poisson Quasi-Maximum Likelihood Estimator (Hausman et al. 1984, Simcoe 2007) as our baseline estimation technique. This estimator has a been used extensively in the extant literature (Azoulay et al. 2010), and offers several benefits over the Poisson and Negative Binomial estimators. First, the estimator is not constrained by the assumptions the Poisson places on the conditional moments of the dependent variable (namely that the conditional variance of *y* given *x* is equal to the conditional mean). Because this assumption is not enforced by the estimation, the assumptions of the model are not violated when the distribution of *y* given *x* does not follow the functional form of the Poisson or Negative Binomial distributions (Wooldridge 1997). Additionally, the estimator allows for the generation of consistent and robust standard errors even when the distribution of the dependent variable is not Poisson (Azoulay et al. 2010). We first test the effect of the change in broadcast media on firm founding rates using this methodology, with industry zone fixed effects and robust standard errors, using the following equation:

$$xtpqml\ (Num\ Founded_{ijk}) = f\ (Broadcast\ Media_{i-1jk} + Poverty_{ijk} + Median_{ijk} + Employment_{ijk} + Num\ Firms_{ijk} + EA\ Population_{ijk} + VC\ Capital_{ijk} + VC\ Investments_{ijk} + Patenting_{ijk}) \quad (1)$$

As we wish to test a model of mediation we next include the *Social Media* as part of the regression while simultaneously dropping the *Broadcast Media*. To complete the assertions of mediation we run both items simultaneously and finally regress *Social Media* using a simple time series OLS on *Broadcast Cascade.* The

results of these regressions can be seen in Table 3.4. Before we discuss these results in detail, we address some potential issues in the baseline specification above through additional robustness checks described below.

3.4.1 Robustness Checks

The first empirical issue that we face is that not all economic zones experience the founding of a firm in each industry. Therefore, in the regression estimated above, a significant portion of the sample is omitted because the dependent variable (firm founding) is non-time varying. A second empirical concern is that the non-linear nature of the Poisson Quasi Maximum Likelihood Estimator precludes us from performing more exacting psychometric tests of mediation above and beyond the original framework laid down by Baron and Kenny (1986) (such as the Sobel (1982) test). To resolve both these concerns, we re-estimate the original model shown in equation (1) using a time series OLS estimation[10] which linearizes the specification by assuming that the DV is interval-scaled. Although the DV in this case is a count model, the large number of possible values it can take (the supremum of the DV in our case is 87) indicates that a linear model may be a reasonable approximation (Wooldridge 2009). We therefore re-estimate our results, with industry zone fixed effects and robust standard errors, using the following equation:

[10] One possible alternate methodology to resolve the problem posed by the fixed effect's impact on the size of our sample would be to repeat this analysis using random effects and a time series Poisson estimator. Although the results are consistent in terms of significance the Hausman test indicates there is difference between the coefficients.

$$xtreg\ (Num\ Founded_{ijk}) = f\ (Broadcast\ Media_{i-1jk} + Poverty_{ijk} + Median_{ijk} + Employment_{ijk} + Num\ Firms_{ijk} + EA\ Population_{ijk} + VC\ Capital_{ijk} + VC\ Investments_{ijk} + Patenting_{ijk}) \quad (2)$$

As with the previous model, we repeat the remainder of the steps to meet the empirical requirements for mediation. The results of these regressions can be seen in Table 3.5.

A more pressing concern in our analysis revolves around the endogeneity of the broadcast media variable with respect to firm founding. Two significant sources of bias may influence the results obtained from the above analysis. First, it is possible that an omitted variable or event could increase both the media coverage and the firm founding rate for an industry sub segment. Prior work suggests, for example, that a change in technological regimes could potentially spark off widespread media coverage (Peterson 1979) and subsequently also increases firm founding (Shane 2001, 2001). If this is the case, then our estimates for the effect of both *Broadcast* and *Social Media* on firm founding will be biased (Wooldridge 2009). To address this endogeneity issue, we require an instrument that is correlated with the extent to which both medias discuss technology-related issues, but is uncorrelated with firm founding. Pursuant to this logic, we instrument for the omitted variable using the number of natural disasters, within the entrepreneurial firm's economic zone, during the period prior to that firm's founding. Natural disasters here are defined as events such as earthquakes, fires, hurricanes, thunderstorms and so on, which are by definition exogenous in the context we model. The occurrence of these events will constrict the amount of "column inches" that broadcast and social media will dedicate to technology-related content but should have no significant effect on firm founding in the six-

month period. Under these circumstances, this variable should, we argue, reasonably instrument for any omitted variable that may affect both the media and firm founding.

A second issue with endogeneity of the broadcast media arises from reverse causality, i.e. it is possible that the entrepreneurial team actively influences editorial decisions on the news media and increases media discourse on key technologies. Here too, the exogeneity of both the social and broadcast media is in doubt. We account for some of these effects by lagging media coverage. However, we also instrument for these effects by measuring the discourse on technologies in the foreign press, specifically the *London Financial Times* and *The Sun*[11]. The logic behind using discourse in the Foreign Press is as follows: while an individual entrepreneur may be able to influence the editor of a local newspaper or be able to predict discourse at the local newspaper, the chances of them simultaneously influencing or predicting the editors of both major English newspapers is limited. This instrument therefore allows us to rule out the possibility of reverse causality.

Using these sets of instruments for broadcast media, we now estimate a panel two-stage least squares estimation where in the first stage, Natural Disasters and Foreign Media instrument for Broadcast and Social Media change. The equation estimated is as follows:

[11] We follow the same methodology described before to capture increases in the foreign press coverage of the industry subclasses.

$$xtivreg2\ (Num\ Founded_{ijk}) = f((Broadcast\ Media_{i-1jk} = Natural\ Disasters_{i-1jk}, Foreign\ Media_{i-1jk})_{+} Poverty_{ijk} + Median_{ijk} + Employment_{ijk} + Num\ Firms_{ijk} + EA\ Population_{ijk} + VC\ Capital_{ijk} + VC\ Investments_{ijk} + Patenting_{ijk}) \quad (3)$$

As before we wish to test a model of mediation we, once again, include the *Social Cascade* as part of the regression while simultaneously dropping *Broadcast Cascade*. Finally, we run both independent variables simultaneously and then finish by using the *Social Cascade* as the dependent variable. The results of these regressions can be seen in Table 3.6.

3.4.2 Results

Before describing into the results regarding our focal variables, we first discuss the results of the control variables presented in Table 3.4. Consistent with the extant literature we see that an increase in the amount of venture capital and an increase in the median income of the economic zone are correlated with an increased firm founding rate. This suggests that as the financial resources available in the region increase, there is, all else equal, a corresponding increase in firm founding. There is also a significant correlation with the population of the area, suggesting that either people are moving to areas with high entrepreneurial firm founding or that when there is more human capital to draw on in a location the firm founding rate will be higher. Somewhat surprisingly, there is a negative, and significant, relationship between poverty and firm founding, which seems to contradict the extant literature. Considering the human capital requirements (i.e. technical skills and education) for founding firms in IT, this is not shocking as

lower income workers may not have the necessary training for entering the market space.

We next consider the results relating to our research variables from Table 3.4. With respect to the baseline model (Column 1 of Table 3.4), we see a strong and positive correlation between *Broadcast Media* and the number of firms founded in that technology subclass. Moreover, we also see a strong and positive correlation between *Social Media* and the number of firms founded (Column 2 of Table 3.4). Each of these estimates lends strong support to Hypotheses 1, indicating that increases in media coverage (both from the broadcast and social media) are strongly correlated with firm founding rates. It is possible that the presence of industry and zone fixed effects may change these broad results. Therefore, we consider the results from the time series OLS regression (Columns 1 and 2 of Table 3.5). Here too, both *Broadcast Media* and *Social Media* are significant on the number of firms founded, lending support to Hypothesis 1.

Hypothesis 2 argues for a mediation effect of *Social Media* on the relationship between Broadcast Media and firm founding; we return to Table 3.4 to consider the results of these tests. We first see that *Broadcast Media* is a significant predictor of *Social Media* (Column 4), which indicates that the agenda that is set by the news media does contribute to seeding discussion on social media. This supports the notion that social media tends to feed on topics that are brought to the public's agenda through the traditional press. When *Social* and *Broadcast Media* are regressed on firm founding together, the effect of *Broadcast Media* is rendered insignificant while that of *Social Media* retains significance

and magnitude (Column 3 of Table 3.4), indicating the presence of a mediated relationship. We observe the same patterns from the panel analysis reported in Table 3.5; the coefficient of *Broadcast Media* becomes insignificant when *Social Media* is introduced into the analysis (Column 3 of Table 3.5). As the results from the OLS model are linear we also conduct a Sobel (1982) test, which indicates a test statistic of 2.89 ($p < 0.01$) suggesting that a significant mediating relationship exists, lending support to Hypothesis 2.

We finally consider the results from the instrumented regressions reported in Table 3.6. We first examine the strength of our instruments. Our tests indicate that the first stage regression is robust, with a minimum Kleinenberg Paap F-Statistic of 12.847, thereby meeting the minimum strength requirements prescribed by Stock and Yogo (2005). The results of the Anderson-Rubin test for under-identification are also significant, indicating that the model is not under-identified. After effectively instrumenting for the econometric concerns which may be present in the baseline specification we again find that *Broadcast Media* and *Social Media* are strongly and positively correlated with the number of firms founded when considered individually, indicating support for Hypothesis 1. Moreover, the mediation results from above hold, as seen from Columns 3 and 4 of Table 3.6, supporting Hypothesis 2. Extending the mediation testing framework to include the Sobel test also provides a significant test statistic (2.494, $p< 0.05$).

3.4.3 Post Hoc Analysis

One final post-hoc analysis we conduct pertains to the concern that our sample is limited to entrepreneurs who receive venture capital funding, which may lead to a biased sample. In the Kauffman Foundation dataset, for example, only 11% of entrepreneurs surveyed receive venture capital financing (Kauffman 2012). Other estimates suggest that the number may be even lower (Goldfarb et al. 2005). To ensure that our results extend to entrepreneurial activity outside this sample, we replicate our analysis using the County Business Partners (CBP) dataset provided by the US Census Bureau. Although this dataset does not provide data on *de novo* firms, it allows us to track changes in the number of firms, by county and number of employees, which exist in IT industries (as classified by NAICS). By focusing on the number of very small firms (fewer than 50 employees) in an economic zone, we are able to approximate firm founding behavior and thereby provide a comparison to the main analysis presented above[12].

The dependent variable in this analysis is the number of firms with less than 50 employees (*Under_50*) in industry *i*, county *c*, and time *t* [13] we replicate our analysis using the same two stage least squares estimation used in Table 3.6. Results of these estimations can be found in Table 3.7. As with our prior estimations we see a strong and significant correlation between the *Broadcast* and *Social Media* (Column 1 and 2 of Table 3.7), when regressed independently, on

[12] A description of the matching process between the CBP and VentureXpert Industry classifications is available in the Appendix

[13] Unlike the earlier analysis, we use counties here and accordingly disaggregate data from economic zones to fit the county level analysis.

the number of firms with fewer than 50 employees in the county. However, when the number of firms is regressed on the change in *Broadcast* and *Social Media* concurrently (Column 3 of Table 3.7) the effect of the *Broadcast Media* is rendered insignificant once again indicating a fully mediated relationship. Extending the mediation testing framework to include the Sobel test also provides a significant test statistic (2.964, $p< 0.01$).

3.5 Discussion

In this paper, we start with the broad notion that the radical increases in discourse and media coverage can influence decision-making. In particular, we argue that increased media coverage, on certain technology industries, in the broadcast print media and social media can lead to an increased founding of firms in that technological space. The extant literature in strategy and entrepreneurship has suggested two potential pathways for why this may occur. The first pathway contends that media attention leads to increased salience and the use of the availability heuristic (Sunstein 2003), thereby leading to more firm founding. Alternatively, the neoinstitutional literature argues that media plays a legitimizing role and this will induce entrepreneurs to found firms in the technology areas that are currently experiencing this media attention (Deephouse 2000). Although we cannot distinguish which mechanism dominates here, our analysis shows that increased discourse in broadcast and social media is associated with increased firm founding. However, our analysis takes these relationships a step further. We argue, and show, that the option to participate that social media provides contributes by mediating the relationship between the uni-directional broadcast

media and firm founding. More simply, social media allows participation in the agenda-setting process, which helps convert the broader agenda set by the broadcast media into observable action, i.e. the founding of the firm.

There are two significant extensions we make in this paper to extant theory in media and entrepreneurship, which have implications for both academic research as well as practice. The existing literature on the effects of media on firms or individuals have rightly argued that through the twin pathways of legitimacy and salience, observable changes in behavior or decision-making can be elicited (Pfarrer et al. 2010, Pollock and Rindova 2003, Pollock et al. 2008, Sunstein 2003). However, a large portion of this research is considers only the one-directional broadcast media, and overlooks the critical role that participation plays in converting impressions generated in the public domain into actual action. The advent of social media brings this participation element in to stark relief and allows us to significantly advance the literature discussing media's effect on decision making (Pollock and Rindova 2003) by identifying a missing link in the causal chain between the broadcast media and eventual action.

This work similarly offers several extensions to theory that can result from the introduction of participatory social media into current research on media's effects on behavior. We only focus on blogs as they were the social media of choice at the time of our analysis. However, current technologies offer variations on the form and structure of participation available to consumers. YouTube, for instance, offers participation in the form of multimedia (video), which allows participation in discourse creation but in a much richer manner. Alternatively,

Twitter allows a thinner stream of discourse but by lowering the entry barriers, allows quantity and ease. Facebook allows personalization by invoking discourse through existing social ties. All of these technologies facilitate participation but vary the parameters of participation. Not only does our work point out the need to incorporate technologies like these when investigating the effect of media on decision making, it also suggests that one fruitful avenue of future research will be the examination of how the form, content, and richness of participation will influence outcomes differentially. A further layer extension which can be made is considering the source of participation and how it impacts consumer decision making. If, for example, firms participate in the discourse concerning their products on social media, do consumers respond favorably compared to traditional advertising avenues? Alternatively, does the benefit of participation only manifest when third-party entities participate? Going one step further, opportunities exist to expand the theorizing on media to consider the interactions of types of broadcast and social media on consumer behavior? For example, does the option to participate in, and comment on, a firm's advertisement during the Super Bowl on Twitter lead to observable benefits for the firm in contrast to simply the Super Bowl advertisement? The juxtaposition of participatory social media and multiple forms of broadcast media (indie video, film, print, TV) provides many rich interaction stories for researchers, with clear managerial implications. Managers would be well-advised to consider the joint impacts of varieties of social and broadcast media on the many dimensions of economic

outcomes critical to their work. Our work here hopefully provides direction to this promising stream of research in the future.

We also contribute to research on entrepreneurship by introducing the role of media specifically in the context of firm founding. The economics literature on firm founding has focused on many factors that may drive entrepreneurs to found firms in certain areas and technologies based on the extent to which resources and opportunities exist in such domains (Acs and Armington 2006, Acs and Audretsch 1987, Armington and Acs 2002). However, little attention has been paid in this research to the role of media. This omission of the influence of media similarly exists in the entrepreneurship literature, where the focus is typically on the entrepreneur, her characteristics, experience, and specialized skills (Shane and Khurana 2003, Shane and Venkataraman 2000). If, as (Shane 2003) suggests, opportunities are not simply created or discovered (Alvarez and Barney 2007), but instead exist at the nexus of the individual and the technology, then the identification of the opportunity is related not only to the economic assessment of the technological gap, but also on the subjective assessment of the market by the entrepreneur (Grégoire and Shepherd 2012). More simply, we argue that for many entrepreneurs, the identification of a technology opportunity and the subjective judgment of market readiness for the technology are independent evaluations, and likely not co-determined. Rather, the decision to enter the market, i.e. found the firm, requires an idiosyncratic assessment of the market and the risks of failure (Foss et al. 2008). It is exactly here that we contend that the influence of

broadcast and social media will be felt, resulting in the "nudge" factor (Thaler and Sunstein 2008) and thereby increased firm founding.

Anecdotal evidence for such effects exist across the venture capital and entrepreneurship practitioner press. When certain technologies become "hot", there is typically an influx of venture funding into firms in that area[14]. VCs refer to these events as "money chasing deals", where as greater investments go into specific domains, and less defensible criteria are used to fund the next entrepreneurs in these areas. If this is truly the case, the judgment of risks by nascent entrepreneurs in that technological area is likely to be influenced. Similarly, for the entrepreneur, leading publications or online sources provide articles entitled "Hot New Technologies" or "Technologies to Watch"[15]. These publications, and the discourse that results, highlight technological areas where experienced entrepreneurs (Shane 2001, 2001) or those with significantly well-developed product ideas in that technological sector may find burgeoning market opportunities (Grégoire et al. 2010). Our theory about the role of broadcast and social media addresses exactly this context, where increased salience and legitimacy from discourse motivates the entrepreneurial firm to actually be founded. Whether the dominating mechanism of increased salience or enhanced legitimacy that accrues from discourse remains an area for further study in the literature; we cannot clearly identify the mechanism in this context.

[14] Consider the following recent blog post: *www.entrepreneur.com/blog/224074*. It describes the technologies that VCs are currently investing in and includes what would be considered to be the most desirable industry sectors – mobile technology, cloud computing and social computing.
[15] http://www.businessnewsdaily.com/1859-business-technologies-2012.html; http://www.pcworld.com/article/245659/20_most_anticipated_tech_products_of_2012.html

The mediating role of social media suggests that participation may be particularly critical in the entrepreneurial context; organizations and policy-makers would benefit from understanding that entrepreneurship benefits from discussion and cooperative debate. Some evidence of this exists in research studying the success of technology incubators – Colombo and Delmastro (2002) compare new ventures in incubators to ventures outside such incubators and show that the propensity to network, ability to form collaborative arrangements, and ability to discuss issues with peers provide incubator firms with considerable benefits that are not available for off-incubator firms. Following this logic, our work poses the theoretical question – can the collaborative benefits of an incubator be replicated through collaborative social media? Moreover, are there limits to how much technology-mediated collaboration can accomplish? It is commonly accepted in entrepreneurship that location matters, because location provides the venture with resources and access to markets (Bresnahan et al. 2001) as well as venture capital (Sorenson and Stuart 2001). If one of the key benefits of location is relative ease of discussion and collaboration, then arguably participative media can ease the primacy of location in entrepreneurial decision-making. As is evident, the ramifications of participation offered through new social media allow us to ask many theoretically valid research questions within the entrepreneurship literature, opening up several streams of research.

Before we conclude, we discuss the limitations in the presented analysis. First, our measure of firm founding is subject to some inherent error as we only capture the decision to enter the market for VC seeking firms. We address this

limitation by extending our analysis to a different dataset and showing consistent results. However, this remains a potential limitation. A second limitation pertains to endogeneity of the broadcast media variable. We account for this through two sets of instruments with clear arguments for why they may mitigate any bias. However, methodologically, we acknowledge that there may still remain some bias that can only be completely eliminated through randomized experiments. Third, we only include entrepreneurs who have actually incorporated firms. While this may induce a selection bias, given the objective of the analysis, we believe this might be small. Fourth, we intentionally avoid characterizing individual articles and blog posts in our analysis but focus on counts. Empirically, the sheer scale of the sample (304 industries in 11 newspapers over 10 years, 5M blog posts) makes capturing information on specific articles practically infeasible. Finally, while we argue that social media allows collaboration, we do not (and cannot) explicitly capture this collaboration on the part of the entrepreneurial team. Theoretically, agenda setting suggests that the option to collaborate and seeing other collaborate is enough. However, this does represent a limitation here that can hopefully be addressed in future work that uses primary data.

In conclusion, this study investigates how changes in media coverage impacts entrepreneurial firm founding rates. Not only do we empirically validate the effect media can have in inducing entrepreneurs to incorporate their firms but we also identify a critical missing piece in the extant literature on media's effect on decision making, i.e. participation. While the literature discussing the effect media can have on managerial decision making has addressed many different contexts

(Pollock and Rindova 2003, Pollock et al. 2008) it has yet to consider the importance of participation, and how different medias interact, when influencing the decision making process of the manager. We thus extend this literature by considering the role of media on a very important part of the entrepreneurial process, firm founding. We also hope that our work here provides the platform for many more papers that examine the richness and depth that media and social technologies offer in various aspects of the entrepreneurial process.

3.6 Chapter 3 Appendix

In Table 3.8, the right hand column contains a sampling of the VentureXpert Company Industry Subclass 3 industry names and the left hand column contains the North American Industry Classification System industry names which match to those names. In order to replicate our analysis using the CBP data our first challenge is to retain consistency with the industry subclass and the media variables defined earlier. As not all industry subclasses within VentureXpert map cleanly to the NAICS industry classification used in the CBP Dataset we use a text-based approach to provide this mapping.

To complete the mapping we compare the actual text of the industry name in the NAICS classification to each of the ISC names and then calculate the *Levenshtein Distance* to determine the best possible match for each industry. We then discard all matches that are either a) not the best possible match for the industry or b) not above a match threshold of 70%. Robustness checks are conducted on this matching process in two ways. First we manipulate the matching threshold at 60%, 80%, and 90%. We similarly calculate the *Jaccard*

Distance and *JaroWinkler Distance* (two commonly used techniques for calculating text disparity) and replicate the analysis this way. In each case the results are consistent.

CHAPTER 4: PHYSICIAN HEAL THYSELF? CHANGES IN DECISION MAKING AFTER INFORMATION SHOCKS

ABSTRACT

Rapid response to exogenous information shocks is critical in knowledge-intensive professional domains where the underlying scientific body of knowledge changes frequently and in unexpected ways. When confronted with novel information, not only must decision makers update their routines with agility, they must also discern the circumstances for which the new information is relevant and apply it appropriately. We examine physicians' coronary stenting decisions following an information shock about the efficacy of stents released through a new medical guideline. Using a within-subject estimate of stenting decisions before and after the release of the new guideline, on a census of patient admissions into hospitals in the State of Florida from 2001 to 2010, we find that although physicians incorporate the new information into decisions, and are able to discern the cases for which it is relevant, the pace of routine adjustment is not swift. Rather, routine update occurs slowly, with physicians favoring moderate changes in behavior over agile responses, resulting in significant adverse outcomes for public welfare. We also find that the response is conditional on physician characteristics: while board certification is associated with a rapid update, surprisingly, freelancer physicians with superior financial incentives do not react to those incentives. Our findings shed light on existing theoretical tensions related to the agility-routines tradeoff as well as micro level decision making in response to macro level information shocks in the context of expert decision-making in uncertain environments.

4.1 Introduction

Knowledge-intensive professional domains such as medicine, accounting, and law often experience information shocks in the form of changes and updates to the underlying body of knowledge, requiring professional experts to craft swift responses by altering routines and decision making rubrics. Failure to respond correctly, and with speed, can have adverse consequences for personal and public welfare, such as conviction based on overturned legal precedent (Benesh and Reddick 2002) or a firm issuing faulty financial records as a result of outmoded accounting practices (Hronsky and Houghton 2001). In this work, we address two unresolved tensions concerning information shocks and expert decision making under uncertainty. The first tension relates to striking a balance between agility and routinization in the presence of new information. On the one hand, rapid response to new information and concomitant updates to routines have been identified as critical in environments fraught with disruptive shocks (Franco et al. 2009, Mitchell 1989, 1991). On the other hand, scholars have also stressed the pitfalls of routine disruption that is frequently implicated in performance degradation (Nelson and Winter 1982). When confronted with an information shock in their professional domain, experts need to address the difficult dilemma posed by the agility-routine tradeoff.

A second tension is concerned with the ability of decision makers to discerningly apply new information and update their decision rules. When information is costless to acquire and decision makers are highly trained experts, a rational expectation is that this information will be efficiently assimilated into

decision-making rubrics and not wasted (Muth 1961). Countervailing the rationality argument, psychology scholars have noted that decision makers often fail to internalize new information correctly in information intensive environments (Reyna and Brainerd 1991). Understanding whether experts respond to new information with appropriate and relevant changes to decision rules is an important question for policy makers seeking to disseminate new findings in a timely fashion.

We investigate these tensions in a context that is significant in terms of both economic and public welfare: the utilization of coronary stents for patients suffering from coronary arterial disease by physicians in light of new information about their efficacy released through a new medical guideline. We pose the following research questions: What is the nature and speed of physician response to an information shock in the form of guideline release? Specifically, do physicians respond to the new guideline, and if so, how quickly? Additionally, is physician response discerning in the application of the new guideline contingent on patient characteristics? Finally, we ask, is physician response to the new guideline is conditioned by physician characteristics?

The study has important theoretical and practical implications. Practically, to the degree that physician updates to decision processes have been characterized as infrequent and inconsistent (Grimshaw and Russell 1993, Hellinger 1996), the need for a deeper understanding of physicians' reactions to information shocks about the efficacy of commonly used medical treatments is pressing. The documented inability to influence physician decision making in any

systematically effective way is a source of persistent frustration for researchers, policy makers, and consumers (Smith 2000). For researchers and policy makers, the concern is that new knowledge regarding state-of-the-art treatments is not being utilized in a timely and effective manner. For patients, the failure of physicians to stay abreast of cutting edge discoveries poses risks of misdiagnosis, ineffective treatment, and even death.

Our study makes use of an information shock to the knowledge of coronary stents, formally known as percutaneous coronary interventions (PCI), for the treatment of stable coronary arterial disease (SCAD). In January 2006 the American Heart Association (AHA) and the American College of Cardiology (ACC), the two foremost professional organizations in Cardiology, collectively released their updated guideline for the usage of PCI (Smith et al. 2006). The release of the new guideline as the setting for examining our research questions offers two distinct advantages. First, for identification purposes, it is important that the information shock be exogenous to the decision maker. The release of the guideline satisfies this requirement as guideline construction occurs under strict confidentiality agreements[16] and the studied physicians were not part of the AHA/ACC Task Force. Second, the guideline discerns among two classes of patients, those with low and high severity SCAD, by providing a new, and rigorously defined, recommendation for when PCI usage is appropriate for SCAD treatment, and when these more expensive treatments should be foregone in favor of less expensive and safer pharmacological options. By differentiating between

[16] http://my.americanheart.org/idc/groups/ahamah-public/@wcm/@sop/documents/downloadable/ucm_319826.pdf

appropriate and inappropriate conditions for the use of stents, the new guideline also allows us to study the extent to which physicians discerningly utilize stents when treating different classes of patients.

Econometrically, we measure the response of physicians to this new information using a within-subjects estimate of the effect of medical guideline release on practicing physicians. Our data are drawn from a census of all hospital admissions in the state of Florida between 2001 and 2010, and contain rich and comprehensive information at the bed-level on patient, physician, and hospital specific factors. We match these data to additional demographic and economic variables drawn from other sources. We find, in contrast to medical literature (Grimshaw and Russell 1993), that physicians do incorporate the new information into their treatment decisions. Physician response, however, is not swift, creating significant public welfare deficits which could be avoided with a more timely response. Moreover, and in contrast to prior research where longevity of routines is typically associated with cognitive lock-in (Choudhry et al. 2005, Duhigg 2012), we find that board certified physicians whose routines are the most established react faster to new information. Surprisingly, and in contrast to significant literature in the medical field (Gruber and Owings 1994, Hellinger 1996, Shafrin 2009), results also suggest that physicians with strong financial incentives to continue stenting also respond to the guideline release and update their behavior in much the same way as those physicians who do not face these incentives. Finally, we find that physicians are discerning in their application of

new medical information and discriminate between patients when applying the new guideline.

This study contributes to the literatures that inform the two tensions motivating it. In the context of the agility-routines tradeoff, we find that reactions to information shocks do occur, albeit slowly, providing evidence of incumbent inertia. Further, while extant literature has documented limited response to incentives, policy, and peer edicts (Choudhry et al. 2005, Grimshaw and Russell 1993, Hellinger 1996) we find that physicians react, and react strongly, to *expert opinions* presented in the form of a new medical guideline. At the individual level, our study provides evidence that the incorporation of costless information is not delayed by the age or longevity of the routine when decision makers receive adequate training. This result challenges prior findings in the healthcare context, where physician tenure has long been associated with a decreased willingness to update routines and alter behaviors in the face of new medical information (Choudhry et al. 2005). Moreover, the fact that physicians are discerning in their application of this new information suggests that the information intensity of the expert's environment does not necessarily exacerbate the dependence on heuristics in decision making.

The remainder of the paper proceeds as follows. In Section 4.2, we provide a brief description of the study context. Section 4.3 summarizes relevant literature underlying the research questions. In Section 4.4 we describe the data, econometric specifications, and present results. Section 4.5 concludes the paper with a discussion of implications of the findings and future avenues for research.

4.2 Context: The Treatment of Stable Coronary Arterial Disease

4.2.1 Stable Coronary Arterial Disease

Stable Coronary Artery Disease (SCAD) is the narrowing, blockage, or hardening of coronary arteries due to the buildup of plaque -cholesterol and fatty deposits- causing a restriction of blood flow to the heart. Left untreated, SCAD can lead to angina (chest pains), acute myocardial infarction (heart attack), and death. It is currently the leading cause of death in the United States, with half of men and one third of women over 40 developing it during their lifetime (Rosamond 2007). As one would expect, there are multiple levels of severity of coronary arterial disease (ranging from minor blockage to complete occlusion of the artery) and recommended treatment regimens depend on diagnosed severity. The widely accepted SCAD classification system developed by the Canadian Cardiovascular Society (CCS)[17] for distinguishing among severity levels (Table 4.1) includes four levels, ranging from Class I (minor) to Class IV (debilitating). Our study focuses on a change in the recommended approach for treating CCS-Class II angina which results in a "slight limitation to ordinary activity." Details regarding this change in recommendation are provided below.

Although the disease can sometimes be managed effectively through lifestyle changes (e.g. limiting smoking and alcohol consumption, exercise, and weight management), factors not under the patient's control (e.g. genetics, hyperglycemia (through diabetes), high cholesterol, and hypertension (high blood pressure)) can also have a significant effect on the progression of the condition.

[17] We use the CCS system to maintain consistency with the AHA / ACC's updated guideline.

Given the disease's scope and impact, both pharmacological and surgical avenues of treatment have been pursued since arteriosclerosis was added to the International Classification of Diseases (ICD) in 1949.

Attempts at pharmacological treatment of SCAD began after the Framingham Heart Study (Dawber et al. 1951) and the identification of high cholesterol as a leading cause of heart disease. However, pharmacological treatment did not begin in earnest until the 1980s when large randomized trials began to test the efficacy of various drugs. AFASAK (Fossett and Peterson 1989), one of the many trials which established that aspirin could be used to manage angina, for example, was not released until 1989. At present, pharmacological treatments encompass a variety of options, including Nitrates, Beta Blockers, Calcium Blockers, and other Anti-Anginal drugs. Benefits of pharmacological treatment include it being far less invasive than surgical options, and significantly cheaper as well, since most of the standard pharmacological options are no longer protected by patent and generic alternatives are available.

Surgical treatment has an equally long tradition, beginning with the first coronary artery bypass graft (CABG) in 1960 and including the more recent innovation of coronary stents (PCI) in 1995. PCI requires a physician to make a small incision in the femoral artery (the artery in the upper thigh) and thread a balloon catheter through the patient's body to the point of blockage. After proper placement, the balloon catheter is inflated slowly to compress the blockage and stretch the artery. The stent is then inserted into that location and left permanently to keep the artery open. Medically, the objective of the stent is to minimize

arterial restenosis, i.e. blockage building up in the same area or the artery collapsing. As stents significantly reduced the need for highly invasive surgeries like CABG, stenting has experienced a meteoric rise in value since it was approved by the FDA in 1995. Ten years later, 3 million stents were shipped worldwide, with revenues exceeding $5 billion (Wieffering 2011).

4.2.2 The Information Shock – AHA/ACC PCI Guideline Update

Professional organizations in various medical specialties routinely release guidelines to inform the diagnosis and treatment of specific medical conditions. Given the overlap in their objectives, the AHA and ACC have issued numerous guidelines over the years to diffuse recommendations to medical professionals based on the current state of medical evidence for the treatment of cardiovascular and cardiac conditions. More specifically, the objective of an AHA/ACC practice guideline is "to assist healthcare providers in clinical decision making by describing a range of generally acceptable approaches for the diagnosis, management, or prevention of specific diseases or conditions" (Smith et al. 2006). While guidelines can address any number of conditions with specific recommendations or suggestions for treatment, the objective in this particular instance was to define the conditions for PCI use that meet the needs of "most patients", thereby reflecting the current state of expert opinion regarding PCI. This update, the first since the guideline released in June, 2001 (Smith et al. 2001) significantly altered and truncated the language defining the acceptable situations

for PCI as a treatment of CCS – Class II angina[18]. The new guideline recommended that for CCS – Class II angina, the use of PCI for treatment was to be pursued only in very *limited* circumstances, implicitly suggesting that the less invasive (and less expensive) pharmacological treatment was superior in these cases.

The release of the 2006 guideline, which alters the knowledge regarding when the use of PCIs is appropriate, serves as the exogenous information shock in our study. In essence, the guideline defines new "rules" for when the two treatment options (PCI and pharmacological) should be used. However, even though the guideline provides advice on when PCI may be used, there is considerable contextual judgment that is still left to the physician. More relevant to our analysis here, the guideline does not establish the medical superiority of either stents or pharmacological therapy for the treatment of low-severity SCAD patients. Thus, the physician still confronts a choice when a low-severity SCAD patient is presented[19]. If one treatment were clearly indicated to be superior in all scenarios, there would be little ambiguity in the decision-making task for the physician. The continued presence of this ambiguity provides a novel setting in which the responses of expert physicians to new information in their environment can be studied. In order to better understand how and when physician behavior

[18] The 2001 update text can be found here:
http://content.onlinejacc.org/article.aspx?articleid=1127281

[19] We note here that, although the guideline update changes suggested practices, there is no financial loss or additional malpractice liability which the physician is exposed to by electing to disregard the update as stenting is an accepted medical treatment for SCAD (and therefore does not constitute "medical error") (Hofer et al, 2000). Recent lawsuits brought against physicians for excessive stenting, under the legal guise of civil conspiracy and unlawful enrichment, have occurred when physicians have performed hundreds or thousands of unnecessary procedures.

may change, we invoke the literature on expert decision-making and reliance on routines next.

4.3 Experts' Decision Making Following Information Shocks

4.3.1 Speed of Response to Information Shocks: Routines vs. Agility in Medical Treatment

The literature on expert decision-making is extensive and spans multiple disciplines. Although a complete review of this literature is beyond the scope of this paper (see Hutton and Klein (1999) for a synthesis), we briefly present key themes in prior work related to the nature of expertise and expert decision-making. First, expertise is typically developed through extensive practice over a prolonged period of time (Baker et al. 2003). Indeed, Chase and Simon (1973) suggest that a minimum of a decade with thousands of hours of practice are required to quickly and efficiently identify patterns within the focal domain. Second, as expected, expertise is usually domain specific and rarely traverses multiple domains, especially when complementarities between the contexts cannot be exploited by the decision maker (Hutton and Klein 1999). Third, experts typically exhibit above-average performance along three dimensions: objective outcomes (Calderwood et al. 1988, Chen et al. 2006, Nee and Meenaghan 2006), cognitive load required to make decisions (Hutton and Klein 1999, Nee and Meenaghan 2006), and likelihood of strategic misstep or error (Calderwood et al. 1988, Chase and Simon 1973). In other words, experts exhibit cognitive parsimony that allows them to not only make superior decisions

compared to a non-expert decision maker, but also to do so rapidly. Finally, expertise is usually eroded when the decision maker elects to participate in extraneous activities which do not contribute to primary or complementary skill sets within the domain of expertise (Baker et al. 2003). Simply put, expertise is domain specific and requires immersion and practice to attain superior performance.

The speed and accuracy of expert decision making is often a result of what is labeled "compiled knowledge," i.e., knowledge that is tailored for a particular domain of application (Anderson 1983). Compiled knowledge, encoded as decision making routines constructed over years of experience and practice, is efficiently retrieved and applied during any decision making activity. Routines or patterns of behavior thus allow experts to increase efficiency by reducing wasteful information processing and increasing productivity (Nelson and Winter 1982). We observe ample evidence of these relationships in the medical profession, which is characterized by extensive reliance on care protocols, procedural guidelines and treatment routines (Woolf 1992). Research shows that increasing the routinization of activities eliminates unneeded variance and results in superior clinical and financial outcomes (Nallamothu et al. 2006). Evidence of this routinization is ubiquitous in healthcare contexts such as physician diagnosing practices (Reyna and Lloyd 2006), the repetitive treatment of common ailments (Bauer et al. 1999), and group behaviors for the treatment of emergent conditions (Kizer et al. 1999).

As may be expected, routines become habituated with time, especially in experts (Duhigg 2012). Thus, the presence of routines, though critical in expert decision-making, is a double-edged sword. While routines support the cognitive parsimony observed in experts, they can also subvert deep introspection and analysis as well as inhibit the infusion of new knowledge. Although they may enhance efficiency, they can also result in cognitive lock-in with respect to specific courses of action. This inability to respond to new information can hinder expert decision-makers from adequately modifying their routines based on the new information. Some evidence of this effect is also documented in the medical literature. A persistent refusal to update routines has been shown to result in inferior performance in terms of economic efficiency of treatment (Fries et al. 1993) as well as the survival rate of patients (Choudhry et al. 2005). In knowledge-intensive environments such as medicine, where decision makers are constantly bombarded with information, the ability to react swiftly to new information is essential (Franco et al. 2009). How might physicians, experts in medical practice, respond to new information in the form of the new guidelines in their decision-making routines?

As discussed above, the release of the AHA/ACC Guideline represents a shock to the existing knowledge regarding stenting in low severity (CCS Class II and below) SCAD patients. In the presence of new information physicians have two broad choices: they may volitionally ignore the findings and introduce no change in their utilization routines, or they may revise their routines appropriately to account for the new findings. To the degree that experts' choices are more

likely to become routinized simply because of the volume of repetition, the routinization logic would call for an inertial response to the information shock. However, the agility argument, supported by the fact that experts make superior decisions when compared with non-experts (Calderwood et al. 1988, Chen et al. 2006), favors substitution of the cheaper and less invasive treatments such as pharmacological interventions for low severity SCAD. Therefore, in the absence of a clear *a priori* expectation of which effect is likely to be dominant, we empirically explore the competing predictions.

4.3.2 Physician Discernment Among Patient Classes

While the routine-agility tradeoff asks if experts react to information shocks in a timely manner, another important question also relates to the appropriateness of information assimilation. From the neoclassical economics perspective (Becker 1978), decision makers costlessly incorporate all relevant information into decision making. The rational expectations hypothesis (Muth 1961) asserts that information is not wasted; rather, economic agents utilize all available information in their decisions immediately so that errors and deviations from perfect foresight are only random. Thus, when an information shock occurs, its implications are reflected in all subsequent decisions. To the extent that physicians are experts, they should be able to correctly parse the information from a medical guideline and apply the recommended treatments to different patients appropriately. Moreover, medical professionals are required to engage in

continuing education by both the AMA and their state medical boards[20]. On-going training suggests not only that physicians will react to new medical research immediately (consistent with the agility arguments above), but that they should be able to differentiate between patients in their application of the new guideline.

In contrast, a large body of work on fuzzy trace theory and gist (Brainerd and Reyna 1990, Reyna and Brainerd 1991, Reyna and Lloyd 2006) offers an alternative explanation. Scholars in this stream of work contend that when confronted with new information, agents perform an "interim synthesis" (Reyna and Brainerd 1995) and strip communication down to its root components when encoding and internalizing it. In effect, decision makers extract the "gist" of the argument embedded in new information (Brainerd and Reyna 1990, Reyna and Brainerd 1991), especially in environments which are information intensive such as medicine (Reyna and Lloyd 2006). The "gist" logic would imply that physicians would retain the core messages in the updated guideline while, albeit unintentionally, overlooking the caveats and details. In other words, physicians will extract the core message that stents are not always an appropriate treatment for SCAD and that pharmacological intervention is preferred, while not necessarily discerning among patients to whom the findings do and do not apply. Thus, given its greater cost and invasiveness, physicians would reduce the use of stenting treatment for *both* low and high severity patients, disregarding the more nuanced parts of the guideline which discerns between the two classes of patients.

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[20] http://www.acponline.org/education_recertification/cme/state_requirements/2012ama_requirements.pdf

4.3.3 Heterogeneity in Physician Characteristics

Thus far, our focus has been on theorizing about the aggregate response of medical experts. However, the speed and discernment of response to information shocks may depend critically on the characteristics of the physician making the decisions. Differences in incentives and ability of individual decision makers are likely to create variation in their reactions to information shocks. Prior work has documented the fact that physician characteristics are significant influencers of observed physician practices, behaviors, and outcomes (e.g. Brennan et al., 2004; Burke et al., 2007; Rifkin et al., 2004). We investigate two attributes of physicians that can plausibly influence their response to the guideline: board certification and freelancer status. The first attribute, board certification, proxies the knowledge and skill of the physician (Brennan et al. 2004), i.e. level of expertise. The second, freelancer status, captures the effects of operating in different institutional environments in addition to the presence of financial incentives that differ considerably from physicians who work full-time in one hospital.

4.3.3.1 Board Certification is a signal of the breadth and magnitude of a physicians' knowledge stock in a particular specialty and his/her level of expertise. After graduating from medical school, physicians complete a residency that may last from 3-7 years, and then optionally pursue a fellowship program to increase area-specific knowledge in any number of subspecialties (e.g. obstetrics, cardiology, pediatrics, neurology)[21]. The additional 1 to 3 years of training in the

[21] The ABMS provides an overview of the requirements and process for obtaining board certification. Although all physicians in our dataset are board certified in general medicine, which comes with the licensure to practice at the end of residency, only a subset are additionally trained in cardiology https://www.abms.org/who_we_help/physicians/process.aspx

fellowship program leads to board certification and further deepens physician knowledge about the nuances of disease and treatment in the chosen area of specialty. Because board certification involves additional testing, performed every four years, it creates the necessary incentive for board certified physicians to continually update their knowledge and clinical practices. Moreover, as the Advisory Board of Medical Specialists (ABMS) provides oversight on physician certification to ensure that quality standards are maintained, it is unsurprising that board certified practitioners demonstrate both superior examination scores and superior clinical outcomes when compared to their non-certified counterparts (Brennan et al. 2004).

How is board certification likely to affect physician response to the release of a new medical guideline? On the one hand, board certified physicians may resist the prospect of change in their operational paradigm. As a result of their specialized training and expertise, they may see flaws in the suggestions of other experts that are contained in the medical guideline. Moreover, they may interpret the findings of the guideline differently from other physicians. Consistent with the literature on bias in decision making, board certified physicians may therefore discount the information contained in the guideline because of a confirmation bias resulting from strongly held prior beliefs (Christensen-Szalanski and Bushyhead 1981). On the other hand, it is equally plausible that physicians with board certifications will react more quickly to the new medical guideline. The rigorous retraining standards which are required to maintain board certification, as well as the need by these physicians to maintain their reputations of being at cutting edge

of medicine would suggest a greater propensity for these physicians not only to assiduously seek out new medical knowledge that is germane to their specialty, but also react to it quickly and appropriately. Given the absence of clear theoretical insights for which effect is likely to be dominant, we empirically explore competing predictions. That is, on one hand, board certified cardiologists may react slower to the release of the medical guideline, as a result of confirmation bias (Christensen-Szalanski and Bushyhead 1981) or, alternatively, they may react faster as a result of their deeper knowledge repositories and superior training.

4.3.3.2 Freelancer Status, the physician's affiliation with multiple institutional settings, is the second characteristic we consider. Following Huckman and Pisano (2006), we define a freelancer as a physician who is observed to treat multiple SCAD patients in more than one hospital during the same time period. The expectation of differential response to information released in the medical guideline between those who practice in a single institution versus those that are exposed to multiple settings is predicated on two considerations: variation in financial incentives, and institutional norms.

Why should freelancers behave differently from other physicians in clinical care choices? Extant literature has highlighted the fact that financial incentives for staff physicians (i.e. one whose procedures are confined to a single hospital) and freelancers are different. While the former, often referred to as a "hospitalist", is generally a salaried employee and is paid a fixed wage regardless of procedure volume, freelance physicians are typically compensated on a fee for

service model. Moreover, literature has shown that financial incentives can often influence physician decision making (Hellinger 1996), both in terms of clinical care (Gruber and Owings 1994, Hillman et al. 1999) and in resource utilization (Armour et al. 2001, Hellinger 1996), and particularly so after the release of new medical evidence (Howard and David 2012). One expectation, therefore, is that these physicians would be *less* likely to abandon the usage of PCIs given their strong financial incentive to utilize them.

Countervailing the effect of financial incentives is the institutional pressure of social conformity and homophily, i.e. the tendency for individuals to act similarly within social settings (DiMaggio and Powell 1983), such as hospitals. Numerous studies in the extant literature have demonstrated that physicians within a hospital, or social network, tend to imitate each other's prescribing practices (Burke et al. 2007, Hull 1979). Although some physicians are granted primacy in the network, and an increased ability to affect the long term decision making of the group (Nair et al. 2010), similarity in practice remains a consistent theme. Physicians who work in multiple institutions, i.e., freelancers, would therefore be subject to greater variety in norms as compared to those who practice is exclusively confined to one hospital. Drawing on the variation in financial incentives and institutional norms, we study if freelancers respond differently from hospitalists in their response to the information shock.

4.4 Data and Methodology

4.4.1 Data

We draw the data for empirical analysis from multiple sources to enable construction of a novel, longitudinal dataset that tracks physician prescription of PCI to patients at the bed level. Our primary data comes from the State of Florida's Agency for Healthcare Administration (AHCA), which records bed-level prescribing practices of physicians within Florida hospitals for every patient admitted from 2001 - 2010; 2001 being the year the previous AHA/ACC guideline was released (before the focal update) (Smith et al. 2001), and 2010 being the end of data availability. This rich dataset, used extensively in prior literature (Burke et al. 2003, Burke et al. 2007), provides information not only about the focal physician and hospital, but also demographic characteristics about the patient (age/race/sex), their co-morbidities (i.e. the ICD-9 codes), and all surgical procedures they receive within the hospital. As the data are longitudinal, we are able to observe the treatment decision (PCI vs. pharmacological) for SCAD patients by the physician over time. Although these data come from a single state, a state-level analysis is appropriate for at least two reasons. First, Florida, by virtue of being a large and economically diverse state, affords us the ability to see how a wide variety of physicians react to the update over time. Second, as physicians are licensed to practice medicine at the state level we are able to reasonably assume that the dataset captures the population of stenting decisions which were made by the focal physician. Due to privacy concerns, these data are aggregated by the data provider at the quarter level. While the inability to

determine the *exact* date the patient enters the hospital is a data limitation, the objective of the analysis is see the reaction of physicians to the AHA/ACC guideline over time, which quarter level data allows us to do.

We match the Florida data with information from US Census Bureau's Small Area Income and Poverty Estimates dataset to include county level socio-economic data (e.g. median income, population, number of people living in poverty, etc.) for each hospital. Finally, we augment these data with information from the Area Resource File from the US Department of Health and Human Services that provides demographic information about the county in which the physician operates.

4.4.2 Variable Definitions

4.4.2.1 Dependent Variable: The dependent variable, treatment choice for a SCAD patient, is dichotomous: *Stent* is coded as 1 if the patient receives a PCI and 0 if they do not. Although we are studying physician decisions over time we use the dichotomous indicator of stent reception, rather than a panel model of stenting decisions at the quarter level, because it allows us to exploit the richness of our dataset by controlling for otherwise unobserved patient heterogeneity.

4.4.2.2 Independent Variables: Our first two independent variables of interest are two linear splines (*Period1* and *Period2*) that are used to quantify the change in the stenting rate over time. We first explore the data visually. In Figure 4.1 we plot the raw number of stents that have been implanted in patients during the period of our investigation. In Figure 4.2 we graph the ratio of stents to

stenting opportunities which have been implanted during this same period[22]. A sharp change in the stenting behavior of physicians, even in the absence of additional controls, is evident at the beginning of 2006, both in the raw numbers of stents being implanted as well as the ratio of stent usage to stenting opportunities. This change in behavior corresponds to the release of the new AHA/ACC Guideline for PCI. We see that stent usage is consistently rising prior to the publication of the guideline and experiences a decline after the release of the guideline. To account for this change statistically, we incorporate a linear spline that allows us to explore heterogeneity in physician stenting behavior over time. Splines are a piecewise specification that permits localized flexibility in the relationship between two variables without allowing for discontinuities within the data (Kennedy 2003). We place the knot of the spline before the first quarter of 2006 to account for the change in behavior expected after the information shock. Usage of the spline allows us to estimate the change in the relationship between the stenting rate and time after January 2006. The coefficients of *Period 1* and *Period 2* capture the relationship between stenting and time before and after the release of the guideline, respectively.

The second independent variable of interest, *Severe SCAD*, is a dichotomous variable indicating whether or not the patient is diagnosed with CCS-Class II Angina (or below), i.e., if the guideline was applicable to the patient or not. The variable is coded as 1 if the patient has CCS-Class III angina or

[22] Stenting opportunities are defined here as all patients who have been diagnosed with *any* form of SCAD.

above. A description of how SCAD Severity is determined can be found in Appendix 4.6.

In addition to the speed and discernment of response that the spline and severity of illness variables allow us to study, our analysis includes two physician characteristics that may condition these outcomes, viz., board certification and freelancer status. We capture the former characteristic in *CardioCert*, a dichotomous indicator for whether or not the physician is board certified in any of the six following cardiac subspecialties: Thoracic Surgery, Interventional Cardiology, Pediatric Cardiology, Nuclear Cardiology, Cardiovascular Disease Management, or Cardiovascular Medicine. The variable is coded as 1 if the physician possesses any of these board certifications. As board certification is acquired before the physician begins practicing as an attending physician, this variable is non-time varying.

Finally, *FreeLancer*, is set to 1 if the physician is a freelancer and 0 otherwise. Huckman and Pisano (2006) defined a freelancer as a physician who has served as the attending for more than one patient in more than one hospital in one quarter. We augment the Huckman and Pisano (2006) definition of a freelancer to include two or more consecutive quarters to mitigate potential problems relating to physician mobility (i.e. the physician changing which hospital she is employed at).

4.4.2.3 Controls*:* To eliminate variance in treatment decisions caused by other factors, we include a robust set of controls in the analysis. We control for four general categories of confounding effects: *patient characteristics* which may

affect the physician's decision to stent, *hospital level characteristics* which may be influential in the physicians' decision making process, *local area socio-economic variables*, and *physician level factors*. Patient characteristics, beyond co-morbidities, include four controls: *Age* of the patient, *Race* of the patient, *Day* of the week the patient was admitted, and *Sex* of the patient. Each of these factors is controlled for using dummies for each possible value. To account for patient co-morbidities we include dummy variables for each of the possible diagnoses (ICD-9 codes) within the categories of Hypertension, Diabetes, Obesity, Emphysema, High Cholesterol, Reynaud's Syndrome, Cardiac Arrhythmia, and heart thickening (i.e. co-morbidities traditionally associated with SCAD (Roberts 2008)). A complete listing of the controlled for co-morbidities is available in Table 4.2.

At the hospital level we include a dummy control for hospital *ForProfit* status, the number of *Beds* in the hospital, and how busy the hospital was at the time of diagnosis with the number of *Discharges* the hospital made in the focal quarter. Moreover, we include a control for the hospital level change in stenting (*HospChange*) which is operationalized as the percent change in stents implanted from *t-1* to *t*. To account for unobserved hospital heterogeneity we also include hospital fixed effects in the model.

As local socio-demographic factors can also influence physician decision making (Burke et al. 2003) we include several controls operationalized at the county level. These include the *Population* of the county, the median household *Income* for the county, the number of people who are *Medicare* eligible within the

county, and, finally, the number of people living in *Poverty* in the county. At the physician level, we include, in addition to *CardioCert* and *Freelancer*, a measure of physician *Experience*, operationalized as the number of quarters the physician has practiced since her graduation from medical school, and the log of the number of stents the physician has performed during her career (*LnStentsToDate*). Following Burke et al. (2007), we also include a control for the internal prestige of the physician (*Star*) which indicates that the physician has graduated from a top 50 American medical school. Finally, we include a physician fixed effect to account for unobserved heterogeneity.

We apply four restrictions to the dataset before executing our empirical analysis. First, we remove all patients who are diagnosed with an acute myocardial infarction (i.e. heart attack) prior to hospitalization. As patients who have heart attacks are unambiguously suffering from unstable coronary arterial disease, they fall outside the scope of the investigation. Second, we remove all hospitals which do not perform PCIs from the data as they also fall outside the purview of the research questions. Third, following Burke et al. (2007), we remove all patients under the age of 25 because of their low probability of stent reception. Finally, we remove all patients receiving a coronary artery bypass graft, a far more invasive surgery, from the dataset, thereby restricting the data to patients for whom physicians face the choice of pharmacological treatment only or PCI. The resulting dataset is comprised of 3,072,328 observations between the years of 2001 and 2010. Summary statistics for the non-dummy control variables are available in Table 4.4 and a correlation matrix is presented in Table 4.5.

4.4.3 Empirical Specifications

Given the size of the dataset we use a series of linear probability models to estimate coefficients. While logit or probit models are typically preferred for analyses involving dichotomous outcomes, the computational demands arising from the size of the dataset and the need to accurately interpret non-linear interaction terms (Ai and Norton 2003) are considerable. The linear probability model provides an accurate proxy for the effects that we are estimating and also provides for an easier interpretation of the interactions, particular in the case of the three-way interactions we estimate, as described below in this section. Our first question, whether physicians respond to the information shock, of the new guideline, is addressed using the following base specification:

$$\begin{aligned} LPM(Stent) = {} & \beta_1 Period_1 + \beta_2 Period_2 + \beta_3 Severe\ SCAD \\ & + M_1{}' Physician\ Controls + M_2{}' Hospital\ Controls \\ & + M_3{}' Region\ Controls + M_4{}' Patient\ Controls + \varepsilon \end{aligned} \quad (1)$$

where M_1 , M_2 , M_3 , and M_4 , are vectors of coefficients associated with the indicated controls. We estimate two models: one without physician fixed effects (Column 1 of Table 4.6) and a second that includes a physician fixed effect (Column 2, Table 4.6) and excludes the non-time varying physician characteristics (*CardioCert* and *Star*). In these regressions the coefficient of *Period 1* indicates the change in the quarterly utilization of stenting, all else equal, before the information shock and the coefficient of *Period2* captures the physician stenting utilization following the information shock.

To estimate whether physicians are discerning between high and low severity patients in their stenting utilization after the information shock we next

include an interaction of the patient's SCAD Severity with the *Period 2* spline. Results from this analysis are shown in Columns 3 and 4 of Table 4.6, the former without physician fixed effects and the latter with the fixed effect. The use of these interactions provides two significant advantages here. First, the interaction of any variable with the *Period 2* splines provides estimates of trends in stent use after the release of the new guideline, i.e. a general long term increase or decrease in stenting. Second, the spline significantly increases the interpretability of results over the alternative of interacting the patient severity variable with individual time effects.

To understand how physician characteristics, board certification and freelancer status, influence their reaction to the information shock, we introduce a three-way interaction between *CardioCert*, *Severe SCAD*, and the *Period 2* spline, and a three way interaction between *Freelancer* status, *Severe SCAD*, and the *Period 2* spline into the base model. Results of these regressions are available in Tables 4.7 and 4.8. As before, we estimate models both with and without physician fixed effects.

4.4.4 Results

Before interpreting the coefficients of the key independent variables of interest, we first consider the control variables associated with the regressions in Table 4.6. Consistent with the empirical literature regarding PCI use, men receive stents more often than women (Smith et al. 2001). We also find that physicians who have done many stents in the past, board certified physicians, and stars (those

who graduated from top 50 medical schools) all exhibit a higher propensity to stent than other physicians.

To ascertain if and with what speed physicians respond to the new guideline, we examine the coefficients in Column 1 and Column 2 of Table 4.6. As was previously suggested by Figure 4.1 and Figure 4.2, there is an overall increase in stenting before the release of the guideline and an aggregate decrease after (a negative and significant coefficient for the *Period 2* spline). The positive and significant coefficient of the *Severe SCAD* dummy variable suggests, as expected, that significantly more stents are implanted in patients who suffer from severe SCAD. From these results we conclude that physicians are reacting to the information shock. However, we note from the graphical representations of the data (Figures 4.1 and 4.2) that while physicians do alter their behavior when guideline is released, the reaction is slow. In other words, we do not observe a sharp abandonment of stenting in the low severity SCAD patients. As the guideline states that the decision to stent in patients with low severity SCAD can be harmful, this has significant implications for both patient and economic welfare. From the patient's perspective, the inappropriate use of stents exposes them to significant risk and without increasing quality of care (Smith et al. 2006). From the economic welfare perspective, stents are far more costly compared with pharmacological treatment, creating financial burden for patients as well as insurance carriers.

For the second research question, whether physicians are discerning in their reaction to the guideline release, we examine coefficients in Column 3 and

Column 4 of Table 4.6. Consistent with the first set of results, we see a gradual increase prior to release of the guideline and a gradual decrease in the stenting rate for non-*Severe SCAD* patients after (as shown by the *Period 1* and *Period 2* splines). Moreover, we see that, once the effect of the *Severe SCAD* patients is removed from this group the decline in stenting rate accelerates. Finally, examining the coefficients of the interaction terms (*Period 1 * Severe SCAD* and *Period 2 * Severe SCAD*) we see that stenting rates are increasing both before and after the release of the medical guideline for those with high severity SCAD, indicating that physicians are discerning in their application of new information even within information intensive medical environment.

Visual representation of the data is provided in Figure 4.3. We plot the raw data (number of stents implanted divided by the number of opportunities to stent) for each patient class (*Severe* and non-*Severe SCAD*) over time. The vertical line represents the release of the guideline. The figure confirms findings from Table 4.6: before the release of the guideline stents are being adopted faster for *Severe SCAD* patients and that after the guideline release there is a gradual decline in the stenting rate for non-*Severe SCAD* patients while stenting rates continue to rise for *Severe SCAD* patients, but at a slower pace.

Our final question relates to how different physicians react to the release of the new guideline. The results of our analysis for Board Certified physicians can be found in Table 4.7. Once again (Columns 1 and 3) we see not only that there is an increase in the marginal stenting rate before the release of the guideline, and a subsequent decrease after its release, but also that *Severe SCAD*

patients receive far more stents than low severity patients. Likewise, after the release of the guideline, there is a decrease in the stenting of non-*Severe SCAD* patients. Strikingly, the decrease in stenting by board certified cardiologists is faster than for non-board certified (as indicated by the coefficient of the *Period 2* spline and the interaction of *CardioCert * Period 2*). We graph the results in Figure 4.4 to assist in the interpretation of the three way interaction.

Figure 4.4 reveals several interesting patterns. While we see an increase in the overall stenting rate before the release of the guideline, as well as a decrease in the stenting rate after release for non-*Severe SCAD* patients, we also see that physicians with board certifications perform significantly more stents overall. Moreover, before the release of the guideline, board certified physicians also perform significantly more stents for non-*Severe SCAD* patients than non-certified physicians do for *Severe SCAD* patients. Finally, we note that the stenting decrease following the release of the guideline is much larger for board certified physicians in the case non-*Severe SCAD* patients. However, as the non-certified physicians have little possible decrease to make (with a stenting rate of roughly 4%) this is not surprising.

The results for the behavior of *FreeLancer* physicians are available in Table 4.8. Consistent with the results of the previous regressions, we see similar adoption and abandonment behavior before and after the release of the guideline. Surprisingly, we first see, as evidenced by the negative coefficient of *FreeLancer*, that freelancers are not responding to the financial incentives associated with freelance status within a hospital. That is, freelancers are making fewer decisions

to stent than non-freelancers, even though performing more procedures can be revenue-enhancing for them. This lends further support to the evidence that physicians are not always swayed by financial incentives (Smith 2000). The statistical evidence further suggests that *FreeLancer* physicians do more stents for *Severe SCAD* patients overall, and that they are abandoning the use of stents for both non-*Severe SCAD* patients while increasing their stent adoption for *Severe SCAD* patients after the release of the guideline. As with our previous regressions, we plot the raw data to aid in the interpretation of results (see Figure 4.5).

In summary, empirical results reveal several interesting patterns. First, while physicians do respond to guideline release, and are discerning in the application of the guideline, the reaction is not swift, creating significant public welfare deficits. Moreover, our results suggest that *FreeLancer* physicians do not respond to their additional financial incentives and that the reaction of physicians who are board certified in cardiology (*CardioCert*) is much faster than non-board certified physicians.

4.4.5 Empirical Extensions and Robustness Checks

We explore intriguing patterns that emerge from the initial analysis further through an empirical extension. We also conduct additional analyses to establish the robustness of the findings to alternative explanations.

4.4.5.1 Physician Tenure **–**Our main results show the presence of a wide spread in the stenting rate between certified and non-certified physicians for non-*Severe SCAD* patients. We explore this spread in an extended analysis. As Figure

4.4 suggests, the rate of stenting is significantly higher for non-*SevereSCAD* patients, when treated by a board certified cardiologist, throughout the sample; followed by a significantly faster decline after the release of the guideline. This raises the question: which certified physicians abandon stenting for low severity SCAD patients at a greater or lesser rate? Duhigg (2012) argues that the duration of either a habit or a routine can increase the cognitive lock in decision makers exhibit. We therefore extend our original analysis by considering the strength of the physician's stenting routine by virtue of its longevity, i.e. how long the physician has been utilizing stents as a treatment for SCAD. The literature regarding physician change supports this assertion. Choudhry et al. (2005), for example, note that there is a systematic resistance to change which is demonstrated by physicians who have practiced longer. While the authors are unable to isolate the underlying mechanism, i.e., if this is a result of the inability to stay abreast of medical research as physicians progress in their careers or simply due to the cognitive lock-in routines create, either underlying mechanism would yield the same observed outcomes, that physicians who have practiced longer are less likely to change. It is possible, therefore, that the large gap in stenting between board certified and non-board certified physicians for low severity SCAD patients is an artifact of this routine stagnation. To investigate how the longevity of routines influences physician behavior we remove all *Severe SCAD* patients and non-board certified physicians from the sample and re-execute our analysis. To capture physician experience with treating SCAD, we create a new dummy variable, *Appearance*, which is coded as 1 if the physician first

treated a SCAD patient before the release of the 2001 AHA/ACC Guideline release and a 0 if their first SCAD patient was treated afterwards[23]. Results of these regressions are available in Table 4.9.

Several interesting results are observed in Table 4.9. First, we see that physicians who have been treating SCAD longer perform more stents (as seen in the coefficient for *Appearance* in Column 1). Moreover, we observe the normal patterns of increased utilization and decreased utilization before and after the guideline release. But, strikingly, we see that board certified physicians who have been treating SCAD longer abandon the usage of stents significantly faster than physicians who have begun practicing since the release of the 2001 Guideline. As before, we also consider these results graphically (Figure 4.6). This figure corroborates the finding, suggesting that contrary to evidence which has been shown to date (Choudhry et al. 2005), certified physicians of longer tenure appear to react faster to the new medical guideline.

4.4.5.2 Within - Subjects Experiment - Two potential concerns exist with our initial estimations of the reaction of physicians to the release of the 2006 AHA/ACC Guideline. The first is that the physicians who are actively practicing medicine during the timeline (from 2001 – 2010) of our observation window change. Not only are new physicians licensed to practice medicine and receive attending physician placements during this time, but older physicians retire. Second, the extended time frame of this study raises the possibility that the

[23] While graduation year would also be an effective proxy there are often large differences between when a physician graduates from medical school and when they begin practicing as an attending physician. This can be a function of many things including further schooling, fellowships, repeated residencies, and other factors.

physician is responding to multiple information shocks from various medical trials and professional conferences, or other social changes in the practice of medicine and stenting that may have occurred during this time, and not specifically to the information shock that is our focus.

To mitigate these concerns we replicate our analysis by constructing a two period within-subjects experiment from the data to determine the immediate short-term change in stenting that occurs after the release of the new guideline. To construct the experiment we apply the following restrictions to the dataset. First, we remove all observations before the 4th quarter of 2005 (the final period before the guideline release) and after the 1st quarter 2006 (the first period after guideline release). We then aggregate the stenting rate to the physician – SCAD severity level for each time period. In effect, this provides us with two observations for each physician in each time period, one for *Severe SCAD* patients and one for non-*Severe SCAD* patients. Finally, we remove all physicians from the analysis who are not treating patients of the same type in *both* time periods. Results of the two sample t-tests for the 7349 physicians treating non-*SevereSCAD* patients, and the 2875 physicians treating *SevereSCAD* patients, are available in Table 4.10.

The results from the within subjects experiment are consistent with previous findings. A simple comparison of means for the non-*Severe SCAD* patients before and after the application of the guideline release (i.e. the treatment) indicates a drop in the stenting rate of nearly 7.5% that is marginally significant ($p<0.10$). Moreover, results corroborate the ability of physicians to be

discerning in their application of new information as this decline in the marginal stenting rate is not seen for patients with *Severe SCAD*.

4.4.5.3 The COURAGE Trial – One potential further confounding effect is the publication of the Clinical Outcomes Utilizing Revascularization and Aggressive druG Evaluation (COURAGE) trial (Boden et al. 2007) in April of 2007. The objective of the COURAGE trial was to quantify the efficacy of stenting as compared to pharmacological therapy for the treatment of low severity SCAD. Lending further scientific validity to the AHA/ACC Guideline, the trial's results indicated that pharmacological intervention was equally effective as stenting for the treatment of low severity SCAD; thereby providing evidence from a randomly controlled trial which reinforced the guideline[24]. As with the release of the AHA/ACC Guideline, the immediate effect of the release is difficult to predict *ex ante.* On one hand, the further scientific evidence provided by the COURAGE trial may accelerate the decrease in stenting by physicians. Conversely, due to the fact that COURAGE is a single medical trial and the AHA and ACC release periodic updates to the practice of stenting that are based on a synthesis of multiple sources of evidence it is also plausible that physicians will continue their inertial behavior, awaiting further evidence from other trials and endorsement of the findings from governing bodies. To determine the effect of the COURAGE trial's release on the marginal stenting rate we incorporate a third

[24] While information leakage from COURAGE could possibly influence the change in stenting prior to 2007, the strict confidentiality surrounding medical trials, and ample anecdotal evidence, suggests that this is unlikely. We conducted robustness checks to determine if hospitals local to the research centers in Florida involved in the COURAGE trial abandon their usage of stenting before other hospitals; the results suggest no evidence of leakage. These results are available from the authors upon request.

spline into our original empirical analysis by placing a new knot in the second quarter of 2007 (the release date of the COURAGE trial). This strategy not only allows us to see the original change in the stenting rate caused by the AHA/ACC Guideline but also to determine if there is a marginal change in the decline in stenting after COURAGE is released. Results of this analysis are available in Table 4.11.

Results from these regressions further substantiate many of the previous results. First, we see that there is a general increase in stenting prior to the release of the guideline (*Period 1*) and a general decrease in utilization afterwards (*Period 2 & 3*). Our interest, however, is in determining the change in stenting rate after the release of the COURAGE trial (*Period 3*), as compared to that after the release of the AHA/ACC Guideline (*Period 2*). To the degree that COURAGE's results provide evidence that underscores, with results from a randomly controlled trial, the recommendations made in the guideline, our *a priori* expectation would be that the decline in stenting would either stay constant, or accelerate, after the trial is released. However, and surprisingly, we see that for low severity SCAD patients, the abandonment of stenting is significantly slower after the release of the COURAGE trial. Moreover, the results suggest that the adoption of stents for *Severe SCAD* patients is significantly faster after the trial's release. Results of the F-test comparison between the *Period2* and *Period3* spline coefficients confirm that these results are significant at the ($p<0.0001$) level. In other words, the abandonment of stents for low severity SCAD patients is slower (roughly 40% slower) after the release of COURAGE, and the use of stents for

high-severity SCAD patients accelerates (roughly 146% faster). While we do not have a clear theoretical explanation for this result, to the degree that both the guideline as well as the trial suggest that pharmacological treatment is a preferred option to stents (due to equivalent efficacy and greater safety and cost of the former) for low severity SCAD, the finding is disturbing and underscores the need for further investigation of physician response to different forms of information shocks.

4.5 Implications and Conclusion

Our study examined expert decision making in knowledge intensive professional settings in the wake of information shocks. We posed three questions in the context of physician reaction to the release of a new guideline for the use of cardiac stents. First, do physicians react to the information contained in the medical guideline? Second, do they accurately discern between patients in their application of the guideline? And third, how do physician characteristics influence their reaction to the information contained in the guideline? The questions were motivated by two tensions which exist in the literature regarding decision making under uncertainty: the degree to which experts' routines impede speed of response, and the extent to which experts' decision making rules are updated as new information is revealed. Empirical analysis of a large data set of physician choices spanning a 10-year period reveals that although physicians respond to the release of the medical guideline, they alter their routines slowly. We also find that that these experts are discerning in their application of new medical information when it is costless to acquire. Finally, results indicate that

physician characteristics moderate the response: board certified physicians respond to the information shock more expeditiously than non-board certified physicians, and freelancer physicians appear to not respond to financial incentives.

The speed at which new information is incorporated into physician decision making processes poses a significant challenge for policy makers. While slow updates and changes to routines may be beneficial in some contexts, allowing decision makers to continue to leverage their existing routines (Nelson and Winter 1982), this is not necessarily the case in healthcare where the lack of agility may reduce public welfare by exposing patients to unnecessary risk and increasing needless spending. We compute the economic burden of the slow response. Assuming the final low severity SCAD stenting rate in 2010 of 3.6% is stable this suggests that roughly 35,500 patients in the sample have been subjected to unnecessary stenting procedures; procedures which would not have been performed had physicians favored more agile responses to the release of the new medical guideline. Financially this translates, at a cost of $17,000 per stenting procedure[25], to an added and avoidable financial burden of more than $603 million in the state of Florida alone. Given how pervasive SCAD and the practice of stenting are, both domestically and globally, the costs associated with this delay easily reach the tens of billions of dollars over the four year period following the release of the guideline in our data set.

[25] http://www.bostonscientific.com/

Examples of physician non-compliance or slow compliance with medical guidelines are commonplace in both the scholarly literature and the popular press. Recent work presented to the Society of Gynecologic Oncology (Bristow et al. 2013) indicates that less than 40% of women diagnosed with ovarian cancer in the United States receive care that is guideline-compliant, significantly increasing mortality rates. Instances of such behavior are not constrained to rare conditions like ovarian cancer; studies show that the treatment of a wide range of medical conditions, from high cholesterol (Frolkis et al. 1998) to breast cancer (Cox 2009), experience the problem of physician non-compliance with medical guidelines. From a public welfare perspective, these findings are disturbing, and highlight the need for aggressive continuing education within the medical community. Such education may be instrumental in not only preventing needless spending which does not increase clinical care outcomes, but also avoiding the loss of life associated with poor adherence to medical guidelines.

The finding that freelance physicians do not appear to react to financial incentives, above and beyond hospitalists, challenges prior findings relating to physician treatment choice (Armour et al. 2001, Hellinger 1996, Shafrin 2009). The influence of financial incentives on physician behavior has been previously explored in a variety of clinical and administrative contexts, including pediatrics (Hillman et al. 1999), gynecology and obstetrics (Gruber and Owings 1994), and resource utilization within health maintenance organizations(Armour et al. 2001, Hellinger 1996). Results from these studies are mixed however, due in part by the paucity of data available to study such phenomena (Armour et al. 2001) as well as

the selection issues surrounding the decision of the physician to enter the study (Hellinger 1996) . Our results extend this literature considerably both by resolving the empirical concerns of selection as well as investigating how different forms of employment structures, freelance versus hospitalist, influence the reaction of physicians to guideline release. The finding that the freelancer / hospitalist distinction does not meaningfully differentiate the reaction to information shocks begs further investigation into the boundary conditions associated with influencing physician behavior using financial incentives.

The extended analysis and robustness checks also uncover some interesting patterns. First, in contrast to findings in the literature both on physician decision making (Choudhry et al. 2005) as well as routines (Nelson and Winter 1982), our analysis indicates that board certified physicians of longer tenure alter their routines more quickly when compared to recently licensed physicians. The fact that this is true only for physicians who are board certified illuminates the boundary conditions associated with changing routines. Perhaps the problem of longer tenured physicians not updating their practice behavior can be addressed by the continual retraining and recertification board certified physicians are subjected to.

Juxtaposing findings from the analysis of the COURAGE trial information shock with the AHA/ACA Guideline, we find that physician response to a new guideline issued by a professional body is sharper when compared with the response to the results of individual medical trials; even when the guideline is based on consensus opinion as opposed to a randomized-controlled trial. While

the argument can be made that trials are a *single* data point, one tentative implication of this finding is broader; namely that physicians respond to social cues (Smith 2000) from their peers as opposed to new and novel information generated from medical trials. Moreover, it suggests that physicians rely on professional associations to sift through new information generated from medical trials, thereby potentially creating significant bottlenecks in the dissemination of new information.

We acknowledge the limitations of this work and identify fruitful opportunities for extension. First, differentiating between economic significance and statistical significance is difficult given the size of our sample. While a sample size of over three million adds immense power to our tests, and allows us to see general trends and changes in physician decision making, the effect of the large sample size makes many factors statistically significant, when they may not be practically significant. Second, our investigation only considers physician making in the State of Florida. While Florida is a large, ethnically and socio-demographically diverse, state it is possible that state level factors impact the decision making of these physicians in a systematically different way. Although our review of the extant literature, as well as the legal reforms to healthcare within the state has not revealed any evidence that this is occurring, the concern nonetheless exists. One future extension to this work would be to investigate similar questions in a multi-state context and determine which, if any, state level factors influence the decision makers.

A final limitation of this study is the unobservable effect of medical malpractice which may be driving the change in non-*Severe SCAD* patients. As the field of medicine is highly litigious, and the cost of medical malpractice for both hospitals and physicians is a pressing concern, changes to the underlying belief about the efficacy of a procedure can have drastic effects. While this concern is present, we do not believe that it exerts undue influence on the physicians being observed in this study. Malpractice protects against medical errors, and because PCI is an *accepted* treatment for SCAD, its use does not constitute a "medical error" (Hofer et al. 2000). Although stories of overtreatment by cardiac physicians have dominated the news media (Abelson and Creswell 2012) for the last decade it is important to note that these physicians are being investigated on the grounds of Medicare fraud, civil conspiracy, and unlawful enrichment, not medical malpractice, for performing hundreds of unnecessary procedures.

In conclusion, decisions made by professional experts often have significant social and economic ramifications, and particularly so in the domain of medicine where the consequences of faulty decision making can be substantial. To the degree that innovation and discovery are inevitable, and new knowledge is created with regularity, understanding how these information shocks are incorporated into expert decision making is an important question from the perspectives of theory, practice, and policy. We have explored the agility-routine tradeoff decision that physicians face when new information about the efficacy of tried and tested treatments is revealed, and whether they are able to alter decision

making rules appropriately. While results support the general assertion of experts' responsiveness to new information, we find that the ability to discern between patients and react with agility is more pronounced as physician training and tenure increases. Moreover, physicians abandon the use of invasive and more expensive treatments slowly; a response that has substantial public welfare implications given the ever increasing costs of medical treatment, and the widespread prevalence of coronary arterial disease globally. Additional research on understanding the nature and source of information shocks that elicit optimal changes in decision making from physicians is needed for researchers and policy makers to be able to effectively disseminate medical discoveries to those who practice medicine.

4.6 Chapter 4 Appendix

To determine the severity of the patient's SCAD, and by extension the relevance of the guideline release to the patient's treatment decision, we use International Statistical Classification of Disease and Health Related Problems Version 9 (ICD-9) diagnosis codes available in AHCA dataset. Published by the World Health Organization, ICD-9 is "the standard diagnostic tool for epidemiology, health management, and clinical purposes.[26]" We use ICD-9 codes not only to determine the severity of the patient's SCAD, but also to control for other conditions and co-morbidities present (the full list of controls is outlined in Table 4.2). Following the CCS Functional Classification of Angina Pectoris (Table 4.1) on coronary arterial disease we classify a patient as having *Severe*

[26] http://www.who.int/classifications/icd/en/

SCAD, i.e. CCS-ClassIII angina or above, if the patient suffers from any of the following conditions: intermediate coronary syndrome, an acute coronary occlusion without myocardial infarction, or angina decubitus[27]. Intermediate coronary syndrome is severe SCAD according to the ICD-9 description. Acute coronary occlusion without myocardial infarction is a complete blockage of one of the arteries which supplies the heart with blood, and angina decubitus is resting chest pain, which is CCS Class III per the descriptions provided in Table 4.1.

[27] A complete listing of the current ICD-9 classifications is available at http://www.icd9data.com/

CHAPTER 5: EPILOGUE

In this dissertation I investigate how changes in the availability of information influences decision making in inherently ambiguous environments. As the Internet has not only fostered connectivity, but also catalyzed information generation on an unprecedented scale (Siegler 2010), my objective is to revisit the concept of information availability and salience in the digital age. I conduct my empirical analysis in the contexts of entrepreneurship and healthcare, which are significant both theoretically as well as in terms of economic and public welfare. Recent discussions of the importance of these contexts are commonplace in both the academic literature and the popular press. From the perspective of healthcare, the inability of policy makers and governing bodies to effectively and systematically influence physician decision making has led to both cost overruns (Smith 2000) and inferior clinical care outcomes (Bristow et al. 2013, Cox 2009). From the perspective of entrepreneurship, the ability of policy makers to incentivize entrepreneurs to form firms, and financiers to fund them regardless of location, is essential for a robust and vibrant economy (Paulsen and Kind 2013).

In addition to identifying the effect information availability can have on venture capitalist, entrepreneur, and physician decision making, this dissertation highlights many fruitful opportunities for future work; both within the relationship between information availability and decision making, and beyond. In essay 2 I am able to examine the interplay between blogs and print media. However, many outstanding questions remain. How does the richness of different forms of user generated content, i.e. video through YouTube, tweets, or Facebook updates,

influence decision making differently, and under what conditions? Moreover, which mechanism, availability or legitimacy, dominates when decision makers are influenced by media? In essay 1 I investigate how rising perceptions of fashion influence the decision making of venture capitalists. However, extant literature has not yet comprehensively examined the location decisions of entrepreneurs. When will it be preferable for entrepreneurs to re-locate to VC hotbeds? When will it not? Furthermore, where do the entrepreneurs who operate in VC hotbeds come from? Are these *de novo* ventures born within hotbeds as a result of the intense supply side benefits which agglomeration economies offer (Bresnahan et al. 2001) or do they migrate from other economies in order to capitalize on those benefits? In essay 3 I examine how individual physicians react to medical guideline release, as well as the moderating effects of varying physician characteristics. A related and understudied question in the physician decision making context is the effect of the hospital or the competitive environment the hospital faces on the reaction of physicians to new information. Moreover, further work must be done examining how physicians react to new guidelines which are based on the evidence of medical trials, as opposed to expert opinion. Each of these future extensions has the potential to yield important theoretical insights and practical implications for policy makers and managers.

Taken collectively, the findings of this dissertation contribute in significant ways to extant theory regarding information availability and decision making under uncertainty. First, by examining my questions using secondary datasets I am able to investigate real time trade-offs which must be made by

decision makers and quantify the economic effect of increasing information availability. Previous work in this domain, which has primarily been done in laboratory settings, has been unable to do so. Second, by introducing randomness into the empirical specifications, either through instrumentation as in Essay 2 or through exogenous shocks as in Essay 3, I am able to mitigate many of the endogeneity problems which previous studies of information availability in secondary datasets have been unable to resolve. This allows me, in contrast to many of these previous studies, to make causal claims about the effects I observe. Third, as mentioned above, this work is done in two contexts which have significant implications for public welfare. It is my belief that the findings of this dissertation underscore the need for future work in the area of information availability, which will be theoretically fruitful and offer valuable insights to practitioners.

Figures

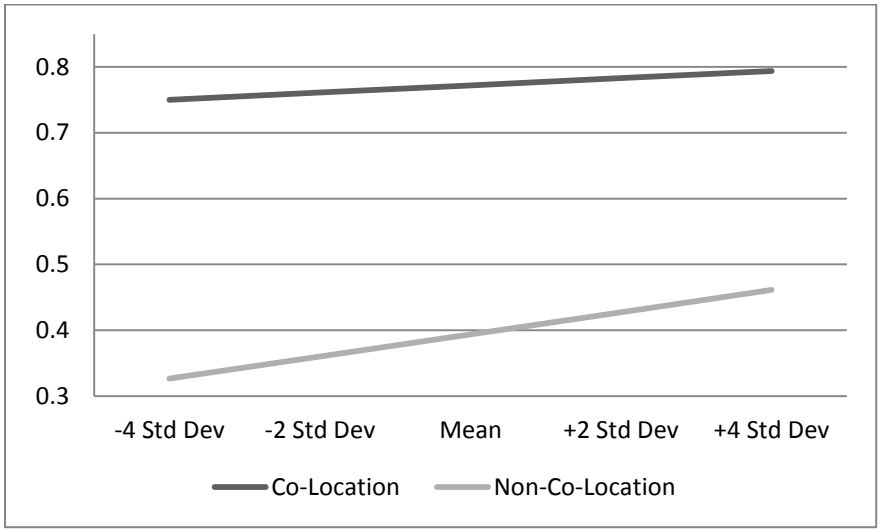

Figure 2.1: Effect of Increases in Media Coverage
Y-Axis: Probability of Funding Reception

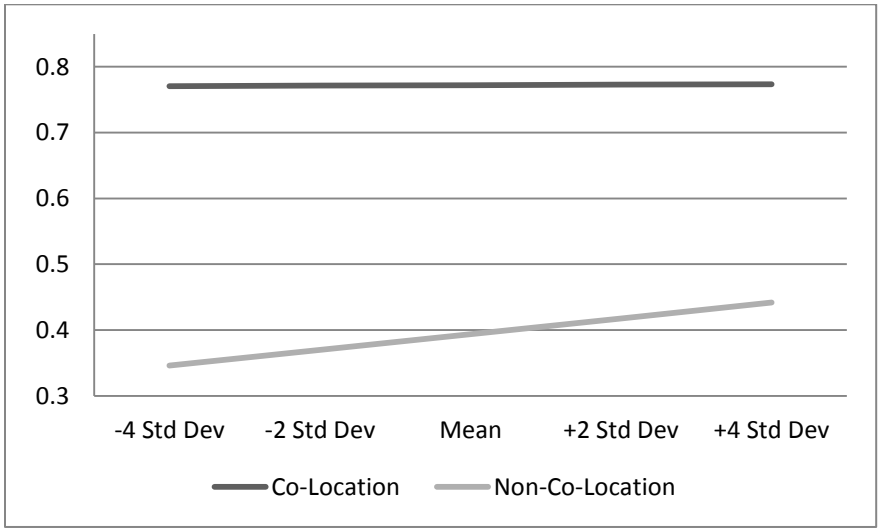

Figure 2.2: Effect of Increases in Herding
Y-Axis: Probability of Funding Reception

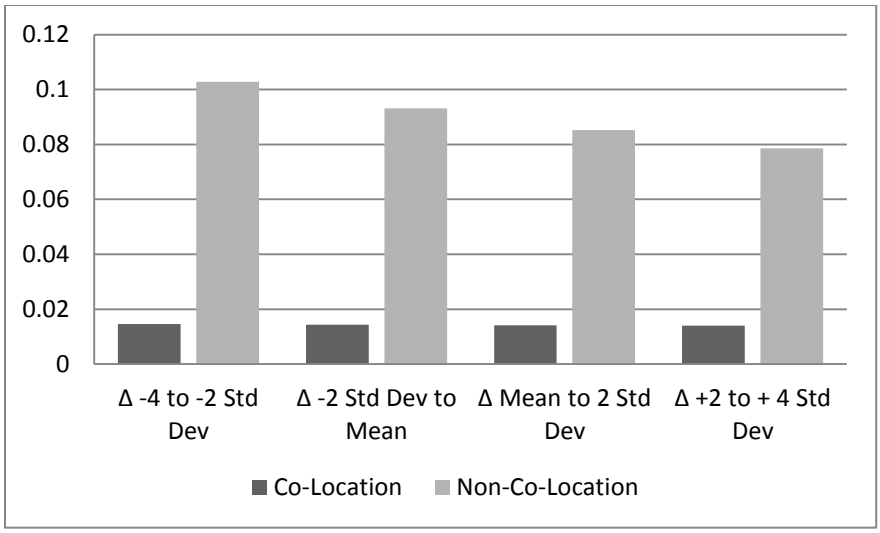

Figure 2.3: Marginal Effect of Increase in Media Coverage
Y-Axis: Change in Probability of Funding Reception

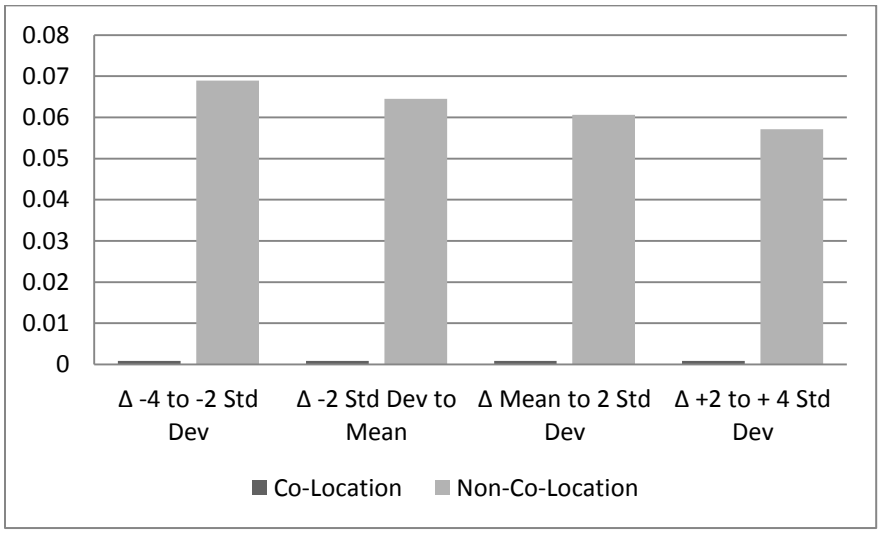

Figure 2.4: Marginal Effect of Increase in Herding
Y-Axis: Change in Probability of Funding Reception

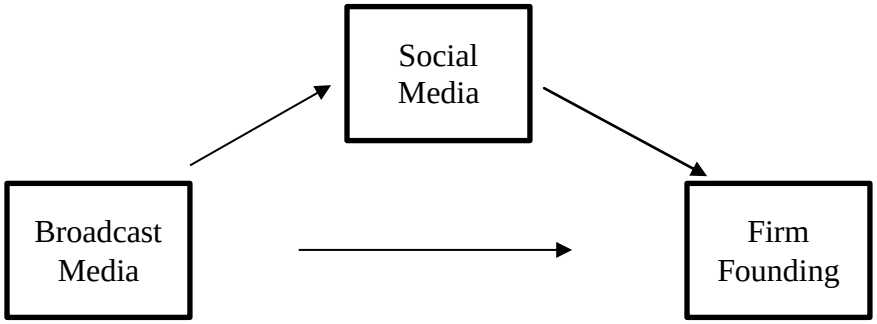

Figure 3.1: Theoretical Model of Media Effect on Firm Founding

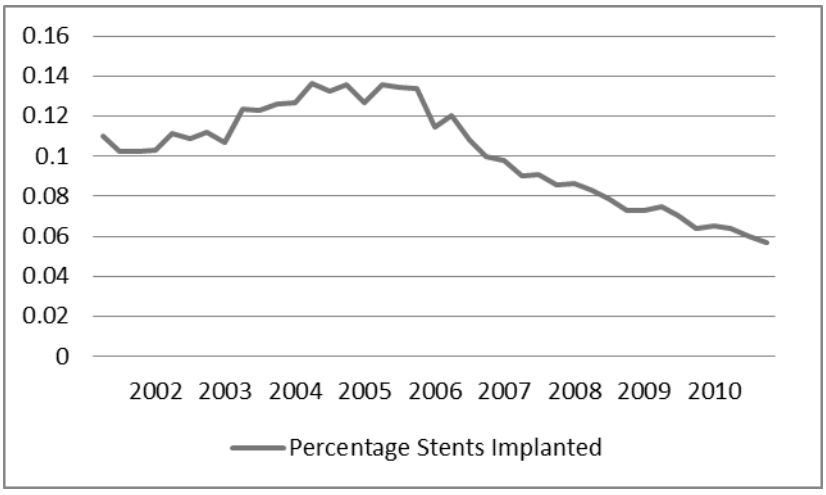

Figure 4.1: Ratio of Stents to Stenting Opportunities

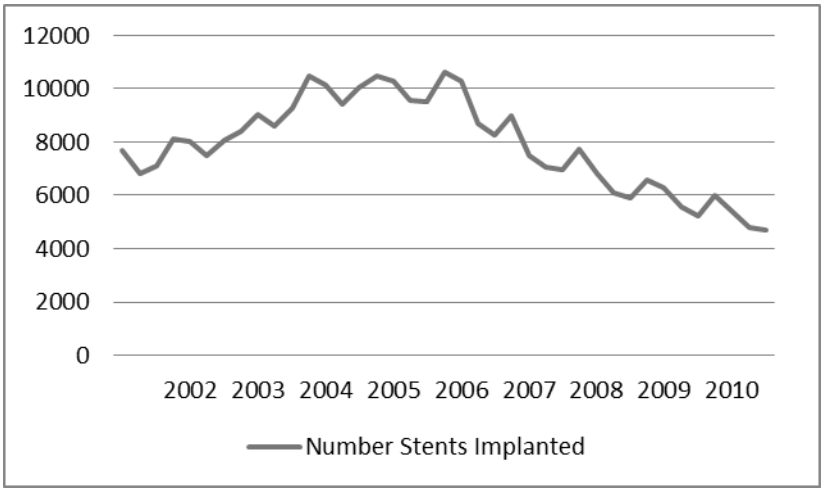

Figure 4.2: Raw Stenting Rate over Time

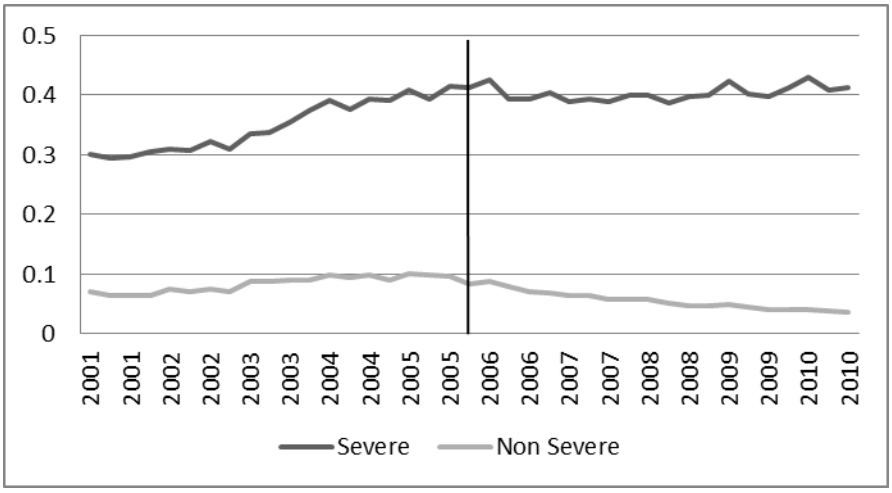

Figure 4.3: Percent Stents Implanted by SCAD Severity
Y-Axis: Number Stents Implanted / Stenting Opportunities
X-Axis: Time by Quarter: 2001 – 2010

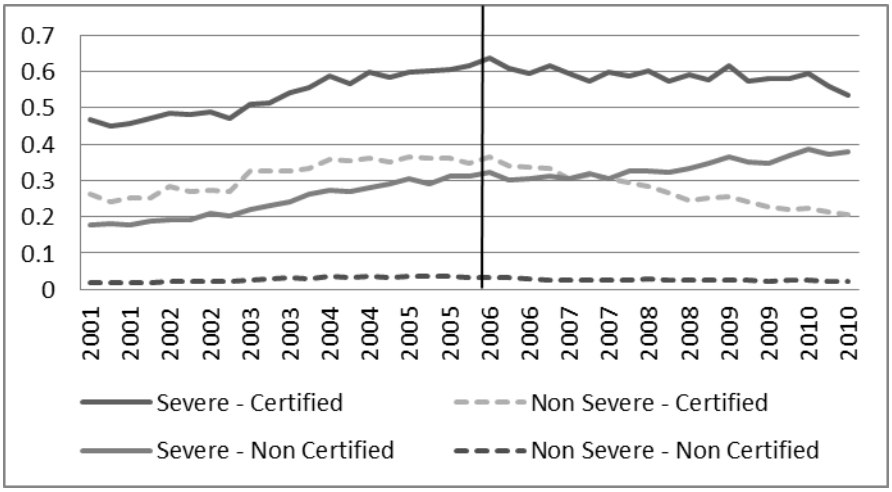

Figure 4.4: Percent Stents Implanted by SCAD Severity and Certification
Y-Axis: Number Stents Implanted / Stenting Opportunities
X-Axis: Time by Quarter: 2001 – 2010

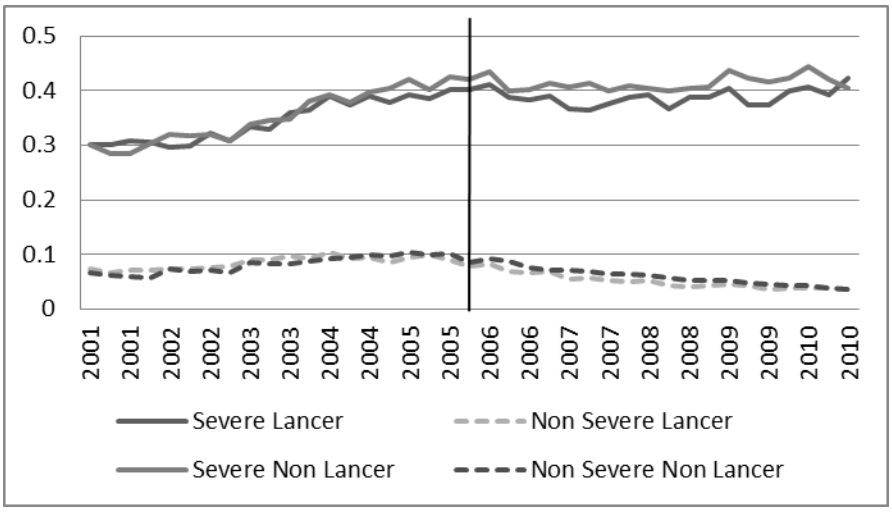

Figure 4.5: Percent Stents Implanted by SCAD Severity and Free Lancer
Y-Axis: Number Stents Implanted / Stenting Opportunities
X-Axis: Time by Quarter: 2001 – 2010

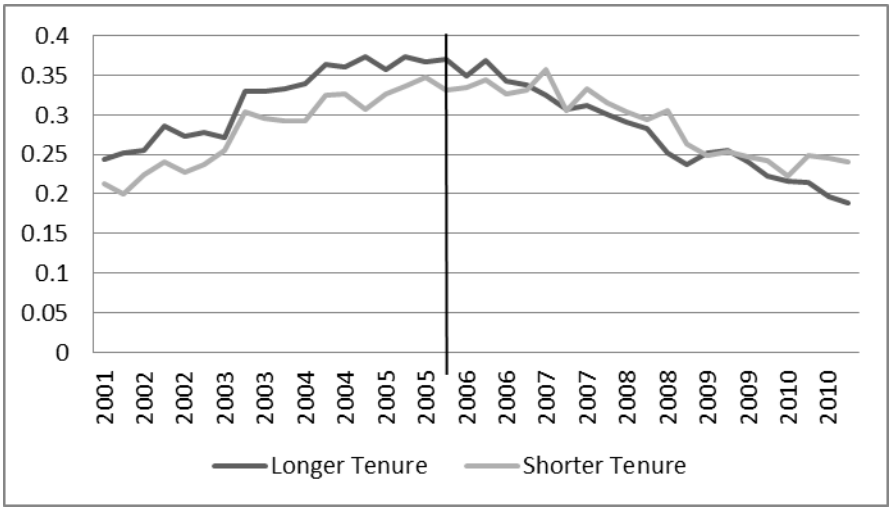

Figure 4.6: Percent Stents Implanted by Board Certified Physicians Practicing Before and After 2001 AHA \ ACC Update
Y-Axis: Number Stents Implanted / Stenting Opportunities
X-Axis: Time by Quarter: 2001 – 2010

Tables

Table 2.1: Summary Statistics and Correlations
N = 39,709

	Variable	Mean	Std. Dev.	1	2	3	4	5	6	7	8	9	10	11	12
1	Funded	0.5001133	0.5000063												
2	Co-Location	0.2843184	0.4510949	0.199											
3	Herding	0.8258763	1.413914	-0.003	0.010										
4	Media	0.8949505	3.519341	0.043	0.023	0.066									
5	Patent Originality	0.0679935	0.2537625	0.008	-0.011	-0.009	-0.015								
6	ln(Entre Age)	0.972207	0.7894311	0.001	-0.095	0.007	0.020	0.068							
7	Herfindahl	0.6309382	0.2681575	0.140	-0.023	0.066	-0.006	0.006	0.017						
8	Entre Concentration	162.5644	207.1353	-0.015	0.206	0.024	-0.119	0.001	-0.182	0.051					
9	VC Concentration	69.69621	75.39999	-0.008	0.133	0.047	-0.125	-0.016	-0.102	0.010	0.455				
10	Firm Size	2.417714	5.429095	-0.106	-0.073	-0.007	-0.014	0.001	0.009	-0.204	0.021	0.051			
11	Firm Age	13.77068	15.0304	-0.102	-0.028	0.018	-0.002	-0.006	-0.007	-0.305	0.019	0.053	0.164		
12	PrevSpending	8.942948	29.06802	0.007	-0.036	0.153	-0.015	-0.006	0.008	0.018	0.040	0.058	0.203	0.069	
13	Syndicate Co-location	0.5368556	0.4986461	0.008	0.464	-0.014	-0.010	-0.020	-0.154	-0.034	0.210	0.125	-0.027	0.010	-0.037

Table 2.2: Logit Model of Entrepreneur-VC Co-location
Year and ISC2 Control Variables Omitted

	(1)	(2)	(3)	(4)
Dependent Variable	*Funded*	*Funded*	*Funded*	*Funded*
Co-Location	1.196***	1.242***	1.177***	1.221***
	(0.0295)	(0.0330)	(0.0300)	(0.0336)
Herding	0.0360***	0.0543***	0.0352***	0.0525***
	(0.0102)	(0.0109)	(0.0102)	(0.0109)
Media	0.0229***	0.0227***	0.0304***	0.0298***
	(0.00330)	(0.00331)	(0.00383)	(0.00384)
Herding		-0.0533***		-0.0501***
* Co-Location		(0.0174)		(0.0174)
Media			-0.0240***	-0.0228***
* Co-Location			(0.00671)	(0.00675)
Patent Originality	0.0537	0.0551	0.0557	0.0569
	(0.0436)	(0.0436)	(0.0436)	(0.0436)
ln(Entre Age)	0.0166	0.0162	0.0168	0.0165
	(0.0142)	(0.0142)	(0.0142)	(0.0142)
Herfindahl	0.999***	1.000***	0.996***	0.997***
	(0.0447)	(0.0447)	(0.0447)	(0.0447)
Entre Concentration	-0.000461***	-0.000463***	-0.000472***	-0.000473***
	(6.82e-05)	(6.83e-05)	(6.85e-05)	(6.85e-05)
VC Concentration	5.21e-05	5.77e-05	4.43e-05	4.99e-05
	(0.000171)	(0.000171)	(0.000171)	(0.000171)
Firm Size	-0.0291***	-0.0291***	-0.0291***	-0.0290***
	(0.00243)	(0.00243)	(0.00243)	(0.00243)
Firm Age	-0.00593***	-0.00591***	-0.00594***	-0.00592***
	(0.000864)	(0.000863)	(0.000863)	(0.000863)
PrevSpending	0.00272***	0.00268***	0.00273***	0.00270***
	(0.000504)	(0.000501)	(0.000505)	(0.000502)
Syndicate Co-location	-0.388***	-0.390***	-0.387***	-0.389***
	(0.0264)	(0.0264)	(0.0264)	(0.0264)
Constant	0.339	0.333	0.343	0.337
	(0.276)	(0.276)	(0.276)	(0.276)
Pseudo R^2	0.077	0.078	0.078	0.078
χ^2	3516.05	3537.62	3540.42	3560.72
Observations	39,709	39,709	39,709	39,709

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.3: Linear Probability Model of Entrepreneur-VC Co-location
Year and ISC2 Control Variables Omitted

	(1)	(2)	(3)	(4)
Dependent Variable	*Funded*	*Funded*	*Funded*	*Funded*
Co-Location	0.378***	0.385***	0.375***	0.382***
	(0.00647)	(0.00721)	(0.00662)	(0.00740)
Herding	0.00565***	0.00901***	0.00557**	0.00874***
	(0.00217)	(0.00242)	(0.00217)	(0.00242)
Media	0.00389***	0.00384***	0.00488***	0.00476***
	(0.000709)	(0.000710)	(0.000776)	(0.000777)
Herding		-0.00903**		-0.00850**
* Co-Location		(0.00371)		(0.00373)
Media			-0.00344**	-0.00321**
* Co-Location			(0.00148)	(0.00148)
Patent Originality	-0.00704	-0.00696	-0.00679	-0.00673
	(0.00918)	(0.00918)	(0.00918)	(0.00918)
ln(Entre Age)	-0.00666**	-0.00673**	-0.00665**	-0.00672**
	(0.00313)	(0.00313)	(0.00313)	(0.00313)
Entre Concentration	-0.000223***	-0.000223***	-0.000224***	-0.000224***
	(1.47e-05)	(1.47e-05)	(1.48e-05)	(1.48e-05)
VC Concentration	0.00101***	0.00101***	0.00100***	0.00100***
	(4.01e-05)	(4.01e-05)	(4.01e-05)	(4.01e-05)
Firm Age	0.00202**	0.00207**	0.00201**	0.00205**
	(0.000927)	(0.000929)	(0.000928)	(0.000929)
PrevSpending	0.000516***	0.000513***	0.000516***	0.000513***
	(9.79e-05)	(9.74e-05)	(9.80e-05)	(9.75e-05)
Syndicate Co-location	-0.0801***	-0.0804***	-0.0799***	-0.0802***
	(0.00559)	(0.00559)	(0.00559)	(0.00559)
Constant	0.474***	0.471***	0.474***	0.471***
	(0.0654)	(0.0654)	(0.0654)	(0.0654)
R^2	0.280	0.281	0.281	0.281
Observations	39,709	39,709	39,709	39,709

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.4: Rare Events Logit Model of Entrepreneur-VC Co-location
Year and ISC2 Control Variables Omitted

	(1)	(2)	(3)	(4)
Dependent Variable	*Funded*	*Funded*	*Funded*	*Funded*
Co-Location	1.118***	1.161***	1.097***	1.137***
	(0.0207)	(0.0230)	(0.0209)	(0.0234)
Herding	0.0356***	0.0589***	0.0356***	0.0568***
	(0.00718)	(0.00951)	(0.00718)	(0.00955)
Media	0.0211***	0.0205***	0.0312***	0.0303***
	(0.00233)	(0.00234)	(0.00293)	(0.00295)
Herding		-0.0488***		-0.0446***
* Co-Location		(0.0121)		(0.0122)
Media			-0.0256***	-0.0245***
* Co-Location			(0.00404)	(0.00406)
Patent Originality	-0.0298	-0.0293	-0.0289	-0.0284
	(0.0351)	(0.0351)	(0.0351)	(0.0351)
ln(Entre Age)	0.0929***	0.0929***	0.0930***	0.0930***
	(0.0118)	(0.0118)	(0.0118)	(0.0118)
Herfindahl	0.979***	0.980***	0.975***	0.977***
	(0.0386)	(0.0386)	(0.0385)	(0.0385)
Entre Concentration	-0.000720***	-0.000711***	-0.000739***	-0.000731***
	(5.69e-05)	(5.70e-05)	(5.73e-05)	(5.74e-05)
VC Concentration	0.000146	0.000149	0.000162	0.000164
	(0.000126)	(0.000126)	(0.000126)	(0.000126)
Firm Size	-0.0353***	-0.0353***	-0.0352***	-0.0352***
	(0.00244)	(0.00243)	(0.00243)	(0.00243)
Firm Age	-0.00926***	-0.00920***	-0.00932***	-0.00926***
	(0.000859)	(0.000858)	(0.000857)	(0.000857)
PrevSpending	0.00346***	0.00344***	0.00345***	0.00344***
	(0.000394)	(0.000391)	(0.000394)	(0.000391)
Syndicate Co-location	-0.293***	-0.295***	-0.291***	-0.294***
	(0.0177)	(0.0177)	(0.0177)	(0.0177)
Constant	0.120	0.112	0.125	0.117
	(0.243)	(0.243)	(0.243)	(0.243)
Pseudo R^2	0.134	0.134	0.135	0.135
χ^2	12414.78	12399.62	12342.63	12332.11
Observations	119,625	119,625	119,625	119,625

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.5: Logit Model of Entrepreneur-VC Co-location
Match Unconstrained by Industry
Year and ISC2 Control Variables Omitted

	(1)	(2)	(3)	(4)
Dependent Variable	*Funded*	*Funded*	*Funded*	*Funded*
Co-Location	1.183***	1.240***	1.155***	1.209***
	(0.0307)	(0.0351)	(0.0318)	(0.0365)
Herding	0.0550***	0.0771***	0.0554***	0.0755***
	(0.0104)	(0.0116)	(0.0104)	(0.0116)
Media	0.0313***	0.0309***	0.0391***	0.0382***
	(0.00317)	(0.00317)	(0.00363)	(0.00365)
Herding		-0.0597***		-0.0544***
* Co-Location		(0.0178)		(0.0180)
Media			-0.0248***	-0.0231***
* Co-Location			(0.00618)	(0.00624)
Patent Originality	0.00782	0.00736	0.00927	0.00877
	(0.0476)	(0.0476)	(0.0477)	(0.0477)
ln(Entre Age)	0.0817***	0.0817***	0.0814***	0.0814***
	(0.0156)	(0.0156)	(0.0156)	(0.0156)
Herfindahl	1.107***	1.107***	1.106***	1.105***
	(0.0479)	(0.0479)	(0.0479)	(0.0479)
Entre Concentration	-0.000465***	-0.000463***	-0.000477***	-0.000474***
	(6.50e-05)	(6.50e-05)	(6.52e-05)	(6.52e-05)
VC Concentration	0.000142	0.000146	0.000157	0.000159
	(0.000161)	(0.000161)	(0.000162)	(0.000162)
Firm Size	-0.0312***	-0.0312***	-0.0311***	-0.0311***
	(0.00256)	(0.00256)	(0.00256)	(0.00256)
Firm Age	-0.00741***	-0.00738***	-0.00747***	-0.00744***
	(0.000929)	(0.000928)	(0.000928)	(0.000928)
PrevSpending	0.00413***	0.00409***	0.00413***	0.00410***
	(0.000565)	(0.000565)	(0.000566)	(0.000565)
Syndicate Co-location	-0.436***	-0.437***	-0.434***	-0.436***
	(0.0273)	(0.0273)	(0.0274)	(0.0274)
Constant	1.810***	1.799***	1.816***	1.806***
	(0.448)	(0.448)	(0.448)	(0.448)
Psuedo R^2	0.155	0.1552	0.1552	0.1554
χ^2	6169.61	6159.47	6192.35	6184.96
Observations	39,718	39,718	39,718	39,718

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.1: Local Periodicals Used by *Founding* Dataset

Zone Number	Area	Periodical
1	New England	*Boston Herald*
2	Mid Atlantic	*New York Times*
3	East North Central	*Chicago Tribune*
4	West North Central	*Minneapolis Star Tribune*
5	South Atlantic	*Washington Post*
6	East South Central	*The Atlanta Journal Constitution*
7	West South Central	*Austin American-Statesman*
8	Mountain	*The Denver Post*
9	Pacific	*San Jose Mercury News*

Table 3.2: Variable Descriptions

Variable	Description
Variables for Firm Founding	
Num Founded	Number of Firms Founded in Economic Zone by ISC
Broadcast Media (Thousands)	Level of the Broadcast Media Change
Social Media (100 Thousands)	Level of the Social Media Change
Poverty(10s Thousands)	Number of People Living in Poverty in Economic Zone
Median (Thousands)	Median Income of Economic Zone
Employment(Hundreds)	Number of people working in IT in Economic Zone
Num Firms	Number of IT firms in Economic Zone
Population(10 Millions)	Population of Economic Zone
VC Capital(100 Thousands)	VC Capital spent in Economic Zone
VC Investments	Number of VC Deals made in Economic Zone
Patenting	Number of Patents Granted within Industry (Past three years)

Table 3.3: Summary Statistics for Firm Founding (1996 – 2006)
N – 54720

		Mean	Std. Dev.	1	2	3	4	5	6	7	8	9	10
-1	*Num Founded*	0.1308845	0.9127452										
-2	*Broadcast Media*	0.0206547	0.4622622	0.0002									
-3	*Social Media*	0.3777396	44.57541	0.0021	0.0795								
-4	*Poverty*	329.3229	179.0479	0.1041	0.006	0.0013							
-5	*Median*	39.41431	4.948846	0.0008	0.016	0.0051	0.5152						
-6	*Employment*	2000.54	1771.167	0.0258	0.0061	0.0019	0.5126	0.5715					
-7	*Num Firms*	126.8918	78.78193	0.0177	0.0076	0.0003	0.6456	0.6039	0.8048				
-8	*Population*	2.858525	1.621409	0.0904	0.0055	0.0003	0.9521	0.6328	0.6604	0.7935			
-9	*VC Capital*	70.77951	3.00E+02	0.1974	-0.0064	-0.0013	-0.0701	-0.0726	-0.0578	-0.0632	-0.0669		
-10	*VC Investments*	259.1959	605.64	0.2843	-0.0096	-0.0013	-0.118	-0.1351	-0.1066	-0.1137	-0.1202	0.7005	
-11	*Patenting*	15.18454	125.2942	0.026	-0.0053	-0.0024	-0.0124	-0.0571	-0.0121	-0.0103	-0.0046	0.0093	0.0263

Table 3.4: Fixed Effect Time Series Quasi-Maximum Likelihood Poisson Estimator
Industry - Zone Fixed Effects and Period Controls Omitted

	-1	-2	-3	-4
Analysis	xtpqml	xtpqml	xtpqml	Time Series OLS
Dependent Variable	*Num Founded*	*Num Founded*	*Num Founded*	*Social Media*
Broadcast Media	0.0841*		0.0777	6.374***
	(0.0417)		(0.0424)	(0.710)
Social Media		0.00144***	0.00143***	
		(0.000417)	(0.000414)	
Poverty	-0.00447**	-0.000624	-0.000619	-0.000835
	(0.00162)	(0.00181)	(0.00181)	(0.00445)
Median	0.182**	0.109	0.109	-0.0165
	(0.0625)	(0.0614)	(0.0614)	(0.103)
Employment	2.59e-05	-1.36e-05	-1.39e-05	1.73e-05
	(3.47e-05)	(3.88e-05)	(3.88e-05)	(7.92e-05)
Num Firms	0.000520	0.00135*	0.00136*	4.34e-05
	(0.000573)	(0.000605)	(0.000605)	(0.00154)
Population	2.388*	2.323*	2.322*	-0.190
	(0.986)	(0.992)	(0.992)	(1.478)
VC Capital	0.000182**	0.000172**	0.000171**	-9.98e-05
	(5.57e-05)	(5.30e-05)	(5.31e-05)	(8.75e-05)
VC Investments	-6.77e-05	-7.71e-05	-7.68e-05	-0.000147
	(4.87e-05)	(4.53e-05)	(4.54e-05)	(0.000124)
Patenting	-7.28e-05	-4.35e-05	-4.38e-05	-0.000463
	(0.000123)	(0.000117)	(0.000117)	(0.000443)
Constant				2.948
				(4.797)
Wald χ ^2	77149.84	84306.75	84351.98	
R^2				0.073
Observations	24,000	24,000	24,000	54,720

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05

Table 3.5: Fixed Effect Time Series OLS
Industry - Zone Fixed Effects and Period Controls Omitted

	-1	-2	-3	-4
Analysis	OLS	OLS	OLS	OLS
Dependent Variable	*Num Founded*	*Num Founded*	*Num Founded*	*Social Media*
Broadcast Media	0.00683*		0.00633	6.375***
	(0.00345)		(0.00347)	(0.710)
Social Media		8.37e-05**	7.92e-05**	
		(2.56e-05)	(2.59e-05)	
Poverty	-0.000679*	-0.000679*	-0.000679*	-0.000321
	(0.000313)	(0.000312)	(0.000313)	(0.00452)
Median	-0.0516***	-0.0516***	-0.0516***	-0.0204
	(0.00629)	(0.00628)	(0.00629)	(0.104)
Employment	-6.08e-06**	-6.09e-06**	-6.08e-06**	1.43e-05
	(2.26e-06)	(2.26e-06)	(2.26e-06)	(7.94e-05)
Num Firms	0.000232	0.000232	0.000232	0.000184
	(0.000121)	(0.000121)	(0.000121)	(0.00155)
Population	-1.578***	-1.578***	-1.578***	-0.240
	(0.119)	(0.119)	(0.119)	(1.479)
VC Capital	8.19e-05***	8.19e-05***	8.19e-05***	-0.000100
	(2.48e-05)	(2.48e-05)	(2.48e-05)	(8.75e-05)
VC Investments	0.000303***	0.000302***	0.000303***	-0.000155
	(6.95e-05)	(6.95e-05)	(6.95e-05)	(0.000124)
Patenting	0.000137*	0.000137*	0.000137*	-0.000463
	(6.04e-05)	(6.03e-05)	(6.03e-05)	(0.000442)
Constant	6.620***	6.618***	6.620***	2.951
	(0.412)	(0.412)	(0.412)	(4.798)
R^2	0.471	0.471	0.471	0.073
Observations	24,000	24,000	24,000	54,720

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05

Table 3.6: Time Series 2SLS Estimation of Firm Founding Industry - Zone Fixed Effects and Period Controls Omitted

	-1	-2	-3	-4
Analysis	Time Series 2SLS	Time Series 2SLS	Time Series 2SLS	Time Series OLS
Dependent Variable	*Num Founded*	*Num Founded*	*Num Founded*	*Social Media*
Broadcast Media	0.493*		0.285	6.374***
	(0.211)		(0.216)	(0.710)
Social Media		0.0136**	0.0127**	
		(0.00500)	(0.00489)	
Poverty	-0.00167***	-0.00166***	-0.00167***	-0.000835
	(0.000313)	(0.000308)	(0.000310)	(0.00445)
Median	-0.0539***	-0.0536***	-0.0539***	-0.0165
	(0.00772)	(0.00764)	(0.00771)	(0.103)
Employment	-2.22e-05***	-2.19e-05***	-2.20e-05***	1.73e-05
	(5.49e-06)	(5.27e-06)	(5.36e-06)	(7.92e-05)
Num Firms	-3.46e-05	-3.35e-05	-3.44e-05	4.34e-05
	(0.000110)	(0.000105)	(0.000107)	(0.00154)
Population	-1.698***	-1.697***	-1.697***	-0.190
	(0.219)	(0.219)	(0.219)	(1.478)
VC Capital	0.000142***	0.000150***	0.000146***	-9.98e-05
	(4.17e-05)	(4.19e-05)	(4.20e-05)	(8.75e-05)
VC Investments	0.000242***	0.000241***	0.000243***	-0.000147
	(6.29e-05)	(6.26e-05)	(6.31e-05)	(0.000124)
Patenting	0.000153	0.000164	0.000160	-0.000463
	(9.85e-05)	(9.87e-05)	(9.78e-05)	(0.000443)
Constant				2.948
				(4.797)
Kleinenberg Paap F-Statistic	23.671	13.608	12.847	
Underidentification χ^2	49.966	25.135	9.228	
F-Statistic	22.19	22.85	21.51	
R^2				0.073
Observations	54,720	54,720	54,720	54,720

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05

Table 3.7: Time Series 2SLS Estimation of Firm Founding using CBP Data
Year Controls Omitted

	-1	-2	-3	-4
Analysis	Time Series 2SLS	Time Series 2SLS	Time Series 2SLS	Time Series OLS
Dependent Variable	*Under_50*	*Under_50*	*Under_50*	*Social Media*
Broadcast Media	1.125***		-0.589	0.615***
	(0.300)		(0.643)	(0.0385)
Social Media		0.268***	0.365**	
		(0.0564)	(0.121)	
VC Capital	-2.76e-07***	-3.00e-07***	-3.21e-07***	-1.43e-07***
	(5.42e-08)	(5.18e-08)	(5.71e-08)	(3.25e-08)
VC Investments	0.0266***	0.0279***	0.0288***	0.00212
	(0.00188)	(0.00180)	(0.00204)	(0.00114)
Poverty	-0.000107***	-0.000107***	-0.000106***	-2.66e-06
	(6.76e-06)	(6.78e-06)	(6.89e-06)	(4.33e-06)
Median	-0.000145***	-0.000171***	-0.000180***	9.82e-05***
	(3.95e-05)	(4.01e-05)	(4.19e-05)	(2.53e-05)
Population	-3.67e-06	-2.33e-06	-1.67e-06	-1.63e-06
	(1.98e-06)	(1.97e-06)	(2.12e-06)	(1.26e-06)
Employment	0.00131***	0.00145***	0.00152***	-0.000296
	(0.000296)	(0.000297)	(0.000309)	(0.000189)
Patenting	-0.671***	-0.440***	-0.362**	-0.987***
	(0.0650)	(0.0859)	(0.122)	(0.0411)
Constant				-0.0166
				-0.213
Kleinenberg Paap F-Statistic	255.51	403.856	82.632	
Underidentification χ^2	491.181	758.639	41.539	
F-Statistic	86.31	86.25	78.93	
R^2				0.541
Observations	14,682	14,682	14,682	14,682

Robust standard errors in parentheses

*** p<0.001, ** p<0.01, * p<0.05

Table 3.8: Matching of NAICS Industry Names to ISC Industry Names

NAICS Industry Name	ISC Industry Name
Computer Training Services	Computer Training
Radio TV Broadcasting Other Related Equipment	Radio & TV Broadcasting & Wireless Communications Equipment
Fiber Optic Cables	Fiber Optic Cables
Semiconductors	Semiconductor Machinery
Electronics Related Equipment	Electricity Measuring & Testing Equipment
Analytical Scientific Instrumentation	Analytical Laboratory Instruments
Optical computing	Optical Instrument & Lens
Wireless Communications Services	Wireless Telecommunications (except Satellite)
Satellite Communications	Satellite Telecommunications

Table 4.1: Canadian Cardiovascular Society Functional Classification of Angina Pectoris

Class	Definition	Specific Activity Scale
I	Ordinary physical activity (e.g., walking and climbing stairs) does not cause angina; angina occurs with strenuous, rapid, or prolonged exertion at work or recreation.	Ability to ski, play basketball, jog at 5 mph, or shovel snow without angina
II	Slight limitation of ordinary activity. Angina occurs on walking or climbing stairs rapidly, walking uphill, walking or stair climbing after meals, in cold, in wind, or under emotional stress, or only during the few hours after awakening, when walking more than two blocks on level ground, or when climbing more than one flight of stairs at a normal pace and in normal conditions.	Ability to garden, rake, roller skate, walk at 4 mph on level ground, have sexual intercourse without stopping
III	Marked limitation of ordinary physical activity. Angina occurs on walking one to two blocks on level ground or climbing one flight of stairs at a normal pace in normal conditions.	Ability to shower or dress without stopping, walk 2.5 mph, bowl, make a bed, play golf
IV	Inability to perform any physical activity without discomfort.	Anginal symptoms may be present at rest. Inability to perform activities requiring 2 or fewer metabolic equivalents without angina

Source:
http://www.clevelandclinicmeded.com/medicalpubs/diseasemanagement/cardiology/coronary-artery-disease/

Table 4.2: Co-Morbidity Controls

Hypertension	**Chronic bronchitis or emphysema**
Malignant Essential Hypertension	Chronic Bronchitis
Benign Essential Hypertension	Mucopurulent chronic bronchitis
Unspecified Essential Hypertension	Obstructive chronic bronchitis
Diabetes	without exacerbation convert
Diabetes without complication	with (acute) exacerbation convert
Diabetes with ketoacidosis	with acute bronchitis convert
Diabetes with hypersmolarity	Other chronic bronchitis convert
Diabetes with coma	Unspecified chronic bronchitis
Diabetes with renal manifestation	Emphysema Emphysematous bleb
Diabetes with ophthalmic manifestataion	Emphysema Other emphysema
Diabetes with neurological manifestation	Bronchiectasis without acute exacerbation
Diabetes with peripheral circulatory disorders	Bronchiectasis with acute exacerbation
Diabetes with other manifestations	Extrinsic allergic alveolitis Farmers' lung
Diabetes with unspesified complication	Extrinsic allergic alveolitis Bagassosis
Obesity	Extrinsic allergic alveolitis Bird-fanciers' lung
Unspecified Obesity	Extrinsic allergic alveolitis Suberosis convert
Morbid Obesity	Extrinsic allergic alveolitis Malt workers' lung
Overweight	Extrinsic allergic alveolitis Mushroom workers' lung
Obesity Hypoventilation Syndrome	Extrinsic allergic alveolitis Maple bark-strippers' lung
Localized adiposity	Extrinsic allergic alveolitis "Ventilation" pneumonitis
Hypervitaminosis A	Other specified allergic alveolitis and pneumonitis
Hypercarotinemia	Unspecified allergic alveolitis and pneumonitis
Hypervitaminosis D	**Misc**
Other hyperalimentation	Pure hypercholesterolemia
Arrhythmia	Thyrotoxicosis without mention of goiter or other cause
Cardiac Arrhythmia	Reynaud's Syndrome
Heart beat under 60 per minute	Peripheral Vascular Disease
Heart beat very fast (150+)	Impairment of the conduction between heart atria and ventricles
Rapid heat beat from ventricular issue	Thickening of the heart

Table 4.3 Variable Definitions

Variable Name	Definition
Stent	Dichotomous indicator of stent reception
	Patient Specific Characteristics
Sex	Patient Gender (1 - Male / 0 - Female)
ER Origin	Patient Enters Through Emergency Room
	Physician Specific Characteristics
Experience	Physician Experience (In Quarters)
LnStentsToDate	Ln(Stents Physician Has Performed To Date)
Certification	Physician Board Certified in Cardiology (1 - Yes / 0 - No)
Star	Physician Attended Top 50 Medical School)
FreeLancer	Physician is Freelancer (1 - Yes / 0 - No)
	Hospital Specific Characteristics
HospChange	Percent Hospital Change in Stenting (t-2 to t-1)
ForProfit	Hospital for profit status (1 - Yes / 0 - No)
Beds	Number of Beds in Hospital
Discharges	Number of Discharges Hospital has made in focal quarter
	Area Specific Characteristics
Income	Median income of focal county
Population	Population of Focal County
Poverty	Poverty level in Focal County
Medicare	Number of Citizens Who are Medicare Eligible in Focal County

Table 4.4 Summary Statistics
Sample N – 3072328

Variable	Mean	Std. Dev.
Stent	0.1001	0.3002
Patient Specific Characteristics - 3072328 Patients		
Sex	0.5549	0.4970
ER Origin	0.6416	0.4795
Physician Specific Characteristics - 345344 Physician Quarter Observations		
Experience	56.8953	37.3001
LnStentsToDate	2.6970	4.1217
Certification	0.1379	0.3448
Star	0.2186	0.4133
FreeLancer	0.2517	0.4340
Hospital Specific Characteristics - 5347 Hospital Quarter Observations		
HospChange	-0.0005	0.0100
ForProfit	0.6041	0.4891
Beds	337.1371	235.7388
Discharges	3776.9460	2572.1362
Area Specific Characteristics - 1248 County Quarter Observations		
Income	42944	6598
Population	439808	399610
Poverty	62711	79459
Medicare	84390	79549

Table 4.5: Correlation Matrix

		1	2	3	4	5	6	7	
1	*Stent*								
2	*Sex*	0.067							
3	*ER Origin*	-0.258	-0.067						
4	*Experience*	0.017	-0.006	-0.129					
5	*LnStentsToDate*	0.392	0.041	-0.082	-0.023				
6	*Certification*	0.382	0.079	-0.310	0.152	0.434			
7	*Star*	0.050	0.032	-0.132	0.125	-0.023	0.151		
8	*HospChange*	0.010	-0.001	-0.004	0.001	0.004	0.014	0.001	
9	*FreeLancer*	-0.002	-0.015	0.098	-0.119	0.215	-0.025	-0.132	
10	*ForProfit*	0.014	0.028	-0.011	-0.057	0.007	0.026	0.067	
11	*Beds*	0.105	0.038	-0.099	0.023	0.144	0.117	0.099	
12	*Discharges*	0.126	0.037	-0.078	-0.021	0.196	0.098	0.085	
13	*Income*	-0.007	0.016	0.025	-0.028	-0.007	-0.055	-0.038	
14	*Population*	0.047	0.000	0.020	0.010	0.104	0.013	-0.069	
15	*Poverty*	-0.024	-0.020	0.052	0.041	0.029	-0.038	-0.104	
16	*Medicare*	-0.011	-0.013	0.053	0.044	0.044	-0.033	-0.111	
		8	9	10	11	12	13	14	15
9	*FreeLancer*	0.01							
10	*ForProfit*	-0.01	-0.09						
11	*Beds*	-0.04	-0.13	0.39					
12	*Discharges*	-0.04	-0.10	0.40	0.87				
13	*Income*	-0.07	0.02	-0.01	-0.03	0.05			
14	*Population*	-0.01	0.09	-0.05	0.13	0.17	0.33		
15	*Poverty*	0.00	0.05	-0.01	0.26	0.16	-0.15	0.43	
16	*Medicare*	0.00	0.08	-0.11	0.14	0.08	0.00	0.64	0.87

Table 4.6: Change in Stenting Based on Patient Class
Hospital, Age, Race, and Co-Morbidity Dummies Omitted
Period 1 (2001 – Guideline Release) Period 2 (Guideline Release – 2010)

	(1)	(2)	(3)	(4)
Dependent Variable	Stent	Stent	Stent	Stent
Period 1	0.00208***	0.00247***	0.00113***	0.00151***
	(5.72e-05)	(7.01e-05)	(5.86e-05)	(7.10e-05)
Period 2	-0.00331***	-0.00198***	-0.00342***	-0.00213***
	(4.07e-05)	(5.84e-05)	(4.15e-05)	(5.88e-05)
Period 1			0.00590***	0.00601***
* Severe SCAD			(8.76e-05)	(8.28e-05)
Period 2			0.00383***	0.00446***
* Severe SCAD			(0.000103)	(9.74e-05)
Severe SCAD	0.212***	0.204***	-0.149***	-0.166***
	(0.000483)	(0.000462)	(0.00497)	(0.00471)
Gender	0.0137***	0.0122***	0.0136***	0.0121***
	(0.000297)	(0.000282)	(0.000297)	(0.000281)
Ln(Stents to Date)	0.0417***	0.0186***	0.0418***	0.0184***
	(0.000106)	(0.000201)	(0.000105)	(0.000200)
CardioCert	0.167***		0.168***	
	(0.000469)		(0.000468)	
Star	0.00579***		0.00568***	
	(0.000415)		(0.000414)	
HospChange	0.312***	0.251***	0.316***	0.255***
	(0.0146)	(0.0138)	(0.0146)	(0.0138)
Experience	-0.000108***	0.000142***	-0.000110***	0.000133***
	(4.33e-06)	(3.99e-05)	(4.32e-06)	(3.98e-05)
FreeLancer	-0.0323***	-0.00404***	-0.0322***	-0.00381***
	(0.000337)	(0.000463)	(0.000337)	(0.000462)
ForProfit	-0.0331***	-0.0383***	-0.0391***	-0.0428***
	(0.00955)	(0.0129)	(0.00953)	(0.0129)
Beds	-7.83e-05***	-6.70e-05***	-6.99e-05***	-5.62e-05***
	(1.37e-05)	(2.02e-05)	(1.37e-05)	(2.02e-05)
Discharge	4.89e-06***	4.28e-06***	4.93e-06***	4.29e-06***
	(3.25e-07)	(3.36e-07)	(3.24e-07)	(3.35e-07)
Income	2.47e-06***	7.34e-07***	2.54e-06***	7.66e-07***
	(1.02e-07)	(1.03e-07)	(1.02e-07)	(1.03e-07)
CntyPopulation	-6.75e-09	3.09e-08***	-4.05e-09	3.22e-08***
	(8.56e-09)	(9.25e-09)	(8.54e-09)	(9.22e-09)
Poverty	1.59e-07***	3.97e-08***	1.45e-07***	2.38e-08
	(1.50e-08)	(1.52e-08)	(1.50e-08)	(1.51e-08)
Constant	-0.267***	-0.199***	-0.214***	-0.143***
	(0.0148)	(0.0151)	(0.0148)	(0.0151)
Fixed Effects	No	Yes	No	Yes
Observations	3,072,328	3,072,328	3,072,328	3,072,328
R-squared	0.295	0.387	0.298	0.390

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4.7: Three Way Interaction of Patient Class, Period 2, and Board Certification
Hospital, Age, Race, and Co-Morbidity Dummies Omitted
Period 1 (2001 – Guideline Release) Period 2 (Guideline Release – 2010)

	(1)	(2)	(3)	(4)
Dependent Variable	Stent	Stent	Stent	Stent
Period 1	0.00208***	0.00113***	0.00247***	0.00151***
	(5.72e-05)	(5.86e-05)	(7.01e-05)	(7.10e-05)
Period 2	-0.00331***	-0.00330***	-0.00198***	-0.00210***
	(4.07e-05)	(4.22e-05)	(5.84e-05)	(5.96e-05)
Period 1		0.00591***		0.00582***
* Severe SCAD		(8.78e-05)		(8.31e-05)
Period 2		-0.00127***		7.73e-05
* CardioCert		(7.69e-05)		(7.95e-05)
Period 2		0.00390***		0.00431***
* Severe SCAD		(0.000112)		(0.000106)
CardioCert		-0.00154		-0.0414***
* Severe SCAD		(0.00119)		(0.00115)
CardioCert * Period 2		0.000410**		-0.000676***
* Severe SCAD		(0.000201)		(0.000191)
Severe SCAD	0.212***	-0.150***	0.204***	-0.141***
	(0.000483)	(0.00503)	(0.000462)	(0.00476)
Gender	0.0137***	0.0136***	0.0122***	0.0120***
	(0.000297)	(0.000297)	(0.000282)	(0.000281)
Ln(Stents to Date)	0.0417***	0.0416***	0.0186***	0.0185***
	(0.000106)	(0.000106)	(0.000201)	(0.000202)
CardioCert	0.167***	0.173***		
	(0.000469)	(0.000584)		
Star	0.00579***	0.00572***		
	(0.000415)	(0.000414)		
HospChange	0.312***	0.313***	0.251***	0.255***
	(0.0146)	(0.0146)	(0.0138)	(0.0138)
Experience	-0.000108***	-0.000108***	0.000142***	0.000135***
	(4.33e-06)	(4.32e-06)	(3.99e-05)	(3.98e-05)
FreeLancer	-0.0323***	-0.0322***	-0.00404***	-0.00375***
	(0.000337)	(0.000337)	(0.000463)	(0.000462)
ForProfit	-0.0331***	-0.0405***	-0.0383***	-0.0408***
	(0.00955)	(0.00953)	(0.0129)	(0.0129)
Beds	-7.83e-05***	-6.97e-05***	-6.70e-05***	-5.60e-05***
	(1.37e-05)	(1.37e-05)	(2.02e-05)	(2.02e-05)
Discharge	4.89e-06***	4.89e-06***	4.28e-06***	4.24e-06***
	(3.25e-07)	(3.24e-07)	(3.36e-07)	(3.35e-07)
Income	2.47e-06***	2.58e-06***	7.34e-07***	7.98e-07***
	(1.02e-07)	(1.02e-07)	(1.03e-07)	(1.03e-07)
CntyPopulation	-6.75e-09	-9.57e-10	3.09e-08***	3.13e-08***
	(8.56e-09)	(8.54e-09)	(9.25e-09)	(9.22e-09)
Poverty	1.59e-07***	1.48e-07***	3.97e-08***	2.46e-08
	(1.50e-08)	(1.50e-08)	(1.52e-08)	(1.51e-08)
Constant	-0.267***	-0.217***	-0.199***	-0.145***
	(0.0148)	(0.0148)	(0.0151)	(0.0151)
Fixed Effects	No	No	Yes	Yes
Observations	3,072,328	3,072,328	3,072,328	3,072,328
R-squared	0.295	0.298	0.387	0.390

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4.8: Three Way Interaction of Patient Class, Period 2, and Freelance Physicians
Hospital, Age, Race, and Co-Morbidity Dummies Omitted
Period 1 (2001 – Guideline Release) Period 2 (Guideline Release – 2010)

	(1)	(2)	(3)	(4)
Dependent Variable	Stent	Stent	Stent	Stent
Period 1	0.00208***	0.00114***	0.00247***	0.00151***
	(5.72e-05)	(5.86e-05)	(7.01e-05)	(7.10e-05)
Period 2	-0.00331***	-0.00326***	-0.00198***	-0.00207***
	(4.07e-05)	(4.65e-05)	(5.84e-05)	(6.27e-05)
Period 1		0.00591***		0.00602***
* Severe SCAD		(8.77e-05)		(8.29e-05)
Period 2		-0.000379***		-0.000133***
* FreeLancer		(4.79e-05)		(5.14e-05)
Period 2		0.00338***		0.00399***
* Severe SCAD		(0.000127)		(0.000120)
FreeLancer		0.00237**		0.00236**
* Severe SCAD		(0.00111)		(0.00106)
FreeLancer * Period 2		0.00104***		0.00109***
* Severe SCAD		(0.000168)		(0.000159)
Severe SCAD	0.212***	-0.151***	0.204***	-0.167***
	(0.000483)	(0.00503)	(0.000462)	(0.00477)
Gender	0.0137***	0.0136***	0.0122***	0.0121***
	(0.000297)	(0.000297)	(0.000282)	(0.000281)
Ln(Stents to Date)	0.0417***	0.0418***	0.0186***	0.0185***
	(0.000106)	(0.000105)	(0.000201)	(0.000201)
CardioCert	0.167***	0.168***		
	(0.000469)	(0.000468)		
Star	0.00579***	0.00568***		
	(0.000415)	(0.000414)		
HospChange	0.312***	0.317***	0.251***	0.255***
	(0.0146)	(0.0146)	(0.0138)	(0.0138)
Experience	-0.000108***	-0.000110***	0.000142***	0.000133***
	(4.33e-06)	(4.32e-06)	(3.99e-05)	(3.98e-05)
FreeLancer	-0.0323***	-0.0309***	-0.00404***	-0.00381***
	(0.000337)	(0.000434)	(0.000463)	(0.000541)
ForProfit	-0.0331***	-0.0379***	-0.0383***	-0.0426***
	(0.00955)	(0.00953)	(0.0129)	(0.0129)
Beds	-7.83e-05***	-7.08e-05***	-6.70e-05***	-5.61e-05***
	(1.37e-05)	(1.37e-05)	(2.02e-05)	(2.02e-05)
Discharge	4.89e-06***	4.91e-06***	4.28e-06***	4.30e-06***
	(3.25e-07)	(3.24e-07)	(3.36e-07)	(3.35e-07)
Income	2.47e-06***	2.54e-06***	7.34e-07***	7.68e-07***
	(1.02e-07)	(1.02e-07)	(1.03e-07)	(1.03e-07)
CntyPopulation	-6.75e-09	-4.52e-09	3.09e-08***	3.18e-08***
	(8.56e-09)	(8.54e-09)	(9.25e-09)	(9.22e-09)
Poverty	1.59e-07***	1.44e-07***	3.97e-08***	2.40e-08
	(1.50e-08)	(1.50e-08)	(1.52e-08)	(1.51e-08)
Constant	-0.267***	-0.215***	-0.199***	-0.143***
	(0.0148)	(0.0148)	(0.0151)	(0.0151)
Fixed Effects	No	No	Yes	Yes
Observations	3,072,328	3,072,328	3,072,328	3,072,328
R-squared	0.295	0.298	0.387	0.390

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4.9: Empirical Extension Based on Physician Practice Longevity
Hospital, Age, Race, and Co-Morbidity Dummies Omitted
Period 1 (2001 – Guideline Release) Period 2 (Guideline Release – 2010)

	(1)	(2)	(3)	(4)
Dependent Variable	Stent	Stent	Stent	Stent
Period 1	0.00264***	0.00353***	0.00253***	0.00344***
	(0.000232)	(0.000342)	(0.000232)	(0.000342)
Period 2	-0.00835***	-0.00538***	-0.00773***	-0.00527***
	(0.000194)	(0.000318)	(0.000210)	(0.000324)
Period 1			-0.00622***	-0.00247***
* Appearance			(0.000420)	(0.000466)
Period 2			-0.00162***	-0.000850**
* Appearance			(0.000319)	(0.000343)
Appearance	0.0336***		0.427***	
	(0.00211)		(0.0252)	
Gender	0.0288***	0.0293***	0.0289***	0.0293***
	(0.00129)	(0.00122)	(0.00129)	(0.00122)
Ln(Stents to Date)	0.0913***	0.0269***	0.0922***	0.0282***
	(0.000368)	(0.000731)	(0.000370)	(0.000752)
Star	-0.0126***		-0.0122***	
	(0.00144)		(0.00144)	
HospChange	0.252***	0.454***	0.234***	0.445***
	(0.0535)	(0.0507)	(0.0535)	(0.0507)
Experience	-0.000695***	0.000819***	-0.000718***	0.000835***
	(2.25e-05)	(0.000255)	(2.26e-05)	(0.000255)
FreeLancer	-0.0281***	-0.00667***	-0.0277***	-0.00659***
	(0.00145)	(0.00180)	(0.00144)	(0.00180)
ForProfit	-0.169***	-0.0829	-0.180***	-0.110
	(0.0501)	(0.0679)	(0.0501)	(0.0681)
Beds	-7.78e-05	-0.000258**	-6.01e-05	-0.000206*
	(6.39e-05)	(0.000105)	(6.38e-05)	(0.000106)
Discharge	1.17e-05***	1.25e-05***	1.19e-05***	1.24e-05***
	(1.34e-06)	(1.34e-06)	(1.34e-06)	(1.34e-06)
Income	1.62e-05***	3.82e-06***	1.71e-05***	4.31e-06***
	(4.40e-07)	(4.48e-07)	(4.45e-07)	(4.55e-07)
CntyPopulation	-6.05e-08*	1.06e-07***	-5.39e-08	1.05e-07***
	(3.56e-08)	(3.69e-08)	(3.56e-08)	(3.69e-08)
Poverty	1.13e-06***	3.62e-07***	1.15e-06***	3.85e-07***
	(6.95e-08)	(6.84e-08)	(6.95e-08)	(6.85e-08)
Constant	-0.920***	-0.379***	-0.970***	-0.387***
	(0.0732)	(0.0763)	(0.0732)	(0.0763)
Fixed Effects	No	Yes	No	Yes
Observations	409,192	409,192	409,192	409,192
R-squared	0.304	0.386	0.305	0.386

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4.10: Results of Within-Subjects Experiment
Untreated Indicates Pre Guideline Release – Treated Indicates Post Guideline Release

	Mean	Std Dev	N	T-Value	P-Value
Non Severe SCAD Untreated	0.067	0.188	7349	1.65	0.099
Non Severe SCAD Treated	0.062	0.180	7349		
Severe SCAD Untreated	0.337	0.401	2875	1.42	0.155
Severe SCAD Treated	0.352	0.400	2875		

Table 4.11: Empirical Extension Based on Incorporation of COURAGE Trial
Spline
Hospital, Age, Race, and Co-Morbidity Dummies Omitted
Period 1 (2001 – Guideline) Period 2 (Guideline – COURAGE) Period 3 (COURAGE – 2010)

	(1)	(2)	(3)	(4)
Dependent Variable	Stent	Stent	Stent	Stent
Period 1	0.00197***	0.00237***	0.000995***	0.00136***
	(5.95e-05)	(7.19e-05)	(6.10e-05)	(7.29e-05)
Period 2	-0.00435***	-0.00295***	-0.00441***	-0.00298***
	(0.000162)	(0.000163)	(0.000165)	(0.000166)
Period 3	-0.00294***	-0.00164***	-0.00308***	-0.00182***
	(6.82e-05)	(8.00e-05)	(6.94e-05)	(8.07e-05)
Period 1			0.00608***	0.00628***
* Severe SCAD			(9.82e-05)	(9.28e-05)
Period 2			0.00229***	0.00221***
* Severe SCAD			(0.000379)	(0.000357)
Period 3			0.00452***	0.00545***
* Severe SCAD			(0.000188)	(0.000177)
Severe SCAD	0.212***	0.204***	-0.158***	-0.179***
	(0.000483)	(0.000462)	(0.00548)	(0.00518)
Gender	0.0137***	0.0122***	0.0136***	0.0121***
	(0.000297)	(0.000282)	(0.000297)	(0.000281)
Ln(Stents to Date)	0.0417***	0.0185***	0.0418***	0.0183***
	(0.000106)	(0.000201)	(0.000105)	(0.000201)
CardioCert	0.167***		0.168***	
	(0.000469)		(0.000468)	
Star	0.00576***		0.00565***	
	(0.000415)		(0.000414)	
HospChange	0.310***	0.249***	0.313***	0.252***
	(0.0146)	(0.0138)	(0.0146)	(0.0138)
Experience	-0.000108***	0.000142***	-0.000110***	0.000133***
	(4.33e-06)	(3.99e-05)	(4.32e-06)	(3.98e-05)
FreeLancer	-0.0323***	-0.00404***	-0.0321***	-0.00381***
	(0.000337)	(0.000463)	(0.000337)	(0.000462)
ForProfit	-0.0343***	-0.0391***	-0.0404***	-0.0437***
	(0.00955)	(0.0129)	(0.00953)	(0.0129)
Beds	-7.63e-05***	-6.51e-05***	-6.76e-05***	-5.37e-05***
	(1.37e-05)	(2.02e-05)	(1.37e-05)	(2.02e-05)
Discharge	4.82e-06***	4.20e-06***	4.85e-06***	4.20e-06***
	(3.25e-07)	(3.36e-07)	(3.24e-07)	(3.35e-07)
Income	3.00e-06***	1.22e-06***	3.12e-06***	1.31e-06***
	(1.29e-07)	(1.29e-07)	(1.29e-07)	(1.28e-07)
CntyPopulation	-7.39e-09	3.00e-08***	-4.91e-09	3.10e-08***
	(8.56e-09)	(9.25e-09)	(8.54e-09)	(9.22e-09)
Poverty	1.60e-07***	3.93e-08***	1.46e-07***	2.37e-08
	(1.50e-08)	(1.52e-08)	(1.50e-08)	(1.51e-08)
Constant	-0.283***	-0.213***	-0.230***	-0.156***
	(0.0150)	(0.0152)	(0.0150)	(0.0152)
Fixed Effects	No	Yes	No	Yes
Observations	3,072,328	3,072,328	3,072,328	3,072,328
R-squared	0.295	0.387	0.298	0.390

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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