Technology Adoption and Career Concerns: Evidence from the Adoption of Digital Technology in Motion Pictures

By

Grant Goehring, Filippo Mezzanotti, S. Abraham Ravid*

First Draft June 2022

This Draft February 2023

PRELIMINARY

This paper shows the impact of career concerns on technological change by studying the adoption of digital cameras in the US motion picture industry in the early 2000s. This setting allows us to collect rich data on the adoption of this new technology at a project level (i.e., movie) as well as focus on the career of the main decision maker (i.e., the director). We find that less experienced directors played a leading role in the adoption of digital cameras, and that this effect appears to be explained by career concerns, rather than alternative motives. We also show that technological background may lead to tendency to adopt new untried technologies. Lastly, we discuss how our results can be informative about career concerns and technology adoption outside the specific context studied.

Key Words: Technology Adoption, Career Concerns, Digital Transition, Film Directors.

* Grant Goehring, Boston University, grantg@bu.edu; Filippo Mezzanotti, Kellogg School of Management, Northwestern University, filippo.mezzanotti@kellogg.northwestern.edu; S. Abraham Ravid, Yeshiva University, ravid@yu.edu. We thank the participants to the Mallen Conference and the Chicago Entrepreneurship Festival as well as seminar participants at NYU Stern and Yeshiva University Syms School of Business for comments on an early version of this study All errors are our own.

1 Introduction

The adoption of new technologies is often slow, even when these new technologies can bring important benefits to the adopter (Geroski, 2000). Several theories have been offered to explain this slow diffusion process. For instance, some papers show that the speed and depth of technology adoption depends on organizational and incentive constraints (Atkin et al, 2017). Other work focuses on learning and informational frictions (e.g. Munshi, 2004, Conley and Udry, 2010, Gupta et., 2019), coordination (Caoui, 2022, Crouzet et al., 2022, Feigenbaum and Gross, 2022); or the extent of financial development (e.g. Comin and Nanda, 2019; Bircan and De Haas, 2019).

This paper empirically examines whether career concerns can affect the process of technology adoption. Since an adoption decision is made by individuals, who can be executives in large companies or entrepreneurs in smaller entities, individual incentives and career concerns should matter to the manifestation of technology adoption in firms.[1] Research has shown that career concerns affect day to day decision making (e.g., Jensen and Murphy, 1990, Gibbons and Murphy,1992, Chevalier and Ellison, 1999b; , Goldfarb and Xiao, 2011). For instance, several papers focusing on the financial industry find that early-career professionals tend to prefer safer options and are more likely to be characterized by some form of "herd behavior" (e.g., Chevalier and Ellison, 1999a; Hong, Kubik, and Solomon, 2000; Lamont, 2002). However, the type of industry and the nature of the tasks studied (i.e., core on-the-job activities) implies that this research may not be as informative about the role of career concerns for technology adoption.

In fact, technology adoption differs from traditional investment decisions or other more routine tasks in several ways. First, the adoption of a new technology naturally involves the abandonment of an older technology where experienced managers may have extensive knowledge. Second, a new technology is generally characterized by a higher-level of risk,[2] which can either come from the novelty of the technology or from the uncertainty about its commercial applications. Third, a new technology is generally not introduced at its full potential, which may imply that early adopters benefit from joining at the early stages of development but may also lead others to wait until the technology is fully developed (See Acemoglu et al. 2022).

In this context, we argue that it is ex-ante unclear how career considerations affect the decision to adopt a new technology. Experienced managers already have some pre-existing knowledge about the old technology, and therefore may not want to try the new one. Newcomers on the other hand, have no experience with either technology. However, typical career concern models (e.g., Holmstrom, 1999) suggest that experienced managers are also more secure in their career prospects, irrespective of the outcome of their next project. As a result, they are more likely internalize any long-term benefits of adopting a new technology early. Second, the higher level of risk that generally characterizes new technologies may complicate the problem further. Inexperienced managers may either avoid high risk strategies (as in Hong et al. 2000 or Chevalier

[1] Some of the major papers in the career concerns literature include Holmstrom and Ricart-i-Costa, 1986; Gibbons and Murphy, 1992, Prendergast and Stole, 1996; and Holmstrom, 1999.

[2] While we would argue that this is a crucial feature of most new technologies, we will also show empirical evidence that is consistent with this hypothesis in the specific setting studied here (Section 3).

and Ellison, 1999a) or if the career progression is sufficiently uncertain, may take greater risks.[3] In other words, theory provides ambiguous predictions regarding the role of career concerns on technology adoption. In a very different context (the match between innovating firms and CEOs of different vintages) Acemoglu et al. (2022) formalize and analyze some of the ideas discussed here.

Much of the literature acknowledges the role of managers in the adoption of new technology. Agrawal Gans and Goldfarb (2019) point this out in the context of AI adoption in the medicine. Acemoglu et al. (2022) is another recent example. A major obstacle to studying empirically the effect of career concerns on technology adoption is the lack of project-level data that would allow the researcher to match information about the agent who makes the decision (i.e., the manager) with actual adoption behavior. This paper overcomes these limitations by examining the adoption of digital movie making in the motion picture industry in the US during the early 2000s. We observe the decision making at the film/director level. Thus, we know who is making the decision to adopt a new technology, the timing of their decision, and the entire trajectory of his or her career. This makes it possible to assess whether career considerations are important for this decision[4].

While available, digital technology was very rarely used to produce movies in the late 1990s. There were two main constraints to the diffusion of digital film making. First, the quality of the early devices was still low relative to traditional cameras that were recording on films. Second, the economic benefits from switching to digital were limited as long as studios were still required to print and distribute a movie on film. While the quality of digital cameras had been constantly improving over time, the second issue was not solved until after 2007, when movie theaters and production companies reached a financial agreement to allow the widespread installation of digital projection. Our core focus will be on the period before this shift, when the lack of a strong economic benefit in adoption digital implies that directors had very large autonomy to decide the technology employed for shooting.

This setting has two main advantages. First, a director's career is risky and starts at a relatively late age, hence career concerns are of paramount importance (See John et al, 2017, Han and Ravid, 2022). Second, this setting allows us to collect data on both the adoption decision at the movie-level as well as the full career of directors.

We show that the experience of a director at the time the focal movies is produced is a strong predictor of her probability of using digital technology: more experienced directors – measured by the number of past movies – are less likely to use digital. A one standard-deviation increase in experience translates into a roughly 20% decline in the average probability of using digital during

[3] As we discuss in Section 3, the level of competition is important to understand the direction of the effect of risk on adoption. In careers characterized by low level of competition (e.g., most managers will keep their job in the future), managers will be more concerned with minimizing downside risks, and therefore they will prefer avoiding a new technology. Instead, in highly competitive careers (e.g., a manager keeps her job only if the performance is exceptional), managers tend to be risk-seeker. We provide a more formal discussion of this result in Appendix B.

[4] Digital technology in film can be viewed as part of the digital revolution, or a general purpose technology (GPT) in the sense of Agrawal et al. (2022). However, here we focus on a specific industry and specific processes to study career concerns and technology adoption.

this period. Furthermore, we find that the largest drop in probability happens between directors that are first-timers relative to directors with some experience. These results are robust to a variety of different modeling choices and are not driven by differences in genres or ratings as well as other confounding factors.

We then show that these effects are likely to be related to career concerns by directors. First, we show that the "first timers" effect is mostly driven by the period between 2002 and 2006, which is exactly when the first wave of adoption happened, and the level of uncertainty about the technology was high. When the use of digital technology became more widespread and economic incentives in favor of this option became stronger, the gap in adoption between experienced and inexperienced directors was much smaller. Second, we also show that our results cannot be explained by differences in bargaining power between the director and the production company. We explore this issue by examining differences in movie budgets and production company preferences.

Furthermore, our results do not reflect an inherent preference for "digital" content among early-career directors. Our data collection allows us to identify movies that were shot on film but were later transferred at least in part into a digital print during the post-production phase.[5] This set of movies was shot on film, but they could have had comparable "digital" content in post-production. We then replicate our findings when we use this sub-sample as the control group.

We also examine the role of technical expertise in explaining results. On the one hand, technical expertise favors adoption. We should emphasize that we are measuring general technical facility, not necessarily specific knowledge about the new technology. We believe this finding is applicable in other settings as well. On the other hand, however, the technical expertise mechanism operates independently from the career concerns of the director as identified earlier.

Our paper contributes to several areas of economics and finance. Broadly, we are part of the huge technology adoption literature. Specifically, our paper provides a showcase for the importance of managerial incentives in understanding the patterns of technology adoption within an industry. These contributions add to our understanding of frictions that prevent the adoption of valuable technologies (e.g., Atkin et al, 2017; Bircan and De Haas, 2019; Comin and Nanda, 2019; Conley and Udry, 2010; Crouzet et al., 2022; Feigenbaum and Gross, 2022; Gupta et., 2019; Munshi, 2004, Acemoglu et al. 2022). In terms of context, the work closest in this area is Caoui (2022), who studies the adoption of digital projection for movie theaters in France. That paper finds that the presence of network effects between movie theaters adopting digital projection and production companies selling digital movies can generate significant excess inertia. Similarly, Yang et al. (2021) show the effect of the diffusion of digital exhibition in South Korea on the choice of films available to consumers. John et al. (2017) and Han and Ravid (2022) discuss the market for film directors.

[5] This step could be taken to incorporate special effects or other changes that are easier to conduct in digital format. Notice that this "digital intermediate" technology was already used at the end of the 1990s and it did not present the same risks as shooting directly in digital, since the original material was always available in film.

This paper also contributes to the literature in finance that has studied empirically the extent to which career concerns affect managers' behavior. Focusing largely on the investment industry, several papers show that younger managers tend to avoid bold decision making, and instead try to align their behavior with the most common strategy in the market (e.g., Chevalier and Ellison, 1999a; Hong, Kubik, and Solomon, 2000; Lamont, 2002).[6] As discussed, our paper finds a different result: among movie directors, less experienced directors are more willing to take the risky strategy, in our case regarding adoption of a new technology. We argue in section 5 that our conceptual framework may help explain the difference between these findings: risk taking makes sense for less experienced managers only when the level of competition is high, and therefore success is defined by only an exceptionally positive result. When competition is lower, inexperienced managers who still need to build up their reputation may prefer to play it safe (e.g., herding, using an established technology), as indeed is the case in the literature focused on the investment industry.[7]

This paper is organized as follows. In Section 2, we present our empirical setting as well the data. In Section 3, we present our conceptual framework and develop our hypotheses. In Section 4, we present the empirical analysis. In Section 5, we discuss our results, with particular focus on external validity. In Section 6, we conclude.

2 Background and Data

In this section, we first describe the introduction of digital cameras and the main forces affecting this process. Then, we discuss the data used in the empirical section.

2.1 Digital Movies

Movies have been shot on film since the beginning of the motion pictures entertainment era. Digital technology started as an expensive toy in the 1980s although the potential for cost savings and simplification of the film making process was clear from the beginning. The first full length movie shot using a digital camera, the Sony High-Definition video system, was Julia and Julia (1987) with Kathleen Turner and Sting. However, the movie had to be converted back to film to be shown in theaters.

In fact, one of the key constraints to mass adoption of digital filming was economic. Digital technology was cheaper during the recording and editing phase, but as long as movie theaters were equipped with traditional projection technologies, the digital output had to be transferred to film and shipped to theaters for exhibition. Thus, the net economic benefit of filming a movie digitally was more limited.

---

[6] An exception to this is Li, Low and Makhija (2017), who study CEO behavior. Interestingly, the authors explain the difference in results because the previous literature in finance has focused mostly on highly specialized labor market (e.g., mutual fund managers), where the need to herd could be stronger. Our paper focuses on a very specialized labor market, but still find results that are inconsistent with the herding literature. Our discussion in Section 5 will try to explain the motivation behind this result.

[7] This discussion is also related to the branch of literature focused on herding behavior (Hirshleifer and Teoh, 2003), and in particular how this type of behavior relates to seniority (Ottaviani and Sorensen, 2001).

In 1999, George Lucas and others introduced the first digital projectors. Initially, digital projectors cost around $250,000 and theater owners in a declining market claimed they could not afford them without the support from producers. In 2002 major movie studios formed a committee to develop standards (“All things considered,” NPR, Mark Uryck, May 13, 2002). However, as of October 2003 there were only 80 digital cinemas in the US and 200 around the world (Eric Taub New York Times, October 13, 2003). In November 2004, The National Association of Theater Owners publicly agreed to digital projection, stating that costs of the new systems should be split between exhibitors and studios (UPI.com, November 22, 2004).

Despite these coordination efforts, the downstream impact was still limited. By 2007 some theater chains had started converting to digital on a larger scale, but only 2200 screens out of 38,000 in the US were digital. The financial breakthrough that year was that studios agreed to pay a fee for every digital copy they shipped (Virtual Print Fee or VPF) to help in financing the initial purchase of digital projectors (NPR, “All Things Considered,” Laura Seidel, March 21, 2007). VPFs were introduced gradually around the country and the world. By 2012, the cost of digital projectors had declined to $75,000 and financial agreements such as VPF allowed theaters to engage in digital projection. By 2015, 4900 of 5700 theaters in the US used digital projection, under various financing agreements. In 2019, only 602 out of over 40,000 screens were not digital. Therefore, from an economic standpoint, digital became a clearly superior option only after 2007, when the ability to distribute digitally significantly improved the payoff of digital movies. A similar adoption pattern was also present outside the US (Caoui, 2022).

Another important aspect of digital shooting is the impact of the medium on quality. Slumdog Millionaire (2008) became the very first movie with digital cinematography to win an Academy Award for Best Cinematography as well as the best film award. In recent decades, digital technology has become progressively cheaper and digital effects have become more accessible. However, even in recent years, although the quality of film and digital is very similar, and more than 90% of movies are shot on digital, there were still directors who argue that film has some advantage in terms of quality.

For instance, Quentin Tarantino famously suggested that he “might retire” if forced to shoot digital, saying “I can’t stand this digital stuff” and that digital was “TV in public”.[8] Indeed, even Tarantino’s most recent film, in 2019 was shot on film (and converted to digital for distribution). The well-known director Steve McQueen, a supporter of films told the New Republic in 2014: “all this technology, it’s changing every five minutes because someone’s making some money out of it.” Other directors supporting film include academy award nominee Christopher Nolan. Nolan’s Tenet, one of the very few films to be released in the pandemic year of 2020, was shot on film. In 2023 the movie “Sharper” was shot on film and the exchange between director Benjamin Caron and interviewer Kerry Nolan is very instructive for our purposes. Ms. Nolan suggests that the cinematographer chose to shoot on film and Mr. Caron corrects her: “That was a decision that I made”. Then this first-time feature film maker (but a long time TV director) says: “If you want a

[8] https://www.digitalspy.com/movies/a441960/quentin-tarantino-i-cant-stand-digital-filmmaking-its-tv-in-public/

film to look like film, I think you shoot it on film, and I don't know any other process that can do what film does"[9].

On the other end of the spectrum, some well-known and experienced directors were early adopters. Oscar winner Steven Soderbergh was one of the first to shoot with a "red camera." Similarly, Danny Boyle, the director of Slumdog Millionaire was one of the early adopters, and Martin Scorsese, a leader in the directing field, shot the Wolf of Wall Street in a digital format in 2012.

We should emphasize that shooting on digital does not mean just using different cameras for principal photography. The entire production process changes. An experienced top movie executive with stints in several major studios told us that directors who shot on digital stock tended to spend more time on the set since retakes were costless and that meant that studios had to watch the number of days in principal photography.

This very short history shows that the process of technology adoption in the creative industries can be far from linear, and that throughout the process leaders in the industry have had very different views of the new technology. Our data allows us to track individual project managers and characterize their actions vis a vis this evolving technology.

2.2 Data on Directors and Technologies

The key pieces of information necessary to study technology adoption in the movie industry are the type of equipment chosen by directors as well as film and director characteristics. Most of the data used in the analysis is collected from the Internet Movie Database (IMDb). IMDb is an online database owned by Amazon. IMDb maintains a unique webpage for films as well as for individuals associated with the production of movies, such as film directors. The film webpages contain information on the technical production process, the content of the film such as genre and rating, and various measures of the film's success such as reviews and box office revenue. Individual webpages contain detailed information on the individual's participation in filmed entertainment in a variety of roles. We focus on directorial roles for theatrical films, defined below.

We start by obtaining from IMDb the list of all films released in the United States from 1975 to 2018 with gross box office revenue of at least $10,000 (2018 inflation-adjusted USD).[10] From the IMDb page we collect film-level data about how the film was created, its content, and various measures of success such as user ratings and box office revenue. The most important information for our purposes relates to the film's production process found in the "Technical Specifications" section on the film web page. This section allows us to categorize the equipment used to shoot the film as either film or digital.

We focus on the "Camera" and "Cinematographic Process" fields of the technical specifications section. We create a comprehensive dictionary of all unique cameras and cinematographic processes used in the filming of movies in our sample. Then we attempt to verify whether the

[9] https://www.wnyc.org/story/director-benjamin-caron-a24-apple-tvs-sharper

[10] The following link displays films released in the United States in 2000 contained in IMDb: https://www.imdb.com/search/title/?title_type=feature&year=2000,2000&sort=boxoffice_gross_us,desc&ref_=adv_nxt

camera or cinematographic process use film or digital processes through online internet searches as well as discussions with professionals. To illustrate the categorization process, consider the 2013 film Dallas Buyers Club. The technical specifications page shows that the camera used to shoot the film was an Arri Alexa, a popular digital camera. Furthermore, the cinematographic process "ProRes 4:4:4 (1080/24P)" is associated with digital filming. Given this information, Dallas Buyers Club is categorized as a digitally shot film. In some instances, a film's technical specifications suggest both digital and film cameras were used in production. We consider these films as digital given that the director chose to adopt digital film technology for at least part of the filming process.

While we collect films in IMDb from 1975 to 2018, we begin film categorization in 1995 since there was practically no digital filming prior to that year. For films that can be categorized Figure 1 shows the proportion of film and digitally shot movies from 1995 to 2018. The story depicted by this figure matches the anecdotal evidence discussed in the previous section. In the early 2000s, the share of digital films was extremely limited. However, adoption started to change during the 2000s, and the share of digital films increased steadily, reaching approximately 21% in 2008. As discussed before, after that year the adoption of digital photography increased even more rapidly as digital projectors were being installed in theaters shifting the economic incentives of the studios in favor of digital. Indeed, we see that by 2018, over 94% of movies are digital. Our categorization process depicted in figure 1 is consistent with the work of Stephen Follow, a data journalist who specializes in the film industry. In a blog post, Follow categorizes the camera type for the top 100 grossing films in the United States from 2000-2015.[11] The trend in adoption of digital cameras he documents is nearly identical to our categorization.

In addition to film characteristics collected from the film's webpage, we obtain information about the directors of the films. For each person involved in the entertainment industry, the IMDb page provides detailed career information listing the complete history of the films which that individual had directed, as well as a range of other roles they may have had in film production and in television. This career information is useful for controlling for other potential mechanisms affecting the decision to adopt digital technology. For example, having had experience in technical roles (e.g., as a cinematographer, DP) might have exposed directors to digital film techniques thus lowering the cost of adopting the new technology once they became directors. The resulting dataset is at the film-director level containing all films with U.S. box office revenue of at least $10,000 from 1975 to 2018.

3 Conceptual Framework

In this section, we discuss how career concerns can influence technology adoption. First, we describe some key features of new technologies that are important for adoption incentives. Second, we develop explicit hypotheses about how such career concerns can affect technology adoption given the specific characteristics of the industry. An illustrative model is available from the authors.

[11] For more information on Stephen Follow's categorization of camera types see: https://stephenfollows.com/film-vs-digital/

3.1 Career Concerns and Technology Adoption

We study the adoption of digital filming by directors to provide new insights about how a manager's career concerns can affect the incentive to adopt a new technology. Film directors are responsible for both the creative and the business aspects of the film. They provide the vision but also have to bring the project to a conclusion on time and within budget. In our context they can be thought as project managers who need to decide which technology to adopt in order to maximize their career prospects in an uncertain labor environment. [12]

The idea that career considerations can affect the decisions of managers is not new: as discussed, a large theoretical literature has shown that a firm's investment planning can be affected by a manager's career incentives (e.g., Holmstrom and Ricart-i-Costa, 1986; Gibbons and Murphy, 1992, Prendergast and Stole, 1996; and Holmstrom, 1999). Empirical tests of these models usually find that younger managers tend to avoid bold decision making, and instead prefer to align their behavior with the most prevalent strategy in their relevant market (e.g., Chevalier and Ellison, 1999; Hong, Kubik, and Solomon, 2000; Lamont, 2002).

However, previous studies differ from our work because they focus on core business decisions (e.g., selecting stocks for a portfolio manager). Adopting a new technology may be different.[13] First, a new technology is a product or process for which no one has extensive experience. This does not necessarily imply that experience with the old technology is not important to operate the new one, but some significant friction in the transfer of knowledge should be expected.

Second, new technologies are usually not introduced at their full potential: adjustments and improvements are common in the early life of a new technology. As a result, if we consider the net benefit (cost) of adopting a new technology, this is likely to increase (decrease) over time relative to the old technology. One implication of this feature is that adopting early may be valuable, at least in some cases. Early adopters – by learning how to use the new technology – may be able to reap some of these improvements over the long run. This feature will depend on the specific nature of the technology, and the extent to which this is likely to generate a "first-mover

---

[12] People who are not familiar with the motion pictures industry may think that producers are in charge of film projects. However, this is generally not the case, although as always, there is some bargaining in every financial decision. As discussed in Han and Ravid (2022), the term (or credit in the movie for) producer means many things in the business. The most important credit is that of "Producer" and it is generally accorded to the person(s) who initiates a project, sells it to a studio, and/or develops and shepherds it through the system until it is produced and released. The Executive Producer credit is usually reserved for a variety of people associated at one time or another with a project, in one form or another. In the independent film world Executive Producer is often a credit accorded to individuals who assisted in raising financing for a film, or who are associated with a financial company or fund that finances a picture. See also the Wall Street Journal article entitled " A plague of Executive Producers" (12/2019) (https://www.wsj.com/articles/a-plague-of-executive-producers-11577648316?mod=searchresults&page=1&pos=3) In other words, the term "producer" may refer to various roles, but producers may originate the project or finance it.

[13] We provide this characterization to help the reader thinking through our conceptual context and provide a benchmark to differentiate the adoption of a digital technology from other investment. Clearly, we do not see this characterization to be universal. Furthermore, we do not think that each new technology will be characterized by all three features with the same strength.

advantage" in the market. On the other hand, waiting may avail the manager with a more user-friendly technology while allowing her to use the old technology to its full potential.

Third, while early on a new technology is not necessarily "better" than an old one, it is generally characterized by a higher level of risk. In other words, a new technology presents both higher upsides and lower downsides. Risk in our context can come from the nature of the technology itself or from uncertainty about market demand. For instance, in our specific application there were concerns about whether viewers would like more (or less) the output produced using digital technology.

Therefore, the problem of technology adoption is sufficiently different from a more core corporate decision to require its own specific examination. In this context, we think that the digital transition in movies fits this conceptual framework well and can represent a fruitful area of analysis. First, directors consider shooting on digital to be different than shooting on film. Not only does the result look different, but the process of creating a digital film is different, for example, it allows virtually costless repetitions of scenes and instant access to results. Second, as the first wave of adoption in early 2000s was progressing, the perception was that digital cameras still had a relatively wide margin for improvements and were generally considered of lower quality than film.

Lastly, recording a movie with a digital camera was perceived as a high-risk endeavor, at least in the relevant period. Many players in the industry were concerned that the quality of the digital output was going to be perceived as lower than films (see earlier discussion). While measuring ex-ante risk is intrinsically very difficult, we can provide evidence consistent with this hypothesis by checking whether ex-post risk for digital movies was indeed higher. For that purpose, we calculate returns on each film in our sample, measured as revenues divided by the production budget. Returns data indeed confirms this idea that digital movies are characterized by relatively higher risk. In Table 1, we classify movies by their family friendliness MPAA rating (G, PG, PG13, R, or Unrated) and by the process – digital or film. We split by rating since prior work suggests that ratings categories provide different returns on average and unlike genres which can overlap, they partition the set of films produced (Ravid, 1999, Basuroy and Ravid, 2004). We then compare the standard deviation of the movie's returns between these categories for movies produced between 1998-2009, as a proxy of the ex-post realized risk for each category.[14]

Across essentially all rating groups digital movies show systematically higher risk than movies recorded on films. For instance, PG movies recorded on films have a standard deviation of 8.93, while the SD for digital is 48.9. Given the highly skewed nature of movies' returns, we also show that this regularity does not depend on the tail of the distribution: in fact, we find the same pattern when we winsorize returns at 1%. The only partial exception to this pattern is movies rated as "PG-13:" The level of realized risk is similar across the two groups, but when we winsorize returns, again, digital movies have a significantly higher risk.

[14] We define returns based on the reported cost and revenues. Notice that this information is not available for all movies used in our analysis.

Altogether, while there may be other characteristics of new technologies we may not capture in our setting, we think that differences in ex-ante expertise, expected benefits, and risks are crucial features that help separate the adoption of a new technology from another corporate actions.

3.2 Hypothesis Development

Having introduced the key features of our technology adoption setting, we want to discuss how career concerns may affect the likelihood of technology adoption.

The most important discussion for our purposes is assessing how the level of experience can affect a director's adoption problem. First, independent of their technology choice, experienced directors are generally more likely to continue in the profession compared to inexperienced directors (continuation advantage). In other words, the ex-ante likelihood to direct a new movie after the next one is higher for experienced directors. Empirically, this idea is consistent with the evidence in Han and Ravid (2022). Conceptually, this hypothesis is consistent with a standard career concern setting. In these models, a manager's ability is revealed slowly over time (Holmstrom, 1999). As a result, a "bad project" is going to damage the reputation of a new manager relatively more than it can damage the reputation of an experienced one. Furthermore, if we assume that low performers are excluded from the industry over time, the pool of experienced managers will be perceived as being of higher quality ex-ante, and therefore also increasing the ex-ante likelihood of continuation for this group.

This line of thinking would lead us to believe that more experienced managers may lead the leap into the unknown. In fact, because of their higher likelihood of being active in the future, they are going to internalize more the long-term benefits of adopting the new technology early. The strength of this mechanism depends on the expected quality of the new technology over the long-run, but also on the expected first-mover advantage of adopting the new technology early.[15]

Second, managers at different points of their careers will also differ in their relative level of familiarity with the two technologies (knowledge premium). Experienced directors have already used the old technology and therefore they are relatively more knowledgeable about it. In contrast, by definition, first time directors will not have any extra familiarity with either of the two options, and therefore they will not have any pre-existing advantage with any of the two options. In other words, experienced directors will have a comparative advantage in the old technology at any point in time, and thus may decide to switch later, everything else equal.

Obviously, this difference in "knowledge" will lower the incentive of established directors to adopt early relative to a newcomer that does not have any history with any of the technologies. Furthermore, the strength of this mechanism will depend on the size of the "knowledge premium.[16]

[15] To be precise, what is relevant in this case is the extent to which the current decision to use digital will be beneficial relative to someone that adopted later. If a director adopting later will be at no disadvantage relative to someone adopting early, the incentive coming from this mechanism could still be low. We come back to this point in Section 5.

[16] Notice that this difference could also be negative: for instance, sometimes a new technology could be so much better that – despite a lack of experience with it – a user can be more productive than with the old technology.

Lastly but crucially, the difference in risk between the new and the old technology may also play a role in affecting the decision. In this case as well, the direction of the mechanism is unclear ex-ante. Consider a case in which the labor market is not very competitive: managers expect to continue their career as long as their next project is not extremely bad. In this case, new managers will – all else equal – prefer to use the old technology. In fact, this labor market incentivizes managers to play it safe, and at the margin avoid undertaking riskier options. Importantly, because experienced managers are more likely to continue operating irrespective of the outcome of the next project, this incentive will get weaker as experience increases. The risk avoidance mechanism is conceptually similar to the traditional "herding behavior," that previous research (e.g., Chevalier and Ellison, 1999a; Hong, Kubik, and Solomon, 2000; Lamont, 2002) proposed as an important process explaining how career concerns affect managers' behavior in the financial industry.

However, the same result does not have to hold in every context. Assume that managers are allowed to continue working only if the next project is extremely successful. This is akin to a very competitive labor markets, where only a few exceptional candidates are rewarded. In this case, managers may be incentivized to be risk-takers in order to maximize the probability of over-performance. As before, this mechanism will affect more inexperienced managers, whose reputation is not yet fully established.

Thus, differences in risk play an ambiguous role, potentially incentivizing the adoption of new technology by newcomers in very competitive markets and reducing adoption by newcomers in more stable environments. A simple numerical example based on a binomial distribution may help building the intuition. The objective function of the manager is assumed to be maximizing the expected rate of return on a project (which is consistent with our empirical setting), subject to staying in the profession. In the very simple example, we will shut the channel of expected return to focus on the role of risk, but the example can clearly be generalized further. Consider two technologies: a risky technology has a 70% probability of generating zero revenue and a 30% probability of generating some positive value M; and a safe option that has equal probabilities of receiving either zero revenues or 0.6M. The two technologies have the same expected revenue, but the riskier technology has a higher variance. If the two technologies have the same cost, then they also have the same expected rate of return. Now we introduce the idea that careers differ in the minimum level of revenue (equivalent also to return which matters much in our context since the costs are the same) required to continue the profession. If this level is low (e.g., 0.2M), then the optimal strategy for the director is to use the safe technology, since this gives her a 50% probability of continuing, as opposed to a 30% probability if the risker technology is adopted. However, if the threshold is high (e.g., 0.8M), then it is optimal for a manager to take the riskier strategy since with the safe strategy the probability of staying in the profession is zero.[17]

This very simple illustration can show how in risky professions such as directing – which has a dropout rate after the first film well north of 50% - young directors may decide to take the leap into a new and risky technology whereas in a relatively safe profession such as analysts (Hong et

[17] A similar example with a continuous Gamma distribution is presented in appendix B.

al.2000) where the probability of termination is 15% (IBID table 2, or similarly in Chevalier and Ellison, 1999 figure 1) the same logic leads to herding.

Altogether, theory does not provide an unambiguous prediction about how career concerns should affect technology adoption. In general, different mechanisms should be at play simultaneously and their impact on the decision is mixed. In Section 5, we come back to the framework presented here to discuss the external validity of our results, outside the specific empirical context studied.

4 Adoption of Digital Filming and Director Experience

This section describes the empirical strategy and presents the results related to director career concerns and the adoption of digital filming technology. The first part describes the empirical strategy and the second presents the main results. The last two sections provide some robustness checks and discuss potential mechanisms.

4.1 Empirical Setting – Movie Directors' Careers

There are a few features of our setting that make it particularly interesting for testing career concerns models. First, as discussed, movie directors can be viewed as managers in charge of large projects. As a result, the movie industry provides a very natural project-level data set, where both the career of the manager of the project (i.e., the director) as well as all the project's characteristics are available to the researchers, and we can discern the career stage of directors adopting the new technology (John et al, 2017; Han and Ravid, 2022).

Second, in a typical organization, the adoption of a technology may reflect both the incentives of a local manager and the authority of the headquarters. Our context is much cleaner in this dimension, since the incentive by production companies to switch to digital was minimal before the transition to digital projection. Furthermore, the transition to digital technology had occurred during a relatively well-defined period of time: thus, we are able to study the entire adoption process, with clear start and end points. As discussed, until the late 1990s there were virtually no digital films, whereas 20 years later there were very few non-digital productions. Third, directors' career is risky and starts at a late age, hence career concerns are of paramount importance. Han and Ravid (2022) as well as John et al. (2017) employ very different data sets, but the career characteristics in the two papers are almost identical. The average director enters the profession at age 39 makes only one film before dropping out and returning to their previous profession. In Han and Ravid (2022) 84% of male directors who had entered the profession between 1995 and 2015 and 90% of the female directors in the same cohort made 2 films or fewer before they dropped out. Given that the average budget in that sample was over $40 million in 1998 dollars it is not surprising that failure or mild success was not sufficient to allow directors to be hired again and control projects worth tens of millions of dollars.[18] In our sample although it was again constructed

[18] The situation is different for experienced directors – both papers (Han and Ravid, 2021 and John et al., 2017) show that previous success (average return or the number of movies) is a strong predictor of obtaining another assignment. Thus, more experienced directors with a good track record can afford to experiment and even fail while still being able to continue their career.

very differently and not focused on the entire career of directors, we find that 70% of the directors drop out after the first movie, and 85% after two movies.

To summarize, this context allows us to observe clearly both the decision to adopt and the career of the director; directors are mostly in charge of the adoption decision, and career concerns are extremely salient. With this framework in mind, we test whether the ex-ante experience of a director increases her incentive to use digital versus films. We estimate an equation of this form:

$$1\{Digital_{mdt}\} = \alpha_t + \beta Experience_{dt} + \gamma X_{mdt} + \varepsilon_{mdt}$$

where $1\{Digital_{mdt}\}$ is a dummy equal to one if the movie m directed by d in year t was recorded using a digital camera, and zero otherwise, α_t is a year fixed-effect, $Experience_{dt}$ is a proxy for the experience of director d in year t, and X_{mdt} are various controls at the movie- or director-level.[19]

There are four features of this model that we want to highlight. First, as our main proxy for experience, we use the inverse hyperbolic sine (IHS) transformation of the past number of movies directed, but we show consistent results with alternative approaches (e.g., non-parametrically defining categories of experience).[20] Second, for simplicity we estimate the main specification using a linear probability model (LPM) for simpler interpretation of the coefficients, but we also show results are qualitatively identical using alternative models (i.e., probit). Third, given our assumption of linearity in the relationship between adoption probability and experience, we reduce the skewness of "Experience" by excluding from the analysis directors at the tail of the distribution (i.e., directors with ten or more movies by 1999). However, we show consistent results with the full sample or using a non-parametric approach. Finally, our main analyses include movies between 1997 and 2009, but we examine different sub-samples in later analyses.[21]

4.2 Main Results

The main question we are trying to answer is whether the level of experience of a director affects the initial wave of adoption of digital filming. Before estimating the regression, we can test whether any difference can be observed in the raw data, without controls. Figure 2 compares the probability of adoption of digital filming across directors with different levels of experience. For simplicity, we divide directors into four groups depending on the number of movies they had directed before the one considered. The findings are striking: directors making their first movie

---

[19] Notice that this equation is estimated with a director-level data set.

[20] We transform the experience variables for two reasons. First, we find that some form of log-transformation would ease interpretation. Second, the variable experience is skewed (i.e., there are more people with zero or one previous movies). However, because directors with zero experience are important in our analysis, we cannot simply log-transform it. In this context, we have use IHS: this approach is generally preferred to using the traditional log(x+1) approach, since it is better behaved around zero. Recently, it is generally used more frequently than the log(x+1). Note, however, that our results do not depend on the transformation. As we show both graphically and in a regression table, our results also hold when we use a non-parametric approach, where we define experience by defining dummies for individuals with zero.

[21] Notice that we also drop movies that are rated as "TV" or "X". We also removed animated movies, since the use of digital was fundamentally different. For obvious reasons, we also exclude a relatively small number of movies for which we cannot identify whether they were shot on digital or film cameras because of a lack of data.

(group 0) have a probability of about 10% to use digital technology which is about double that of directors with one (group 1) or two (group 2) movies behind them, and three times the probability of adoption of directors with even more experience (group 3).

This effect can be replicated in a regression framework. The main result is presented in Table 2: column 1. We find that higher experience translates into a lower probability of using digital over this period. A one-standard-deviation increase in experience translates to a 2% lower probability of doing digital, which corresponds to a roughly 20% decline over the average probability during this period. Across the different columns, we show that results are similar when – in addition to year fixed-effects – we also include controls for the genre of the movie (column 2) or its rating (column 3) or both (column 4).[22]

In Table 3, we examine the same results when defining experience in two alternative ways. First, rather than looking at the simple count of past movies, we proxy this dimension with the IHS of the aggregate amount of revenue generated by that director before the movie considered. This measure allows us to adjust experience weighting previous movies by their level of success.[23] As we show in columns 1 and 2, we find very similar results. In the other two columns, we examine the effect non-parametrically, essentially splitting the sample into four groups based on experience, following the same approach discussed previously for Figure 2.

In addition to confirming that less experience is generally associated with higher adoption probability, this test also gives us a better sense of the relationship between adoption probability and experience. In particular, we find that being a first-time director explains a large part of the effect: on average, this group is more likely to use digital than any other group of directors. However, directors with one previous movie are still roughly twice more likely to use digital than those with two movies. This relationship does not appear fully monotonic since we find that directors with three or more movies are roughly equally likely to use digital than those with a few movies. The same result holds both without and with controls for genre and rating. Notice that this result is very consistent with our interpretation of the relation between career concerns and technology adoption. In this market, the main risk of dropping out is for the first two films. More experienced directors are less likely to worry about the risk of not being hired again. As shown in John et al. (2017) and Han and Ravid (2022) the best predictor of hiring is the average of past rates of return and hence for experienced directors one failure may not derail their career.

4.3 Robustness Tests

The effects we find are robust to several tests. First, we find similar effects when we use a probit model rather than the LPM. Table A1 reports the same results of the previous two tables combined

[22] The genre is defined by including non-mutually exclusive dummy variables that identify whether the reported list of genres in IMDb lists whether the film is action, drama, comedy, thriller, horror, or other (when this information is missing). As discussed previously, our analyses also exclude animation movies, for which the meaning of digital is different.

[23] This measure effectively combines intensive and extensive margins in proxying experience. A caveat of this measure is that the revenue is strongly predicted by costs. This is why we generally prefer focusing on past movie count as a better measure of experience and for success one often uses rate of return (See Ravid, 1999, Palia et al, 2008).

presenting the marginal effects of probit. Despite the expected differences in magnitudes, we find qualitatively identical results from what we presented before. Second, in Table A2 we show that our results are also almost identical when we exclude movies rated as "G." As discussed earlier, there are no digital movies during this early period that were rated "G". This robustness test confirms that this imbalance does not affect our results. In general, this category is relatively small.

Third, in Table A3, we show consistent results when controlling for past adoption of digital. While essentially no film had been shot digitally before our sample period, as we move past 2000 our sample contains directors that might have already filmed a movie digitally and are not considering the technology to use for a follow-up movie. To adjust for this dynamic dimension, we also include past adoption decision by the director.[24] The inclusion of this control does not generally alter our conclusions: if anything, we find a marginal increase in the size of the coefficients. Fourth, in Table A4, we consider the full sample of directors, in particular also including directors with an exceptional level of experience. This inclusion slightly increases the overall sample, but again, it does not significantly affect our magnitude or statistical significance.

Lastly, we also examine the role of the age of the director. Examining this dimension is difficult for two reasons. First, from a statistical standpoint, there is a very strong correlation between age and experience. While there are cases of directors entering the profession much later in life, the data also suggests a very systematic relationship between age and experience. Second, from a conceptual standpoint, the incentive coming from career concerns may also come from differences in age, and therefore it is difficult to separate the role of age as a mechanism from its role as a confounding factor. Indeed, several other career concerns papers focus on age as their main treatment variable (e.g., Gibbons and Murphy, 1993; Li, Low and Makhija, 2011, Acemoglu et al. 2022). However, age and experience may be two different career dimensions. For example, a 45 year old CEO with a 20 year tenure in the company, may be much more experienced than a finance professor who becomes a CEO at age 55. With some limitations, in this paper we can consider age and experience as two separate dimensions since we have a project-by-project data and detailed career background of the directors in our sample.

We find that our results do not simply reflect the behavior of young directors. In Table A5, we focus specifically on the subset of directors that are forty years or older in 2000.[25] This corresponds to roughly the median age of directors in our sample. This sample is much smaller than the main one, but we still find results that are consistent with our previous results.

Before moving forward, we also examine the timing of our effects. We divide the sample period in three parts: (1) before 2002, when digital productions were extremely rare; (2) between 2002 and 2006, which is when digital was still a small share of all movies, but the technology was

[24] To be clear, the control is a dummy equal to one if the director has used digital in the past movie. This variable is zero by construction for first timers.

[25] This analysis also drops those directors for which we cannot confirm the birth year. Notice that birth year was missing for a significant number of directors from IMDb. To supplement this information, we manually searched directors on Wikipedia and identify the birth year for almost 60% of them.

starting to be adopted more broadly; (3) after 2006, which is when the technology started becoming mainstream.

The result of this analysis is reported in Table 6: in particular, we report separately the coefficient of our main treatment effect across the three periods. We find that the effect of experience is completely driven by the initial phase of large adoption, between 2002 and 2006.[26] After 2006, the effect is smaller in size and not significantly different from zero. This evidence is consistent with our interpretation of the differences in adoption as resulting from career concern incentives. In fact, this result suggests that the gap in adoption rates is related to experience only during the early phase of the technology adoption cycle, when the uncertainty and the risk related to digital were high.

Altogether, this set of results shows that career considerations were important for the adoption of digital filming. On average, more experienced directors were less likely to adopt the new technology, and this effect is not explained by differences in the type of movie, as well as other confounding factors. Our result also highlights that these effects are in large part explained by the difference between directors at their first movie versus the rest, and experience appears less important as it accumulates. We also find that this effect is specific to the first wave of digital adoption, and it disappears as digital becomes more widely employed.

4.4 Experience and Technology Expertise

Our interpretation of these results is that differences in experience matter for the adoption of digital recording because career concerns alter the set of incentives faced by a director. However, experience may also affect technology adoption through other channels. In this sub-section, we examine some of the leading alternative interpretations and empirically discuss their importance in the data.

Our data enables us to consider precisely whether general technical proficiency makes a difference for technology adoption. We should keep in mind that most directors, new or old, had no experience in digital technology per se, but since most directors had previous industry experience, then some who had worked in some technical professions are much more adept in technology. One may be concerned that inexperienced directors may be more familiar with the digital medium, at least relative to their experience with film and then we should expect to find that part of the career's effect should be explained by technical expertise.[27]

We conduct this analysis in Table 4. First, we add controls for technical expertise (columns 1 and 2). We find that technical expertise does have a significant positive impact on the probability of adopting digital technology. This supports the idea that our measure of expertise captures a significant dimension of a director's skill set. However, our main effects remain qualitatively and

---

[26] We also find a null effect on the first period: we are not surprised by this result, since this period has very few digital movies in our sample (around 3%). We include it to provide a benchmark or "pre-period" to the time when adoption has actually significantly increased.

[27] We define a director to be more technically skilled, if he had experience on technical roles within the movie industry. Using data on the director's IMDb page we look at whether the director had previous work in the following roles: (1) camera and electrical department; (2) cinematographer; (3) special effects; (4) visual effects.

quantitatively unchanged: while technical expertise matters, this channel seems to run parallel to the one based on experience.

In column 3, we test for differential effects of the career's variable depending on the level of technical expertise. The idea is that – to the extent that the heterogeneity in behavior comes even just in part from differences in technical expertise – we should find that our effects should be higher for more technically skilled. However, our results reject this hypothesis.

This result implies that our effects are orthogonal to the director's level of technical expertise. Technical expertise appears important to explain adoption, but its role does not necessarily explain why directors at different points of their career are adopting at different rates. Technical expertise may however, be a proxy for the ease of learning, as we discuss further below.

4.5 Alternative explanations

Another possibility is that a director's experience may have an effect on the budget, which in turn may affect the type of recording technology used. For instance, inexperienced directors may have tighter budgets and this condition will systematically lead them to the use of digital technology. We address this concern both conceptually and empirically. To start, while plausible, we do not think that this interpretation is likely to be important ex-ante. As discussed before, the large economic advantage of filming a movie digitally is in the distribution process. However, until roughly the end of the first decade of the 21st century, most movie theaters were not equipped for digital films, and therefore most movies were distributed as film copies. This implies that the incentive to go digital to overcome a financial constraint is unlikely to be first order. Also, the cost of film or equipment in general is not paramount for the typical production considered in this study.

As a more direct way to consider this hypothesis, we can use films' budget data. Like age, there is a very strong relationship between a movie's budget and a director's experience. Another issue is that budget is missing for a substantial share of movies: however, missing values are not randomly distributed. As we were able to check manually, budget is generally always available for larger productions, while it may be missing for smaller projects. To rule out the possibility that our results stem simply from differences in financial ability, we replicate our main results by removing large productions, defined as movies with confirmed budget above $50M. Results in Table 5 confirm that despite the significantly smaller sample size, our findings do not simply reflect some difference in the prevalence of inexperienced directors within large budget movies. In fact, our results hold even when we exclude major motion picture projects.

Another related interpretation is that larger studios prefer digital shooting, and their ability to impose their preference on the creative team is greater when it is led by an inexperienced director. Any conversation with industry insiders will suggest that budgets and other movie related strategies are subject to give and take between studios and directors (much in the same way that CEOs have conversations with board and activist shareholders). It is thus plausible that more experienced directors may have more freedom to choose their teams and technology, the implication of this statement is hard to square with the timing of the effects discussed earlier. As we discussed before, the economic benefit of using digital technology increased over time, and it was particularly high after 2007, when digital movies could be distributed directly without going through film. Also, the technology was improving by leaps and bounds and would be much more appealing later in the sample period. Therefore, if our results were to reflect differences in bargaining power between a director and producers, we should expect our results to become larger – and not disappear- at the end of the sample period.

Lastly, we also want to discuss the possibility that directors with different level of experience may prefer digital versus film simply because they tend to direct different types of movies or have preferences for different types of digital content. In general, it is possible that the style of filmmaking of inexperienced directors – in particular first timers – may be different in ways that would require more extensive use of digital filming. For instance, inexperienced directors may focus on making movies that require more special effects, which in turn makes them more likely to benefit from digital filming for reasons that are orthogonal to career concerns.[28]

We consider this hypothesis by comparing movies that are shot digitally to others that were recorded originally on film but were later transferred into digital forms in post-production ("digital intermediary"). The idea of this test is the following: during our period, a director who wanted to shoot the movie in film but still wanted to take advantage of digital technologies to include special effects of various forms could do this by adding an intermediate digital transfer of the movie. In other words, it could transfer the movie (or part of it) into digital format, undertake all the intermediate steps in this format, and then move it back to film for distribution. Importantly, this "digital intermediate" technology was already used at the end of the 1990s and it did not present the same risks as shooting directly in digital, since the original material was always available in film.

Leveraging this feature, in Table 7, we compare movies that were shot digitally to other movies that were not shot digitally but that undertook a digital intermediate step during production.[29] The idea is that these two sets of movies are more comparable than the entire population of movies, since they both can access the same type of post-production features. When focusing on this sub-sample, we still confirm our main results. If anything, the magnitude of the effects is now larger.

While partial in nature, this discussion helps rule out several leading alternative interpretations to our career concerns hypothesis. In particular, our findings that differential adoption is based on past experience level is robust to other possible mechanisms such as variation in technical expertise, financial slack, pressure from production companies, or movie type.

5 Discussion

The empirical evidence in the previous section shows that career concerns may affect the relative incentive to adopt a new technology: during the first adoption wave of digital cameras in the motion picture industry the utilization of this new technology was largely driven by inexperienced directors. This suggests that managers in their early career may play a particularly important role in the propagation of new technologies in the workplace.

---

[29] Data on whether a film used a digital intermediate is also included in the technical specifications section of the IMDb page that we used to categorize the movie cameras as either digital or film.

Before concluding, we want to briefly discuss how our results align with our framework presented in Section 3 and what we learn from this analysis that can be extended outside the specific setting studied here.

The first observation is that - given our knowledge of directors' career - it is not surprising that inexperienced directors played a leading role in the adoption of digital filming. Following the discussion in Section 3, two main forces may have undone this result: a strong incentive to avoid risk among newcomers (similar to herding observed in other settings) and a large "continuation advantage" for experienced directors. In general, we believe these scenarios are both unlikely in our case.

As discussed in John et al. (2017) and Han and Ravid (2022), the market for directors is extremely competitive, and early career directors are able to continue directing movies only if they are extremely successful. In this context, we should expect inexperienced directors to have a strong incentive to be risk-takers, which is exactly what we find. In other words, the "cut-throat" nature of the industry should favor the adoption of the riskier option, and particularly among those directors that are more dependent on current performance. The comparison to Hong et al. (2000) is particularly interesting- in the context of analysts' career where the threshold for continuation is low, we see herding, whereas in our case, where the majority of first-time directors drop out, risk taking is encouraged.

A general conclusion may be that the type of career progression and the mix of young and more experienced employees may critically affect technology adoption in industries. Technology adoption is risky by nature and may explain to some extent the slow adoption present in many cases, compared with the relatively fast adoption in movies.

While harder to exclude ex-ante, we also believe that the benefits of early adoption in our context were probably limited. Even if digital technology became ex-post the norm in the US movie industry, it is not clear that those that were first at using this tool gained a significant advantage relative to those who postponed adoption for a period. Indeed, the movie industry is characterized by large and infrequent projects, and therefore a director who does not adopt immediately is likely to be able to switch to digital later, if the value of switching is high. This explains why more experienced directors who, by definition, have a comparative advantage in the older technology (film) delayed adoption.

This discussion is important because it can also help us in thinking about what to expect in other areas. A particularly interesting aspect to understand is the nature of competition for promotions. In many highly competitive areas, it is reasonable to expect that the need to "stand out from the crowd" can generate a strong incentive for newcomers to adopt new technologies or business methods, similar to our findings on film directors. However, the same mechanism should not work in areas where the career progression is more linear and the bar to clear for promotion is low. In this sense, public administrations may represent an interesting case to study, since in several developed countries career progression is mostly tied to tenure. In this situation, managers may prefer "to play it safe" or "herd" and avoid taking any initiative that would generate downside risk, irrespective of the upside that can be captured.

More broadly, this aspect of our framework may perhaps explain why in other industries inexperienced players tend to be more conservative. For instance, in the financial industry, portfolio managers may be more concerned with the downside of doing something different than the peers, rather than the potential upside. As a result, inexperienced managers tend to herd and go with the “proven” strategy (Chevalier and Ellison, 1999; Hong, Kubik, and Solomon, 2000; Lamont, 2002).

Another important aspect is the long-run benefit of early-adoption. As we discussed above, this parameter depends on both the actual value of the technologies over the long-run and the benefit that accrues to early adopter. As a result, an important dimension to consider is the presence of large reputational benefits to early adopters. All else equal, if adopting early will generate strong reputation, we should expect experienced agents to be more active in experimenting with the new technology. The importance of these reputational benefits will depend on the specific nature of the industry.

In our view, there are two takeaways from this discussion. First, we believe that our result is likely to replicate in a variety of contexts where the level of competition in the labor market is fierce; and the long-run benefits of early adoption are more limited. For instance, we think that many artistic or intellectual professions share a lot of similarities with the film industry, and therefore our results may have a more direct application to those contexts.

Second, we also want to recognize that – outside these areas – the relationship between career concerns and technology adoption remains still ex-ante ambiguous. In these cases, a detailed analysis of the competitive landscape is helpful in assessing the type of frictions that career concern may generate. Other industries and technologies may differ across dimensions in our conceptual framework – such as the threshold for being able to continue, the long-run value in adopting the new technology, or the inherent riskiness in the new technology – and this may lead to different results than found here. A final take away from our work is the importance of technological background in technology adoption. While this may seem intuitive, only detailed data on prior experience allows us to establish that general technological background will encourage people to try new technologies. This easily generalizes to other industries and contexts.

Our analysis represents one of the first attempt to provide a systematic empirical and conceptual framework to guide researchers studying these other areas.

Section 6 Conclusion

This paper studies how career concerns may affect the adoption of new technologies. To examine this question, we focus on the adoption of digital filming in the motion picture industry and then present a simple conceptual framework to discuss how our findings may extend outside this context.

In the first decade of the twenty-first century there was a dramatic shift in the technology used in films. Focusing on this period, we find that inexperienced directors played an important role in this transition. This effect does not appear to be explained by differences in the movie genre, rating, or technical expertise. We also argue that this relationship is likely explained by a difference in career concerns rather than other mechanisms, like differences in funding or preferences for digital content between more and less experienced directors.

At face value, these results suggest that managers in their early career may play a particularly important role in the propagation of new technologies in the workplace (which conceptually is similar to Acemoglu et al.,2022). However, we also want to highlight how our conceptual framework suggests that this relationship is likely to be context dependent. Three features appear to be particularly salient: the degree to which experience with the old technology accumulated by more experienced managers may generate sizable benefits; the long-term value of switching to the new technology early; and the extent to which high levels of competition may incentive early-career managers to take riskier options, therefore favoring the adoption of a new technology.

In general, we think that our results are likely relevant to important areas like creative or intellectual professions. However, we also acknowledge that the actual incentives provided by career concern may differ across different types of industries or technologies. In this regard, we hope that future research will examine the relationship between career concerns and technology adoption across areas where the set of incentives and aspects of the technology differ from our setting.

Bibliography

Acemoglu, D. U. Akcigit, and M. Alp Celik, 2022, Radical and Incremental Innovation: The Roles of Firms, Managers, and Innovators *American Economic Journal: Macroeconomics 14(3): 199–249* *https://doi.org/10.1257/mac.20170410* *199*

Agrawal, A, J. Gans, and A. Goldfarb. 2019. Artificial Intelligence: The Ambiguous Labor Market Impact of Automating Prediction. *Journal of Economic Perspectives*, 33(2): 31-50.

Agrawal, A., J. Gans, and A. Goldfarb, 2022, Similarities and differences in the Adoption of General Purpose Technologies. NBER working paper, 30976 http://www.nber.org/papers/w30976

Atkin, D., Chaudhry, A., Chaudry, S., Khandelwal, A. K., & Verhoogen, E. (2017). Organizational Barriers to Technology Adoption: Evidence from Soccer-Ball Producers in Pakistan*. *The Quarterly Journal of Economics*, *132*(3), 1101–1164. https://doi.org/10.1093/qje/qjx010

Bircan, Ç., & De Haas, R. (2020). The Limits of Lending? Banks and Technology Adoption across Russia. *The Review of Financial Studies*, *33*(2), 536–609. https://doi.org/10.1093/rfs/hhz060

Boyle, D., & Tandan, L. (Directors). (2008). *Slumdog Millionaire* [Crime, Drama, Romance]. Celador Films, Film4, Fox Searchlight Pictures.

Caoui, El H., 2022, Estimating the Costs of Standardization: Evidence from the Movie Industry. *The Review of Economic Studies*.

Chevalier, J., & Ellison, G. (1999a) Career Concerns of Mutual Fund Managers *The Quarterly Journal of Economics*, Volume 114, Issue 2, May, 389–432, https://doi.org/10.1162/003355399556034

Chevalier, J., & Ellison, G. (1999b). Are Some Mutual Fund Managers Better Than Others? Cross-Sectional Patterns in Behavior and Performance. *The Journal of Finance*, *54*(3), 875–899. https://doi.org/10.1111/0022-1082.00130

Comin, D., & Nanda, R. (2019). Financial Development and Technology Diffusion. *IMF Economic Review*, *67*(2), 395–419. https://doi.org/10.1057/s41308-019-00078-0

Conley, T. G., & Udry, C. R. (2010). Learning about a New Technology: Pineapple in Ghana. *American Economic Review*, *100*(1), 35–69. https://doi.org/10.1257/aer.100.1.35

Crouzet, N., Gupta, A., & Mezzanotti, F. (2023). Shocks and Technology Adoption: Evidence from Electronic Payment Systems. *Journal of Political Economy*. Forthcoming.

Feigenbaum, J, Gross, D. (2022). Organizational Frictions and Increasing Returns to Automation: Lessons from AT&T in the Twentieth Century. Working Paper.

Geroski, P. A. (2000). Models of technology diffusion. *Research Policy*, *29*(4), 603–625. https://doi.org/10.1016/S0048-7333(99)00092-X

Gertler P., S. Higgins U. Malmendier and W. Ojeda (2022). Why are Firms Slow to Adopt Profitable Opportunities, working paper

Gibbons, R., & Murphy, K. J. (1992). Optimal Incentive Contracts in the Presence of Career Concerns: Theory and Evidence. *Journal of Political Economy*, *100*(3), 468–505. https://doi.org/10.1086/261826

Goldfarb.A. and M Xiao (2011) Who Thinks about the Competition? Managerial Ability and Strategic Entry in US Local Telephone Markets, *American Economic Review*, 101 (7), December, 3130-61.

Gupta, A., Ponticelli, J., & Tesei, A. (2021). Access to Information, Technology Adoption and Productivity: Large-scale Evidence from Agriculture in India (SSRN Scholarly Paper No. 3335542). https://doi.org/10.2139/ssrn.3335542

Han, S. and S. A. Ravid (2022) Do Age and Gender Affect Managers' Career Progression? Evidence From the Careers of Movie Directors (SSRN 3797345) https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3797345.

Hirshleifer, D., Teoh S. (2003), Herd Behavior and Cascading in Capital Markets: a Review and Synthesis, *European Financial Management.*

Holmstrom, B. (1999). Managerial Incentive Problems: A Dynamic Perspective. *Review of Economic Studies*, *66*(1), 169–182. https://doi.org/10.1111/1467-937X.00083

Holmstrom, B., & Costa, J. R. I. (1986). Managerial Incentives and Capital Management. *The Quarterly Journal of Economics*, *101*(4), 835. https://doi.org/10.2307/1884180

Hong, H., Kubik, J. D., & Solomon, A. (2000). Security Analysts' Career Concerns and Herding of Earnings Forecasts. *RAND Journal of Economics, 31*(1), 121–144. https://doi.org/10.2307/2601032

John, K., Ravid, S. A., & Sunder, J. (2017). Managerial ability and success: Evidence from the career paths of film directors. *Journal of Corporate Finance*, *44*, 425–439. https://doi.org/10.1016/j.jcorpfin.2014.11.001

Lamont, O. A. (2002). Macroeconomic forecasts and microeconomic forecasters. *Journal of Economic Behavior & Organization*, *48*(3), 265–280. https://doi.org/10.1016/S0167-2681(01)00219-0

Li, X., Low, A., & Makhija, A. K. (2017). Career concerns and the busy life of the young CEO. *Journal of Corporate Finance*, *47*, 88–109. https://doi.org/10.1016/j.jcorpfin.2017.09.006

Monte, P. D. (Director). (1988, February 5). *Julia and Julia* [Drama, Fantasy, Romance]. RAI Radiotelevisione Italiana.

Munshi, K. (2004). Social learning in a heterogeneous population: Technology diffusion in the Indian Green Revolution. *Journal of Development Economics*, *73*(1), 185–213. https://doi.org/10.1016/j.jdeveco.2003.03.003

Ottaviani, M., Sorensen, P. (2001), Information aggregation in debate: who should speak first? *Journal of Public Economics*, Volume 81, Issue 3.

Prendergast, C., & Stole, L. (1996). Impetuous Youngsters and Jaded Old-Timers: Acquiring a Reputation for Learning. *Journal of Political Economy*, *104*(6), 1105–1134. https://doi.org/10.1086/262055

Ravid, S. A. (1999). Information, Blockbusters, and Stars: A Study of the Film Industry. *The Journal of Business*, *72*(4), 463–492. https://doi.org/10.1086/209624

Ravid, S. A., & Basuroy, S. (2004). Managerial Objectives, the R-Rating Puzzle, and the Production of Violent Films. *The Journal of Business*, *77*(S2), S155–S192. https://doi.org/10.1086/381638

Reynolds, S. (2012, November 30). Tarantino can't stand digital filmmaking. *Digital Spy*. http://www.digitalspy.com/movies/a441960/quentin-tarantino-i-cant-stand-digital-filmmaking-its-tv-in-public/

Sydell, L. (Director). (2007, March 21). Digital Projection in Theaters Slowed by Dispute. In *All Things Considered*. NPR. https://www.npr.org/templates/story/story.php?storyId=9047637

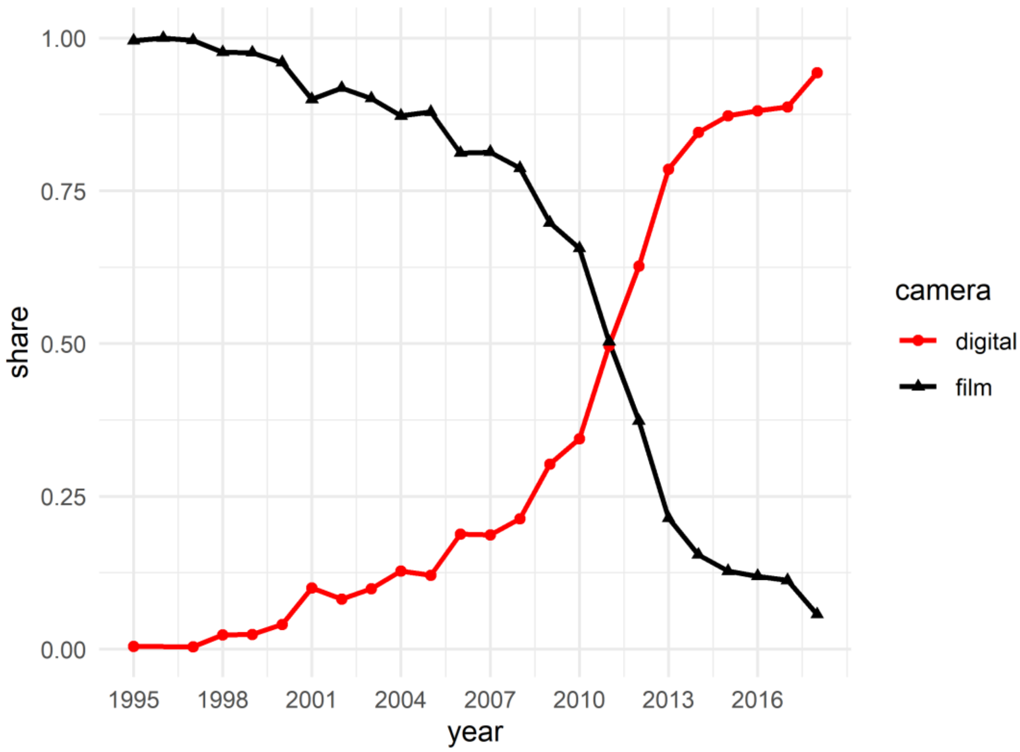
Taub, E. (2003, October 13). *Technology; Digital Projection of Films Is Coming. Now, Who Pays? - The New York Times*. https://www.nytimes.com/2003/10/13/business/technology-digital-projection-of-films-is-coming-now-who-pays.html

Urycki, M. (Director). (2002, May 13). Digital Projectors. In *All Things Considered*. NPR. https://www.npr.org/templates/story/story.php?storyId=1143297

Yang, J., Anderson, E., Gordon, B. (2021). Digitization and Flexibility: Evidence from the South Korean Movie Market. *Marketing Science*, Vol. 40, No. 5.

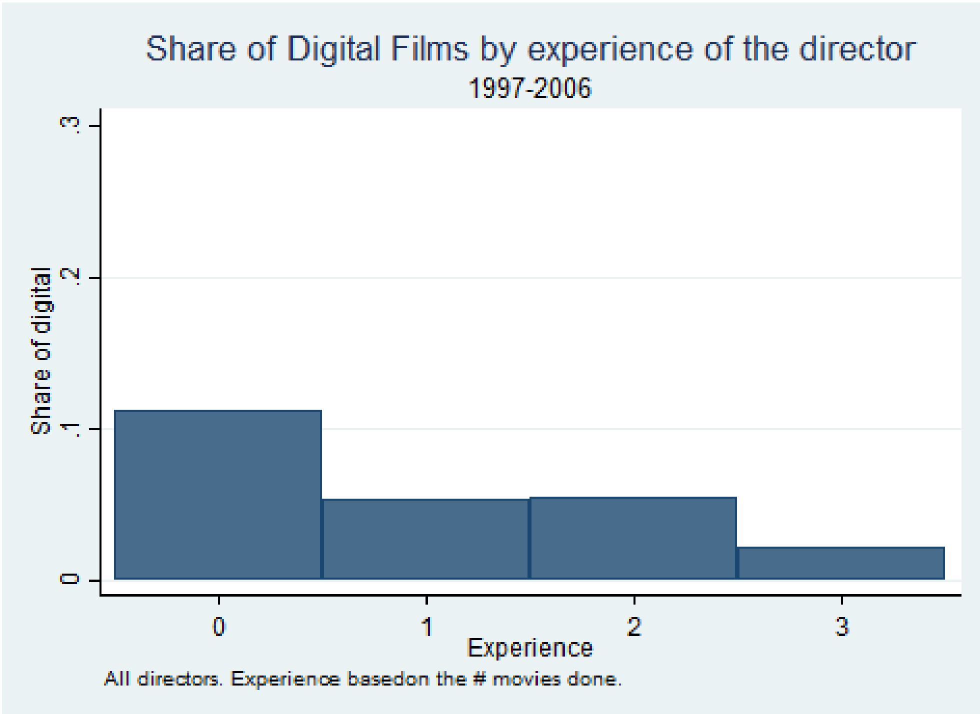
Figures

Figure 1



Notes: this figure reports the share of films that were categorized as being films with either a digital or film camera in a year. A film was categorized using the "Technical Specifications" information on the film's IMDb page.

Figure 2



Notes: this figure reports the probability that a director will choose a digital camera conditional on different levels of previous experience. Group 0 are directors that have directed no previous films. Group 1 are directors with one previous film. Group 2 are directors with two previous films. Groups 3 are directors with more than two previous films.

Tables

Table 1: Standard Deviation of Film Returns

Period		1998-2009	2001-2009	Winsor 1998-2009	Winsor 2001-2009
G	SD Film	4.71	5.53	4.71	5.53
	SD Digital	NA	NA	NA	NA
PG	SD Film	8.93	9.83	3.06	3.41
	SD Digital	48.96	49.97	8.12	9.57
PG13	SD Film	4.76	5.14	2.92	3.21
	SD Digital	4.84	4.85	4.52	4.84
R	SD Film	122.84	9.49	3.75	3.98
	SD Digital	1048.77	1066.57	5.56	6.11
Unrated	SD Film	6.53	6.91	3.97	4.56
	SD Digital	9.51	9.76	6.02	6.64

Notes: this table reports the standard deviation of move returns for each camera type by film rating and time period. Film returns are defined as the difference between worldwide gross revenue and the budget relative to the budget, as reported in IMDb. The last two columns winsorize the data at the top and bottom one percent.

Table 2: Probability of Adoption (Baseline Results)

	(1)	(2)	(3)	(4)
	digital	digital	digital	digital
# Previous films (IHS)	-0.017***	-0.017***	-0.012**	-0.011**
	(0.005)	(0.005)	(0.005)	(0.005)
Genre F.E.	No	Yes	No	Yes
Rating F.E.	No	No	Yes	Yes
Observations	3776	3776	3776	3776
Adjusted R^2	0.057	0.059	0.070	0.073

Notes: year fixed effects included, robust errors in parenthesis. This table reports the results from the main specification. The outcome is a dummy for whether the director used a digital or film camera. The main variable of interest is the inverse hyperbolic sine of the number of previous movies the director had directed.

* p<0.10, ** p<0.05, *** p<0.01

Table 3: Probability of Adoption (Alternative Measures of Experience)

	(1) digital	(2) digital	(3) digital	(4) digital
Previous Movie Revenue (IHS)	-0.009***	-0.005**		
	(0.002)	(0.002)		
Only One Prev. Movie			-0.039***	-0.033**
			(0.014)	(0.014)
Only two previous movies			-0.068***	-0.058***
			(0.016)	(0.016)
>2 Prev. Movies			-0.043***	-0.030**
			(0.012)	(0.013)
Genre F.E.	No	Yes	No	Yes
Rating F.E.	No	Yes	No	Yes
Observations	3776	3776	3776	3776
Adjusted R^2	0.059	0.073	0.060	0.075

Notes: year fixed effects included, robust errors in parenthesis. This table presents regression results for two alternative measures of director's past experience. Columns 1 and 2 include the cumulative gross revenue of past movies. Columns 3 and 4 consider a non-parametric measure of experience using bins of total previous films. The outcome is a dummy for whether the director used a digital or film camera.
* p<0.10, ** p<0.05, *** p<0.01

Table 4: Probability of Adoption (Controlling for Previous Technical Expertise)

	(1) digital	(2) digital	(3) digital
# Previous films (IHS)	-0.015***		-0.016***
	(0.005)		(0.006)
Only One Prev. Movie		-0.032**	
		(0.014)	
Only two previous movies		-0.059***	
		(0.016)	
>2 Prev. Movies		-0.037***	
		(0.013)	
Technical Expertise=1	0.077***	0.076***	0.072***
	(0.013)	(0.013)	(0.021)
Technical Expertise=1 # # Previous films (IHS)			0.004
			(0.013)
Genre F.E.	Yes	Yes	Yes
Rating F.E.	Yes	Yes	Yes
Observations	3776	3776	3776
Adjusted R^2	0.083	0.085	0.083

Notes: year fixed effects included, robust errors in parenthesis. This table presents regression results controlling for a director's past experience in the technical production of films. Data on a director's technical expertise is taken from the "Filmography" section of the director's IMDb page. The technical expertise variable is a dummy that is equal to 1 if the director was listed as being in the "Camera and Development", "Cinematographer", "Special Effects", or "Visual Effects" departments on a previous film. Column 1 uses the inverse hyperbolic sine of the number of previous movies whereas column 2 uses dummy bins for the number of previous movies. Column 3 includes the interaction between past experience and past technical expertise. The outcome is a dummy for whether the director used a digital or film camera.

Table 5: Probability of Adoption (Exclude Major Projects)

	(1) digital	(2) digital	(3) digital	(4) digital	(5) digital	(6) digital
# Previous films (IHS)	-0.018***	-0.013**				
	(0.006)	(0.006)				
Previous Movie Revenue (IHS)			-0.011***	-0.007***		
			(0.002)	(0.003)		
One Prev. Movie					-0.036**	-0.029**
					(0.015)	(0.015)
Two Prev. movies					-0.061***	-0.050***
					(0.017)	(0.017)
>2 Prev. Movies					-0.044***	-0.034**
					(0.014)	(0.014)
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Genre F.E.	No	Yes	No	Yes	No	Yes
Rating F.E.	No	Yes	No	Yes	No	Yes
Observations	2981	2981	2981	2981	2981	2981
Adjusted R^2	0.065	0.081	0.066	0.080	0.069	0.084

Notes: year fixed effects included, robust errors in parenthesis. This table presents regression results excluding from the sample the major motion picture projects. Excluded films must have a confirmed (non-missing) budget above $50 million. The different columns present the results for the three alternative measures of a director's past experience. Columns 1 and 2 use the inverse hyperbolic sine of the number of previous films. Columns 3 and 4 use the cumulative revenue of past directed films. Columns 4 and 5 use dummy bins for the previous number of films. The outcome is a dummy for whether the director used a digital or film camera.
* p<0.10, ** p<0.05, *** p<0.01

Table 6: Probability of Adoption (Effect Over Time)

	(1) digital	(2) digital
Prev. Films X 1997-2001	-0.005	0.001
	(0.005)	(0.005)
Prev. Films X 2002-2006	-0.035***	-0.028***
	(0.008)	(0.008)
Prev. Films X 2006-2010	-0.002	0.000
	(0.014)	(0.014)
Genre F.E.	No	Yes
Rating F.E.	No	Yes
Observations	3776	3776
Adjusted R^2	0.059	0.075

Notes: year fixed effects included, robust errors in parenthesis. This table presents regression results examining the effect of past director experience on adoption over time. The variables of interest interact the inverse hyperbolic sine of the number of previous films directed with different time periods. The outcome is a dummy for whether the director used a digital or film camera.

* p<0.10, ** p<0.05, *** p<0.01

Table 7: Comparing Digital vs. Digital Intermediary

	(1) digital	(2) digital	(3) digital	(4) digital
# Previous films (IHS)	-0.062***	-0.042***		
	(0.012)	(0.012)		
Only One Prev. Movie			-0.140***	-0.111***
			(0.034)	(0.034)
Only two previous movies			-0.200***	-0.164***
			(0.036)	(0.036)
>2 Prev. Movies			-0.167***	-0.116***
			(0.029)	(0.030)
Genre F.E.	No	Yes	No	Yes
Rating F.E.	No	Yes	No	Yes
Observations	1436	1436	1436	1436
Adjusted R^2	0.063	0.109	0.072	0.116

Notes: year fixed effects included, robust errors in parenthesis. This table presents regression results with films that were not shot digitally but undertook a digital intermediary post-production process. The different columns present the results for the two alternative measures of a director's past experience. Columns 1 and 2 use the inverse hyperbolic sine of the number of previous films. Columns 3 and 4 use dummy bins for the previous number of films. The outcome is a dummy for whether the director used a digital or film camera.

* p<0.10, ** p<0.05, *** p<0.01

Appendix A: Additional Tables

Table A1: Probability of Adoption (Main Specification Using Probit)

	(1) digital	(2) digital	(3) digital	(4) digital	(5) digital	(6) digital
# Previous films (IHS)	-0.098***	-0.071**				
	(0.029)	(0.030)				
Previous Movie Revenue (IHS)			-0.050***	-0.030**		
			(0.012)	(0.013)		
Only One Prev. Movie					-0.222***	-0.191**
					(0.079)	(0.081)
Only two previous movies					-0.394***	-0.361***
					(0.100)	(0.102)
>2 Prev. Movies					-0.248***	-0.182***
					(0.067)	(0.069)
Genre F.E.	No	Yes	No	Yes	No	Yes
Rating F.E.	No	Yes	No	Yes	No	Yes
Observations	3776	3766	3776	3766	3776	3766

Notes: year fixed effects included, robust errors in parenthesis. This table presents regression results for the main specification using probit instead of a linear probability model. The different columns present the results for the three alternative measures of a director's past experience. Columns 1 and 2 use the inverse hyperbolic sine of the number of previous films. Columns 3 and 4 use the cumulative revenue of past directed films. Columns 4 and 5 use dummy bins for the previous number of films. The outcome is a dummy for whether the director used a digital or film camera.
* p<0.10, ** p<0.05, *** p<0.01

Table A2: Probability of Adoption (Dropping Rated G movies)

	(1)	(2)	(3)	(4)	(5)	(6)
	digital	digital	digital	digital	digital	digital
# Previous films (IHS)	-0.017***	-0.011**				
	(0.005)	(0.005)				
Previous Movie Revenue (IHS)			-0.009***	-0.009***		
			(0.002)	(0.002)		
Only One Prev. Movie					-0.039***	-0.032**
					(0.014)	(0.014)
Only two previous movies					-0.067***	-0.057***
					(0.016)	(0.016)
>2 Prev. Movies					-0.043***	-0.030**
					(0.013)	(0.013)
Genre F.E.	No	Yes	No	No	No	Yes
Rating F.E.	No	Yes	No	No	No	Yes
Observations	3742	3742	3742	3742	3742	3742
Adjusted R^2	0.057	0.073	0.059	0.059	0.060	0.075

Notes: year fixed effects included, robust errors in parenthesis. This table presents regression results for the main specification dropping the sample of films that are rated G since no rated G films in are sample were filmed digitally. The different columns present the results for the three alternative measures of a director's past experience. Columns 1 and 2 use the inverse hyperbolic sine of the number of previous films. Columns 3 and 4 use the cumulative revenue of past directed films. Columns 4 and 5 use dummy bins for the previous number of films. The outcome is a dummy for whether the director used a digital or film camera.
* p<0.10, ** p<0.05, *** p<0.01

Table A3: Probability of Adoption (Controlling for Past Adoption)

	(1) digital	(2) digital	(3) digital	(4) digital	(5) digital	(6) digital
# Previous films (IHS)	-0.027***	-0.022***				
	(0.005)	(0.005)				
Previous Movie Revenue (IHS)			-0.012***	-0.012***		
			(0.002)	(0.002)		
Only One Prev. Movie					-0.053***	-0.047***
					(0.014)	(0.014)
Only two previous movies					-0.083***	-0.073***
					(0.016)	(0.016)
>2 Prev. Movies					-0.065***	-0.052***
					(0.012)	(0.012)
Top Production						
1Past Adopt	0.315***	0.306***	0.309***	0.309***	0.314***	0.306***
	(0.043)	(0.042)	(0.043)	(0.043)	(0.043)	(0.042)
Genre F.E.	No	Yes	No	No	No	Yes
Rating F.E.	No	Yes	No	No	No	Yes
Observations	3776	3776	3776	3776	3776	3776
Adjusted R^2	0.090	0.104	0.091	0.091	0.092	0.106

Notes: year fixed effects included, robust errors in parenthesis. This table presents regression results for the main specification controlling for whether the director had previously adopted digital filming. The past adopt variable is a dummy for whether any of the director's previous films were filmed using a digital camera. The different columns present the results for the three alternative measures of a director's past experience. Columns 1 and 2 use the inverse hyperbolic sine of the number of previous films. Columns 3 and 4 use the cumulative revenue of past directed films. Columns 4 and 5 use dummy bins for the previous number of films. The outcome is a dummy for whether the director used a digital or film camera.
* p<0.10, ** p<0.05, *** p<0.01

Table A4: Probability of Adoption (Results Using the Full Sample)

	(1) digital	(2) digital	(3) digital	(4) digital	(5) digital	(6) digital
# Previous films (IHS)	-0.015***	-0.009**				
	(0.005)	(0.005)				
Previous Movie Revenue (IHS)			-0.008***	-0.004**		
			(0.002)	(0.002)		
Only One Prev. Movie					-0.039***	-0.033**
					(0.014)	(0.014)
Only two previous movies					-0.068***	-0.058***
					(0.016)	(0.016)
>2 Prev. Movies					-0.043***	-0.029**
					(0.012)	(0.012)
Genre F.E.	No	Yes	No	Yes	No	Yes
Rating F.E.	No	Yes	No	Yes	No	Yes
Observations	3937	3937	3937	3937	3937	3937
Adjusted R^2	0.060	0.075	0.061	0.075	0.062	0.077

Notes: year fixed effects included, robust errors in parenthesis. This table presents regression results for the main specification for the full sample of directors. This includes exceptional directors with ten or more previous films directed. The different columns present the results for the three alternative measures of a director's past experience. Columns 1 and 2 use the inverse hyperbolic sine of the number of previous films. Columns 3 and 4 use the cumulative revenue of past directed films. Columns 4 and 5 use dummy bins for the previous number of films. The outcome is a dummy for whether the director used a digital or film camera.

* p<0.10, ** p<0.05, *** p<0.01

Table A5: Probability of Adoption (Restricting to Directors At Least 40 Years Old in 2000)

	(1) digital	(2) digital	(3) digital	(4) digital	(5) digital	(6) digital
# Previous films (IHS)	-0.016**	-0.014**				
	(0.007)	(0.007)				
Previous Movie Revenue (IHS)			-0.006**	-0.003		
			(0.003)	(0.003)		
Only One Prev. Movie					-0.045**	-0.042**
					(0.021)	(0.021)
Only two previous movies					-0.041*	-0.035
					(0.024)	(0.024)
>2 Prev. Movies					-0.049***	-0.043**
					(0.018)	(0.019)
Genre F.E.	No	Yes	No	Yes	No	Yes
Rating F.E.	No	Yes	No	Yes	No	Yes
Observations	1668	1668	1668	1668	1668	1668
Adjusted R^2	0.042	0.052	0.041	0.050	0.043	0.052

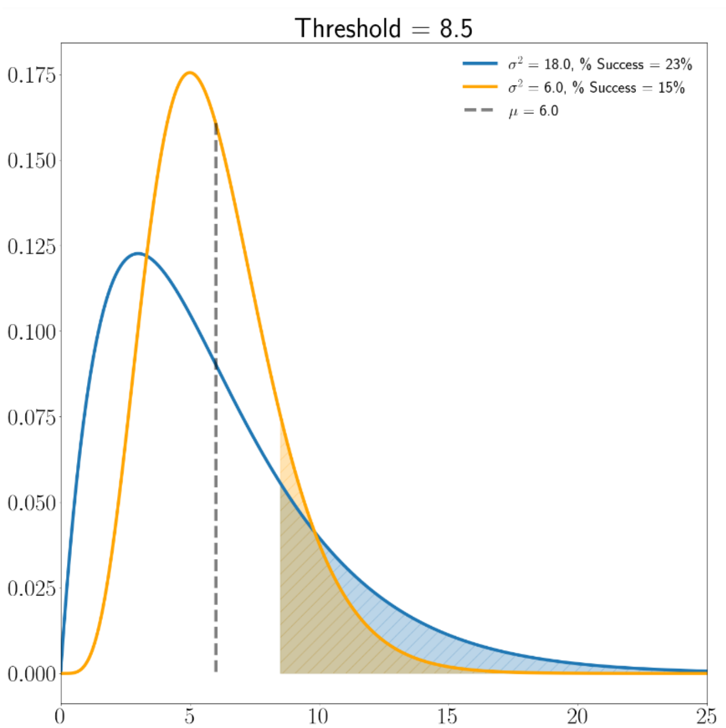
Notes: year fixed effects included, robust errors in parenthesis. This table presents regression results for the main specification restricting to directors that are at least forty years old. The different columns present the results for the three alternative measures of a director's past experience. Columns 1 and 2 use the inverse hyperbolic sine of the number of previous films. Columns 3 and 4 use the cumulative revenue of past directed films. Columns 4 and 5 use dummy bins for the previous number of films. The outcome is a dummy for whether the director used a digital or film camera.

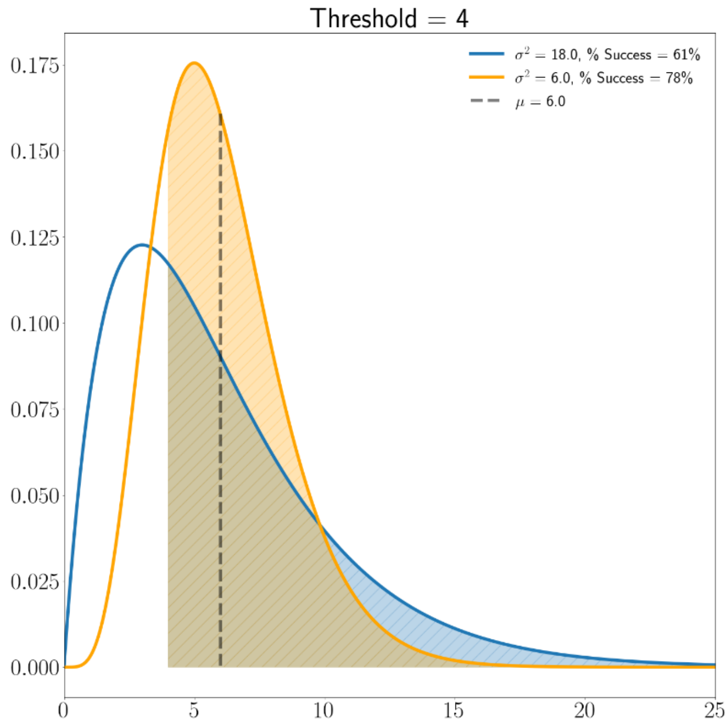
* p<0.10, ** p<0.05, *** p<0.01

Appendix B- A Continuous Example of Risk Taking

The manager has to choose between two projects, where revenues follow a Gamma distribution with a mean of 6. The riskier project has a variance of 18 and the less risky project has a variance of 6.

If the threshold for passing is “low” (in our context, making another movie is likely)- in this example 4, then the low variance distribution leads to a probability of 78% of passing vs. only a probability of 61% for the high variance distribution. The ranking reverses for a “high” threshold, 8.5. Here the risky distribution allows passing with a probability of 23% and the low variance distribution limits the probability of passing to 15%.




Threshold = 4
σ^2 = 18.0, % Success = 61%
σ^2 = 6.0, % Success = 78%
μ = 6.0
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
0
5
10
15
20
25