"What's Wrong with the Way I Talk?"
The Effect of Sound Motion Pictures on Actor Careers

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ABSTRACT: Economists have long debated the effect of technological innovation on employment. The development of sound motion pictures in the late 1920s provides one of history's most evocative examples – film historians have long believed that the transition to sound cut short the careers of a number of silent film stars. However, whether this was due to the new technology itself (actor careers are unpredictable at the best of times), and if so, whether more than a small number of famous stars were affected, has not been explored systematically. In this paper, I analyze a data set of nearly 10,000 actors who played in motion pictures from 1920 through 1940, inclusive. I find that the transition period is associated with a substantial increase in career terminations, not only among major stars, but also among more minor actors. However, I also find that sound films raised hazard rates generally, so that whereas the silent era is associated with a hazard rate that is 30-to-50 percent lower than that of the transition period, the sound era it is associated with only a 10 percent lower hazard rate. Finally, I calculate that the total number of actors cast in feature films rose substantially in the sound era (partly reflecting increased demand spurred by the innovation), illustrating the potentially heterogeneous effects of innovation on employment.

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I. INTRODUCTION

Economists have long acknowledged – and the general public has long feared – that technological innovation, while potentially welfare-improving, may have deleterious effects on employment.[1] A distinction is sometimes made between a product innovation, which can expand employment by increasing demand, and a process innovation, which can contract employment by replacing "humans" with "machines."[2] That said, it is generally not possible to measure the direct effect of innovation on the employees of the innovating firms.[3] In this paper, I will seek to do so, investigating how the development of sound motion pictures influenced actor careers.

Nearly a century after the fact, the transition from silent to talking pictures in the late 1920s remains the stuff of legend. Classic movies such as *Sunset Boulevard* and *Singin' in the Rain* portray, alternately, the pathos ("I *am* big", says former star Norma Desmond, "It's the *pictures* that got small") and the comedy ("What's wrong with the way I talk? Am I dumb or sumpin'?" says the thoroughly unappealing Lina Lamont) of actors unable to meet the demands of the new medium. *The Artist*, a mostly silent film released in 2011, won the Academy Award for best picture (and best director and best actor) for its tale of a romance between an older silent star whose

[1] For surveys of the literature on innovation and employment, see, e.g., Chennell and Van Reenen (2002), Spiezia and Vivarelli (2002), Vivarelli (2014). Fears that technological change will increase employment have a long history, dating from at least the "Luddites" of the 19th century and continuing through today's debates over the likely effect of artificial intelligence (and robots generally) on jobs. For example, a recent Nasdaq release states that robots are "taking a record number of jobs," https://www.nasdaq.com/article/robots-are-taking-a-record-number-of-us-jobs-cm1110600, while a Tech News article argues that "robots will not take over most jobs", https://www.techrepublic.com/article/robots-will-not-take-over-most-jobs/ and a Wall Street Journal columnist poses the question "will artificial intelligence destroy more jobs than it creates?" https://www.wsj.com/articles/will-ai-destroy-more-jobs-than-it-creates-over-the-next-decade-11554156299

[2] A product innovation – a "better" product – changes the demand function, while a process innovation – a better production technique – changes the production function; see, e.g., Van Reenen (1997). Chennell and Van Reenen (2002, 215) conclude, "Overall, there appear to be consistently positive effects of proxies for product innovation on the growth of employment . . . [but] The results for process innovations are very mixed."

[3] See Aghion et al. (2018) for a pioneering attempt to measure how innovation revenues are shared among workers within firms. They write, "In particular, we [i.e., economists] do not have a good understanding of how innovation revenues are shared within firms, even though the innovation and the subsequent commercialization efforts are incurred not only by the inventor but also by her co-employees and by the owners in the firm" (208).

career is waning, and younger sound actor whose career is on the rise.

Film historians have researched the transition from silent to sound extensively, and generally agree that the coming of sound led to the premature termination of the careers of a number of major stars, although the reason has been debated. As interesting and informative as many of these studies are, they rarely proceed beyond qualitative analysis of a relatively small set of very famous actors. Given that most actor careers are of unpredictable (and generally short) duration even at the best of times, it would be surprising if at least some career terminations did not coincide with the transition to sound. Furthermore, no evidence has been presented as to whether the effect was restricted to major stars, or whether the careers of more "average" actors were influenced, as well.

In this paper, I conduct a systematic investigation of how the transition to sound affected the careers of silent film actors. Based on the results, I conclude that film scholars are correct – the coming of sound disrupted the roster of major stars profoundly. However, I find that the effect went well beyond major stars – the hazard rate (likelihood of an actor's career ending in a specified year given the actor had survived until that year) for *all* actors rose during the period of transition. Yet I also find that even after the transition period had ended, the hazard rate remained higher than it had been during the preceding silent era (although not as high as during the transition). Therefore, some of the dramatic effects attributed to the transition from silent to sound films may simply reflect the fact that exit rates were higher during the first decade of sound motion pictures.

I begin by reviewing the history of the development of sound films. The start of the transition to sound is typically marked by the release of *The Jazz Singer* in late 1927, although 1) sound films had been a technological possibility for some time previously, and 2) *The Jazz Singer* was basically a silent film in plot and structure that contained a few minutes of song and a few

seconds of spontaneous dialogue. Nonetheless, *The Jazz Singer* was a huge hit, making it clear that "sound" films had large audience appeal. The transition period lasted several years, as movie producers struggled both with questions as to what a "sound" film should be, and with the technological challenges presented by the new medium. Nearly half of films released in 1929 had little if any spoken dialogue, and not until 1930 were the majority of the nation's cinemas wired for sound. I define the transition period as 1929-1932, but investigate alternate definitions, as well.

To determine whether the transition affected the careers of silent film actors, I analyze the 1920-1940 period. I begin with 1920 because the feature film was by then well-developed and the structure of the film industry – consisting of three vertically related activities, production, distribution, and exhibition – well-established (e.g., Hanssen 2000, 2010). I end with 1940 because many careers would be interrupted (or terminated) by the United States' entry into World War II the following year. Thus, I have nine years over which silent films – and silent film actors – predominated (1920-28), eight years over which sound films – and sound film actors – predominated (1933-40), and a four year transition period (1929-32).

I begin by looking for evidence that the transition to sound disrupted the careers of major stars, as film scholars have posited. In order to define "major star" consistently over time, I employ the results of an annual exhibitor poll first conducted in 1915 (and continued through 2013), in which cinema managers were asked to name their "top ten money-making stars." Seventy-two different actors made this Top Ten list between 1920 and 1940, and most of these actors appeared on the list multiple times (not surprisingly – stardom is persistent). Nonetheless, the list is sharply bifurcated: A number of actors made the list multiple times in the 1920s, and a number of actors made the list multiple times in the 1930s, but none spanned both the silent and sound eras. Furthermore, the years up to and including the transition to sound were characterized by an

unusually high rate of departure from the Top Ten listings. Stories about the effect of sound on the careers of major movie stars appear to have an empirical basis.

I then turn to systematic analysis of the larger population of movie actors. Drawing from the Internet Movie Database (IMDB), I assemble a data set of every actor who played one or more credited roles in feature films from 1920 through 1940, inclusive – nearly 10,000 actors in total.[4] I define the beginning of an actor's career as the year in which she played her first credited role, going back to 1915. I define the end of her career as the year in which she played her last credited role, through 1940; all careers that continued beyond 1940 are considered censored. The career of the average actor in my data set lasts about five years (censoring not accounted for) and the modal career lasts only a single year, the minimum possible given that roles are observed annually. Accounting for censoring, I find that about 20 percent of actors exit motion pictures in their first year, rising to 30 percent by the end of the second year. Actor exit rates are high, not surprisingly.

I employ duration analysis to measure whether the transition period is associated with a change in the rate of actor exits from the film industry. Estimating both continuous time and grouped duration data models, and controlling for actor age and gender (both of which affect exit rates), I find the transition period to be associated with a hazard rate (rate of exit) that is between 20 and 50 percent higher than that of the non-transition years. It does indeed appear that the transition to sound saw unusually high rates of departure from the movie-acting profession.

I then investigate whether actors who played bigger roles were affected differently than actors who played smaller roles (as noted, most studies have focused on famous stars). Film scholars have put forward two principal (and not necessarily mutually exclusive) explanations for the increase in career terminations brought about by the transition to sound: 1) some actors had

[4] For a discussion of IMDB data, see Section IV. To confirm the IMDB's accuracy, I checked it against listings from the American Film Institute.

voices that were simply at odds with their silent screen images (or images that did not translate well to sound films), and 2) a sound film required fundamentally different skills. I find very little difference in the transition period hazard rates between actors who played major roles and actors who played more minor roles, which suggests that explanations turning on an actor's image are unlikely to explain the bulk of the increase in exit rates. It appears that the alternative explanation, that the required skills were different, may hold more generally.

Next, I compare silent-era and sound-era hazard rates. I find that the sound era is associated with substantially higher hazard rates than the silent era. Accordingly, whereas the transition period is associated with a near-doubling of exit rates as compared to the silent era, it is associated with only a ten percent higher exit rate as compared to the sound era (at least through 1940). Therefore, some of the exits ascribed to the coming of sound may simply reflect the higher rate of actor "churn" that sound films appear to have brought with them.

Finally, I briefly review evidence on total employment in the film industry. I find that sound films are associated with what appears to be an attendance-driven rise in the number of films produced. The average sound feature film also cast more actors than the average silent feature film, perhaps because plots could be more intricate once spoken dialogue was possible. The net effect was a substantial rise in the employment of motion picture actors.

The results of this paper thus confirm that a product innovation – such as sound films – can indeed increase aggregate employment in an industry. However, they also demonstrate that if the new good drives out an old good – as sound films drove out silent films – not only will the expansion in demand be moderated, but the mix of those who work may change.[5] The evidence

[5] On skill-biased technical change, see e.g., Acemoglu (1998), Berman, Bound, and Machin (1998), Goldin and Katz (1998). Technological change need not be skills-promoting; for example, Goldin and Sokoloff (1982) and Atack, Bateman, and Margo (2002) find evidence of "de-skilling" as manufacturing moved to larger, more capital intensive establishments in the 19th century.

presented here suggests that David Ricardo was correct when he wrote,

> The opinion entertained by the laboring class that the employment of machinery is frequently detrimental to their interests is not founded upon prejudice and error, but is conformable to the correct principles of political economy. (*On The Principles of Political Economy and Taxation* 1821, Chapter 31.)

But it also confirms John Stuart Mill's statement that "I do not believe that . . . improvements in production are often, if ever, injurious, even temporarily, to the *labouring classes in the aggregate* [italics added]" (*Principles of Political Economy* 1848, Chapter 6). The careers of many silent actors appear to have been ended prematurely by sound, but sound motion pictures boomed subsequently, and the number of Hollywood actors who played credited roles in feature films annually in the first decade of the sound era was nearly double that employed in the last decade of the silent era.

II. THE COMING OF SOUND

The potential for the simultaneous projection of pictures and sound has existed since the dawn of "the movies" – Thomas Edison developed versions of both the movie projector and the phonograph in the late 19th century, and he experimented with linking the two.[6] However, it was not until the mid-1920s that sound technology had developed sufficiently to allow it to be systematically synchronized with moving pictures. The lead in the process was taken by Warner Brothers, then a relatively small film studio, which formed a joint venture – Vitaphone – with

[6] See, e.g., Gomery (1985), Crafton (1997, 9), Eyman (1997, chapter 1). The slow movement to adapt sound to motion pictures (even after it was discovered in 1915 that connecting a power transformer and battery to existing electrical circuitry could increase the volume of recorded sound substantially, an innovation adopted by radio) is consistent with the observation that technology diffusion is usually "a . . . rather slow process" (Hall and Kahn 2003, 1). The key choice, as Hall and Kahn point out, is generally not between adopting and not adopting, but rather between adopting today and adopting tomorrow. It is noteworthy that the "first mover" was Warner Brothers, a minor studio with much lower levels of capital (physical and reputational) sunk in silent film production and in silent film stars than many of its rivals (and none in cinemas, which would have to be wired for sound). See Rosenberg (1972) for a seminal discussion of the diffusion of innovation.

Western Electric in April 1926 to promote Western Electric's sound-on-a-disc system. Fox was the only studio to respond immediately; it contracted for the rival Movietone system, which placed the sound on film instead (this latter method eventually became the industry standard). The other movie companies adopted a "wait and see" approach, agreeing in 1927 that none of them would convert to sound until they all did.[7] By moving first, Warner Brothers propelled itself into the top tier of movie studios.[8]

The first public showing of a "sound" feature film occurred in 1926, when Warner Brothers fitted their film *Don Juan*, originally intended as a silent feature, with synchronized music. The company then released several talking shorts (mostly comedy and musical acts) over the following months, while Fox produced a talking newsreel. But the dawn of the sound era is generally considered to coincide with Warner Brothers' release of *The Jazz Singer* in late 1927. *The Jazz Singer* actually contains only three short sound sequences, each a song by its star, Al Jolson, accompanied by a bit of dialogue (291 words in all). Like many of the very early sound features, it had been conceived as a silent film; a sound track was added later in the production process. It was extremely popular, earning $2 million through 1931 (Crafton 1997, 111), and made clear the appeal of sound motion pictures.

"Kaput!"[9]

Film scholars have long maintained that the coming of sound films altered fundamentally

[7] This is referred to as the "Big Five Agreement," because it was signed (in February 1927) by five of the most important film companies: Loew's (MGM), Universal, First National (later purchased by Warner Brothers), Paramount, and Producers Distributing Corporation. The firms agreed that for one year none would adopt any sound technology unless (1) a standard had been identified as best for the industry, (2) that technology was made available to all producers on equal terms, and (3) it was to be adopted by all simultaneously. See e.g., Gomery (1985) and Walker (1979) for more detail.

[8] See Sedgwick and Pokornoy (1998) for an analysis of Warner Brothers financial performance (and financial strategies) from the early 1920s through 1940.

[9] The subtitle is taken from Griffith and Mayer's (1957, 247-251) section on how sound affected the careers of silent stars.

the roster of major stars.[10] Exactly why has been the subject of some debate. Initially, the general feeling was that certain actors simply had weak voices. For example, the 1929 edition of *The Motion Picture Almanac* (published at the end of 1928) ran an article titled, "Have You a 'Screen' Voice," complete with a sample "experimental diagnosis sheet", and several speech worksheets. John Gilbert, MGM's most popular silent actor and the most famous purported victim of sound, was said to suffer from a malady known as "white voice" – i.e., a light tenor (e.g., Griffith and Mayer 1957, 248). Some of the other purported victims, such as Vilma Banky and Karl Dane, had strong foreign accents (Hungarian and Swedish, respectively). Hollywood producers rushed to sign Broadway actors, under the assumption that they, at least, knew how to talk. Yet stage and screen proved to be sufficiently different that many of the stage performers had only brief Hollywood careers.

Today, the "weak voice" explanation is largely discounted, and film scholars propose two (not mutually exclusive) alternatives. The first is that although a voice might be fine per se, it could clash with the image the actor had developed in silent films. For example, Basinger (1999, 396-7) writes of John Gilbert,

> It was sound that killed Gilbert. Not because he had a bad voice or a high voice and not because his sound roles were silly, since some of them . . . are quite entertaining and modern. It was sound that killed him because sound diminished John Gilbert. . . . His true forte was as the fulsome romantic idol. Sound added nothing to his ability to convey a man in love, to present a sensuous, impassioned romantic. On the contrary, sound subtracted heavily from it.[11]

[10] John Gilbert was probably the biggest male star of the late-silent era; he made the last of a series of very unsuccessful sound films in 1934, and then proceeded to drink himself to death at the age of 38. Vilma Banky, Clara Bow, Colleen Moore, Marion Davies, Mary Pickford, Constance and Norma Talmadge, Dolores Costello, and William Haines were major stars who never made it big in sound (although some, like Mary Pickford, were approaching middle age). Karl Dane's story was particularly sad; he went from MGM's A-list in the late 1920s to peddling hotdogs outside the MGM gates in 1933, and shot himself in 1934 (Eyman 1997, 314).

[11] A contemporary columnist wrote, "It isn't that Mr. Gilbert's voice is insufficient; it's that his use of it robs him of magnetism, individuality, and strangest of all, skill. He becomes an uninteresting and inexpert performer" (quoted in Cohen 2001, 70).

In the same vein, whereas Greta Garbo's husky Swedish accent nicely fit her "woman of mystery" silent-film image, Vilma Banky's heavy Hungarian accent undercut her delicate appearance, and thus her appeal. Similarly, Dolores Costello (another of sound's casualties) had a much remarked-upon "Madonna-like beauty" (Griffith and Mayer 1957, 224) that was strongly at odds with her flat speaking voice and pedestrian Midwestern accent.[12]

The second possible explanation is that the nature of the required skills changed (e.g., Walker 1979). It is important to recognize that silent and sound films are fundamentally different – a sound film (of the type we see today or even saw in the early 1930s) is not simply a silent film plus talking and music. Silent plots were by necessity simpler than sound plots; the lack of dialogue meant that complicated ideas and plot twists could not be communicated easily.[13] The cinematography was also somewhat different – wide-lens views of the scene and the action alternated with tight close-ups on the faces of the actors. Silence created a distance between actor and audience that encouraged exaggeration. The gestures and facial expressions that actors used were highly stylized – broad, sweeping movements and widening or narrowing of the eyes would indicate anger, anguish, happiness, and so forth in ways that were recognized by contemporary audiences, but are far removed from how people actually react (which is approximately what sound films show). Indeed, silent film acting bore some resemblance to mime (although the greatest silent actors were also able to communicate warmth and humanity). By contrast, sound films put

[12] Costello is "famous" for voicing the phrase "Merthy, merthy, have you no thister of your own" in the 1928 film *Tenderloin*, although there is some debate as to whether her lisp or the poor quality of sound recording (and broadcasting) technology is primarily to blame. That said, I watched her in the part-talking 1928 film *Noah's Ark* and can attest that any magic created by her ethereal appearance quickly dissipated when she spoke.

[13] The very pattern of cinema-going was different during the silent era – patrons could show up in the middle of the film and simply stay through the subsequent showing until they were back to the point where they had arrived. Walker (1979, 97) writes, "Silent movies had enabled the casual customer to drop in, and within a minute or two be locked into the story and characters. Mime-acting made the characters' predicaments easily intelligible; sub-titles gave people emotional cues to follow rather than narrative points to recall. But dialogue altered this: it demanded attention." Sound films initially discomfited both audiences and theater managers by necessitating that all viewers arrive before the film began.

a premium on *underacting* – the apparent "realism" of what one views on the screen magnifies the importance of every gesture or facial tic.[14] Eyman (1990, 226) describes the difference as follows:

> Talkies were less romantic than silents, more real; less utopian, more democratic; less behavioral, more psychological. Because silent films were such an anomalous hybrid, and closer to ballet than to anything else in the arts, actors who had an aptitude for them often seemed comparatively ordinary, if not inadequate, in the more plebian talkies.

Talkies also differed in more mundane ways; directors could no longer shout instructions during filming (as was the norm during the silent era), and actors could no longer improvise dialogue; they had to memorize lines. I will use my findings to distinguish (to the degree possible) between these two explanations: The effect of an actor's silent-era image versus a change in the necessary skills.

Defining the Transition Period

The trouble with the whole industry is that it talked before it thought (Joseph M. Schenk)[15]

In order to determine whether actor careers were affected by the coming of sound, I must define a transition period, to contrast with well-defined "silent" and "sound" periods. I will therefore briefly trace the development of the sound film and the dissemination of sound technology. It should be emphasized that the appeal of sound caught the industry by surprise, and a period of debate and experimentation followed, as acting (and writing, directing, filming, etc.) styles adjusted and technology (microphones, cameras, etc.) advanced.[16] It was also necessary to

[14] Basinger (1999, 393) writes, "The successful delivery of sound dialogue needs a certain nonchalance, an ease with words. Since the medium takes the viewers in close to the actor, there is no need for declaiming or hitting a point so the back row won't miss it. The medium calls for naturalism, behavior that people in the audience somehow take for the essence of the actor."

[15] Quoted in Walker (1979, title page).

[16] The development and implementation process, requiring much tinkering and adjustment (e.g., Meisenzhal and Mokyr 2011), threw the industry into turmoil, with long-term effects on both competitive structure and organizational form. For more detail, see Hanssen (2002) and the citations therein. Bakker (2001) presents evidence that the transition to sound shortened director survival rates.

wire thousands of cinemas for sound, an expensive proposition.[17]

Despite the success of *The Jazz Singer* in late 1927, many industry pundits initially regarded sound as a fad, and even supporters expected talking and silent films to coexist indefinitely. The author of a Harvard case study of a cinema considering the conversion to sound in 1928 wrote, "It was difficult to judge the permanence of the appeal of sound pictures. Theatrical managers were convinced that the appeal at first was largely one of curiosity" (Clayton Theater 1930, 491). Jack Warner, the champion of the talking picture, said as late as 1928 that he expected most future films to be part sound and part silent (Crafton 1997, 174). Adolph Zukor, President of Paramount Pictures, was quoted in late 1928 as saying,

> By no means is the silent picture gone or even diminished in importance. . . . there always have been subjects which could not be augmented in value or strength by the addition of sound and dialogue. (*The Film Daily 1929 Yearbook*, 513)[18]

What followed was a period of debate and experimentation, aimed (however chaotically) at determining what a sound film should be. Should it have talking scenes, and if so, how many? Should comedies remain non-talking (with synchronized music and sound track) while dramas included speech? Initially, a number of producers responded by simply adding synchronized music and sound effects to what were essentially silent films, including perhaps a few short scenes with spoken dialogue (which served more than anything to reveal how different silent and sound films really were). This led to confusion among fans, and much unhappiness with the resulting product.[19]

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[17] According to a 1928 article in *Variety* (June 6, 1928, p.5) wiring for sound cost between $5000 and $14,000 per cinema (approximately $75-200,000 in current dollars), depending upon cinema size and configuration.

[18] *Scientific American* summed up the "scientific consensus": "[The silent film] has a wonderful appeal to its audience – an appeal entirely distinct from that of the spoken play. It is in no wise an imitation of the spoken play; it is a thing by itself. Why, therefore, replace it with a more or less realistic imitation? Our belief is that the talking picture has great possibilities in many directions, but as a factor in the motion picture field it must not be taken seriously." Quoted in Eyman (1997, 53).

[19] For fans, determining whether a film had spoken dialogue (as most desired) or merely synchronized music and sound effects became a source of tension. As the editor of the *1929 Film Daily Yearbook* (page 501) wrote,

The Internet Movie Database (IMDB) lists the "sound mix" used by film, which allows me to divide feature films into three categories: 1) silent, 2) sound sequences (synchronized music and sound effects; perhaps some spoken dialogue), and 3) fully talking.[20] The chart at the top of Figure 1 plots the proportion of films of each category released by year, from 1926 (when the first "sound" feature film was released) through 1932 (when essentially all feature films were fully talking). As noted, *Don Juan* appeared in 1926 and *The Jazz Singer* late in 1927, but the first fully talking films were released in 1928, and accounted for only two percent of all feature films released that year, while another twenty percent had sound sequences.[21] By 1929, more than half of all releases were fully talking, and less than twenty percent were completely silent. By 1930, nearly all feature films were fully talking.

Of course, to show talking films, one needed cinemas wired for sound. Warner Brothers initially promoted the establishment of Vitaphone sound systems in large cinemas in major urban areas. According to the *1929 Film Daily Yearbook*, by April 1928, the Vitaphone system was in use in 250 cinemas, and Western Electric, Warner Brothers' partner in sound, set the goal of 1000 wired houses by the end of 1928.[22] However, more than 20,000 cinemas were then in operation, so this still represented a small minority (albeit with a focus on larger cinemas) and into 1930 at least, film producers tended to release both talking and silent versions of their feature films, the

"Overzealousness of exhibitors in efforts to cash in on the [sound] craze was developing a danger for sound films in the form of misleading advertising. The 'See and Hear' keynote lines were being used for synchronized as well as dialogue films. The difficulty of ascertaining the difference led to a reaction, which soon made itself felt at the box office. Since, the exhibitors have been wary of misleading copy."

[20] For a more detailed description of the IMDB data, see Section IV.

[21] Warner Brothers again took the lead, releasing the fifty percent talking feature *The Lion and the Mouse* in May of 1928 (*The Jazz Singer* had been less than five percent talking), and the first fully talking picture, *The Lights of New York* (based on a Broadway play), the following July. See, e.g., Crafton (1997).

[22] Flush with cash from the unexpected success of *The Jazz Signer*, Warner Brothers began to acquire cinemas in 1928 (e.g., Sedgwick and Porkonoy 1998, 198-9). All the biggest studios were then vertically integrated; see, e.g., Hanssen (2010).

latter to be shown in unwired houses.[23]

In order to trace the wiring of cinemas for sound, I present data drawn from the *Film Daily Yearbook* (1929-33 editions) and the *Motion Picture Almanac* (1929 edition) in the chart shown at the bottom of Figure 1. The pattern is roughly the same as that shown for the sound mix of films, directly above (not surprisingly). By the end of 1928, only six percent of the approximately 21,000 cinemas then in operation could show sound films. That had risen to more than 40 percent by the end of 1929, as the total number of wired cinemas hit 9000, and to 60 percent (13,000 cinemas) by the end of 1930. However, the Great Depression was by then striking the film industry (which had enjoyed an initial respite), and over the next two years, nearly half of all cinemas closed. As one would expect, the majority of the closures were among cinemas that had never been wired for sound. By 1931, only about ten percent of unwired houses remained in operation, and nearly all of them would close or convert by the end of 1932.

Even after cinemas had been wired and talking films were the norm, experimentation continued, as the technology improved and acting, presentation, and storylines were refined. Directional microphones, three-way speaker systems, and techniques for "looping" (the re-recording of vocals post-production) were all developed in the 1930s (e.g., Crafton 1997, Chapters 13 and 14).[24] To allow sufficient time for silent actors to exhibit the requisite ability (or not), I will define the "transition period" as beginning in 1929 and ending in 1932. As a robustness test,

[23] Among the "Twenty Compelling Film Facts" listed in the *1930 Film Daily Yearbook* (page G) is that "Nearly 350 silent versions of dialogue [talking] pictures are on '29-30 [film] lists."

[24] For example, Crafton notes that the soundtrack of the 1930 Josef von Sternberg classic *Morocco*, starring Gary Cooper and Marlene Dietrich, was "rather noisy. The splices are clearly audible because they were not altogether successfully blooped" (360). With regards to *The Big Trail*, a 1930 Western directed by Raoul Walsh and starring a young John Wayne, "[s]ometimes the balance between the planes of sound effects is not good. On the steamboat landing, for instance, the actors can scarcely be heard through the layers of din. . . . [and] occasionally the voices did not come from the mouths of the players" (364-5). A pre-Sherlock Holmes Basil Rathbone successfully plays a detective in a 1930 film despite the fact that "microphone placement problems sometimes make his speech fade in and out" (365). And so forth.

I will also estimate the results for several alternative periods: 1928-30, 1928-31, 1929-31, and 1930-32.

Before proceeding, it should be noted that, however defined, the transition to sound overlaps the onset of the Great Depression. Is this likely to contaminate my results? On the one hand, it is certainly possible that rising unemployment rates nationwide affected the stock of would-be actors, which could in turn have influenced actor hazard rates. On the other hand, an "excess supply" of actors – working at menial jobs in hopes of a chance at movie stardom – is a longstanding phenomenon.[25] Furthermore, as will be shown, the transition period displays a higher actor hazard rate than the rest of the 1930s, although unemployment rates did not peak until 1933, and did not return to the level of 1930 until 1941.[26] Nonetheless, the reader will note that I have included the 1928-30 period among my alternative transition period definitions – in 1930, the Great Depression was still in its infancy. If my results are picking up merely or largely the results of the Great Depression, I should find little effect for this alternate transition period definition.

III. MAJOR MOVIE STARS AND THE COMING OF SOUND

Because film scholars have long proposed that sound shortened the careers of a number of famous silent-era actors, I begin my analysis with major movie stars.[27] Of course, that requires

[25] A famous industry ad from the early 1920s (run in newspapers around the country) reads in large print, "Don't Try to Break into the Movies", and in smaller print beneath, "Out of 100,000 Persons Who Started at the Bottom of the Screen's Ladder of Fame, ONLY FIVE REACHED THE TOP." In 1927, the publication *Photoplay* ran a four part series titled, "The Truth About Breaking into the Movies" that ended with the ominous warning, "Don't go to Hollywood!" See, e.g., Burr (2012, 43). A copy of the industry ad can be found at https://martinturnbull.com/2012/11/10/dont-try-to-break-into-the-movies-advertisment/. For a discussion of, and some citations from the literature on, the labor supply and careers choices of creative artists (including actors), see Throsby (1994).

[26] Bureau of Labor Statistics, *Historical Statistics of the United States Colonial Times to the 1970, Part I* (U.S. Government Printing Office, 1975), Series D 85-86 Unemployment: 1890-1970, 135.

[27] During both the silent era of the 1920s and the sound era of the 1930s, the vast majority of actors worked on a per day, week, or film basis. Most major movie stars, however, were signed to long-term contracts (see, e.g., Hanssen and Raskovich 2018). That said, the most long-term contracts contained a semi-annual renewal option, allowing studios to rid themselves easily of actors whose popularity dipped (because of the coming of sound, for example).

me to define "major movie star" in a manner that is consistent over time. I will make use of a unique measure: results from an annual poll of movie exhibitors, who were asked to list their ten top "money making stars." From 1915 through 2013, the *Motion Picture Herald*, a trade weekly, and its successor the *International Motion Picture Almanac*, surveyed thousands of exhibitors annually.[28] A version of the following request was made: "Please list the ten players whose pictures drew the greatest number of patrons to your theater over the last twelve months" (*Motion Picture Herald*, December 28, 1935, page 13). Votes were tallied and actors ranked according to number of votes received (order of ranking by individual exhibitors was disregarded). If one is willing to assume that exhibitor respondents answered honestly (and they had no reason not to), one can expect the actors most popular with audiences to have received the most votes.[29]

I will begin my analysis in 1920, by which time the feature film and the structure of production-distribution-exhibition that would characterize the industry for the rest of the silent era were well-established. I will end in 1940, just before the U.S. entered World War II, bringing the careers of many actors to a precipitous (and sometimes permanent) halt. Seventy-two different actors made the Top Ten between 1920 and 1940 inclusive (excluding 1930's ninth most popular actor, the canine star Rin Tin Tin). Table 1 lists the years of appearance between 1920 and 1940 inclusive for the 33 actors who were voted to the Top Ten at least three times over that period. To the left I put all actors who made their debuts on the list in the 1920s, and to the right all actors

Where an actor's contact did not contain a renewal option (typically because the actor was so big a star the studio was willing to forgo it), the contract had to be bought out instead. Silent star John Gilbert was one of the few "casualties of sound" to refuse a buy-out; MGM had to keep churning out his pictures (films that that fans refused to see) until not even Gilbert could take any more (see, e.g., Basinger 1999).

[28] The weekly publication was known as the *Exhibitor's Herald* from 1915-1928. After absorbing a rival publication, *Motion Picture World*, it was renamed the *Exhibitor's Herald World* (1928-1930) and then the *Motion Picture Herald*. The *Motion Picture Herald* was eventually closed, and the poll continued in an annual sister publication, the *International Motion Picture Almanac*.

[29] Even casual perusal of the Top Ten data indicates that the chosen actors are major stars. For example, the 2011 Top Ten were (in order): Brad Pitt, George Clooney, Johnny Depp, Leonardo DiCaprio, Matt Damon, Sandra Bullock, Bradley Cooper, Robert Downey, Jr., Meryl Streep, and Ben Stiller.

who debuted on the list in the 1930s, by initial year of appearance. It is notable that each actor made the list as either a silent star or a talking star – few span the two eras. This is not to say that all the careers played out entirely within one or the other era; for example, Great Garbo and Joan Crawford were popular actors in silent films before becoming Top Ten stars in sound films, and a number of the silent Top Ten stars acted in sound films, but not to the same level of acclaim.[30] Figure 2 plots the number of each year's Top Ten stars who were still on the list five years later. The years of the transition to sound technology appear very low relative to the years that preceded and followed.

Thus, evidence from exhibitor polls suggests that the careers of top stars were indeed disrupted by the coming of sound, as film scholars have proposed. I now turn to a systematic analysis of the larger population of movie actors.

IV. ALL CREDITED ACTORS

I will develop a data set of all actors who played one or more credited roles in feature films between 1920 and 1940. My source is the Internet Movie Data Base (IMDB), a website that seeks to provide information on all films ever released and distributed in the United States (it lists films dating back to the 19th century).[31] The IMDB also includes data on actor age and gender. Because

[30] For example, the three silent era late-comers to the Top Ten list are Clara Bow, whose last film was released in 1933 when she was only 28 years old; William Haines, whose last film was released in 1934 when he was only 34 years old; and Richard Barthelemess, who lasted until the early 1940s and played a number of sound roles, but is best known today for his work in silent films. Silent star Colleen Moore made the list in 1931, but her most recent movie at that point was a non-talking film released in 1929. After an enormously successful silent career, Moore retired in 1934 at the age of 35, having made only four talking films.

[31] I exclude documentaries and animated films, which have no actors in the typical sense of the word. According to its own statistics (http://www.imdb.com/stats), the IMDB has compiled information on several million actors who acted in nearly half-a-million feature films, millions of TV episodes, and hundreds of thousands of film shorts. (It is updated continually.) I have worked extensively with IMDB data (e.g.. Fleck and Hanssen 2016; Hanssen and Raskovich 2018), and have found relatively few errors. To test the accuracy of my data set, I compared it to film listings from the American Film Institute (AFI) (https://catalog.afi.com/Catalog/Showcase) for selected years (the process is time consuming). I found a match rate of about 95 percent, with most differences accounted for by the fact that my dataset includes serials (which the AFI does not) and excludes documentary, animated films, and shorts (which

it is important to control for age when estimating an actor's "mortality" (see Fleck and Hanssen 2016), I will include in the data set only actors who have a birth year listed.[32]

My data set, thus defined, consists of 8930 actors, each of whom played at least one credited role in a feature film between 1920 and 1940, inclusive.[33] I set up the data as an unbalanced panel. An actor enters the panel the first year in which he or she plays a credited role and leaves it the last year he or she plays a credited role. I will consider an actor's career to be ongoing in year t if he or she played any credited roles in any subsequent year $t+k$, where $k \geq 1$. I will consider an actor's career to terminate in year t if the actor played no credited roles in any subsequent year. I will consider an actor's career to be censored if he or she played a credited role after 1940, when my sample period ends. I take actor careers back to 1915, five years before the start of my sample period, so that (for example) an actor who played at least one credited role in every year from 1915 through 1919 will enter the data set in his sixth career year.[34] There is thus a possible (censored) maximum of 26 career years per actor in my data set.

The top of Table 2 provides summary statistics. The average actor is 38 years old, and has a career that lasts slightly less than six years.[35] Roughly two-thirds of the observations are accounted for by male actors. Figure 3 presents a histogram of the length of actor careers. More than half the actors in the data set have careers of two years or less in length, not adjusting for censoring. Consistent with the stereotype, for most actors, time in the spotlight is brief.

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the AFI includes occasionally). In addition, my data are restricted to U.S.-produced films and co-productions, while some of the films listed by the AFI are foreign productions.

[32] Actors for whom no birthdate is provided are also likely to be less well-known, and thus may have more poorly documented careers. Actors without birthdates account for about 10 percent of total credited roles listed by the IMDB for the 1920-40 period (but only three percent of lead roles).

[33] I define "feature films" as a film of 50 minutes or longer. Film "shorts," mostly musical or comedy, were a regular part of movie viewing through at least the 1930s.

[34] Actors whose careers began before 1915 may be subject to some censoring, but given how dramatically the nature of film roles changed with the spread of the feature film at about the same time, this latter censoring may not be severe. The revolutionary (and controversial even then) film *The Birth of a Nation* was released in 1915.

[35] The "0's" in the age data do not reflect missing observations, but rather the fact that babies were sometimes cast in films.

The Effect of the Transition to Sound on Actor Careers

How were actors affected by the transition to sound? In Figure 4, I plot the percentage of actors in year *t* who also played a role in any year > *t*, through 1940. Consistent with the short career lengths shown in Figure 3, anywhere from 15 percent to 20 percent of actors who played a credited role in a given year disappeared from the data set subsequently. As compared to the silent years, the transition years of the late 1920s/early 1930s show a fall in the proportion of actors who played credited roles in subsequent years, a hint that the transition years may have increased actor mortality. But note that the increase appears to extend beyond the transition period – whereas all but one of the pre-1927 years show repeat rates greater than 85 percent, none of the post-1927 years does so.

The right-censoring present in the raw career-length data will lead to an underestimation of the duration of actor careers if not taken into account – some "employment spells" were ongoing when the sample period ends in 1940. Career length is censored for approximately one-third of the actors in the data set – and censoring affects more sound-era than silent-era actors, for the simple reason the former enter the data set later than the latter. I will therefore turn to duration analysis.

I begin by plotting Kaplan-Meier empirical survival curves – the Kaplan and Meier (1958) estimator takes censoring into account. The top of Figure 5 plots a survival curve for the entire 1920-40 time-period, while Table 3 presents the underlying data.[36] Survival rates are lowest at the beginning of an actor's career – nearly twenty percent of actors cast in credited roles did not make it beyond their first year, and nearly thirty percent did not make it beyond their second. After three

[36] The Kaplan-Meier empirical survival function is $S(ti) = \prod_{j \le t}(1 - \frac{di}{ni})$, where *t* signifies the time period; n_i is the number of subjects at risk at the beginning of time period t_i; and d_i is the number of subjects who exit during time period t_i. Censored observations are excluded, so that $c_i = n_{i-1} - d_{i-1} - n_i$.

years of experience, the rate of survival increases, and then remains relatively constant, with about ten percent of actors exiting with every additional career-year that passes. The median career lasts about five years. The bottom of Figure 5 plots Kaplan-Meier survival curves separately for the transition and non-transition years. The transition period survival curve is everywhere below the non-transition-period survival curve – for all levels of experience, exit rates were higher during the transition to sound. In other words, the probability of making it to period t+1 (one's sixth year, say) given one had survived until period t (one's fifth year) dropped for all values of t.

The Kaplan-Meier calculations are made under the assumption that the sample is homogenous, but, in fact, the actors in the data set differ in two important and observable ways: by age and by gender. Age has been shown to affect career mortality, and the effect to differ by gender (Fleck and Hanssen 2016).[37] Any sorting along such characteristics may mask true changes in the hazard function. For example, if silent actors "aged out" in large numbers coincident with the coming of sound (which occurred roughly a decade after the feature film became the norm in the mid-to-late teens), one could find the pattern displayed at the bottom of Figure 5.

To control for time-varying age and gender, I will estimate proportional hazards models.[38] The proportional hazards model not only allows the inclusion of time-varying covariates, but avoids the necessity of making an assumption regarding the underlying distribution for the baseline hazard. The instantaneous hazard function for individual i at time $t > 0$ takes the form

$$1. \quad h_i(t|x) = \lambda_0(t)*\exp(\boldsymbol{x_{it}}'\beta)$$

where λ_0 is the (non-negative) baseline hazard function, which is permitted to vary with time; $\boldsymbol{x}$ is a vector of covariates associated with individual i at time t; and β is a vector of parameters to be

[37] Fleck and Hanssen find that female actors play lead roles at younger ages, exit motion pictures at younger ages, and have shorter careers on average than male actors.
[38] On duration models, see, e.g., Kiefer (1988); Wooldridge (2002, Chapter 20).

estimated. The hazard rate measures the instantaneous probability of leaving state *s* (in this paper, employment in credited roles) at time *t*, conditional on having survived in state *s* until time *t*.

I begin with the widely used Cox proportional hazards model. The initial regressor of interest will be an indicator variable signifying the transition period years.[39] I will present hazard ratios in my tables rather than raw coefficients, because hazard ratios are easier to interpret. A hazard ratio is calculated by dividing the "treatment" hazard (in this case, the hazard rate during the transition period) by the "control" hazard (in this case, the hazard rate during the non-transition years). A hazard ratio of 1.10, for example, would indicate that the treatment is associated with a ten percent increase in the hazard, while a hazard ratio of 0.90 would indicate that the treatment is associated with a ten percent decrease in the hazard. I will present z-statistics from a test of the null that the hazard ratio is equal to one (i.e., the variable has no effect on the hazard rate). I will also include age and age-squared, and age and age-squared interacted with a male dummy variable, to allow age to affect males and females differently.

Estimated hazard ratios (and corresponding z-statistics) from the Cox model are shown in Table 4, columns 1 and 2. The first column shows the result without age and gender controls; the second column including age and gender controls. The predicted effect of the transition to sound is essentially invariant to the inclusion of the controls (although the controls themselves have a statistically significant effects on the hazard rate). Transition to sound is associated with a 43 percent higher hazard rate – greater likelihood of exit – than the non-transition years.

The Cox model requires the assumption that the exact duration of spell lengths is known. However, in my data set, I do not observe the precise moment that an actor exits from motion pictures, but rather the last year in which an actor played a credited role in a feature film. In other

[39] Thus $\exp(\beta)$ can be interpreted as the proportional change in the hazard rate associated with moving from a regressor value of zero to a regressor value of one.

words, I observe the underlying continuous durations only in disjoint intervals, with all actors who exited in a given year grouped together. Some will no doubt have exited earlier than others (in January rather than November, say), which introduces spurious "ties" (i.e., equal observed durations for different actual durations) that may affect the estimated hazard rate. I will therefore also estimate a grouped duration data model, based on the framework developed by Prentice and Gloeckler (1978). Prentice and Gloeckler add to the Cox model the assumption that the baseline rate is piecewise constant – i.e., constant within each measured interval, but may vary from one interval to another. Each career-year will thus be allowed a different but constant baseline hazard, up through the 20th year. Relatively few actors in the data set experience careers that extend beyond 20 years (see Table 3), so career years 21 through 26 are grouped together and assumed to have the same, constant baseline hazard.

Columns 3 and 4 of Table 4 show hazard ratios from the grouped duration data model.[40] The transition to sound is associated with a twenty-three percent increase in the hazard rate relative to the non-transition years, a somewhat smaller effect than implied by the Cox model, but still large in magnitude and highly statistically significant. The age and gender controls are statistically significant, and of roughly the same implied magnitude as in the Cox estimations; as also in the Cox estimation, they appear to be largely orthogonal to the transition period indicator.

To check the robustness of these findings, I do two things. First, I estimate the models using different transition periods: 1928-30, 1928-31, 1929-31 and 1930-32. The estimates (not shown) are qualitatively equivalent to those presented in Table 4: The transition period hazard rate rises by 30-45 percent in the Cox model, and by 15 to 30 percent in the grouped duration data

[40] I use the maximum likelihood-based estimation procedure developed by Jenkins (1997), who provides a concise and lucid summary of the grouped duration data model. I also employ Jenkins' procedure to estimate the effect of incorporating a gamma mixture distribution to summarize unobserved heterogeneity (see what follows).

model.[41] Second, following Meyer (1990), I estimated a version of the grouped data model that incorporates a Gamma-distributed random variable to account for unobserved individual heterogeneity ("frailty") across individuals (estimates not shown). The variance of the gamma mixture was very small as compared to its standard error, and the estimated hazard ratios were essentially the same (to several digits) as those presented in Table 4, suggesting that unobserved individual heterogeneity is not important in explaining the effect of the transition to sound on career duration.

"Major Actors" versus "Minor Actors"

Thus, the period of transition to sound technology is associated with a substantial rise in the hazard rate for *all* actors who played credited roles, not merely the major stars. That said, the definition of major stars I employed in Section III was very exclusive – many popular actors had long and successful careers without being voted to the Top Ten.[42] Were actors who were generally better known – although not necessarily Top Ten stars – more or less likely to make the transition to sound?

As discussed in Section II, the reason why the coming of sound shortened actor careers is debated: Was it because the actor's silent image was simply wrong for sound (or for that actor playing in a sound film), or was it instead because sound roles required different skills – skills that many silent actors lacked? The explanations are not mutually exclusive, but to the degree better-known actors were more seriously affected by the coming of sound, an image-based explanation

[41] For the 1928-30 period, the hazard ratios are 1.35 (Cox model) and 1.15 (grouped data model), both highly statistically significantly different from 1.0.

[42] The 72 Top Ten actors account for less than one percent of all actors in the data set, and less than two percent of the actor-year observations in the panel. Estimating hazard rates for the set of Top Ten actors separately, I find slightly smaller hazard ratios than for the entire population of actors (1.15 versus 1.23 using the grouped data model), but they are very imprecisely estimated (which is not surprising given the tiny size of the Top Ten sample).

becomes plausible, whereas if both better- and lesser-known actors were similarly affected, the skills-based explanation becomes more plausible.

In order to distinguish between better-known and lesser-known actors, I will make use of the fact that the IMDB lists for each film the order in which actors appeared in the credits. I will classify an actor listed as first or second in the credits as playing a "lead role." This is an imperfect designation – there are sometimes more than two leads in a film (as in a Marx Brothers production, say), or it may be difficult to determine any "leads" (as in "all-star" projects). However, to the degree the order of listing in the credits is correlated with the significance to the film of the role played, first or second listing can serve as a proxy for having played an important role.

I will explore whether the transition to sound affected actors who played at least one lead role, thus defined, ("ever-leads") differently from actors who never played a lead role ("never-leads"). Of the 8930 actors in the data set, 2589 played at least one lead role. The second part of Table 2 shows summary statistics for "ever-leads" and "never-leads" separately. Actors who played at least one lead role had longer careers – more than three years longer – were slightly younger on average, and much more likely to be female (which probably accounts for the age difference – female actors tend to start and end their careers at younger ages). These differences suggest my measure is indeed picking up more and less "important" actors. Actors who played one or more lead roles account for about 30 percent of the actors in the data set, but nearly half of the actor-year observations in the panel.

I will begin by including an {ever-lead x transition period} interaction term along with an ever-lead dummy variable in the Cox model estimation. The interaction term will pick up whether the transition period affected actors who played lead roles differently from actors who did not. The estimated hazard ratios and corresponding z-statistics are shown in the first two columns of

Table 5. Playing a lead role is associated with substantially lower career mortality, not surprisingly, but the point estimates on the interaction term are very close to 1.0, the z-statistics are very small, and the hazard ratios for the transition indicator are more-or-less the same as those shown in Table 4. It appears that the transition period affected major and minor actors in roughly equal measure.

Turning to the grouped duration data model, given that each career year is allowed a different but constant baseline hazard, I cannot include a transition period interaction term. Instead, I simply estimate hazard ratios separately for ever-leads and never-leads. The results are shown in columns 3-6 of Table 5. Similar to the Cox model results, the point estimates of the hazard ratios for the transition period are nearly equal across the two groups.

In short, the coming of sound appears to have affected major and minor actors (defined by whether the actor ever played a lead role) similarly. Indeed, if anything, the point estimates indicate that less well-known (never-lead) actors had *higher* hazard rates. This suggests that the increased hazard rate – rate of exit – associated with the transition years cannot be due primarily to the actor's silent film image. Rather, it suggests the alternative: that the skills needed to succeed in sound films were simply different than the skills needed to succeed in silent films.

Silent Era versus Sound Era Exit Rates

By using a single transition period indicator, I am picking up how the transition-period hazard rate compares to the average hazard rate over the silent and sound periods combined. However, it is possible that the underlying hazard rate changed with the coming of sound. To see if this were so, I will first exclude the transition period (1929-32) and simply compare the silent and sound eras. I will then then replace the transition period dummy variable with separate silent era (1920-28) and sound era (1933-40) dummy variables, and estimate the relationship over the

entire 1920 through 1940 interval. This latter approach will not affect the average influence of the transition period, of course, but it will allow it to differ across the two eras.

The results are shown Table 6. The first four columns show that hazard rates were from 30 to 80 percent higher in the sound era than in the silent era (depending on the model), transition period excluded. Columns 5 through 8 show that whereas the silent-era hazard is 30 to 50 percent below the transition period hazard, the sound-era hazard is less than ten percent below. Interestingly, the two duration models now produce hazard ratios that are much closer in value.

In short, it appears that although the rate of actor exit fell somewhat after the very early 1930s, it did not return to what it had been through most of the 1920s. This suggest the possibility that some of the effect generally attributed to the transition period may instead reflect the fact that actor rates of exit were simply higher (at least through the 1930s) once sound films became the norm.

It should be emphasized that because I measure hazard rates only through 1940, I cannot say whether the higher career mortality (relative to the silent era) I document for the 1930s continued, was magnified, or fell back in subsequent years. Moul (2001) argues the quality of sound films improved in the 1930s with cumulative experience, as the result of "learning by doing." It is certainly true that 1939 has been labeled a "golden year" for motion pictures – it saw the release of *Gone with the Wind, The Wizard of Oz, Mr. Smith Goes to Washington, Stagecoach,* and a number of other now-classic films.[43] But "learning" presumably occurred during the silent era, too. Motion pictures were then a relatively new phenomenon, with feature films dating back

[43] See, e.g., http://www.latimes.com/entertainment/envelope/la-et-mn-en-oscar-archives-1939-films-20141125-story.html, http://articles.latimes.com/1989-01-01/entertainment/ca-223_1_greatest-year, https://blog.findmypast.com/1939-the-golden-year-of-cinema-1436604449.html. See Sedgwick (2002) for a discussion of product differentiation in movies from the mid-1940's through the mid-1960s.

only to the early-to-mid-teens.[44] Many critics consider the art of the silent film to have reached its apex in the late 1920s (just as sound films emerged), with the release of such motion pictures as *Sunrise*, *The Passion of Joan of Arc*, and *The Crowd*. Motion pictures have continued to change through the present day. Determining whether actor hazard rates have risen, fallen, or remained unchanged over time is a topic for future research.

V. A QUICK LOOK AT THE NUMBER OF ACTORS EMPLOYED

The general consensus among economists is that product innovation, as opposed to process innovation, expands employment.[45] The coming of sound was a bit of both – a product innovation that changed the factor mix. "Actor" was the largest category of employee directly affected.[46] What happened to total actor employment?

Sound indeed appears to be associated with increased demand for motion pictures, as to be expected of a successful product innovation – movie attendance rose from an average of nearly 50 million tickets sold annually during the 1920s to nearly 80 million sold annually during the 1930s.[47] Using IMDB data, I calculate that the number of feature motion pictures produced rose

[44] For a brief history of the emergence of the feature film and how it affected the structure of the film industry, see Hanssen (2000, 401-8) and the citations therein.

[45] A product innovation changes the demand function, while a process innovation changes the production function, as, e.g., Van Reenen (1997) discusses. For surveys of the literature on innovation and employment, see, e.g., Chennell and Van Reenen (2002), Spiezia and Vivarelli (2002), Vivarelli (2014). Chennell and Van Reenen (2002, 215) conclude, "Overall, there appear to be consistently positive effects of proxies for product innovation on the growth of employment . . . [but] The results for process innovations are very mixed."

[46] Studios also employed directors, cameraman, and so forth (albeit in smaller numbers; e.g., Friedman 1937), who may also have been affected by the coming of sound. Sound also created new jobs (e.g., sound editor) while destroying old (e.g., title card writer).

[47] The 1947-8 edition of the *International Motion Picture Almanac* provides annual attendance figures. All else was not equal over the period, of course. In particular, the Great Depression began near the start of the sound era, which could either have contributed to or subtracted from the rise in attendance – as incomes fell, some customers presumably reduced their movie attendance while others, substituting away from more expensive alternatives, increased it. In fact, film attendance rose precipitously through 1930, fell for the next three years (consistent with the conventional wisdom that the Depression arrived in Hollywood a year late) and then rose to near-double silent-era levels and remained there for the rest of the decade.

from an average of about 300 per year during the 1920s (when film shorts were more common) to more than 500 per year in the 1930s. Furthermore, because sound plots were more complex, casts were larger – the average silent film featured 8.5 credited actors, while the average sound film featured nearly thirteen. As a result, the number of different actors playing credited roles annually nearly doubled, from about 450 per year in the 1920s to nearly 800 per year in the 1930s. Thus, although silent-era actors had good reason to be distrustful of the new technology (as the hazard ratios estimated in this paper indicate), aggregate employment in the movie acting profession increased substantially, just as models of product innovation predict (e.g., Van Reenen 1997).

VI. CONCLUSION

The replacement of silent by sound motion pictures may not be history's most important technological development from a social welfare perspective (though given the amount of time devoted to watching "sound film" today in a large variety of forms, who knows?), but it provides one of its most colorful examples of how product innovation can affect employment. Almost since its inception, the disruptive effect of sound technology on the careers of some of the silent era's most important actors has fascinated observers. In this paper, I conduct what I believe to be the first systematic analysis of the effect of the introduction of sound technology on actor careers. I analyze a data set of nearly 10,000 actors who played in motion pictures from 1920 through 1940, inclusive. I find the transition period to be associated with a large rise in hazard rates – in the rate at which actors exited from the movie acting business – not only among major stars but also among those who played more minor roles. I also find that sound films raised hazard rates generally, so that whereas the transition period is associated with 30-to-50 percent higher hazard rates as compared to the silent era, it is associated with only about 10 percent higher hazard rates as

compared the sound era (at least through the 1930s). The sound era also saw an increase in both the number of movies produced and the number of actors cast per movie (sound plots could be more complex), leading to a sharp rise in the total number of actors playing credited movie roles, consistent with the employment-expanding effects posited for product innovation.

In a widely cited article, Van Reenen (1997, 256) notes the "dearth" of studies on the direct effect of innovation on employment, a dearth he attributes to the fact that

> It is difficult to obtain firm-specific measures of technology on a consistent basis over time. Furthermore, when this information is available, one must control for the fact that technology, as well as employment, are chosen by the firm.[48]

By examining a technological innovation that upended an industry – and that was adopted by all firms at roughly the same time – I am largely able to get around these problems. I am also able to track how existing employees were affected, not merely how aggregate employment changed (e.g., Aghion et al 2018). Of course, the motion picture industry is idiosyncratic in many ways, and the impact of sound technology was unusually dramatic. Yet there have been other similarly dramatic developments and diffusions in the entertainment business: the effect of radio on vaudeville, the effect of television on movies, the effect of streaming on both – to mention only a few. If the information technology industry continues to churn out potentially Schumpeterian innovations, the coming of sound motion pictures may offer ever-more-relevant lessons for the years to come.[49]

[48] The question his paper addresses is "Is there a negative or positive association between innovation and employment at the firm level" (256). His is one of the few analyses that is able to develop a data set of firm-level data on innovation activity that can be matched to jobs. He explores the effect of competitive dynamics of innovation – what happens when one firm innovates while another does not – which I am not able to do in my study.
[49] For example, a 2017 *Hollywood Reporter* article discusses whether future films will need human actors at all: https://www.hollywoodreporter.com/behind-screen/how-artificial-intelligence-will-make-digital-humans-hollywoods-new-stars-1031553

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TABLE 1: Actors with at least Three Appearances in "Moneymaking Top Ten" from 1920 through 1940

Name	# appear.	First year	Last year
Douglas Fairbanks	7	1920	1926
Mary Pickford	7	1920	1926
Norma Talmadge	6	1920	1926
Marion Davies	4	1921	1925
Gloria Swanson	4	1921	1925
Rudolph Valentino	4	1922	1925
Thomas Meighan	5	1922	1926
Harold Lloyd	7	1922	1928
Lon Chaney	6	1922	1929
Colleen Moore	8	1923	1931
Fred Thomson	3	1925	1927
Hoot Gibson	3	1926	1929
Clara Bow	5	1927	1931
Richard Barthelmess	3	1928	1930
William Haines	3	1928	1930
Janet Gaynor	5	1930	1934
Joan Crawford	7	1930	1936
Marie Dressler	4	1931	1934
Norma Shearer	4	1931	1934
Wallace Beery	8	1931	1940
Will Rogers	4	1932	1935
Joe E. Brown	3	1932	1936
Clark Gable	9	1932	1940
Shirley Temple	6	1934	1939
Bing Crosby	3	1934	1940
Fred Astaire	3	1935	1937
Ginger Rogers	3	1935	1937
James Cagney	3	1935	1940
Robert Taylor	3	1936	1938
Sonja Henie	3	1937	1939
Mickey Rooney	3	1938	1940
Tyrone Power	3	1938	1940
Spencer Tracy	3	1938	1940

Source: *Motion Picture Daily* annual poll of exhibitors. Does not include pre-1920 or post-1940 appearances.

TABLE 2: Summary Statistics

Variable	mean	stdev	min	max	# obs
Entire sample					
Career years	5.91	4.83	1	26	42,447
Age	38.3	13.9	0	86	42,447
Male	0.68	0.46	0	1	42,447
Ever-lead = 1					
Career years	7.33	5.23	1	26	19,548
Age	36.2	13.2	0	85	19,548
Male	0.62	0.49	0	1	19,548
Ever-lead = 0					
Career years	4.70	4.01	1	26	22,899
Age	40.0	14.3	0	886	22,899
Male	0.74	0.44	0	1	22,899

Source: IMDB. 8930 actors who played a credited role in at least one feature films between 1920 and 1940, inclusive

TABLE 3: Empirical Survival Function

Actor career year	Beginning total	Exits	Censored	Survival function	std. error
1	8930	1478	659	0.83	0.00
2	6793	1029	435	0.71	0.00
3	5329	670	300	0.62	0.01
4	4359	417	268	0.56	0.01
5	3674	354	236	0.51	0.01
6	3084	290	197	0.46	0.01
7	2597	239	162	0.42	0.01
8	2196	189	139	0.38	0.01
9	1868	161	146	0.35	0.01
10	1561	157	110	0.31	0.01
11	1294	98	117	0.29	0.01
12	1079	100	83	0.26	0.01
13	896	96	66	0.23	0.01
14	734	79	50	0.21	0.01
15	605	52	51	0.19	0.01
16	502	57	35	0.17	0.01
17	410	48	30	0.15	0.01
18	332	34	29	0.13	0.01
19	269	30	17	0.12	0.01
20	222	17	28	0.11	0.01
21	177	15	19	0.10	0.01
22	143	13	21	0.09	0.01
23	109	6	23	0.09	0.01
24	80	9	25	0.08	0.01
25	46	2	21	0.07	0.01
26	23	1	22	0.07	0.01

Source: IMDB – 8930 actors who played credited roles between 1920 and 1940, inclusive

TABLE 4: The Transition Period
(Hazard Ratios)

Time to exit (i.e., career end), in years (z-statistics in parentheses)

Variable	Cox model		Grouped data model	
Transition	1.432	1.438	1.229	1.224
	(11.2)	(11.3)	(6.4)	(6.3)
Age		1.021		1.031
		(2.9)		(4.1)
Age2		1.000		1.000
		(-1.5)		(-2.4)
Male		1.781		1.843
		(3.4)		(3.6)
Male x age		0.945		0.939
		(-6.4)		(-7.1)
Male x age2		1.001		1.001
		(7.1)		(-7.9)
# obs	42,447	42,477	42,477	42,477
# subjects	8930	8930	8930	8930
# failures	5641	5641	5641	5641
Ln likelihood	-46874	-46668	-16244	-15946

The table shows hazard ratios, with z-statistics in parentheses. The data set covers the 1920-1940 period, but counts years playing credited roles back to 1915. An actor's career is censored if he/she played a credited role after 1940.

TABLE 5: Ever-leads versus Never-leads and the Transition Period
(Hazard Ratios)

Time to exit (i.e., career end), in years (z-statistics in parentheses)

Variable	Cox model		Grouped data model			
			Ever-lead = 1		*Ever-lead = 0*	
Transition	1.466	1.467	1.253	1.250	1.307	1.307
	(10.4)	(10.4)	(3.5)	(3.5)	(7.2)	(7.2)
Everlead	0.405	0.393				
	(-24.9)	(-25.0)				
Transition x ever-lead	0.982	0.984				
	(-0.3)	(-0.2)				
Age		1.019		1.141		0.995
		(2.6)		(6.8)		(-0.8)
Age2		1.000		0.998		1.000
		(-2.6)		(-6.0)		(-0.8)
Male		1.396		4.079		0.910
		(2.1)		(3.0)		(-9.6)
Male x age		0.946		0.867		0.969
		(-6.5)		(-5.9)		(-3.4)
Male x age2		1.001		1.002		1.000
		(7.8)		(6.7)		(4.9)
constant			0.082	0.008	0.121	0.095
			(-9.0)	(-10.8)	(-7.0)	(-4.6)
# obs	42,447	42,477	19,548	19,548	22,899	22,899
# subjects	8930	8930	2589	2589	6341	6341
# failures	5641	5641	1403	1403	4238	4238
Ln likelihood	-46416	-46219	-5019	-4867	-10711	-10563

The table shows hazard ratios, with z-statistics in parentheses. The data set covers the 1920-1940 period, but counts years playing credited roles back to 1915. An actor's career is censored if he/she played a credited role after 1940.

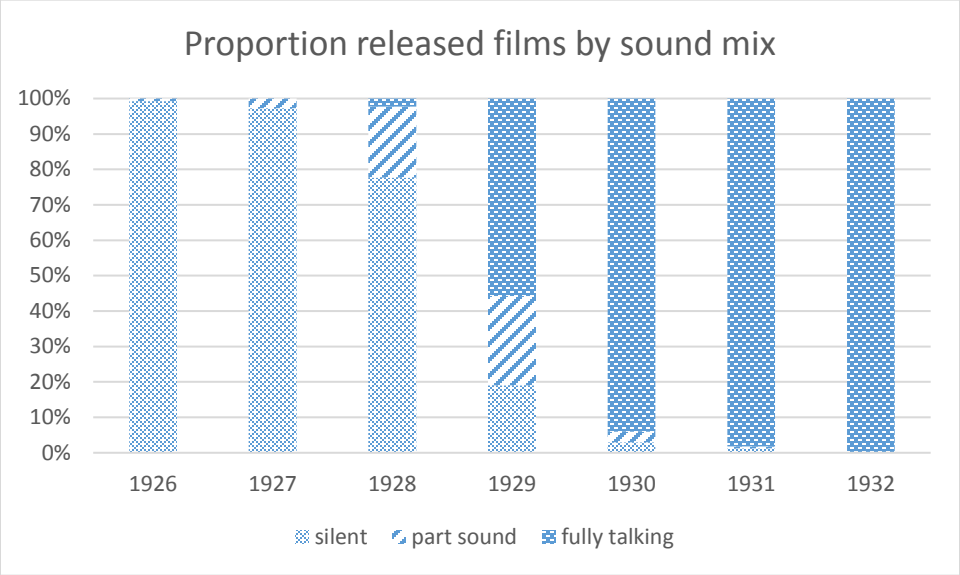
TABLE 6: Silent Period versus Sound Period
(Hazard Ratios)

Time to exit (i.e., career end), in years (z-statistics in parentheses)

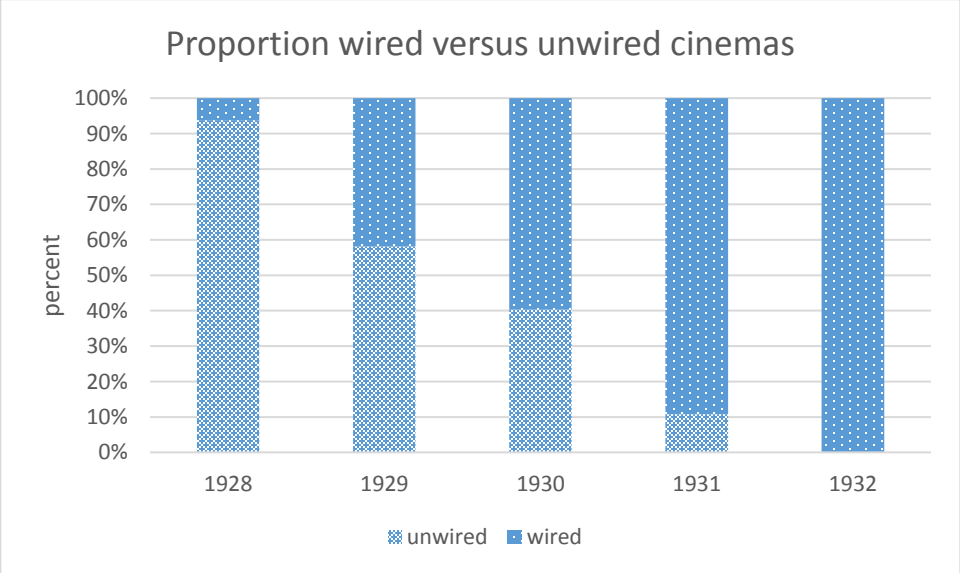
	Transition years excluded				All years (1920-40)			
Variable	Cox model		Grouped data model		Cox model		Grouped data model	
Silent					0.512	0.508	0.689	0.691
					(-18.1)	(-18.3)	(-10.0)	(-9.9)
Sound	1.785	1.805	1.327	1.333	0.925	0.927	0.926	0.931
	(18.4)	(18.7)	(9.0)	(9.1)	(-2.3)	(-2.2)	(-2.2)	(-2.1)
Age		1.021		1.030		1.023		1.030
		(2.5)		(3.6)		(3.0)		(4.1)
Age2		1.000		1.000		1.000		1.000
		(-1.2)		(-2.0)		(-1.6)		(-2.3)
Male		1.671		1.728		1.709		1.824
		(2.7)		(2.9)		(3.3)		(3.6)
Male x age		0.946		0.941		0.945		0.940
		(-5.6)		(-6.2)		(-6.4)		(-7.0)
Male x age2		1.001		1.0001		1.001		1.001
		(6.2)		(7.0)		(7.1)		(7.9)
constant			0.084	0.039			0.086	0.039
			(-12.9)	(-13.0)			(-10.0)	(-11.6)
# obs	34,289	34,289	34,289	34,288	42,447	42,477	42,477	42,477
# subjects	8328	8328	8328	8328	8930	8930	8930	8930
# failures	4334	4334	4334	4335	5627	5627	5627	5627
Ln likelihood	-34977	-34802	-12687	-12459	-46694	-46482	-16199	-15927

The table shows hazard ratios, with z-statistics in parentheses. The data set covers the 1920-1940 period, but counts years playing credited roles back to 1915. An actor's career is censored if he/she played a credited role after 1940. The transition period 1929-32 is omitted from the first four columns' estimations.

FIGURE 1: Proportion of Silent versus Sound Feature Films (1926-32)

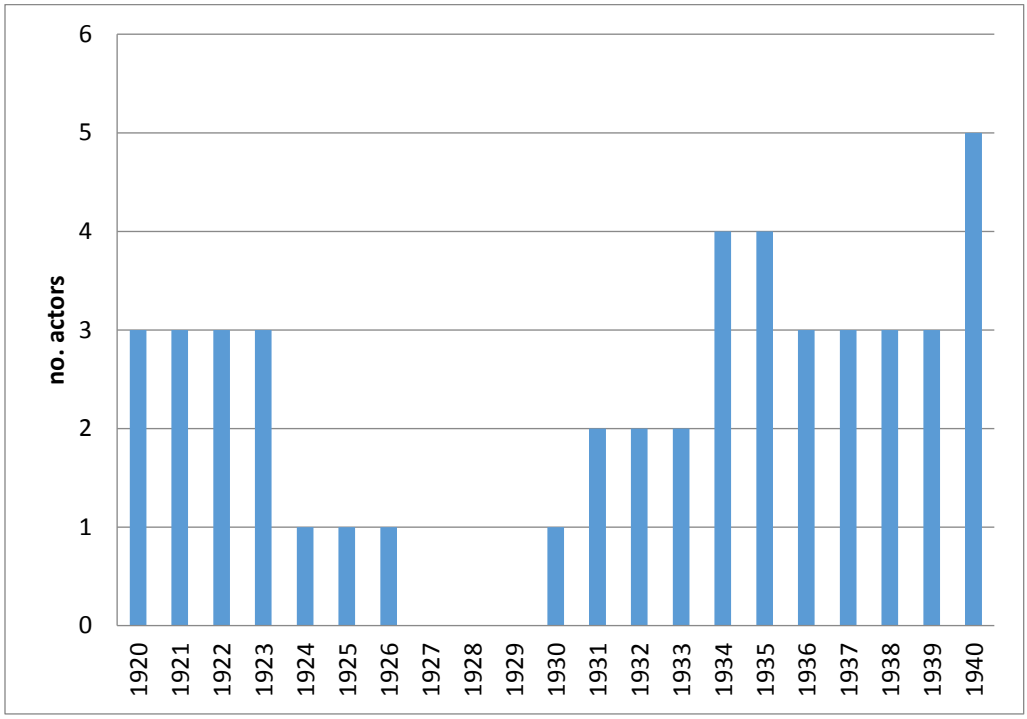


Source: IMDB



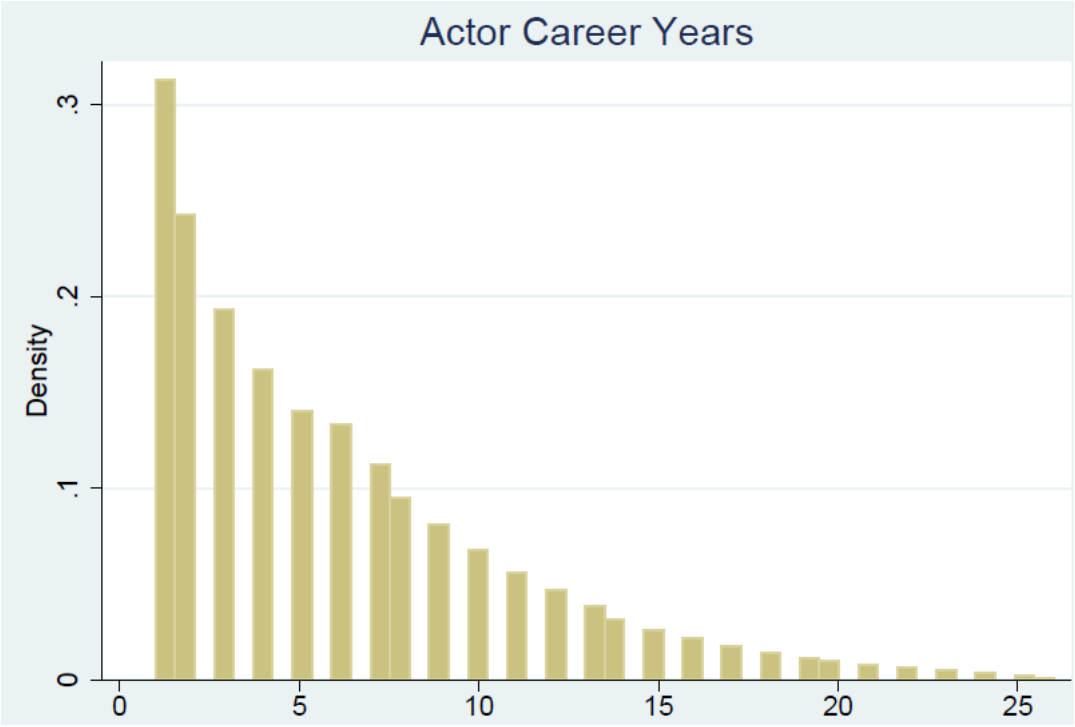
Source: 1929 *Film Daily Yearbook*, p 577; 1929 *Motion Picture Almanac*, p 111; *1930 Film Daily Yearbook*, p 3; pp 706-; *1931 Film Daily Yearbook*, p 706; *1932 Film Daily Yearbook*, p 706; *1933 Film Daily Yearbook*, p 706

FIGURE 2: Number of Actors on Top Ten List Five Years Later



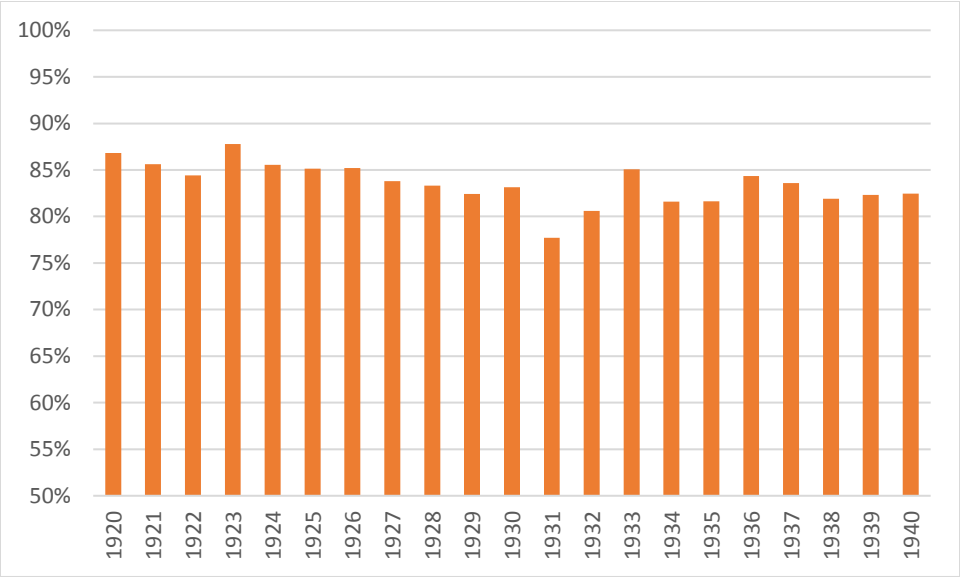
Source: *Motion Picture Daily* annual poll of exhibitors.

FIGURE 3: Histogram of Actors by Career Length (Years)



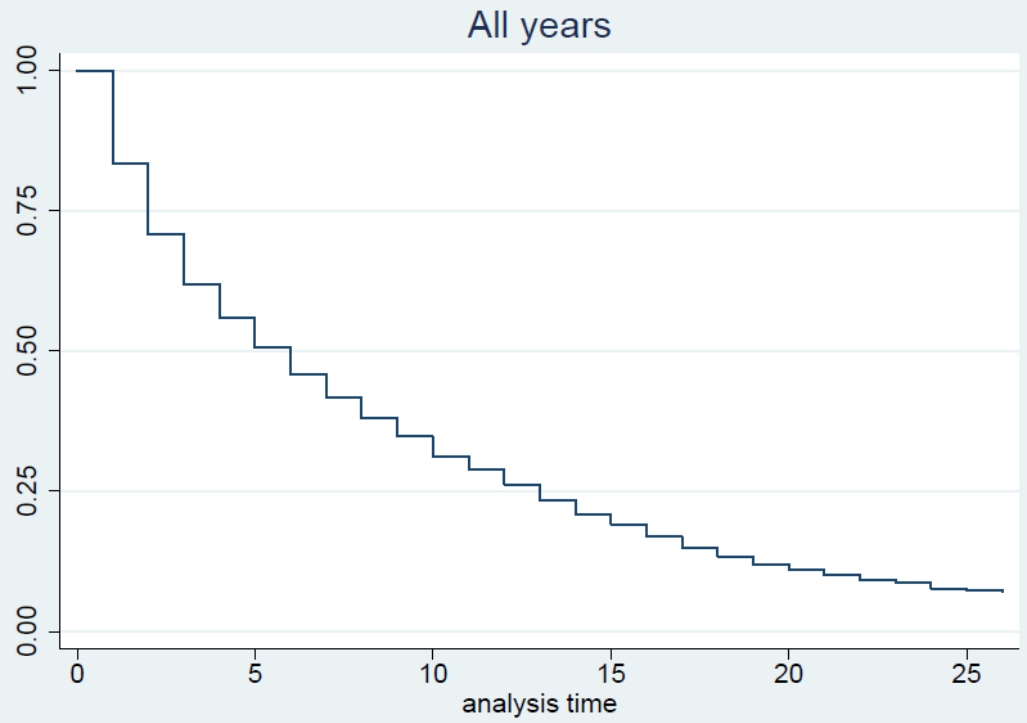
Source: IMDB – 8930 actors who played credited roles between 1920 and 1940, inclusive

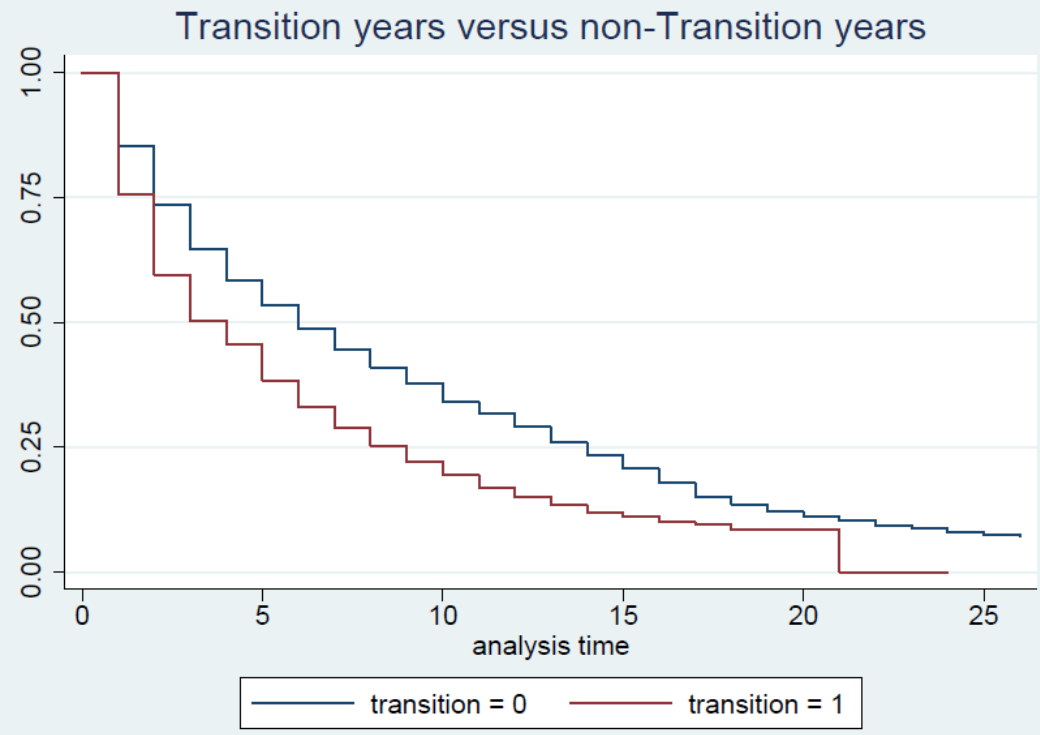
FIGURE 4: Proportion of Actors Repeating in a Future Year (1920-40)



Source: IMDB – 8930 actors who played credited roles between 1920 and 1940, inclusive

FIGURE 5: Kaplan-Meier Empirical Survival Curves (1920-40)





Source: IMDB – 8930 actors who played credited roles between 1920 and 1940, inclusive