EVIDENCE OF QUALITATIVE LEARNING-BY-DOING FROM THE ADVENT OF THE ‘TALKIE’*

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Empirical work on learning-by-doing has largely been limited to examinations of production costs. In this paper I present anecdotal and statistical evidence of qualitative learning (the idea that product quality improves as producers gain experience with the relevant technology). Using U.S. motion picture industry data from 1925 to 1941, I reject that the transition to sound pictures resulted in a fixed increase in film-quality in favor of my hypothesis that this quality differential increased with the producing studio’s sound-experience. These results are robust to several different specifications.

‘[The Jazz Singer] is the most important event in cultural history since Martin Luther nailed his theses on the church door.’—Frances [Mrs. Samuel] Goldwyn, on the Los Angeles premiere of the first ‘talkie’ feature

Since the formal conception of learning-by-doing (Arrow [1962]), theoretical models and empirical studies have focused upon how production costs change as a function of firms’ production experience (Clemhout and Wan [1970], Gemery and Hogendorn [1993], Parente [1994], Irwin and Klenow [1994], Benkard [1999]). One could additionally consider, however, how the quality of a firm’s products might change with production experience. I am aware of only one empirical study that considers such a relationship between experience and quality (Thompson [2001]), and it emphasizes a trade-off between the quantity and quality of output. The goal of this paper is to consider a different angle and document evidence of an increasing relationship between a product’s quality and its producer’s level of production-experience. Towards this end, I examine the American motion picture industry over the time period

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1 Berg, p. 173.
surrounding the adoption of synchronous sound-recording technology (1925–1941).

The transition from silent to sound-recorded pictures coincided with a significant increase in consumer demand for movies. Loew’s, the parent corporation of Metro-Goldwyn-Mayer and one of the largest studios before the introduction of sound, saw its real revenues grow 171% from 1925 to 1941. Warner Bros. pioneered the commercial use of synchronous sound-recording and experienced revenue growth of over 2500% in the same period. Sound’s arrival seems a likely candidate to explain this growth, but the manner in which the transition to sound pictures might have caused it is less obvious. Below I provide evidence rejecting the view that consumers simply preferred sound pictures to silent pictures. In its place, I propose that studios improved the quality of their movies as they gained experience with sound-recording technology, and that consumers responded to this higher quality by increasing their demand for sound pictures.

A few statements on the nature of movie quality will prove helpful for what follows. Motion pictures, like most other goods, exhibit both horizontal and vertical differentiation. The former is characterized by different genres (e.g., comedy rather than horror) and is a response to heterogeneous tastes among consumers. The latter is my focus in this paper. While movie quality is clearly a less tangible commodity than Thompson’s [2001] rates of defective welding among the Liberty ships, such quality most certainly exists. Consumers then and now recognize (and avoid if they can) poor lighting, clumsy writing, and stilted dialogue, to name a few negative traits. If this vertical differentiation is important, it will manifest itself in demand. An additional benefit of examining this industry is the largely fixed nature of admissions prices, implying that demand changes map directly into revenues. There is little concern that higher quality movies face higher admissions prices, which might counteract quality’s direct effect on demand.

This paper is divided into four sections. Section I gives a brief historical background of movie production as it pertains to sound as well as idiosyncratic details of the motion picture industry of the time. In it I motivate the appropriateness of my sample for this topic and the model that I take to the data. The data set is outlined in Section II, and Section III discusses the intuition behind the reduced-form estimation and the statistical results. I conclude with potential extensions in Section IV.

1. HISTORY

Work to integrate recorded sound into movies began shortly after projection technology was introduced in 1898.2 Technical difficulties,

2 I am indebted to Krow’s The Talkies [1930] for this historical overview.
however, were severe, and the industry was soon littered with technologies that failed to resonate with exhibitors and consumers.\(^3\) By 1926, even Thomas Edison, the inventor of the motion picture, publicly stated that movies could not be improved with the addition of sound.

Western Electric's decision to spend three years improving its sound-on-disc technology\(^4\) can be best understood as a by-product of this cautious environment. In March of 1925, Western Electric's representatives (rejected by the major studios) finally approached Sam Warner of Warner Brothers about making synchronous-sound motion pictures. A partnership was formed, and sound-recording began under the trademark Vitaphone.

At about the same time, William Fox of Fox Productions was experimenting with the rival recording system Movietone, a sound-on-film technology.\(^5\) His attempts to bypass Vitaphone patents failed when negotiations with General Electric regarding vacuum-tube amplifiers broke down, and he was forced to sublicense Western Electric's amplifiers in December 1926. Although the two technologies coexisted for several years, the common amplifier eventually led to a relatively painless transition to the sound-on-film technology that has survived to the present day.

These new technologies were first used in shorts, movies of less than fifteen minutes that preceded the feature presentation. Vitaphone's premiere was August 6, 1926, and included a recorded soundtrack for the feature as well as several shorts with recorded dialogue. Movietone was not introduced until January 21, 1927, and its shorts were news footage (the Movietone News) rather than entertainment. Sound was relegated to these shorts for several months while both companies improved their technical skills.

The first feature in which synchronous sound recording was used for dialogue came in the autumn of 1927. Warner Bros. released *The Jazz Singer* starring Al Jolson on October 6, and sound made its auspicious, if somewhat compromised, entrance. The movie was a technical mongrel, with recorded songs but virtually all dialogue in text.\(^6\) Consumers responded very favorably, and *The Jazz Singer* went on to set records for both its box office grosses and its longevity.

Those records provided the impetus for the major studios to begin the adoption of sound-recording technology. Although they had experimented

\(^3\) A few of the failures were the Kinetophone, the Vivaphone, and the Chronophone. (Fielding, p. 5).

\(^4\) Sound-on-disc technology was effectively a phonograph-like record played in synchronization with the film.

\(^5\) This technology records the sound directly onto the film, greatly facilitating the synchronization process.

\(^6\) The lone spoken line ("Wait a minute, wait a minute, you ain't heard nothing yet . . . Wanna hear "Toot, Toot, Tootsie"?"") supposedly drove viewers wild.
with sound in shorts, only Paramount had released any features (Wings, recorded soundtrack) using such technology before 1928. Shortly thereafter, though, Warner Brothers released the first all-talkie (The Lights of New York, February 1928), and the revolution of sound was fully upon Hollywood. The rapid and total nature of sound's adoption can be seen in Figure 1. By mid-1930, virtually all features from both major and independent studios used synchronous sound-recording. Theatres also adopted the new technology rapidly. Figure 2 illustrates the short time frame in which theatres were 'wired' for sound. By 1935, all theatres were wired to handle the exhibition of sound pictures.

While shorts were used as laboratories for technical challenges (e.g., lighting, sound-proofing, and synchronization), some less tangible, if no less important, issues could be improved only through trial and error. First, screenwriters were now responsible for dialogue that not only forwarded the story but also seemed realistic. Early talkies were often mocked for their unwieldy and stilted lines. Second, actors and actresses had to learn how to use their voices as well as their bodies. Some could not make the transition. Foreign accents killed a number of careers. A few players looked and sounded good on screen but couldn't remember their lines. Diction was at a premium, and a mass migration from the legitimate theater to Hollywood occurred. Third, plots had to evolve to fully exploit the new possibilities of sound. The Jazz Singer was the first such example, and musicals followed for many years as a genre that had no counterpart.
in silent films. Likewise, certain plot devices (e.g., traditional vaudeville) that had succeeded in silent pictures seemed slow and overly simple when paired with recorded dialogue. Quality improvements along all three of these dimensions could only be observed by noting films’ gross totals and revising future projects appropriately.

Because of Western Electric’s initial caution, this new technology was nearly mature at its original application. Additionally, it changed little beyond the transition to sound-on-film over the coming years. I argue that talkies were produced with an essentially static underlying technology, and consequently the trends that I now examine were not based upon improvements of Vitaphone and Movietone. Any industry-wide improvements in movie quality stemmed from filmmakers learning how to better utilize these technologies. The market environment appears to suit the necessary conditions for a learning-by-doing analysis.

Certain aspects of the modern motion picture industry date back to the era of silent pictures. Specifically, studios then and now handle most of a movie’s promotion, arguably to prevent free-riding. After a movie has been produced, this promotion is one of the major costs of the distributor. The other major decision for a distributor is the number of screens on which to show a given movie. Unlike today, many theatres (primarily the more extravagant first-run ones) were owned by the major studios prior to

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Figure 2
The Transition to Wired-for-Sound Theatres (Data from Film Daily Yearbook (1946), p. 53)

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See DeVany and Eckert [1991].
the Paramount Consent Decrees. Finally, admissions prices, then as now, were generally fixed over time and over movies at any given theatre. The market effectively clears by changing the length of a movie’s run.

II. DATA

I collected my data primarily from The Film Daily Yearbook, an annual industry publication from 1919 to 1969. The Yearbook includes financial reports from the major contemporary movie-related companies (production studios, theater chains, Kodak, etc.), a detailed listing of all feature releases in the previous year, and other various statistical items. Beginning with the 1929 edition (covering films released in 1928), movies were categorized as Silent, Synchronized/Sound Effects, Part-Talkie, or All-Talkie. Films released prior to 1928 have been categorized using the Internet Movie Database. I mapped these three sound categories into a binary sound variable using a frontier criterion. Releases in 1928 and earlier were considered sound pictures if they fell into any of the three sound categories. Only talkies (either part or all) released in 1929 were considered sound pictures. In 1930 and all following years, only all-talkies qualify as sound-pictures. I measure a studio’s experience in sound-pictures with the number of sound releases produced by that studio prior to that year.

Production studios were admitted into the sample if revenue data from the Yearbook were available for any part of the 1925–1941 time period. The starting year of these revenues depends upon the date of the studios making their stock publicly available. All revenues have been deflated to 1925 dollars by the consumer price index. Of the major studios at the time, only United Artists is absent from the Yearbook’s records. Additionally, the independent studio Monogram has been included, bringing the total number of studios to eight. The resulting (unbalanced) panel consists of 97 observations. The starting dates for the studios are as follows: 1925—Loew’s, Universal, and Warner Bros.; 1929—RKO and Fox; 1933—Columbia; 1935—Paramount; and 1938—Monogram.

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8 Those decrees in 1948 concluded the government’s antitrust case against Loew’s, Paramount, RKO, 20th Century Fox, and Warner Bros. Among other conditions, those studios were required to divest themselves of all theatre holdings.

9 www.imdb.com

10 In 1928 and 1929, most features were released in both sound and silent form. In such cases, the more advanced sound technology determines the binary variable.

11 The sample ends in 1941 to avoid the unknown yet potentially large impact of the U.S. entry into World War II.

The rapid transition to sound resulted in this sample being heavily skewed towards distributors which released only talkies. In only 19 of the observations are any silent movies released by the given studio, and only seven observations involve distributor portfolios that are exclusively silent pictures. Since the qualitative learning hypothesis does not depend upon distributors having mixed portfolios, this is problematic only from the econometric perspective and not from the conceptual one.

Horizontal integration within the industry also needs to be addressed among the studio aggregates. I assume that a merger yields a strict addition of experience, namely that the acquiring studio gains the acquired studio’s sound-picture experience the following year. This is relevant at three separate points in my sample. First, RKO was formed in 1929 when the Radio Corporation of America (RCA) acquired Film Booking Office (a production studio) and Keith-Albee-Orpheum (an exhibition chain). Second, Warner Brothers completed its acquisition of First National in 1929. Third, RKO acquired Pathe in 1935. The takeover of Loew’s by Fox was so short-lived that I have ignored it.13

Finally, in an unfortunate accident of timing, the adoption of synchronous sound recording coincided with the Great Depression. Though

13 Fox announced he had acquired a majority of Loew’s stock in March 1929. His highly leveraged move was poorly timed, though, and all Fox assets were divested after the October stock market crash.

the sentiment of the motion picture industry is that movie demand is neutral with respect to the business cycle, I include the U.S. unemployment rate to control for the wide variation in national prosperity from 1925 to 1941. I also consider a time trend variable (1925 is year 1) to control for widespread trends that might be confused with the studio-experience variable.

A glossary of variables can be found in Table 1, and summary statistics are available in Table 2.

### III. RESULTS

The reduced-form estimates that are feasible with these data require some discussion regarding their interpretation. I require two basic conditions to yield testable implications regarding my qualitative learning-by-doing hypothesis. First, the relevant demand must be convex with respect to its favorable determinants. This assumption yields the plausible result that distributors emphasize their best prospects by showing them on more screens and promoting them more heavily. It also neatly meshes with Rosen's model of superstars [1981], in which product differentiation leads to 'imperfect substitution among sellers' and technology is such that 'costs of production do not rise in proportion to the size of the seller’s market.'

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**Table 2: Summary Statistics**

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*Note: unbalanced panel of 97 observations from 8 studios (1925–1941)*

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15 This is sufficient since the demand for any movie is presumably monotonically increasing in both of the distributor's decision variables, advertising and the number of exhibiting screens.

16 Rosen, p. 847.

Second, movies are primarily experience goods that consumers typically purchase only once. Given this reality, some mechanism is needed for consumers to know which movies are of higher quality prior to their purchase decisions. While it is possible that consumers responded to the identity of the producing studio in a sort of 'brand-loyalty' effect, it seems likelier that consumers improved their pre-viewing information in other ways. Possible avenues for this information include the opinions of movie reviewers and signaling equilibria through advertising expenditures. The most probable form of information transmission, however, was the word-of-mouth dynamic among consumers. De Vany and Walls [1996] provide empirical support for the importance of information transmission among current movie consumers, and there is little reason to believe that such transmission was less relevant some sixty years earlier.

The general equation that I estimate with the data is

\[
\text{REV}_{ij} = \alpha_0 + \alpha_1 \text{UNEMP}_t + \alpha_2 \text{TIME}_t + \alpha_3 \text{SHARE}_{ij} \\
+ \alpha_4 \text{SHARE}_{ij} \times \text{EXP}_t + \epsilon_{ij}
\]

The variables of most interest to the learning hypothesis are the share of a studio’s releases that use sound (SHARE) and the interaction of that share with the studio’s experience using sound (SHARE*EXP). A simple consumer preference of talkies to silent pictures implies that \(\alpha_3 > 0\) and \(\alpha_4 = 0\): Studios’ per-movie revenues (REV) rise as studios’ portfolios of movies move towards exclusively talkies. If, however, consumers also respond to the quality of talkies and that quality is increasing in production experience, then \(\alpha_4\) should be positive. My least squares estimates (displayed in Table 3 [1]) offer strong support that consumers did respond favorably to the movies of more experienced studios. The estimated coefficient of the interaction variable is positive and highly significant. From the point estimates, a studio with experience producing 100 talkies and with a portfolio of entirely talkie features averaged about $500,000 more per movie than a studio with all talkies but no production experience. In line with the industry’s conventional wisdom, unemployment’s effect on per-movie revenues is not significant, but the time-trend is a significantly negative determinant.

The reduced-form nature of the above estimation eliminates any theoretical reasons to suspect bias from the endogeneity of distribution. However, it does not address the potential endogeneity of production, specifically the decision regarding whether any given movie will be silent or a talkie. Consider the following. Throughout my sample, MGM is clearly the largest studio, having the most revenues in all but two of my sample’s 17 years. This occurs despite the number of its annual releases being comparable to the other major studios. Suppose it dominated in this way because it consistently made better, higher budget movies. It might seem
Table 3: The Effect of Experience in Producing 'Talkies' on Revenues

<table>
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Studio-specific intercepts? No Yes No Yes No Yes No
Studio-specific coefficients? No No Yes No Yes Yes No

R^2 0.39 0.91 0.88 0.91 0.88 0.92 0.90
F statistic n/a 69.21 49.80 68.32 49.47 80.42 57.49

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Notes:
Dependent variable: yearly per-release revenues by studio (REV).
Least squares estimates: each coefficient estimate above its estimated standard error.
F statistic: test statistic regarding common intercept or coefficient restriction.
All F statistics significant at 99% confidence level.

intuitive that such a studio would have both the inclination and the resources to quickly make the transition from silent to sound pictures and in so doing accumulate much experience with the sound recording technology. This also appears to describe MGM, its experience with talkie production lagging only the pioneering Warners. Given this, it seems not only possible but likely that the positive effect of the experience interaction term is due not to qualitative
learning but instead to the fact that MGM and similar studios made more expensive and better movies throughout the sample.

I address this concern by estimating studio-specific intercepts and studio-specific coefficients on SHARE. Ideally, I would estimate both simultaneously, but the fact that the late-coming studios released no silent features during my sample precludes this. I maintain a common coefficient on the experience interaction term. The studio-specific parameters allow studios to vary in their average quality of all movies in the intercept case and in their average quality of talkies in the coefficient case. Results can be found in Table 3 [2-3]. This potential source of bias does not appear to be driving my primary result. Estimates of the experience parameter are positive, robust, and precisely estimated. In both instances, I reject the hypothesis of a common parameter in favor of the studio-specific alternative. The estimates of the studio-specific parameters support the intuition behind the 'big-spending' studio critique, even if the concern was not decisive. MGM's per-movie revenues were significantly greater than any other studio's revenues over my sample, a result that is especially apparent in the case where studios differ in the average quality of their talkies.

There are other candidates for omitted variable bias that might distort the estimates. One obvious criticism concerns the gradual wiring of the country's theatres for sound. A studio's revenues might be expected to increase with sound releases at greater rates when more theatres are available to exhibit those movies. It is difficult to directly incorporate this concern because of the degree of vertical integration in the industry. The relevant number of available wired theaters might lie anywhere along the continuum of a studio's own wired theatres to the total number of wired theatres in the country. Unfortunately, while my data include the number of all wired theatres for each year, those data are not subdivided by ownership. Here I assume that ownership is total, and I approximate each studio's number of wired theatres (WIREDTHS) as the product of the total number of wired theatres and the proportion of the studio's sound releases to that year's total sound releases. The intuition behind this measure is that studios would wire their theatres largely to keep pace with their own talkie production.

The results using the additional regressor of SHARE*WIREDTHS (Table 3 [4-5]) do little to detract from the conclusions of the base model. They do suggest that my data on wired theatres is deficient. In neither specification is the coefficient on the WIREDTHS interaction term significantly greater than zero. This is disturbing since the rapid wiring of theatres indicates that it is was profitable to do so, and the likeliest cause of such profitability is that wired theatres were a critical component in

17 Additional research might be warranted into this example of hardware and software, where hardware is wired theatres and software is movies.
revenue generation. The critical experience parameter, though, *is* significantly greater than zero in both cases, lending even more support to the existence of qualitative learning-by-doing. Better data on theatre wiring are necessary to convincingly dismiss the wiring hypothesis in favor of the learning hypothesis.

A second possibility is that learning was indeed the process that drove the growing quality differential between silent and talkie movies, but that it was consumers, not studios, who were the learning agents. Perhaps consumers needed experience viewing talkies before the movies were accepted, and it is this experience that causes the results. If that is the case, one would expect the demand for talkies to rise as a function of consumer experience with all talkies (CONSEXP). I use such a regressor in the results listed in Table 3 [6–7]. Again, the appropriate variable is SHARE*CONSEXP. The estimates suggest that if consumer learning had any effect, it was to *reduce* demand, perhaps as the novelty of sound wore off. Given the insignificant effect of the time trend in this specification, it seems likely that the significantly negative effect of the time trend in the other specifications is caused by the omission of this consumer experience variable. Most importantly, the effect of the experience-interaction variable is again positive and highly significant in both specifications.

IV. CONCLUSIONS

Using reduced-form estimation appropriate for the motion picture industry, I have rejected the explanation that the increasing movie studio revenues of the 1920s and 1930s stemmed from a constant quality advantage of sound pictures over silent pictures. The hypothesis that I accept for now is that the quality of sound pictures (and the resulting quality differential over silent pictures) increased as studios gained experience with synchronous sound recording technology. The list of alternative explanations of this result is large, but I have incorporated three of the more obvious and found that they do not alter my original findings. This paper then offers the first quantitative evidence of the existence of qualitative learning-by-doing.

Possible extensions are numerous. Replicating these results in other industries is a natural step. A basic concept of learning-by-doing is that gains from learning decrease with experience, and I have made no attempt to document such concavity regarding qualitative learning. Additionally, it would be interesting to model the theoretical strategic considerations of this sort of learning and especially to test if (in the motion picture industry) studios 'overproduced' talkies from a static point-of-view to purposely improve their future movies' quality and maximize some dynamic concept of profits.
REFERENCES


