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Time and Productivity Growth in Services: How Motion Pictures Industrialized Entertainment

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Abstract
When taking into account time, services can experience similar productivity gains as manufacturing. Motion pictures constituted the first technology that industrialized a labour-intensive service. Measuring output in time spent consuming them doubles output growth from 4.2 to as much as 9 percent per annum, accounting for 2 percent of U.S. GDP-growth between 1900 and 1938. Pure productivity growth caused 60 percent of this, their growing GDP-share 24 percent, and input transfers and physical capital each 8 percent. Falling ticket prices and rising opportunity costs kept the full-cost per spectator-hour constant, suggesting that the surge in demand was caused by rising full incomes and entertainment's high income elasticity. Imploding prices limited the pictures' expenditure share and made the economic impact go largely unnoticed.

> So long as the number of persons who can be reached by a human voice is strictly limited, it is not very likely that any singer will make an advance on the £10,000 said to have been earned in a season by Mrs. Billington at the beginning of the last century, nearly as great as that which the business leaders of the present generation have made on the last.
>
> Alfred Marshall[1]

When Charlie Chaplin was nineteen years old he appeared in three music halls a night. On one fine day he started in the late afternoon at the half empty Streatham Empire in London. Directly after the show he and his company were rushed by private bus to the Canterbury Music Hall and then on to the Tivoli (Chaplin, 1964; Ehrlich, 1986). This constituted the maximum number of venues an entertainer could visit on an evening, and thus the inherent limit to a performer's productivity. Yet, barely five

[1] 1947: 685-686; as quoted in Rosen (1981).

years had passed and every night Chaplin would appear in thousands of venues across the world at the same time. His productivity had increased almost unimaginably. He himself was able to capture only a small part of this efficiency increase, but yet this tiny percentage made him the world's highest-paid performer.[2]

Chaplin's experience epitomizes the massive increase in productivity modern service technologies have made possible. These efficiency gains often came as a thief in the night because inputs such as labour or capital have been used as output proxies, and because sharply falling prices kept expenditure shares modest even as quantities skyrocketed. What was widely noticed - in the entertainment industry at least - was the sharp increase in stars' income, even though these reflected only a limited part of the efficiency gains that the new technology brought about.

For services, output measurement has been a heavily debated issue.[3] Valuing entertainment output by the time spent using it, for example, increases output growth threefold relative to conventional measures.[4] Gary Becker (1965: 507), when discussing differences between manufacturing and services notes: "Service industries like retailing, transportation, education and health, use a good deal of the time of households that never enter into input, output and price series, or therefore into measures of productivity. Incorporation of such time into the series and consideration of changes in its productivity would contribute, I believe, to an understanding of the apparent differences in productivity advance between these sectors."

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[2] Chaplin's weekly pay increased from $150 at Keystone in 1913, to $1,250 at Essanay in 1914, to $10,000 at Mutual in 1916, to about $13,000 at First National in 1918 [Kindem, 1982: 82-83].

[3] For examples see Barzel (1974); Griliches (1992); Triplett and Bosworth (2004), Berndt and Hulten (2007).

[4] The approach follows Goolsbee and Klenow (2006), who reach similar conclusions for internet-access services. For a general analysis of time allocation dynamics between 1965 and 2005, see Krueger (2007).

Motion pictures can be seen as new (capital) goods that, when used with a projector, delivered a service to consumers. The entertainment industry was one of the first services to become industrialized and therefore may be significant for understanding productivity growth in other service industries.[5] Performances were automated, standardized and made tradable, resulting in rapid market integration and massive output growth (Bakker, 2001). Moving images replaced actors, floor managers, musicians and stage hands. This industrialization may have been not unlike the way in which information and communication technology (ICT) would automate, standardize and make tradable certain services after 1945 (Freeman and Soete, 1997: 403-408). The sharp growth in the quantity consumed per capita (eighteen times between 1900 and 1938) was partially hidden by a sharp fall in prices, keeping the expenditure share of entertainment relatively low and making the industrialization relatively unnoticed.

This paper analyses the impact of cinema technology on the productivity of the spectator entertainment industry and on economic growth between 1900 and 1938. It shows that when output is valued by the time spent consuming entertainment, using the ‘spectator-hour’ as a measure, output and productivity growth were several times higher than conventionally measured. In 1938, for example, entertainment as share of consumers’ leisure time was 5 times that of its expenditure share. The paper uses growth accounting to estimate total factor productivity (TFP) growth, quantifies the impact on the economy and compares this to that of what some have called general purpose technologies (GPTs) (Crafts and Mills, 2005; Lipsey et al., 1998).

[5] The term industrialization of services has been coined before, for example by Levitt (1976, 1983), although in a slightly different context. See also Bakker (2001) and Broadberry (2006).

This paper differs in three key aspects from Baumol and Bowen's (1966) work on stagnating productivity in the performing arts. First, it assumes that all spectator entertainment is part of the same market, irrespective of the delivery technology, whether live actors or projected images. Although they acknowledge the massive productivity increase enabled by audiovisual technologies, Baumol and Bowen assumed that the 'performing arts' formed an entirely different market. This was probably less accurate before 1940, when cinema and live entertainment were engaged in a competitive struggle, than in the 1960s, when the surviving live entertainment—either heavily subsidized (e.g. *avant garde* plays) or high-value added (e.g. Broadway musicals)—was far more differentiated, and that was precisely how it survived. Second, while Baumol and Bowen studied performing arts such as symphony orchestras and theatre, this paper includes popular entertainment such as vaudeville and burlesque, which were rather important before 1940. Third, the current paper uses a real output measure, the 'spectator-hour', rather than input proxies, such as the person-hours a string quartet uses to perform. The latter per definition underestimates productivity growth, because it disregards the spectator-hours the quartet could sell through audiovisual technologies.

This paper has three key findings. First of all, when measured in spectator-hours, entertainment's output growth in the early twentieth century - nine percent annually - was at least two to three times larger than conventionally measured. Most of this was hidden by a massive fall in prices because of sharp TFP-growth of over five percent per annum, higher than that of most other new activities during the period (Field, 2003) and far higher than conventional estimates, which average minus 0.3 percent annually.

Second, spectator entertainment had a not insignificant impact on national economic growth. It accounted for almost two percent of GDP-growth and more than three percent of national TFP growth between 1900 and 1938. This was somewhat lower than, but not unlike that of other new activities at the time. Third, 60 percent of its contribution was caused by pure productivity growth, 24 percent by its increasing GDP-share and 8 percent each by input transfers and capital growth. Fourth, falling ticket prices and rising opportunity costs kept the full-cost per spectator-hour constant, suggesting that the surge in demand was not caused by falling full costs, but by rising full incomes combined with the high income elasticity of entertainment.

The implications of these findings are, first, that certain service industries are not per definition stagnant, but, in the face of market forces, can adopt new technologies and potentially be subject to similar or even higher productivity growth than in agriculture and manufacturing. Second, inadequate output measurement may leave a substantial part of this growth unmeasured, and the current productivity estimates may therefore understate both national productivity growth as a whole as well as the part due to certain services. Angus Maddison (2001: 138), for example, showed how the Bureau of Economic Analysis' use of an annual chain index and of hedonic indices to adjust for quality changes resulted in an upward revision of U.S. economic growth by a third, from 2.63 to 3.48 percent per annum between 1929 and 1950. The current paper suggests that we still are understating the wealth the twentieth century has brought us, and that improved measurement of service output may lead to significant further upward revisions.

The remainder is organized as follows: Section I sketches the historical background, and discusses measurement methods. Section II and III discuss data and measurement. Section IV uses a Solow model to estimate TFP-growth in quantities and prices, and changes in mark-ups. The next section assesses the contribution to GDP-growth. Section VI compares the results with those for GPTs. Section VII concludes.

I. Historical Background

During the nineteenth century stand-alone entertainment venues made way for theatre circuits and local stock companies for travelling companies, helped by the railways. Central booking offices on Union Square in New York routed creative inputs efficiently across the nation. Innovations such as the steel frame and reinforced concrete enabled a sharp increase in theatre size as well as price differentiation, with cheaper tickets for the galleries. On the demand side, falling working hours, rising disposable income, urbanization, rapidly expanding transport networks and strong population growth boosted consumption of entertainment.

At the turn of the century, when the existing industry faced decreasing returns to further process innovations, cinema was adopted. It industrialized live entertainment by automating it, standardizing it and making it tradable (Bakker, 2001). Actors needed only to make one performance, which was reproduced infinitely. This standardized the public's viewing experience; they were guaranteed they would see the entertainment as advertised, without understudies, second-rank sets, reduced musical support or actors having a bad night. Before cinema, only creative inputs were mobile and relatively permanent in time, now the performances themselves became tradable. They were not produced anymore at the time and place of consumption, usually one of the characteristics of a service. Tradability increased competition among creative inputs for the audience's attention and integrated entertainment markets.

Until the emergence of cinema, the number of actors and actresses per 100,000 inhabitants increased sharply (figure 1). It stagnated subsequently, while real revenue per performer increased sharply. Between c. 1905 and 1917, prices for film increased while demand grew rapidly (Gomery, 1992), suggesting substitution. Films were often interspersed with live entertainment or vice versa. Particular good data for Boston in

1909 (Jowett, 1974) show that local consumers could chose between at least eight forms of theatrical entertainment, ranging from opera at a $2 ticket price to moving pictures at ten cents (figure 2). These figures form a static, early snapshot of a dynamic process of creative destruction. Three years after their emergence, cinemas supplied half of Boston's capacity. Given the low prices, however, it took in only a sixth of expenditure. The rapid diffusion was reflected in the increasing price elasticity of demand at lower prices, as tentatively suggested by the evidence (table 1). The cheapest vaudeville reacted by interspersing live performances with films. The radical new technology not only swept away the traditional entertainment delivery technology, but also opened up new markets, supplying consumers that had never seen theatrical entertainment before. Gradually, cinema would automate away more and more lower-priced live entertainment, leaving standing only the most differentiated and expensive forms.

In the late 1920s sound films constituted a major jump in substitutability by automating away most of the remaining live acts.[6] Before their introduction, Americans spent $1.33 per capita on theatre, versus $3.59 on movies, while in 1938 the figures were $0.45 vs. $5.11 (figure 3). Theatre historians note how motion pictures increasingly became a substitute for live entertainment (Moore, 1968). Jack Poggi (1968: 79, 43), for example, writes:

> First the movies created a new audience, many of whom had never been to the theatre; but the desertion of the galleries in theatres in all the large cities indicates that they also began to lure away that part of the theatre audience with the lowest income. Then, as the movies improved in quality and respectability, people from the business and professional

[6] Kraft (1994a, 1994b) and Ehrlich (1986: 197-210) analyze talkies' disastrous effect on musicians' employment for the US and Britain. Ehrlich discusses one-person cinema organs (replacing whole orchestras) as an important labour-saving innovation before the coming of sound.

> classes might be expected to change their entertainment habits. (...) Possibly the habitual New York theatregoers went to both theatre and films for a time and then gradually limited their attendance at live theatre to special occasions. This theory would explain why the less popular plays began closing more quickly, causing a drop in the number of theatre weeks. (...)
> The motion pictures could not have crushed the legitimate theatre if there had been a real preference for live drama. Theatre managers would never have turned their buildings over to the movies if they could have made more money by booking plays; a few might have been satisfied if there had been equal profit, or even a little less, in live theatre. Again we come back to the same point: people were simply not willing to pay the price necessary to maintain live theatre, except in the largest cities. If they could get what they wanted from the movies, why should they look elsewhere?

Production data (figure 3) suggest a process of creative destruction, in which spectator entertainment became industrialized in two stages: from the mid-1900s onwards, cinema automated away small-town live entertainment (proxied by ‘road productions’) and from 1927 talking pictures creatively destroyed the high-value-added metropolitan entertainment (proxied by ‘Broadway’).

During this process industry and market definition changed. Sometimes final-year industry/market definitions are used to show that the new high-productivity service served an entirely different market. Initially film and live entertainment were close substitutes with high cross-price elasticities, but over time, the surviving live entertainment became more and more differentiated from film. It was either heavily subsidized or a commercial metropolitan premium product. Given the available evidence, this paper will treat live entertainment as the best substitute for film.

II. Measuring Output

Services play an essential part in understanding long-run economic growth and development. Stephen Broadberry (1997, 2006) and Broadberry and Ghosal (2002), for example, note how demand patterns shifted in favour to services as incomes rose, and how the superior productivity performance of the United States vis-à-vis Europe can be explained mainly by its productivity lead in services, which had been previously overlooked because of the difficulty to measure services output.

A related problem is how to measure the contribution of new goods to productivity growth and economic welfare. Several studies deal with this by measuring the services that these good delivers. William Nordhaus (1997), for example, focused on the services that light bulbs and other devices have provide since Babylonian times, concluding that the consumer price index severely understates their price decrease. Walter Oi (1997) examined the welfare effect of air conditioners, and others those of products such as mobile phones, minivans and apple-cinnamon breakfast Cheerios (Hausman 1997a, b; Petrin 1997). Assessing the historical contribution of new goods, J. Bradford DeLong (2000) concludes that 'no previous era and no previous economy has seen anything like the level of material wealth and productive potential attained by the twentieth century's economy.' DeLong argues that we take this for granted because we have come to expect progress.

To proxy output growth in services, often employment or capital is used. As these are inputs, this inevitably leads to observing limited TFP-growth.[7] This paper uses a common measure for output for both live and filmed entertainment, the 'spectator-hour'. Not unlike passenger-miles, the seats in a venue times the performance duration constitute the

[7] The TFP-figures below show capital is a better proxy than labour growth, as Millward (1990) suggested, although far from perfect.

spectator-hours produced, the proportion filled the hours actually sold. Valuing a service by the time spent using it seems justified, given the large amount of time consumers spent on spectator entertainment relative to its expenditure share. In 1900 the share of leisure time and wages spent on entertainment were roughly equal, but by 1938 the former was five times the latter (table 2). Intuitively, this suggests a substantial welfare increase that is not fully captured in GDP-estimates.[8]

An additional reason for using time to measure output is the 'third person criterion', often used in household satellite accounts that supplement national accounts (Murgatroyd and Neuburger 1997; Reid 1934). If an activity can not be delegated to a third person (going to the dentist, hairdresser, listening to music, etc.), it is considered household consumption. If it can be, it is household production. Activities such as childcare, cooking and doing the laundry can be produced in the market in different ways and at different prices, which can be compared to household production. Consumptive activities like cinema-going do not have a delegation option. The only way other activities can compete is for the time they involve. This suggests that time is the most fundamental output of the entertainment sector, and therefore a useful way to value its output.

Between 1900 and 1938 the labour hours needed to pay for one hour of entertainment decreased substantially, from over two hours to about ten minutes. At the same time opportunity costs started to dominate monetary costs, increasing from 31 to 88 percent of full costs.[9] The price

[8] The approach here follows Goolsbee and Klenow (2006), who apply it to the internet, and reach similar conclusions for that service. For a general analysis of the dynamics time allocation between 1965 and 2005, see Krueger (2007).

[9] We assume opportunity costs equalled the wage rate, also for the unemployed, following Nordhaus and Tobin (1972), who estimate leisure time in the 1930s. Alternatively, the unemployed could have opportunity costs proportionate to unemployment duration, following, for example, Layard (1981) and Crafts (1987). The unemployed then needed low prices because they had little income, the employed because their opportunity costs were so high. Assuming linear proportions and a 26-

decrease and wage increase balanced each other out so that the full cost to the consumer remained unchanged (table 2).[10] At the aggregate level, if we value output by the hours spent using it, growth was 9.2 percent and TFP-growth 5.9 percent annually (table 3).[11] If we value output by its price relative to all other goods and services, growth was just 4.2 percent and TFP-growth 0.9 percent annually. If we value output by opportunity costs, growth was as much as 12.3 percent and TFP-growth 9.0 percent. If we sum the last two measures, to value output by its full cost, we get an output and TFP growth that is similar to weighing the output in spectator-hours, because the effect of price falls and wage rises cancelled each other out. The surge in opportunity costs may have driven the implosion in prices, as venues needed to keep full costs low to keep drawing customers.[12] The remaining puzzle is how consumption could increase with 7.6 percent per capita per annum, given that the full cost of one spectator-hour remained constant.

Becker (1965) notes how during the first half of the twentieth century the productivity of both labour and leisure increased. The increasing productivity of leisure led people to change labour into leisure hours (substitution), or vice versa (the income effect).[13] Likewise, rising labour productivity (and thus rising wages) would lead to changing leisure for labour hours (substitution) and labour for leisure hours (the income

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week average duration, and taking the unemployment rates of 5 percent and 12.47 percent for 1900 and 1938 (Barber 1976), our findings hardly change: opportunity-cost output- and TFP growth (table 3, line 3) decline by 0.12 and 0.10, and total-costs output- and TFP growth both by 0.14 percentage points. The ratio of total consumption costs for the employed to those for the unemployed then increased from 1.25 to 8.8 between 1900 and 1938. Valuing everyone's leisure hours at a different proportion of wages obviously only affects total-costs growth rates. Valuing leisure time at half the wage rate, for example, reduces output- and TFP growth from 9.2 to 6.9 and from 5.9 to 3.6 percent.

[10] Following Becker (1965) 'full costs' is used rather than 'total costs' to emphasize they include opportunity costs and relate to 'full income'.

[11] The TFP-growth accounting is explained in section IV.

[12] An example of a cost-reducing innovation is the cinema-organ mentioned above.

[13] Owen (1970) notes substantially falling prices of leisure goods and services as evidence of rising productivity of leisure time.

effect). If both productivities increased at the same rate, which Becker suggests was likely, then the respective substitution and income effects cancelled each other out. With an income elasticity of time-intensive activities greater than unity, however, labour hours fall and leisure hours rise, and this is what happened in the early twentieth century, according to Becker. So the story is not simply one of increasing labour productivity with the income effect dominating a substitution effect, but of the effects of labour and leisure productivity growth offsetting each other, with at the higher full income a larger demand for time-intensive activities.

The historical evidence indeed suggests a sharp increase of both market and household productivity, even if both cannot always be measured perfectly (Owen 1970). Moreover, the income elasticity of time-intensive activities was high in this period. Bakker (2007), for example, finds an income elasticity for motion pictures of 2.3 in 1918 and 1.5 in 1935, and for live entertainment of 4.4 and 8.2 respectively.[14] Mincer (1963) and Becker (1965) note that these income elasticities would be higher still if the full costs were taken into account, since opportunity costs increase with income.

The constant full cost of a spectator-hour suggests that Becker's conjecture held for the case of spectator entertainment. The effect of an increase in productivity of leisure time (the falling price per spectator-hour) was off-set by the increase in labour productivity (rising real wages). Thus, entertainment demand per capita did not increase because of falling ticket prices, but because rising leisure and labour productivity increased full income, which led to more expenditure on entertainment, as its income elasticity was far above unity.

[14] In 1889-1890 the income elasticity of 'amusements and vacations' ranged between 1.2 and 1.4 for families with positive expenditure and was 2.1 for all families. Estimates for Britain and France reach similar or higher elasticities (Bakker 2007).

With constant full costs, any per capita consumption increase between 1900 and 1938 must have been due to the long-run full-income elasticity of demand. Using the wage rate to reflect the change in full income, we get a long-run full-income elasticity of demand of 3.96.[15]

Historical evidence suggests that in an earlier place and time - during the British Industrial Revolution - on the contrary, leisure productivity increased sharply while labour productivity remained stagnant, and that the income effect dominated the substitution effect (Voth 2000). When their full income increased because of more productive leisure, consumers chose to spend more hours labouring.

In the case of entertainment, the income and substitution offsets can be observed so clearly because it was time-intensive at the extreme: consumption involved a fixed, chunky amount of time, few other activities could be done simultaneously, and hardly any goods were used by the consumer. The compensation of falling prices by rising opportunity costs is not inconsistent with Becker's (1993: 386) observation that the day's 24-hour limit forever prevents us from reaching a cornucopian Utopia:

> Economic and medical progress have greatly increased length of life, but not the physical flow of time itself, which always restricts everyone to 24 hours per day. So while goods and services have expanded enormously in rich countries, the total time available to consume has not. Thus wants remain unsatisfied in rich countries as well as in poor ones. For while the growing abundance of goods may reduce the value of additional goods, time becomes more valuable as goods become more abundant. The welfare of people cannot be improved in a utopia in which everyone's needs are fully satisfied, but the constant flow of time makes such a utopia impossible.

[15] This is substantially higher than estimates not taking into account opportunity costs / full income. Bakker (2001), for example, finds a long-run GDP-elasticity of demand for entertainment of 2.32 for this period, which is an upper bound to long-run income elasticity, as GDP grew faster than per capita income and the price decrease was ignored. Intertemporal elasticities are different from cross-sectional elasticities, naturally.

The above does not take into account changes in the quality of a spectator-hour. Given the massive increase in production expenditures and new product characteristics - such as cinema itself, the feature film, talking pictures, air-conditioned venues - quality change was probably positive.[16] Robert Lamson (1970), for example, studied the quality of motion picture theatres between 1947 and 1964, including dimensions such as crowding, parking spaces, and theatre age. Quality change was substantial and not captured in the national accounts; it would lower the admission price series with about two-thirds, and increase total factor productivity from zero to 2.7 percent. This suggests that the current paper's assumptions understate actual productivity growth.

III. Data

Spectator entertainment is defined as theatrical entertainment such as opera, theatre, concerts, vaudeville, burlesque and cinema. Two benchmark years have been selected for the growth estimate: 1900, the first census year before cinema's take-off, and 1938, when the industrialization was complete. Since 1927 sound had driven out most live entertainment, and television had still to arrive.[17] Reliable and exact data sources could not be obtained easily. Especially for 1900, sometimes estimates had to be made based on indirect indicators. Appendices A and B explain each estimate in detail.[18] Yet, we do not need to quantify everything perfectly to make the point that the entertainment's impact on

[16] Initially, pictures' lack of audience-interaction and sound were inferior characteristics. Live entertainers provided both aspects during and between pictures, before the talkies.

[17] The other major new media - recorded music and radio - were partially different products. The phonograph had remained an elite product. Although in the 1920s radio expanded rapidly, it would only reach its peak during the 1940s and early 1950s. Choosing 1938 makes the estimates more conservative because motion picture and live entertainment expenditure grew rapidly from 1940 onwards.

[18] These are attached and also available from the authors.

GDP-growth was substantial. Following Fogel's (1964) approach, we bias our estimates against the idea that entertainment's growth contribution was large. If we then still find a significant growth contribution, data imperfections are unlikely to change our findings. It is not our aim to get the exact value of entertainment's contribution, something that is hardly possible given data imperfections, but merely to show that given the available evidence, its impact must have been big.

For the primal growth accounting, data on the capital stock, the labour quantity and output (in spectator-hours) have been collected. Labour quantity is measured in hours using industry full-time employment estimates linked with data on national average working hours from Huberman and Minns (2007). Labour quality has been proxied by the average number of years of education for the population from Maddison (1995). For dual growth accounting, prices and factor prices have been estimated. The 1900 estimates are based on the census, the Historical Statistics of the United States (U.S. Department of Commerce 1975), a household expenditure survey, Owen (1970), and on studies in theatre and film history. No reliable industry wage data were available; the national average has been used. Capital is GDP-deflated and other values are deflated by the consumer price index to make them comparable with 1938.

The data for 1938 is slightly more reliable, as most estimates are based on the National Income and Product Accounts, supplemented by data from industry studies such as Greenwald (1950) and Conant (1960). Wage data were only available for film and 'amusements and recreation'. Combined with other sources, the latter only gives an indication of live entertainment wages. An upper bound estimate of accumulated welfare benefits, using Fogel's (1964) social savings method, was made with (the more reliable) 1938 data only.[19] It is a good test to assess whether the TFP-estimates are in the right ballpark.

IV. The Growth in Total Factor Productivity

Traditional growth accounting captures the contribution of technological change to growth through the Solow residual (TFP). With the standard Cobb-Douglas production function and competitive assumptions:

$$Y = AK^{\alpha}L^{1-\alpha} \tag{1}$$

the Solow residual is computed as:

$$\frac{\Delta A}{A} = \frac{\Delta Y}{Y} - s_k \frac{\Delta K}{K} - s_l \frac{\Delta L}{L} \tag{2}$$

With Y = output (in spectator-hours), K = capital, L = labour, A = the Solow residual, and s_k and s_l are the factor income shares.

A term for changes in labour quality has been added in table 4. At nine percent annually for almost forty years, output growth was remarkably high.[20] A third was explained by increases in capital and labour, the rest was due to TFP-growth. Growing over five percent annually, the latter was significantly higher than in other industries.[21]

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[19] Social savings estimate the cost-savings of a new technology compared with the next-best alternative:

$$SS = (p_c - p_a)q_a$$

Where p_c is the price of the next best alternative (live entertainment), p_a the actual price at the current technology, and q_a the actual quantity consumed. Assuming the actual quantity remains unchanged at the counterfactual price yields the upper bound. The advantage compared to TFP is that only final-year (1938) data is needed.

[20] For the estimation of factor elasticities, value of human capital and the effect of international trade, see Appendix A.

[21] See section VI.

Using the average share of motion pictures in all spectator entertainment, it is possible to disaggregate total TFP-growth into the contribution of live and film technology:[22]

$$g_{film} = \frac{g_{live+film} - s_{live} g_{live}}{s_{film}} \qquad (3)$$

Where g denotes the annual average growth rate between 1900 and 1938 and s the share of the respective technology in output.

Live entertainment showed substantial negative output growth of 1.24 percent annually (table 4). However, inputs where shrinking far faster than output, mainly driven by an exodus of the labour force, resulting in moderately positive TFP-growth.[23] Cinema output grew thirteen percent annually, sixty percent of it driven by TFP-growth. By 1938 it was 13 times as productive as live entertainment.

The Solow residual can also be computed as

$$\frac{\Delta A}{A} = \frac{\Delta(Y/L)}{Y/L} - s_k \frac{\Delta(K/L)}{K/L} \qquad (4)$$

This shows entertainment labour productivity increasing with 7.5 percent per annum (table 5). Only slightly more than a tenth was explained by capital deepening, and slightly more by increased education of the workforce. Live labour productivity grew 2.3 percent annually, largely driven by capital deepening and increased education of the work force, while film labour productivity grew over nine percent annually, mostly

[22] This assumes that live technology accounted for all output, because Nickelodeons emerged only in 1905 and film TFP-growth is extremely sensitive to imprecisions in a 1900 size estimate. Live's share was 0.263, the geometric average of the assumed 1900 (1) and 1938 share. Interpolating geometrically from benchmark estimates for 1909, 1914, 1919, 1921, and so on, using US Department of Commerce (1975), combined with industry growth indicators (Bakker, 2005: 344-347) yields an 0.224 share. To keep the TFP-growth estimate for cinema technology conservative, the higher live share is used.

[23] Increasing efficiency in a declining technology is not unusual. Utterback (1996), for example, shows gas lighting's efficiency improved remarkably, and prices fell concurrently, when faced with electric light competition.

because of TFP-growth. In 1900, one hour of labour produced 1.3 spectator-hours, by 1938 this had increased to 19.5 hours.[24]

By 1938, the industry level of TFP was over eight times what it had been in 1900, and for the film industry alone it was over seventeen times as much. The changes in the industry production structure were significant. The industry doubled the capital/labour ratio (figure 4). Even the declining live entertainment's ratio was only a fifth lower than that of cinema by 1938 (table 6). The capital/output ratio declined sharply, from $0.71 to $0.15 per spectator-hour.[25] The technical rate of substitution at least doubled. By 1938, about $16,000 of capital was needed to replace one worker.[26]

Although the underlying Cobb-Douglas function is probably not a perfect model of actual production, sensitivity tests comparing the wage/rental ratio, factor costs and income shares with their Cobb-Douglas values suggest that it is a good approximation in this case.[27]

A dual method to estimate of TFP growth was used Zvi Griliches and Jorgenson (1967) and has been applied to economic history by Antras and Voth (2003) and Crafts (2003). The decline in price of a good, all factor prices remaining the same, must be the result of an increase in efficiency. The dual highlights the welfare interpretation of TFP through real cost reduction (Hulten 2001, Harberger 1998), including unconventional benefits. The dual of expression (2) thus becomes:

[24] Arrived at by multiplying Y/L (table 3) with the average years of education (6.38 in 1900, 10.03 by 1938). The increase was driven by both rising labour and leisure productivity, as reflected in rising real wages and falling ticket prices.
[25] This is partially responsible for the large 'shift-effect' (input transfer effect), discussed in section IIIc.
[26] Arrived at by taking 1756 hours * 10.03 years of education * 0.90 (the TRS).
[27] Using:

$$|TRS| = \frac{w}{r} = \frac{1-\alpha}{\alpha}\frac{K}{L};\; r = \frac{w}{|TRS|} = \frac{\alpha}{1-\alpha}\frac{L}{K}w;\, w = r\cdot|TRS| = \frac{1-\alpha}{\alpha}\frac{K}{L}r;\, \alpha = \frac{rK}{rK+wL}$$

Wage/rental ratios for total, live and film varied between 1.02 to 1.15 of the CD TRS. Actual rental rates were between 1.03 to 1.21 of CD-rates, and actual wages 1.03 to 1.15 of CD-wages.

$$\frac{\Delta A}{A} = s_k \frac{\Delta r}{r} + s_l \frac{\Delta w}{w} - \frac{\Delta P}{P} \qquad (5)$$

The results are more tentative than for primal TFP, because rough estimates had to be made for wages and rentals in 1900.[28] Most productivity gains were passed on to consumers: real prices fell phenomenally, with over four percent per annum for nearly forty years, before television had even arrived (table 7). Because live entertainment prices fell by 'only' 1.3 percent annually, film technology had the largest downward force on prices, decreasing them with about six percent per annum over almost forty years.[29] The dual estimates give confidence that our TFP-estimates are in the right ballpark.

V. <u>The Impact on Aggregate Economic Growth and Productivity</u>

Entertainment's growth contribution can be calculated following traditional growth accounting (Crafts, 2004a). Multiplying the growth of capital by entertainment's profit share, we arrive at the extensive contribution, which was very small (table 8). The intensive growth

[28] See Appendix B. Sensitivity tests comparing estimated wages or rentals with those of the Cobb-Douglas production function, show that the dual results for total and film TFP are not very sensitive, but that dual live TFP and all markups are sensitive to small estimation errors.

[29] The difference between primal and dual TFP-growth should reflect changes in markups (Crafts and Mills, 2005) using:

$$\frac{\frac{P_t}{MC_t}}{\frac{P_0}{MC_0}} = \left(1 + (g_{primal} - g_{dual})\right)^t \qquad (6)$$

Where P and MC denote price and marginal cost, and g denotes primal or dual TFP-growth as a fraction. Although markups are very sensitive to estimation imprecisions, our data suggests they did not increase, and probably declined (table 7). Thus, dynamic efficiency did not happen at the expense of allocative efficiency in the long run, consistent with Nordhaus' (2004) findings for US industries between 1948 and 2001.

contribution, that is producing more outputs without increasing any inputs, consists of three effects.[30] The pure productivity effect captures entertainment's contribution if its GDP-share had remained the same; it is the 1900 share times TFP-growth.[31] The share effect captures the contribution caused by increased relative spending on entertainment. It is TFP-growth times the average additional GDP-share. The input transfer, or 'shift', effect, takes into account that inputs were used more efficiently in entertainment than elsewhere; it is the growth of inputs times the difference between entertainment's GDP-share and input-share.

It turns out that 1.87 percent of GDP-growth can be explained by entertainment.[32] This growth contribution was large compared to the industry's size. It was 2.5 times its average GDP-share and over two-thirds of steam's intensive contribution in Britain between 1870 and 1910 (Crafts, 2004a). Only eight percent of entertainment's contribution was due to extensive growth (embodied in new capital), sixty percent to pure productivity, a quarter to the share effect and as much as seven percent to the input transfer effect. Entertainment's growth contribution was achieved almost without adding new inputs.

Motion pictures' share of aggregate TFP-growth, therefore, was even larger (table 9).[33] It amounted to as much as three percent of TFP-growth, over five times its GDP-share. Another way of reassuring

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[30] Nordhaus (2002), who names the share effect the Baumol effect and the shift effect the Denison effect.

[31] Entertainment's expenditure share in GDP is its so-called Domar weight. Economy-wide these weights sum to greater than 1. For an algebraic justification see Hulten (1978).

[32] An alternative method, dividing GDP in entertainment and a composite good and then correcting entertainment prices, suggests entertainment accounted for 1.59 percent of GDP-growth, slightly less (possibly because it is innocent of the shift effect) but still in the same ballpark, suggesting our findings are not unreasonable.

[33] Angus Maddison (1995: 255). For the U.S. private non-farm economy Field (2003) finds a growth rate of 1.70, Abramovitz and David (1999) 1.40 and Gordon (2000) 1.43 percent per annum. Rates for various intervals were converted into 1900-1938 equivalents, using weighted geometric averages. Maddison's estimate is used because it encompasses the whole economy. Other estimates leave entertainment-TFP-growth still several times general TFP-growth.

ourselves that there is a real welfare gain is to use the concept of social savings popularized in the economic history literature following Fogel (1964). This is simply the difference in the resource cost of supplying a given volume of output using old and new versions of the technology. The previous section showed how TFP-growth can be interpreted as the rate of real cost reduction. Social savings from reductions in the cost of spectator entertainment as a proportion of GDP can therefore give an upper bound estimate of the welfare gains of real cost reduction.[34]

Motion pictures' social savings in 1938 relative to a world where they did not exist are obtained by taking all film spectator hours produced (7 billion) times the price difference with live entertainment. These turn out to be almost $2 billion, or 2.2 percent of 1938 GDP. Being an upper bound estimate, this is slightly higher than the accumulated TFP-growth (real cost reduction) between 1900-1938, giving confidence that our growth accounting results are not unreasonable.

VI. Discussion

Comparing this paper's findings with existing growth data on recreation suggests that our current understanding of GDP-growth in this period may seriously underestimate the contribution of certain services. Existing pre-1929 GDP series are based on benchmark-year estimates, which do not include entertainment separately before 1909. Using the price relative to all other goods and services, however, combined with the expenditure for 1900 and 1938 yields an output growth of 4.2 percent and

[34] The upper bound arises because the technique in its simplest form, used by Fogel (1964), assumes that demand is inelastic, and thus that consumers keep consuming the same quantity at old technology prices. Social savings are innocent of international trade, but motion picture exports were small compared to domestic expenditure (see Appendix A) and cannot materially alter our findings. The TFP/social savings comparison follow Crafts (2004a: 344-345).

a price increase of 1.4 percent annually, and a TFP growth of 0.90 percent (table 10).

From 1929 onwards the national accounts contain price indices for live and filmed entertainment. If we link them to our 1938 estimates, and then weigh the output by price rather than spectator-hours (the method traditionally applied), this reveals an annual output decline of -0.47 percent per annum between 1929 and 1938. If we assume that the growth of inputs calculated for 1900-1938 was not much different during the 1930s, this yields a negative TFP-growth of -3.76 percent. If we use the NIPA indexes to estimate the number of spectator hours for 1929 and then value output by those, output grows with 0.15 percent, and TFP is still sharply negative. Even if input growth would have been a fraction of the 1900-1938 trend rate, TFP-growth would still be negative. In short, the national accounts underestimate entertainment's growth contribution.

We can also compare motion pictures to Lebergott's (1996) growth estimates for all recreation services, which amount to 4.2 percent annually for 1900-1938, yielding TFP-growth of 1 percent. If we combine Lebergott's price series for 1900-1929 with entertainment's share in recreation services and our output and price data, all recreation services grew with just 0.16 percent per annum, and their price with 13.7 percent per annum. Both are highly improbable and suggest entertainment is currently not well-measured. Detailed estimates by Owen (1970) for all recreation services as well as goods between 1901 and 1938 show an output growth of 4.3 percent annually. If spectator entertainment output grew at the same rate, TFP would have been just one percent.

On average, the above existing estimates imply output, price and TFP growth of 3, 0.2 and -0.33 percent per annum, respectively (table 10). They underestimate output growth by at worst minus 5 percent and at best 58 percent of that measured in this paper, leading to an underestimate of TFP-growth of at worst minus 63 percent and at best 35 percent of actual TFP-growth.

No well-measured industry surpassed entertainment's TFP-growth during the first half of the twentieth century (table 11). Only rubber products and electric utilities came close, with 10 and 13 percent lower TFP-growth. If we compare other industries' thirty-year intervals with entertainment's 38-year, only rubber exceeded entertainment's TFP-growth by nine percent. If we take twenty and ten year intervals, more industries surpass entertainment, showing that its TFP-growth was not unheard of, but that no other industry experienced it for so long. Over shorter intervals, entertainment TFP-growth was in the same league as transport, electricity and their supply sectors oil and gas and rubber, but its growth contribution lower because sharply falling prices, together with low exports and a demand elasticity bounded by the 24-hour day, kept its GDP-share lower. Motion pictures thus led the big league in TFP-growth, but lagged in impact because of its small GDP-share.

The fact that entertainment accounted for about 3 percent of over-all TFP-growth suggests that it was part of the broad-based U.S. shift to accelerated TFP-growth, and of the TFP-surge outside manufacturing during the 1930s identified by Field (2003, 2006). Compared to TFP-growth in other service industries, motion pictures remained exceptional. TFP-growth, for example, was 'only' 1.8 percent per annum between 1919 and 1938 in the telephone industry, 3.9 percent in electric utilities and 2.2 percent for the railroads (Kendrick, 1961).[35]

High TFP-growth has been associated with General Purpose Technologies (GPTs), 'a technology that initially has much scope for improvement and eventually comes to be widely used, to have many

[35] Derived from 1919-1929 and 1929-1941 intervals. Only 'Trucking and warehousing' and 'Transportation by air' had higher TFP-growths than film (13.6 and 13.7 percent annually) for 1929-1941 (Field, 2006: 219).

uses, and to have many Hicksian and technological complementarities' (Lipsey, 1998; Crafts, 2004a). GPT's initial productivity impact is typically minimal; it may take 40 to 120 years to become substantial. Film technology possessed some GPT-properties: initially it needed many improvements and became widely used nationally and internationally, in almost every town. Motion pictures probably had their largest productivity impact only after thirty to forty years, with the coming of sound in 1927. Their uses, however, as well as complementarities, remained largely constrained to spectator entertainment, and this limited their growth impact compared to GPTs.

Entertainment's GDP-share was much lower than that of GPTs, except early British steamships (table 12). Yet its TFP-growth and intensive growth share were higher than most other GPTs. Only fin-de-siècle British railways experienced growth more intensively, and only because passenger time savings have been included in output (Leunig 2006). Because of its small size, cinema's total growth contribution was smaller than that of GPTs.

Its accumulated *intensive* growth contribution was in the same ballpark as many GPTs and higher than British railways, steam and steamships before 1870 (table 12).[36] The high contribution was possible because the extreme intensiveness of growth compensated for

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[36] Calculated using

$$G_t = 1 - \left\{ 1 - \frac{s_y \left[\left(\frac{A_t}{A_0} \right)^{\frac{1}{t}} - 1 \right]}{\left(\frac{GDP_t}{GDP_0} \right)^{\frac{1}{t}}} \right\}^t \quad (7)$$

Where G_t = the 'growth impact', the accumulated intensive growth as fraction of GDP, s_y = the share of spectator entertainment expenditure in GDP and t = the number of years. This is a formalization of the methodology used by Crafts (2004b) and Foreman-Peck (1991).

entertainment's small expenditure share. Without the plunge in prices resulting from the efficiency increase, this share might have been far higher.

To assess an industry's growth impact, its accumulated growth contribution (real cost reduction) can be expressed as a fraction of the national accumulated intensive growth (using expression (7)) (Table 12, column 12). The latter was 37 percent of GDP in 1938 relative to 1900. Using only technologies available in 1900, the US would have needed additional inputs to the value of a third of actual GDP to produce the same output. A technology's share in national real cost reduction can potentially quantify the extent to which it is a GPT. This growth impact assessment takes account of both intensive growth and industry size and scales this to economy-wide efficiency gains. Motion pictures accounted for 3.8 percent of national real cost reduction, a growth impact lower than that of any GPT except early British steamships because of entertainment's low GDP-share and high national intensive growth during its emergence.[37]

VII. Conclusion

During the early twentieth century, spectator entertainment experienced a phenomenal output growth hidden by a massive fall in prices, driven by a TFP-growth of over five percent per annum for forty years. Spectator-hours consumed per capita increased seventeen fold, real prices fell by 5/6th and the ratio of leisure time share to expenditure share increased fivefold.

[37] If national intensive growth was the average of that during the emergence of other GPTs, entertainment's growth impact would be 7.3 percent. If its GDP-share equalled the GPT-average, its growth impact would be 11.1 percent. Combined, the impact would be 16.4 percent, lower only than ICT and British railways before 1870. (National intensive growth, GDP-share and the joint effect account for 28, 59 and 13 percent of growth, respectively).

The implications of these findings are that certain service industries are not per definition stagnant, but, in the face of market forces, can potentially be subject to similar or even higher productivity growth than agriculture and manufacturing.[38] Inadequate output measurement may hide a substantial part of this growth. Empirical evidence corroborates Becker's (1965) hypothesis that much of the productivity difference between the production of goods and services disappears once we include time in our output valuation. Measured by the time spent watching them, motion pictures made a substantial contribution to the general surge in TFP-growth in services identified by Field (2003; 2006) for the interwar period, and this surge may therefore have been even higher.

The proper weighing of time is particularly important for time-using activities, time-saving technological change and technological change that leads to quality of life outcomes (i.e. that extends time at the ultimate extensive margin). The concept of output is essential to measure productivity performance in services, both publicly and privately provided services, and should be measured in terms of its incremental contribution to total welfare (Atkinson 2004: 44). One could get misleading measures of economic welfare if one does not take into account better outcomes. At the micro-level everybody accepts these as benefits, but at the macro level they are often not considered. Time-savings of new highways, for example, are routinely compiled at the micro-level before they are built, but do not show up in national accounts (Fernald 1999).

The railways' contribution to economic welfare between 1850 and 1912, for example, as measured by their social savings, was over three times as high if we factor in the opportunity-costs of travel time (Leunig 2006). Likewise, conventionally measured, the contribution of medical

[38] See also Lee's (1994) historical overview of British services. Lee concludes that services' poor productivity performance in a particular period 'was not an eternal constant, to be built into grim forecasts of the end of growth'.

services to overall productivity growth seems negligible at best, but when changes in outcomes are examined, it could be substantial. William Nordhaus (2005: 386) finds that between 1900 and 1950 the value of improvements in life expectancy where substantially above the increase in the value of all other goods and services put together, and Cutler and Richardson (1997), find that between 1970 and 1990 the increase in quality-adjusted health capital per capita was about five times the increase in medical spending per capita. Frech and Miller (1999) show that doubling drug expenditure at age 40 increases life expectancy by two percent (about a third of the effect of doubling GDP), implying again that the output achieved with healthcare inputs may not be properly reflected in national accounts. These studies suggest that the twentieth century has brought us much that has gone unmeasured.

Contrary to the index case of the eighteenth century textile industry, in many of these twentieth century services industrialization came as a thief in the night. Exceptional output growth was accompanied by sharply falling prices that limited the growth of expenditure shares, by rapid industry growth that made the decline in traditional employment more relative than absolute, and by a shift to product innovations that obscured industry/market definition. Measuring productivity only in the traditional sector of these industries often shows a productivity slowdown, but this approach is like using the output of the independent village tailor to claim that productivity growth in the textile industry has been stagnating since 1750. Spectator entertainment might be the prime example of a group of industrialized services that - although individually different - together have sharply increased productivity, output and our welfare over the twentieth century. The happenings of the early motion picture industry therefore may give insight into the nature of technological change in many service industries to come.

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TABLE 1

PRICES, CAPACITY, SALES POTENTIAL, ESTIMATED "PRICE ELASTICITY" AND "CONSUMER SURPLUS" FOR VARIOUS TYPES OF THEATRICAL ENTERTAINMENTS, BOSTON, 1909

	Price ($)	Capacity (seats)	Sales ($)	Percentage of Capacity	Percentage of Sales	"Price elasticity of demand" arc	informal	Log-log	Consumer surplus ($)	(%)	CS/Rev. (%)
Opera	2.00	13,590	27,180	2	10	-2.41	-3.86	-0.30	19,230	17	71
First-class theatres	1.00	111,568	111,568	14	42	-2.41	-1.45	-0.30	55,784	48	50
Popular theatres	1.00	17,811	17,811	2	7	-0.96			8,906	8	50
Stock houses	0.75	21,756	16,317	3	6		-1.08	-1.42	2,720	2	17
Vaudeville houses	0.50	45,744	22,872	6	9	-0.61	-0.82	-1.42	5,718	5	25
Burlesque houses	0.25	80,700	20,175	10	8	-0.48	-0.96	-1.42	10,088	9	50
Vaudeville and moving pictures	0.15	79,362	11,904	10	4	-0.48	-0.99	-1.42	3,968	3	33
Moving-picture theatres	0.10	402,428	40,243	52	15	-1.76	-1.23	-1.42	10,061	9	25
All above entertainments	0.35	772,959	268,070	100	100	-1.07	-0.53	-0.78	116,473	100	43
All live entertainment	0.67	330,850	221,875	43	83	-1.17			104,428	90	47
Motion picture entertainment	0.10	442,109	46,195	57	17	-1.76			12,045	10	26

Source - Calculated from data from Boston Committee 1909, as mentioned in Garth S. Jowett, 1974.
Notes - Capacity = the weekly seating capacity as estimated by the Boston committee (venue capacity times number of performances).
Sales = sales potential, when all seats are sold at the listed prices.
Arc elasticity = between respective price and the next price down.
Informal elasticity = based on best tangents to demand curve at data point, using mixed log-lin, polynomial and power curves at various stretches of the demand curve.
Log-log elasticity = based on constant elasticity log-log model split for two parts of demand curve to get best fit (R2=0.998 and 0.945).
CS = Consumer surplus = area above price line and under hypothetical demand curve for the respective stretch of the curve. For opera, the intercept at q=0 is set at $4.83, the price that equalizes
"upward and downward" arc elasticity for opera.
Rev. = Revenue.

TABLE 2

TIME AND MONEY SPENT ON CONSUMING SPECTATOR ENTERTAINMENT AND ANNUAL GROWTH RATES, 1900-1938

	1900			1938			1938 disaggregated	
	(hours)	($)	(%)	(hours)	($)	(%)	Film	Live
Spectator-hours consumed per entertainment consumer	9.63			81.32			79.53	1.79
Expenditure per entertainment consumer		3.46			8.33		7.66	0.67
Share of leisure time used			0.67			3.10	3.03	0.07
Share of wages used			0.73			0.61	0.56	0.05
Share leisure/share wages			91.30			508.57	540.88	139.23
Hourly wage rate		0.16			0.78		0.78	0.78
Price of one spectator-hour		0.36			0.10		0.10	0.37
Hours of work per spectator-hour	2.23			0.13			0.12	0.48
Full costs to consumer		0.52			0.88		0.87	1.15
in real dollars of 1938		0.88			0.88		0.87	1.15
Opportunity costs / all costs			30.94			88.37	88.99	67.54
One spectator-hour/all weekly leisure time			3.61			1.98		
Price / all weekly expenditure			3.95			0.39	0.37	1.42

	Real annual growth rates, 1900-1938	
	All	Live
One spectator-hour/all weekly leisure time	-1.56	
Real hourly wage rate	2.80	
Real price of one spectator-hour	-4.58	-1.27
Real full cost to consumer	0.00	2.12
Hours of work per spectator-hour	-7.18	-3.96

Sources - Wages from Dewhurst, consumer price deflator from Mitchell (1998); entertainment prices and quantities from Appendix B.
Notes - All values are averages for consumers of spectator entertainment. For 1900 this has been set at 1/3 of the population, for 1938 at 2/3. Most findings are insensitive to this assumption as they concern ratios. All dollar values in current dollars, unless otherwise stated. Opportunity costs / all cost as indicator of time intensity has been taken from Goolsbee and Klenow (2006).
Leisure time is total annual hours minus annual working hours from Huberman and Minns (2007) and 365x12 hours for sleep and personal/household care. The findings are not very sensitive to the hours subtracted

TABLE 3
EFFECT OF OUTPUT VALUATION METHOD ON OBSERVED TFP-GROWTH FOR ENTERTAINMENT, 1900-1938

Valuing output by	Unit	Output (million)		Growth rates 1900-1938	
		1900	1938	Output	TFP
Spectator-hours	spectator-hour	249	7,038	9.19	5.90
Relative price	$ of 1938	151	721	4.19	0.90
Opportunity costs	$ of 1938	68	5,479	12.25	8.96
Full costs	$ of 1938	219	6,200	9.19	5.90
	MEMORANDUM				
Price	$ of 1938	0.61	0.10	-4.58	
Wage rate	$ of 1938	0.27	0.78	2.80	
Full costs	$ of 1938	0.88	0.88	0.00	

Sources - Appendices A and B.
Notes - Relative price = relative to all other prices for consumer goods and services, using the CPI. Opportunity costs = wage rate times spectator-hours. Full costs = adding output weighed by price to that weighed by opportunity costs. Growth rates in percent per annum.

TABLE 4
CONTRIBUTIONS TO OUTPUT GROWTH IN SPECTATOR ENTERTAINMENT, 1900-1938, PER CENT PER ANNUM

	TOTAL	DISAGGREGATED	
		Live technology	Film technology
Output	9.19	-1.24	12.86
Contributions			
Capital	1.22	-0.17	
Labour quantity	1.17	-2.58	
Labour quality	0.90	0.90	
All above inputs	3.29	-1.85	5.10
TFP	5.90	0.60	7.76

Source - Appendices A and B.
Note - The contribution of film technology is an estimate based on the total and live contribution, using expression (3) from the text.

TABLE 5
CONTRIBUTIONS TO LABOUR PRODUCTIVITY GROWTH IN ENTERTAINMENT, 1900-1938, PERCENT PER ANNUM

	TOTAL	DISAGGREGATED	
		Live technology	Film technology
Labour productivity	7.52	2.27	9.44
Contributions			
Capital deepening	0.82	0.72	0.95
Labour quality	0.90	0.90	0.90
TFP	5.79	0.66	7.60

Source - Appendices A and B.
Note - The contribution of film technology is an estimate based on the total and live contribution, using expression (3) from the text.

TABLE 6
KEY PRODUCTION FUNCTION RATIOS FOR THE U.S. ENTERTAINMENT INDUSTRY, 1900 AND 1938

Ratio	Unit	1900	1938	1938 disaggregated	
				Live	Film
Y/L	s-h/hour/yedu	0.20	1.95	0.29	2.23
	$/hour/yedu	0.12	0.20	0.11	0.22
K/Y	$/s-h	0.71	0.15	0.88	0.14
	$/$	1.16	1.51	2.36	1.43
K/L	$/hour/yedu	0.14	0.30	0.26	0.31
TRS	$/hour/yedu	0.41	0.90	0.77	0.92

Source - Tables 4 and 5; Appendix B.
Notes - TRS = The technical rate of substitution; s-h = spectator-hour. yedu = average years of education of the labour force; 6.38 in 1900 and 10.03 in 1938, as in Maddison (1995). Dollars have been deflated to 1938 dollars using the consumer price deflators in Mitchell (1998).

TABLE 7
CONTRIBUTIONS TO REAL PRICE DECLINE IN SPECTATOR ENTERTAINMENT, 1900-1938, PERCENT PER ANNUM

	TOTAL	DISAGGREGATED	
		Live technology	Film technology
Real price	-4.58	-1.27	-5.74
Contributions			
Rental	-0.18	-0.85	
Real wage (quality adjusted)	1.83	1.08	1.93
Dual TFP	6.23	1.50	7.89
Primal TFP	5.90	0.60	7.76
Markup	-0.33	-0.90	-0.13
	1938 VALUES (1900 = 100)		
Real price	17	62	16
Rental	76	27	83
Real wage (quality adjusted)	250	172	263
TFP-level	883	126	1711
Markup	88	71	95

Sources - Appendices A and B; national wages: unskilled: Williamson (2006); all: USDC (1975).
Notes - Wages and prices deflated with Mitchell's (1998) consumer price deflators, before real price and wage growth is computed. Wage growth rate is based on average real wage per person-year of education (pyedu).
For comparison: national real unskilled hourly wages grew by 0.87 percent per pyedu per annum, total national hourly wages grew by 0.98 percent per pyedu per annum. The markup is calculated using expression (6) in the text.

TABLE 8
GROWTH CONTRIBUTION OF THE ENTERTAINMENT INDUSTRY, 1900-1938

	Growth (% p.a.)	Fraction (%)		Growth contribution (%-point p.a.)
Extensive growth contribution				
Growth capital	4.90			
Profits/GDP		0.07		
Total extensive growth contribution				0.003
Intensive growth contribution				
Growth TFP	5.90			
Output/GDP in 1900		0.44		
Pure productivity effect			0.026	
Average additional output/GDP 1900-1938		0.18		
Share effect			0.011	
Growth of inputs	3.29			
Average input share in GDP 1900-1938		0.30		
Input transfer effect			0.003	
Total intensive growth contribution			0.039	0.039
Total growth contribution				0.043
Real GDP growth	2.27			
Caused by entertainment		1.87		0.043
Explained by extensive growth entertainment		0.14		0.003
Explained by intensive growth entertainment		1.73		0.039
Extensive growth/all growth		8		
Pure productivity effect/all growth		60		
Share effect/all growth		25		
Input transfer effect/all growth		7		

Sources - Entertainment data: Appendix A. 1900 and 1938 nominal GDP and real GDP-growth: Williamson (2006).
Note - Profits/GDP and output/GDP: the mid-year value is taken of a geometrical series based on the 1900 and 1938 ratios. The pure effect is the gross output/GDP share (the Domar weight) in 1900 times TFP-growth 1900-1938, the share effect is the same times the average output share 1900-1938 minus the initial share. The input transfer effect is (average value added / GDP) minus (entertainment input / all inputs) for 1900-1938 times the growth rate of inputs. Based on primal TFP-growth. Using dual TFP-growth yields a similar outcome (1.96 percent of GDP-growth explained by entertainment, 1.82 %-point of which intensive.

TABLE 9

CONTRIBUTION OF THE ENTERTAINMENT INDUSTRY TO NATIONAL TFP-GROWTH, 1900-1938

	PRIMAL		DUAL	
	Growth (% p.a.)	Fraction (%)	Growth (% p.a.)	Fraction (%)
National TFP growth	1.14			
TFP-growth entertainment industry	5.90		6.23	
Output/GDP		0.61		
National TFP-growth explained by entertainment		3.19		2.38

Sources - Appendices; Maddison (1995: 255).
Note - National TFP-growth is the weighted average of 1870-1913 and 1913-1950.

TABLE 10

VARIOUS ESTIMATES OF OUTPUT GROWTH FOR SPECTATOR ENTERTAINMENT, AND RECREATION GOODS AND SERVICES, 1900-1938

CATEGORY	OUTPUT VALUED BY	PERIOD	AVERAGE ANNUAL GROWTH OF			SOURCE
			Output	Price	Implied TFP	
Spectator Entertainment	Relative price	1900-1938	4.19	1.40	0.90	This paper; CPI
	Price	1929-1938	-0.47	-1.31	-3.76	NIPA
	Spectator-hours	1929-1938	0.15	-1.31	-3.14	NIPA; this paper.
Recreation Services	Price	1900-1929	5.38	3.13	2.09	Lebergott (1996)
	Price	1900-1938	4.22		0.93	Lebergott (1996)
Recreation Goods	Price	1900-1929	4.65	1.44	1.36	Lebergott (1996)
	Price	1900-1938	3.32		0.03	Lebergott (1996)
Recreation Services and Goods	Price	1900-1929	5.27	2.35	1.98	Lebergott (1996)
	Price	1900-1938	3.81		0.52	Lebergott (1996)
	Price	1901-1938	4.27	0.27	0.98	Owen (1970)
Average		1900-1938	2.96	0.44	-0.33	
Spectator entertainment as measured in this paper	Spectator-hours	1900-1938	9.19	-4.58	5.90	This paper

Sources - Owen (1970); Lebergott (1996); Bureau of Economic Analysis, National Income and Product Accounts of the United States (NIPA).
Notes - All rates in percent per annum. Spectator entertainment was on average 57.8 percent of recreation services between 1900 and 1929, when Lebergott data is combined with this paper's data; spectator entertainment shrank from 65 percent to 51 of all recreation services expenditure percent. Spectator entertainment was on average 18.6 percent of all recreation goods and services between 1900 and 1938, when Owen data is combined with this paper's data; its share grew from 15 to 23 percent of all recreation goods and services expenditure. The latter suggest that the expenditure share of recreation goods must have dropped sharply relative to services.
Implied TFP' speculatively assumes that inputs grew at the rate for spectator entertainment reported in table 4.
Average: the unweighted average of spectator entertainment growth rates, recreation services growth rates and Owen's estimate of the recreation goods and services growth rate.

TABLE 11

GROWTH OF TOTAL FACTOR PRODUCTIVITY BY INDUSTRY GROUP, UNITED STATES, 1899-1937, IN PERCENT PER ANNUM

RANK	INDUSTRY	38 YEARS	30 YEARS		20 YEARS			10 YEARS			
		1899-1937	1899-1929	1909-1937	1899-1919	1909-1929	1919-1937	1899-1909	1909-1919	1919-1929	1929-1937
1	Spectator entertainment	6.0									
2	Rubber products	5.4	5.8	**6.5**	4.8	**7.5**	**6.0**	2.3	**7.4**	**7.7**	4.0
3	Electric utilities	5.2	5.3	5.2	**6.7**	5.3	3.6	5.2	**8.2**	2.5	5.0
4	Transportation equipment	4.2	5.5	5.3	4.0	**7.7**	4.4	1.1	**7.0**	**8.4**	-0.4
5	Tobacco	4.1	3.5	5.1	3.0	4.6	5.2	1.2	4.9	4.4	**6.3**
6	Residual Transport	3.8	2.5	5.6	0.1	4.4	**8.0**	-1.2	1.5	7.4	**8.8**
7	Oil and Gas mining	3.7	2.5	4.6	1.1	3.2	**6.6**	1.3	0.9	5.5	**8.1**
8	Manufactured gas	3.6	4.1	3.4	4.5	4.1	2.5	4.1	5.0	3.2	1.6
9	Printing, publishing	3.3	3.5	3.1	3.4	3.3	3.2	3.9	3.0	3.7	2.6
10	Paper	2.8	2.5	3.0	1.3	2.5	4.5	2.4	0.3	4.7	4.3
11	Metals mining	2.8	2.4	3.4	1.6	3.0	4.0	1.1	2.2	3.8	4.3
12	Stone, clay, glass	2.7	2.8	2.9	1.4	3.2	4.2	2.2	0.7	5.7	2.3
13	Petroleum, coal products	2.7	2.7	3.4	-0.2	3.7	5.9	0.7	-1.0	8.6	2.7
14	Telephone	2.7	2.8	1.9	3.3	1.7	2.0	4.8	1.9	1.6	2.4
15	Local Transit	2.6	2.6	3.1	1.9	3.4	3.4	1.1	2.7	4.1	2.5
16	Chemicals	2.5	2.4	3.2	0.0	3.3	5.4	0.7	-0.7	**7.4**	3.0
17	Fabricated metals	2.5	2.9	2.6	2.0	3.2	3.0	2.3	1.8	4.6	1.0
18	Apparel	2.5	2.5	3.1	1.7	3.3	3.3	0.7	2.7	4.0	2.5
19	Textiles	2.2	1.6	2.7	1.0	1.9	3.7	1.1	0.9	2.9	4.6
20	Railroads	2.2	2.4	2.4	2.6	2.6	1.8	1.8	3.4	1.9	1.7
21	Nonmetals mining	2.2	2.6	2.4	1.0	3.1	3.6	1.6	0.4	5.9	0.7
22	Miscellaneous mfg.	1.9	1.6	2.2	0.1	2.0	3.8	0.8	-0.6	4.6	2.9
23	Electric machinery	1.8	1.5	2.3	0.4	1.9	3.4	0.6	0.3	3.5	3.2
24	Primary metals	1.7	2.5	1.4	1.1	2.5	2.4	2.7	-0.5	5.5	-1.3
25	Machinery, on-electronic	1.7	1.5	1.9	0.8	1.8	2.6	1.0	0.7	2.9	2.3

26	Leather products	1.7	1.2	2.2	0.3	1.7	3.2	0.1	0.5	2.9	3.6
27	Foods	1.7	1.7	2.1	-0.1	2.4	3.6	0.3	-0.4	5.3	1.5
28	Beverages	1.7	-1.7	1.9	-2.4	-2.9	6.4	0.9	-5.6	-0.2	**15.2**
29	Telegraph	1.6	1.5	1.7	0.1	1.5	3.3	1.5	-1.2	4.3	2.1
30	Bituminous coal mining	1.6	1.8	1.8	1.5	2.1	1.8	1.2	1.8	2.4	1.0
31	Natural gas	1.1	0.4	1.5	0.5	0.6	1.7	0.0	1.1	0.2	3.7
32	Residual sector	1.0	1.0	0.7	1.6	0.7	0.3	1.7	1.5	-0.1	0.8
33	Anthracite coal mining	0.9	0.0	1.4	0.0	0.2	1.9	-0.4	0.5	0.0	4.3
34	Furniture	0.8	0.9	1.4	-0.7	1.8	2.5	-0.8	-0.5	4.2	0.5
35	Farming	0.4	0.2	0.5	-0.3	0.4	1.0	-0.2	-0.3	1.2	0.8
36	Lumber products	0.3	0.3	0.6	-0.8	0.6	1.6	-0.4	-1.2	2.5	0.4
Private domestic economy											
	Total	1.5	1.4	1.6	1.1	1.5	1.8	1.2	1.1	2.0	1.6
Unweighted summary statistics											
	Minimum	0.3	-1.7	0.5	-2.4	-2.9	0.3	-1.2	-5.6	-0.2	-1.3
	Maximum	5.4	5.8	6.5	6.7	7.7	8.0	5.2	8.2	8.6	15.2
	Range	5.1	7.4	6.0	9.1	10.6	7.7	6.4	13.8	8.8	16.5
	Average	2.4	2.2	2.8	1.4	2.6	3.5	1.4	1.4	3.9	3.1
	Standard deviation	1.2	1.5	1.4	1.8	1.9	1.7	1.4	2.7	2.3	3.0
	Coefficient of variation	0.5	0.7	0.5	1.3	0.7	0.5	1.1	1.9	0.6	1.0

Source - Spectator entertainment: tables 3, 4, 6, above. All else: Kendrick (1961: 136-137).
Notes - 1899-1937 rates are arrived at by computing 1937 levels using period growth rates and then calculating 1899-1937 as if there had been a constant rate of growth. Spectator entertainment TFP is average of primal TFP through output calculation, through labor productivity calculation, and the dual TFP. Values equal to or higher than entertainment TFP-growth have been set in boldface.

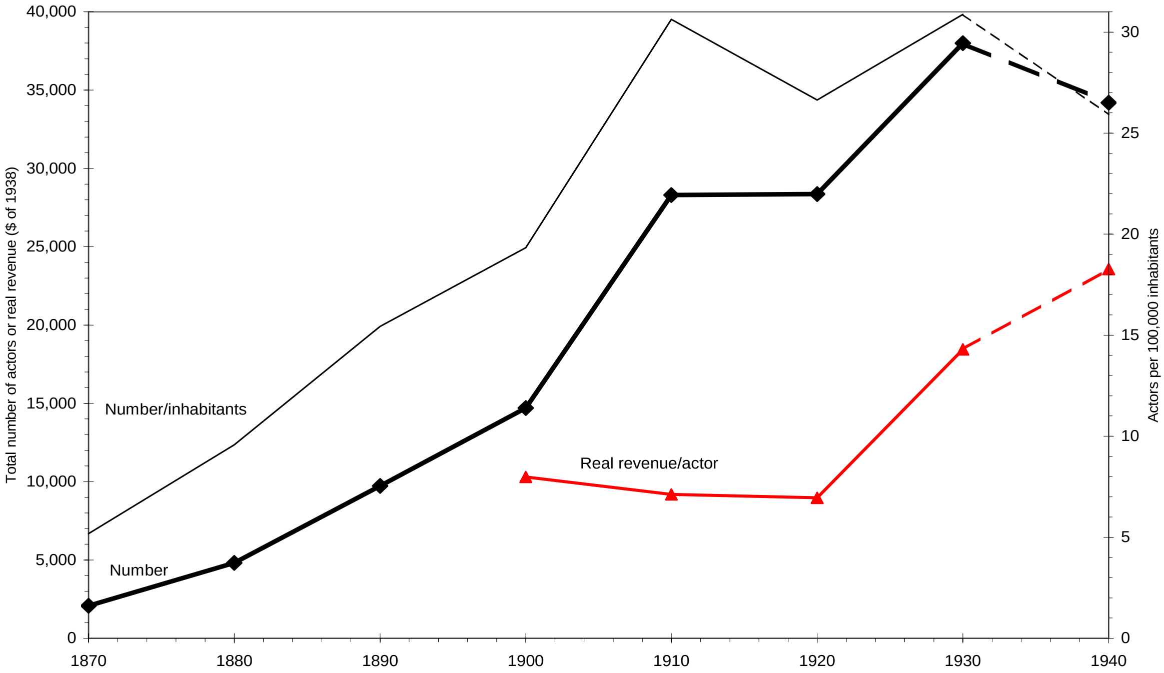
TABLE 12

THE GROWTH CONTRIBUTION OF CINEMA TECHNOLOGY VERSUS THAT OF GENERAL PURPOSE TECHNOLOGIES (GPTS) AT VARIOUS INTERVALS, 1830-2000

GPT	COUNTRY	INTERVAL	LAG	GDP-SHARE	GROWTH OF		GROWTH CONTRIBUTION			ACCUMULATED INTENSIVE CONTRIBUTION			NATIONAL GROWTH	
					TFP	K/L	Int.	Ext.	Total	Industry		National	TFP	GDP
			(years)	(%)	(%p.a.)	(%p.a.)	(%)	(%)	(%-point)	(% GDP)	(%Nat)	(% GDP)	(%)	(%)
Film technology	US	1900-1938	25-40	0.6	5.9	3.3	92	8	0.04	1.4	3.8	36.1	1.14	2.27
Railways	US	1840-1890		3.1	2.8	-1.3				1.6	10.9	15.0	0.34	4.76
	UK	1830-1870		2.5	5.5	14.0	52	48	0.27	5.3	38.5	13.7	0.75	2.13
	UK	1870-1910		6.0	3.8	0.2	96	4	0.24	8.5	43.1	19.7	0.56	1.70
Steam	UK	1850-1870	80	1.8	3.5		50	50	0.12	1.2	8.8	13.7	0.75	2.39
		1870-1910	80-120	2.7	1.7		64	36	0.14	1.8	9.1	19.7	0.56	1.70
Steamships	UK	1850-1870		0.7	1.6	9.7	33	67	0.03	0.2	1.6	13.7	0.75	2.39
		1870-1910		3.4	1.6	4.5	50	50	0.10	2.1	10.7	19.7	0.56	1.70
Electricity	US	1929-1948	40		4.6									
ICT	US	1973-1995		3.9			38	62	0.74	5.8	72.6	8.0	0.39	2.84
		1995-2000		6.7			41	59	1.84	3.6	75.4	4.7	1.00	4.10
		2000-2006		5.8			46	54	1.12	3.0	56.0	5.3	0.92	2.36

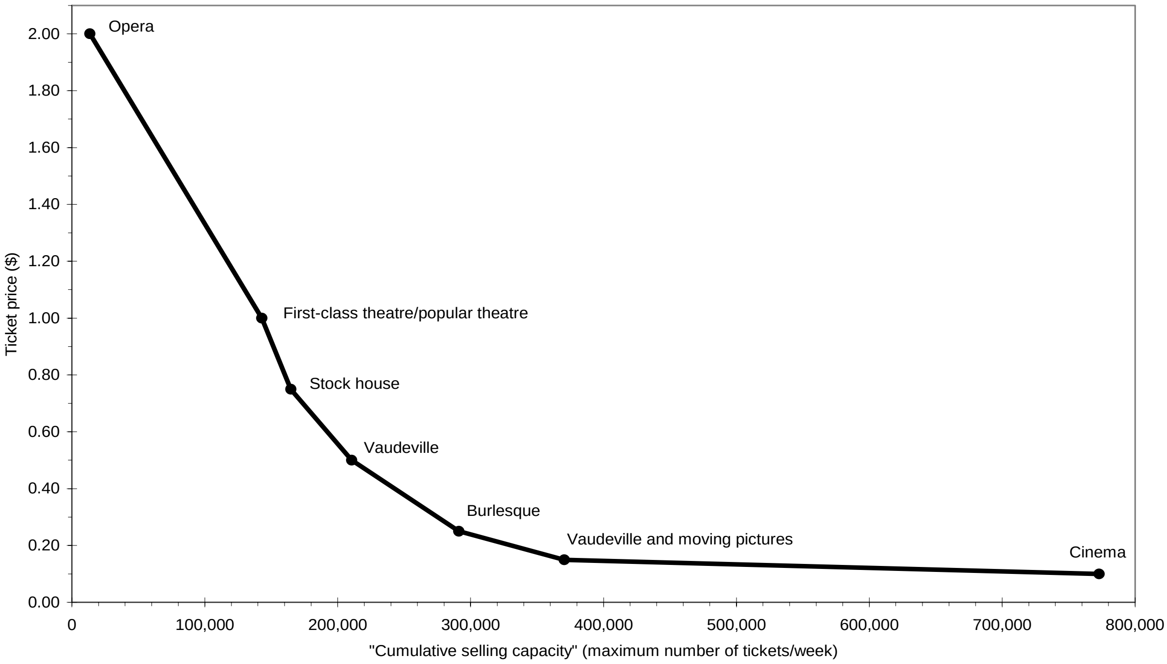
Sources - US Railways: Passell and Atack (1994: 450) based on Fogel (1962) and Fishlow (1966). UK Railways: Leunig (2006). Steam and steamships: Crafts (2004). US electricity data is the geometric average of 1919-1929-1941-1948 growth intervals from Kendrick (1961), as reported in Field (2003). ICT: Oliner, Sichel and Stiroh (2007). National TFP growth for US 1900-1938 from Maddison (1995), for the UK from Crafts (2003). US 1973-2006 is the rate for private output as reported in Jorgenson, Ho and Stiroh (2008). National US and UK GDP growth from Williamson (2006).
Notes - Lag = estimate of time between innovation and productivity impact. Int. = intensive. Ext. = extensive. %Nat = percentage of accumulated industry growth contribution of accumulated national intensive growth over the time interval. The TFP-growth of UK railways include time-savings, following Leunig (2006), which roughly double the 1830-1870 and triple the 1870-1910 growth contribution. These rates have been calculated from the social savings reported in Leunig (2006) using expression (7) from the text. ICT = information and communication technologies.

<u>FIG. 1: Number of Actors and Actresses and Real Revenue per Actor/Actress in the US, 1870-1940.</u>



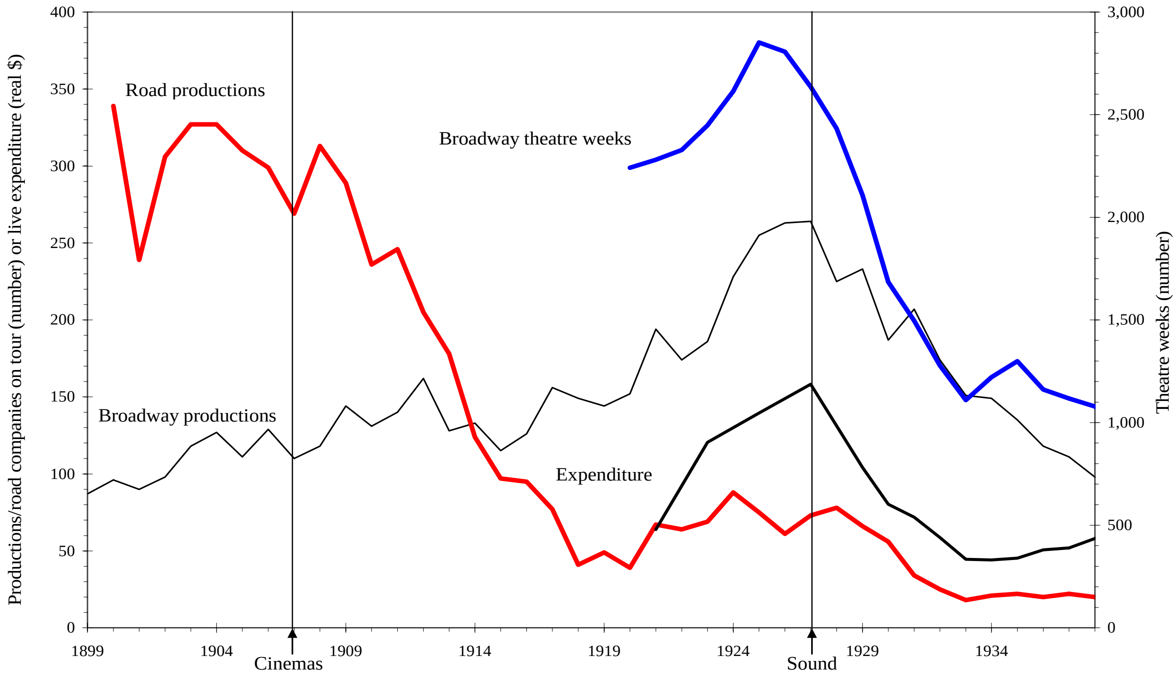
Source - US Census, 1870-1940; United States Department of Commerce, Historical Statistics; Appendix B.
Note - the 1940 data is a lower-bound estimate, because 1940 census figures for actors/actresses are not comparable with the 1930 census (Alba M. Edwards, 1943). In 1930 37,993 persons were classified as actor or actress, in 1940 only 19,232. The fact that 1940 census classified persons by the work they were doing during one particular week in March, may have had particularly an effect on the number of actors/actresses. To arrive at a very conservative estimate, it has been assumed that, had the 1930 classification been used, employment would only have decreased by ten percent, yielding a 'comparable' number of 34,194. It is likely that the real comparable number was very much lower.

<u>FIG. 2: Ticket Price Versus Cumulative Ticket-Selling Capacity For Theatrical Entertainment Venues In Boston In 1909 ($ And Maximum Number Of Tickets Per Week)</u>



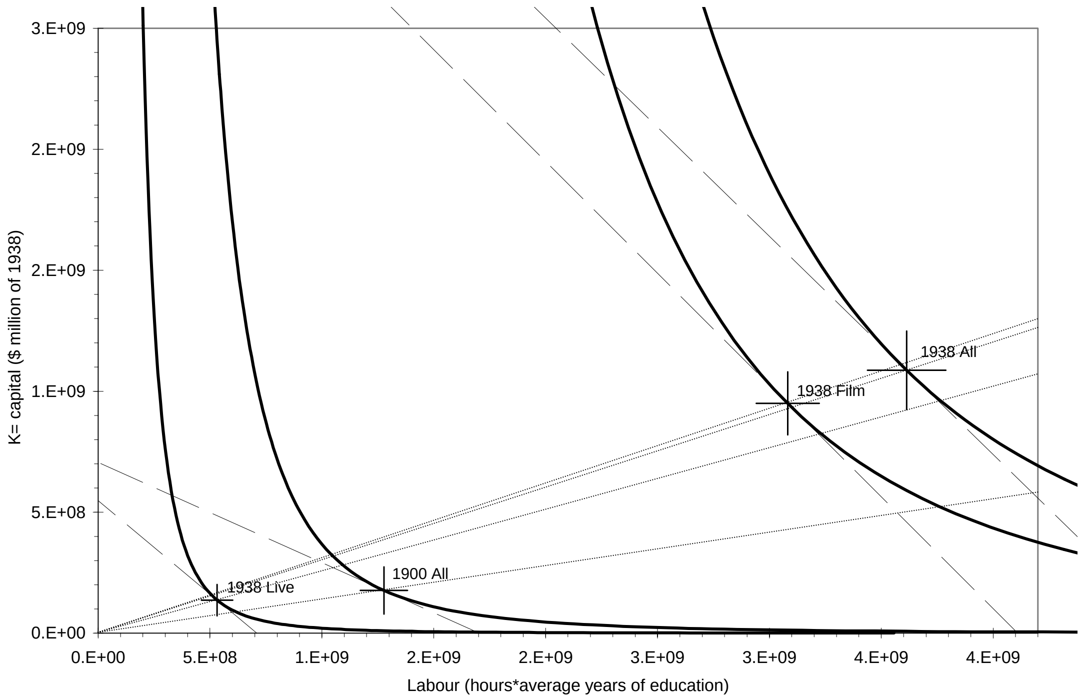
Sources: Table 1; compiled from Boston Committee (1909), as mentioned in Garth S. Jowett (1974).

FIG. 3.—Indicators Of US Live Entertainment Production (Number Of Road Productions On Tour, Broadway Productions, Broadway Theatre Weeks And Real Expenditure), 1899-1938.



Sources - Bernheim (1932); McLaughlin (1974: 271-280), US Department of Commerce (1975).
Notes - Road productions: this is the average of the total number of companies on tour in April and in December, as listed in Variety. Real expenditure: this it total consumer expenditure in millions of 1938 dollars, deflated by the consumer price index from B. R. Mitchell (1998).

<u>FIG. 4.—Cobb-Douglas Production Function For US Spectator Entertainment, 1900 And 1938.</u>



Sources - See Appendix A and B.
Notes - The lines tangent on the Cobb-Douglas functions are the technical rate of substitution [(a/(1-a)*K/L].
The lines through the origin and through the four data points are the capital/labour ratios, of course.

APPENDIX A:

Estimating TFP-Growth

This section briefly discusses the data estimates made to calculate TFP-growth, the estimation of factor elasticities, value of human capital and the effect of international trade.

I. Data Estimates

Since the sectoral data are at times sparse and incomplete, especially for 1900, approximate estimates had to be made in some cases. Appendix B lists in detail how these estimates were arrived at. Most of the 1938 data is from the US Department of Commerce, the US Bureau of Labor Statistics and the Bureau of Economic Analysis (1977). The 1900 labour data are calculated from census figures, the 1900 consumer expenditure data is arrived at by combining the US Department of Commerce 1909 expenditure data with John Owen's (1970) growth rates on real US consumer expenditure on recreation. The 1900 price and capital estimates are based on expert estimates of theatre historians and the contemporary trade press and directories. They have been made as conservatively as possible, by rounding them up or down in the direction that would diminish TFP-growth and social savings between 1900 and 1938, not unlike the way Robert Fogel (1964) estimated the social savings of US railways.

II. Factor Elasticities

For motion pictures, between 1929 and 1947 the share of wages in national income was 0.78 on average and for other amusements and recreation 0.81 (table A-1). The latter category comprised far more than live entertainment, which was just a small share of it, but further disaggregated national income data are not available. The 1930s data suggests a labour elasticity of about 0.80, but this value was affected considerably by the depression, which decreased the income share of capital. The shares in 1929 and 1930 and in the 1940s warrant a somewhat lower estimate of long-run income-share of 0.70.

For 1900, unfortunately no industry national income figures are available. If we multiply the employment with average national wages (as opposed to wages of entertainment workers), we arrive at a labour share of industry revenues of 0.66 in 1900, versus 0.52 in 1938. Given the estimated 1929-1947 capital costs and taking into account the effect of the depression it does not seem unreasonable to assume that the factor price of capital was 0.15 in 1900. Using 1900 benchmark estimates (Appendix B) - the labour share was then 0.81 in 1900. Both estimated suggest that the share of labour was somewhat higher in 1900 than in the 1930s. An average share of 0.75 for the whole period therefore does not seem unreasonable.

III. Quality of Human Capital

The over-all average quality of US labour increased substantially between 1900 and 1938. Education, for example, improved from 6.38 years to 10.03 years per worker.[39] Further, with the film industry's ageing labour quality probably improved, because of an increasing number of employees who had been trained on the job. Since this is rather difficult to measure, the national increase in labour quality is used as a lower bound proxy.

[39] Calculated by geometric interpolation from the benchmark years 1890, 1913 and 1950. Maddison (1995): 37, 253.

TABLE A1

NATIONAL INCOME GENERATED BY THE MOTION PICTURE INDUSTRY AND 'AMUSEMENTS AND RECREATION' AND FACTOR INCOME SHARES

Year	NI	Compensation of Employees	Compensation of Capital	Corporate profits	Other capital income	L/NI
			MOTION PICTURES			
1929	440	310	130	59	71	0.70
1930	438	313	125	51	74	0.71
1931	361	307	54	2	52	0.85
1932	194	241	-47	-83	36	1.24
1933	210	227	-17	-40	23	1.08
1934	283	253	30	2	28	0.89
1935	329	282	47	13	34	0.86
1936	391	317	74	29	45	0.81
1937	437	360	77	33	44	0.82
1938	426	346	80	39	41	0.81
1939	434	353	81	41	40	0.81
1940	448	353	95	51	44	0.79
1941	513	386	127	78	49	0.75
1942	652	425	227	155	72	0.65
1943	830	477	353	253	100	0.57
1944	882	531	351	246	105	0.60
1945	929	573	356	238	118	0.62
1946	1129	703	426	304	122	0.62
1947	1046	719	327	224	103	0.69
Average						0.78
			AMUSEMENTS AND RECREATION — EXCEPT MOTION PICTURES			
1929	379	323	56	1	55	0.85
1930	336	299	37	-9	46	0.89
1931	268	256	12	-20	32	0.96
1932	177	191	-14	-30	16	1.08
1933	154	161	-7	-23	16	1.05
1934	197	176	21	-9	30	0.89
1935	211	180	31	-5	36	0.85
1936	253	205	48	2	46	0.81
1937	305	239	66	5	61	0.78
1938	266	216	50	2	48	0.81
1939	288	230	58	4	54	0.80
1940	310	246	64	9	55	0.79
1941	368	270	98	18	80	0.73
1942	388	281	107	18	89	0.72
1943	436	291	145	34	111	0.67
1944	507	337	170	42	128	0.66
1945	613	384	229	71	158	0.63
1946	816	524	292	93	199	0.64
1947	797	566	231	64	167	0.71
Average						0.81

Source - Bureau of Economic Analysis 1977.
Notes - NI = national income. Other capital income = proprietors' income, rental income, net interest. L/NI = share of wages in national income. All other values in millions of current dollars.

IV. International Trade

The net dollar revenues from US films abroad should be included in the national income, as calculated by the Bureau of Economic Analysis. Industry output, however, has been calculated by dividing domestic revenues by price. It is difficult to do this for export revenues, because precise data lack and also because ticket prices varied substantially across the world. If one assumes that about a third of US box office revenue went to distributors and one uses the expert ballpark estimate that the Hollywood studios' foreign earnings were about one third to one quarter of domestic revenues, then foreign income in 1938 would be about 1/9th to 1/12th of domestic expenditure, between $55 and $74 million.

The final output generated abroad, however, uses mainly foreign labour and capital and these are not included in the US figures. The only US share would be those from employees working in film production, about 33,000 in 1938, and those in international distribution, relatively negligible. Given the number of assumptions to be made, it seems most appropriate to ignore the foreign issue. Given that, for US producers, those foreign spectator-hours had marginal costs approaching zero, that the US economy did not consume that additional output, and given that that the dollars received for it were national income, it does not seem unreasonable to exclude foreign output. It will certainly make our TFP-estimate more conservative.

APPENDIX B:

Data Used for the Estimates[40]

This appendix provides the sources for the estimates on labour, capital and output. Since the available data are sparse, approximate estimates had to be made in some cases. The estimates have been made transparent and replicable by stating all the steps. They also have been made as 'conservative' as possible; they have been rounded up or rounded down in the direction that would diminish overall TFP growth between 1900 and 1938. For 1900 estimates for prices, labour and capital will have a downward bias, those for output an upward bias and vice-versa for 1938.

Table B-1 gives an overview of all the data used and estimates made.

I. Entertainment in 1900

A. Labour in 1900

1. The US census lists 57,777 persons classified under entertainment. These are only management and creative inputs, not the practical workers that worked in the entertainment industry.

2. In the 1910 census, which contains a disaggregated breakdown of these categories, 15.89 percent of the persons above were listed under classifications that largely involve non-theatrical entertainment, and which were not present in the 1900 census. It is simply assumed that this percentage was the same in 1900, we arriving at 0.8411 x 57,777 = 48,596 persons classified under entertainment.

3. In 1930, for the first time, both practical workers classified in the census under entertainment (Census of Population, 1930) and

[40] This paper's estimates differ in five respects from those of Gerben Bakker (2004): the current paper takes into account the changes in hours worked; it has better price estimates based on more precise data; it has better capital data; and, finally, it is more accurate in the data on total consumer expenditure and in the size of the total entertainment labour force in 1938.

practical workers working in entertainment but classified in the census under other industries (US Bureau of Economic Analysis, 1977) are available. Therefore this year will be used as a benchmark year. The census contained 203,251 persons working in spectator entertainment (249,177 – 6,097 aviators – 10,718 ‘keepers of pleasure resorts, race tracks etc.’ – 29,129 ‘keepers of billiard rooms, dance halls, skating rinks etc.’ = 203,251 persons). 31.1 percent of these had practical occupations. If we make the bold assumption that this percentage was the same in 1900, we arrive at (57,777/68.9)*100 = 70,532 persons working in the industry in 1900.

4. Data on workers classified in other industries but working for the entertainment industry are only available from 1930. Using the same method as will be used to calculate 1938 labour (see below), we arrive at 71,122 live entertainment fte in 1930, making a total of entertainment fte of 153,000 for film and 71,122 = 224,122 fte, suggesting that 20,871 persons, or 10.3 percent of the census total, were classified under non-entertainment occupations. Assuming that this percentage was the same in 1900, we arrive at 1.1026 * 70,532 = 77,774 persons working in the entertainment industry in 1900.

5. This is a rough estimate, and sources lack to make a more precise estimate. Yet, the directions and the magnitude of the findings are not that sensitive for an estimation error of say plus or minus 10,000 persons (see text)

TABLE B1
PRODUCTIVITY INDICATORS FOR ENTERTAINMENT IN THE UNITED STATES, 1900-1938

	LIVE + FILM	DISAGGREGATED	
		Live technology	Film technology
Labour (hours)			
1900	200,212,948	200,212,948	
1938	360,296,080	52,994,324	307,301,756
Capital ($)			
1900	176	176	
1938	1,086	137	949
Sold output (million sh)			
1900	249	249	
1938	7,038	155	6,883
Expenditure (million 1938$)			
1900	151	151	
1938	721	58	663
Price (1938$)			
1900	0.608	0.608	
1938	0.102	0.374	0.096
Labour productivity (sh/hour))			
1900	1.24	1.24	
1938	19.53	2.92	22.40
Capital productivity (sh per 1000$)			
1900	1,412	1,412	
1938	6,479	1,131	7,251
Labour costs ($/hour)			
1900	0.28	0.28	0.28
1938	1.09	0.75	1.15
Capital Costs ($ per $ of K)			
1900	0.1268	0.1268	0.1268
1938	0.0963	0.0341	0.1052
Capital factor income in $million			
1900	17.65	17.65	
1938	74.65	2.75	71.91
Labour factor income (wage bill)			
1900	55.81	55.81	
1938	394.09	40	354
Capital consumption			
1900	4.73	4.73	
1938	29.93	1.93	28.00
Capital/(hour)			
1900	0.9	0.9	
1938	3.0	2.6	3.1
Population (millions)			
1900	76	76	76
1938	130	130	130
Output/capita (sh)			
1900	3.3	3.3	0.0
1938	54.2	1.2	53.0

Expenditure/capita (1938 $)			
1900	2.0	2.0	0.0
1938	5.6	0.4	5.1

Sources - Appendix; education: Maddison (1995).
Note - All amounts at 1938 prices; sh = spectator-hour (see text). Labour productivity (in spectator-hours per hour worked) is uncorrected for increases in labour quality.

6. Since data on full time and part-time proportions is lacking for 1900, the 1938 ratio of fte over the total number of employees, 0.8762, has been used to convert these persons into ftes, arriving at 68,146 fte.
7. As industry-specific working hours are lacking, these persons have been multiplied by the average annual working hours (2938) taken from Huberman and Minns (2007), to arrive at a grand total of 200.2 million hours.

B. Wages in 1900

For 1900, the national average wages (from Dewhurst, 1955) have been used, as reliable industry wages series are not available.

C. Consumer Expenditure in 1900

1. Entertainment expenditure in 1909 was $167 million (US Department of Commerce, 1975) which amounts $260.937 million in 1938 dollars, using the consumer price deflators in Mitchell (1998). All amounts that follow are changed into 1938 dollars using these same deflators.
2. This figure is back-projected to 1901 by using Owen's growth rates for real total consumer expenditure for 1906-1913 (7.99 percent) and 1901-1906 (5.85 percent) (Owen, 1970), yielding an expenditure of $155.930 million in 1901.
3. This figure is then further back-projected by assuming 1900-1901 had at least half the growth rate (to make the estimate more

4. conservative) as 1901-1906, yielding 1900 expenditure of $151.499 million (in 1938 dollars).

5. A rough cross-check is made by taking the average household expenditure on ‘amusements and vacations’ from the US Commissioner of Labor Survey (as reported in Bakker, 2001). This was 1.1 percent. It is then assumed that half of this, 0.55 percent, was spent on spectator entertainment. Using the 1917/1919 expenditure on spectator entertainment (Bakker, 2001), of 0.63 percent, it is tentatively assumed that in 1900, on average 0.59 percent of labour income was spent on spectator entertainment. If we take the share of labour income in national income in 1900 to be 0.54 (Rosenbloom, 2005), we arrive at consumer expenditure on spectator entertainment in 1900 of $66 million, which is $112 million dollars of 1938. This rough estimate confirms that estimate (3) is in the right ballpark, but about a quarter lower, and thus may lead to underestimating productivity growth.

6. Since (3) is the more careful estimate, and also the more conservative one (i.e. the one that would tend to over-estimate productivity in 1900 and thus lower the TFP-estimate, estimate (3) is taken.

D. Prices in 1900

1. It is difficult to obtain reliable estimates of entertainment prices in 1900, but one for high-quality live entertainment in 1913 is $2 per ticket (Poggi, 1968: 71). In the 1900s, also lower priced live entertainment existed and cheaper tickets. Robert C. Allen (1980: 296), for example, found that standing place tickets for vaudeville ranged from 15 to 50 cents, while Felicia Hardison Londré and Daniel J. Watermeier (1998: 265) describe how low-priced resident

stock theatre companies emerged between 1900 and 1920, whose prices usually varied between ten and thirty cents, and rarely exceeded 75 cents. Glen Hughes (1951: 305) writes how an early vaudeville theatre in the 1880s charged 10 cents for standing places and 15 cents for seats. Using rough estimates like these, and assuming ticket prices rose in line with inflation during the 1900s, we arrive at an average price of $1.25 for the most expensive live entertainment, $0.35 for the entertainment in between, and $0.20 for the cheapest live entertainment in 1900. These are deliberately lower bound estimates, to make our calculation more conservative.

2. It is then assumed that in the most expensive places, a performance lasted 2.5 hours, in the intermediate places 2 hours, and in the cheapest places 1.5 hours. Combining this with (1) yields average prices per spectator-hour of 50, 17.50 and 13.33 cents, respectively.

3. Given that no systematic price data is available, an estimate has to be made. It is assumed that in 1900, about half of all tickets sold was for ‘first-class’ live entertainment. Using contemporary sources, Londré and Watermeier (1998: 185) identify 1,700 theatres nation wide available for touring and about 1,000 unlisted theatres. If it is assumed that the unlisted theatres were of a lower quality and charged lower admission prices, this would yield a ratio of 63 percent. To keep our estimate conservative, we set the ratio at fifty percent, and assume that this ratio was the same for the vaudeville, burlesque, and others theatrical entertainments. We then simply assume that another 25 percent of tickets were for intermediate entertainment, and another 25 for the cheapest form of entertainment.

4. Correcting for differences in output, the weight of the three forms of entertainment becomes then 58.82 percent (0.5*2.5/(0.5*2.5+0.25*2+0.25*1.5)), 23.53 percent and 17.65 percent respectively.

5. Combining (2) and (4) we arrive at an average price per spectator-hour in 1900 of (0.5882*50) + (0.2353*17.50) + (0.1765*13.33) = 35.88 cents in 1900 prices. This amounts to 60.81 cents in 1938 dollars.

6. Particularly good data on spectator entertainment prices and quantities for the period when cinemas already were omnipresent enables us to check whether the estimate above is roughly in the right ballpark. The data is for Boston in 1909, is reported in Gart S. Jowett (1974), and is based on an investigation by the Boston Committee on Amusements (see also table 1 and figure 2 in the main text). It contains ticket prices and estimated ticket-selling capacities for each category of spectator entertainment, from opera, at $2.00 a ticket to cinema, at $0.10 a ticket. If we ignore the two lowest priced categories, motion picture theatres (52 percent of total capacity) and theatres showing ‘vaudeville and motion pictures’ (10 percent of total capacity, price $0.15), we arrive at weights of 49 percent for high-priced entertainment (opera, first-class and popular theatre), 23 percent for medium-priced entertainment (‘stock houses’ and ‘vaudeville houses’) and 28 percent for low-priced entertainment (‘burlesque houses’), with average ticket prices of $1.10, $0.58 and $0.25, yielding an average ticket price of 76.25 cents and an average duration (using the durations mentioned in (4) above) of 2.105 hours. This results in an average current ticket price of 35.27 cents. This price is nearly equal to the current 1900 price of 35.88 cents. In real terms, the price is somewhat lower, 53.43 cents of 1938. If both our

estimates would be entirely accurate (a big if) then this would suggest that during the 1900s, the live entertainment price decreased with 1.43 percent per annum relative to all other prices, leaving the nominal price unchanged. This does not seem unreasonable, given the increasing competition of cinema from 1905 onwards. Given that by 1909, about three to four years after the first cinemas emerged, 52 percent of Boston capacity existed of cinemas, an average price of 35.27 cents in the face of strong cinema competition suggests that the price could have been far higher in 1900.

7. Although the data analyzed under (6) suggests that our 1900 price estimate reported under (5) may be somewhat on the low side, the price estimate under (5), of 35.88 cents, or 60.81 cents in 1938 dollars is kept, to keep the estimate of TFP-growth conservative.

E. Capital in 1900

1. Exact data on capital invested in the entertainment industry in 1900 is not available. The number of theatres was estimated to be 2,700 in 1905; 1,700 first-class listed theatres and about 1,000 others (Londré and Watermeier, 1998). A different estimate for 1910 arrived at 1,520 first-class listed theatres (Bernheim 1932). It is thus estimated that in 1905 the total number was 2,700 and that on top of this, 1,000 vaudeville theatres existed, and 1,000 other entertainment venues, yielding a total of 4,700. It is then assumed that between 1900 and 1905 the number of venues grew at the rate of the real expenditure on recreation (5.58 percent per annum) found by Owen (1970). This yields 3,537 venues in 1900.

2. Because no systematic data is available, based on anecdotal historical construction costs and acquisition data for individual

theatres from the theatre history literature (see bibliography) a rough and ready ballpark estimate was made that the capital needed to build an average theatre in 1900 was about $35,000.

3. It is assumed capital will depreciate in fifty years and that in 1900, the average age of an entertainment venue was ten years, given the boom in entertainment expenditure towards the end of the 19th century. This yields an average depreciated invested capital per theatre of $28,000, and a total invested capital of $99.036 million, amounting to $176 million in 1938 dollars (using the GDP-deflator from Williamson (2006)).

F. Cost of Capital in 1900

1. This is calculated as (capital factor income + capital consumption)/(capital stock).

2. Since no reliable industry data on capital income exist, an estimate had to be made; capital income been set at ten percent of stock, slightly higher as in 1938, given the effect of the depression, and capital consumption at the same percentage as in 1938 (2.68 percent of stock). This yields a cost of capital of 0.1268, or $17.65 million in 1938 dollars.

II. <u>Entertainment in 1938</u>

A. Labour in 1938

Cinema:

Employment was 171,000 full-time employment equivalent (fte). In addition, there were 7,000 self-employed.(Bureau of Economic Analysis, 1977: 206). The latter have been converted to fte using the ratio of fte/(full-time and part-time employees) for the employees and then assuming that that these self-employed worked for 5/8 of their time in entertainment, yielding a total of 175,001 fte.

Cinema wages:

From same source as above (Bureau of Economic Analysis 1977: 206) the total compensation paid was $354 million.

Live entertainment

1. In Amusements and Recreation employment was 163,000 full-time employment equivalent (fte). In addition, there were 49,000 self-employed.(Bureau of Economic Analysis, 1977: 206). The latter have been converted to fte using the ratio of fte/(full-time and part-time employees) for the employees, and assuming they worked for 5/8 in entertainment, yielding 24,835 fte self-employed and a total of 187,835 fte (table B-2).

TABLE B2
ENTERTAINMENT EMPLOYMENT AND COMPENSATION, 1938

	Employees	Self-employed	Total
	FILM		
Full-time and part-time employees	187,000	7,000	194,000
Fte	171,000	4,001	175,001
Total wages and salaries	332,082,000	7,769,298	339,851,298
Total compensation of employees	346,000,000	8,094,920	354,094,920
Wages and salary/fte	1,942	1,942	1,942
Total compensation/fte	2,023	2,023	2,023
Wages and salary/employee	1,776	1,776	1,752
Total compensation/employee	1,850	1,850	1,825
	AMUSEMENTS AND RECREATION		
Full-time and part-time employees	201,000	49,000	250,000
Fte	163,000	24,835	187,835
Total wages and salaries	207,010,000	31,540,703	238,550,703
Total compensation of employees	216,000,000	32,910,448	248,910,448
Wages and salary/fte	1,270	1,270	1,270
Total compensation/fte	1,325	1,325	1,325
Wages and salary/employee	1,030	1,030	954
Total compensation/employee	1,075	1,075	996
	LIVE		
Full-time and part-time employees	32,294	7,873	40,166
Fte	26,188	3,990	30,179
Total wages and salaries	33,259,224	5,067,481	38,326,706
Total compensation of employees	34,703,601	5,287,551	39,991,152
Wages and salary/fte	1,270	1,270	1,270
Total compensation/fte	1,325	1,325	1,325
Wages and salary/employee	1,030	1,030	954
Total compensation/employee	1,075	1,075	996
	FILM + LIVE		
Full-time and part-time employees	219,294	14,873	234,166
Fte	197,188	7,991	205,179
Total wages and salaries	365,341,224	14,804,995	380,146,219
Total compensation of employees	380,703,601	15,427,536	396,131,137
Wages and salary/fte	1,853	1,853	1,853
Total compensation/fte	1,931	1,931	1,931
Wages and salary/employee	1,666	1,666	1,623
Total compensation/employee	1,736	1,736	1,692

Source - United States Bureau of Economic Analysis (1977).

2. The problem arises that this figure aggregates several other activities with live entertainment and that disaggregated figures are not available. We can therefore only make a rough estimate of the number of people working in live entertainment.

3. Using the disaggregated consumer expenditure figures for 1938, including spectator sports, clubs, and commercial participant entertainment - the latter consisting of billiard parlours, bowling alleys, dancing, riding, shooting, skating, and swimming places; amusement devices and parks; golf courses; sightseeing buses and guides; and private flying operations - (U.S. Bureau, 1977: 337), and not weighing clubs and fraternities, we arrive at an upper bound estimate of live entertainment revenue share in 'Amusements and Recreation' of 58/361 = 16.07 percent. Assuming that live entertainment has the same revenue/labour ratio as other recreation, we arrive at 30,179 fte. This figure is not out of line with the 1930 and 1940 census figures, when adjusted for the pronounced dip in live entertainment expenditure during the 1930s. It suggests that cinema has over twice as much revenue per fte as cinema, which does not seem entirely implausible.

Live wages:

From same source as above: only available at the level of 'Amusements and Recreation' as a whole; $1,325 per annum per fte. For legitimate theatre, wages may have been substantially higher than those of cinema (if we exclude film production). Detailed minimum wage data from the League of New York Theatres (Wharton 1961) report weekly wages from about ten dollars for an usher to $100 for house managers and $150 to advance agents. The data suggests that a $1325 average annual compensation per fte is not unrealistic.

Cinema + live

Total employment then was 205,179 fte (table B-2).

8. As industry-specific working hours are lacking, these persons have been multiplied by the average annual working hours (1756) taken from Huberman and Minns (2007), to arrive at a grand total of 360.3 million hours.

B. Consumer Expenditure in 1938

This was $721 million, $663 million for cinema and $58 million for other spectator entertainment (US Department of Commerce 1975: 854-855).

C. Prices in 1938

Cinema:

1. According to the *Film Daily Yearbook*, in 1938 the average price of a cinema ticket was 23 cents (as quoted in Harold L. Vogel, 2004: 500). However, this estimate is not very precise (making the actual price vary between 22.5 and 23.5 cents, and it is unclear how it is arrived at).

2. More careful estimates for 1935 and 1939 prices have been made by Michael Conant (1960: 4), using data from the Department of Commerce and the Bureau of Labor Statistics. He arrives at nominal prices of 24.9 cents in 1935 and 26.5 cents in 1939, which translate into 25.67 and 26.768 constant cents of 1938. Using the 1935-1939 real growth rate we arrive at an average price of 26.489 cents in 1938. This price is taken as it is the most reliable and highest (most conservative) estimate.

3. The average duration of a cinema performance is taken to be 2 hours and 45 minutes, which is a conservative estimate, as most

US theatres showed double features and of course shorts. This yields an average price per spectator-hour of 9.632 cents.

Live:

1. Since the total number of live entertainment admissions is not given with the expenditure data, the average price cannot be calculated exactly. Therefore, an estimate of the average price is being made on information from the trade press.
2. For Broadway, reliable time series of top-ticket average price are available from 1926-1965, for both ‘straight shows’ and musicals (Moore, 1968: 151). In 1938, they were $3.22 and $4.16 respectively.
3. From 1949 onwards, also time-series on the average Broadway ticket prices are available (Moore, 1968: 151). Over this period, the range of the ratio top/average price for straight shows and musicals are 1.16-1.52 and 1.18-1.47, respectively. To keep the price estimate conservative, here the highest ratios are used to calculate average Broadway ticket prices for 1938. This yields $2.12 and $2.83 as average ticket prices. To make the estimate even more cautious, the average price for musicals is discarded.
4. It is then assumed that the average ticket price of all other live entertainment in the US was a third of the Broadway ticket price, 0.33 * 2.12 = $0.70, which is again conservatively low.
5. It then is assumed Broadway tickets accounted for 1/10 of all ticket sales in the US and other live entertainment for 9/10. (“Broadway” is here taken to represent most metropolitan entertainment, such as in Boston, Chicago, Los Angeles, etc.). This yields an average ticket price for live entertainment of $0.842.

6. It is then assumed that a live performance lasted 2 hours and 15 minutes on average, which yields an average price of $0.3742 per spectator-hour.

Cinema and Live

1. Total spectator-hours sold for cinema were 663,000,000/0.09632 = 6883.3 million, and for live entertainment 58,000,000/0.3742 = 155 million, making a total of 7038.3 million. The average price then, is (0.9780*$0.09632)+(0.0220*$0.3742)= $0.10244 per spectator-hour.

D. Capital in 1938

1. In a detailed study William I. Greenwald (1950: 228) calculated capital value for 1944 based on statistics of the US Bureau of Internal Revenue. He arrives at $1552 million invested in the motion picture industry, and $303 million invested in other live entertainment.

2. Because of the depression, in 1938 the industry was running below capacity. If we assume that one quarter of the growth rate in motion picture and live entertainment admissions between 1938 and 1944 (6.1 and 13.3 percent annually, respectively) was accommodated by improved capacity utilization, we arrive at 1938 capital of $949.3 million for motion pictures and $136.9 million for live entertainment, yielding a grand total of $1086 million, all in 1938 dollars.

3. No capital data is available for the self-employed, which made up 2.3 percent of all fte in film and 15.2 percent in amusements and recreation, of which live entertainment was part. Given the absence of data also for 1900, it is considered best to ignore this potential capital. If it was proportionately the same in

1900 and 1938 it would not affect the findings. It is not expected that any major shift in this small category could affect this paper's findings.

E. Cost of Capital in 1938

1. This is calculated as (capital factor income + capital consumption)/(capital stock).

2. To calculate the cost of capital, proprietors' income, rental income, corporate profits, net interest is calculated from the Bureau of Economic Analysis (1977). From national income are subtracted total compensation paid to employees and estimated (implicit) compensation paid for their own employment by the self-employed. The latter has been estimated using the estimated number of self-employed fte, times the average industry compensation per fte. Live entertainment national income had to be estimated from the aggregate Amusements and Recreation national income using the method in A above, where the estimated share of live entertainment in all amusements and recreation expenditure is used.

3. The above method results in \$71.9 million + \$2.7 million for live = \$74.4 million dollars.

4. To this is added the capital consumption, \$28.0 + \$1.9 million, to arrive at a total cost of capital of 104.6 million, or 9.63 percent of the capital stock (for film this was 10.52 percent, for live 3.41 percent (cents per dollar of capital)).

5. To check this finding, the resulting 1938 value for the motion picture industry, 10.01 percent, is compared to the value in 1937, reported in a contemporary work (Huettig, 1944: 100, which bases itself on a survey by the Securities and Exchange Commission). This value was 10.67 percent. The two values are close enough to

make the value estimated above credible. Based on an analysis SEC and Bureau of Internal Revenue surveys, Huettig also notes that the motion picture industry in 1937 was the tenth most profitable US industry in terms of return on investment, and the 45th most profitable industry in terms of the absolute dollar amount of profits (Huettig, 1944: 56-57, 99-101).

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