Example Student Project

EC2212 Industrial Growth and Competition
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This document is not intended to demonstrate an ideal project report. As one would expect, it has certain particularly good features – learn from the features that are good.

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"The Radio Industry : Exit and Survival"

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The Radio Industry : Exit and Survival

For a firm to survive , it must go through periods of various difficulties such as recessions ,changes in product or process technologies and other risk factors(turnover of skilled personnel ,aggressive price cutting of competitors etc.),not only surmounting them but preferably redirecting changes into their own benefit.Thus, it can be operationally said that firms survive as much longer as they go more successfully through these changes in market conditions.
However firm success cannot be analysed in an identical manner in all industries (defined at the product level) since each industry is characterised by a specific type of competitive evolution and technological change. Infact evolutionary patterns and the role of technology often differ completely across industries.
In this study ,we will restrict our analysis of exit and survival to the radio industry narrowly-defined to include radio receiving sets only.So in the rest of this essay the expression 'radio industry' will only correspond to one particular segment of this broad industry, namely the radio receiver industry.We will focus on the evolution of the industry and the effect of different factors on survival.
In the first part of this essay,we will present an overview of the development of the radio industry in the United Kingdom,highlighting the key technological innovations that occurred in this industry.
We will also mention important features of the production process involved in radio receivers manufacturing.In the second part we will describe the data set of UK radio receivers producers that will be used for the empirical analysis.We will relate the evolution of the industry to some common evolutionary pattern,which we will attempt to explain by referring to some classical theoretical models.We will then use survival analysis in order to test some implications of this models and to draw some conclusions about the impact of some specific variables as well as technological activity on firm survival . Finally in the last part we will summarize our findings ,list some limitations associated with the data analysis and propose some worthwile directions of further study.

In order to gain a better understanding of the competitive dynamics of the radio industry,we need to outline the history of this industry.I will briefly cover the origins and the technological development of radio,focusing mainly on the UK according to Crisell(1986,p.19 to 44):
Guglemo Marconi (1874-1937),the inventor of the wireless telegraph was the first one to send and receive wireless signals in 1895.He was offered no support by the Italian Ministry of Posts and Telegraphs nor by the Postmaster-General in Britain,which started controlling wireless telegraphy in 1904(act of Parliament) and more generally wired communications.Hence he funded his own private company in December 1898,the Wireless Telegraph and Signal Company,Ltd. ,whose name was changed in 1900 to the Marconi Wireless Telegraph Company(Inglis,1990,p.34).The Marconi Company became the most important wireless company in England.
Two key technological innovations were fundamental in the early history of radio:

'the diode rectifier tube in 1904 by Sir John Flemming,and the audition or vacuum tube ,a triode amplifier with a filament plate,and grid in 1906 by American Lee de Forest
considered by some to be the "father" of radio'(Hilliard,1985,p.4). It can also be added that in 1905 Reginald Fassenden of Canada invented the continuous wave voice transmitter.In the primitive years radio was used mainly for communications(in particular within the Navy for point-to-point transmission).It was only in 1922 that the commercial value of radio was highlighted through "the demonstration in 1922 by inventor Edwin H.Armstrong of the superheterodyne as a broadcaster receiver"(id,p.4).So wireless radio sets on sale for home entertainment started around 1920.Therefore Census of manufacturers in the UK such as the Kelly's Directory do not generally contain the category of radio receiving sets before 1920.In February 1920,the Marconi Company was allowed by the Post Office to broadcast for the first time and in 1922 the Post Office distinguished between "technology which adressed individuals and that which adressed all and sundry"(Crisell,1986,p.20).
Normally,wireless manufacturers were willing to "conduct broadcasts as a way of stimulating the sale of their radio receivers"(id.,p.20).Given that the Post Office was hesitant to give away to many licenses, it encouraged leading manufacturers in the industry to form a united broadcasting firm,the British Broadcasting company,a cartel which was nearly a monopoly in the Broadcasting industry.In January 1927,the BBC became a public institution because of financial difficulties and its key role in society.It was renamed the British Broadcasting Corporation and his first director general was J.C.W Reith.Nevertheless,it remained largely autonomous.It was soon very successful.
Let us come back to radio sets manufacturing:
the first radio receivers produced were crystal sets,whose cost was low and manufacture easy (the price for a radio receiver with two pairs of headphones was between £2 and £4 in the 1920s).
In the late 1920s,a series of significant improvements took place:a large segment of technology aimed at improving sound quality.The carbon microphone was largely abandoned and replaced by the condenser and then the dynamic microphone,making the sound more real due to better frequency response.In 1929 electrical transcription records were introduced,improving significantly both sound quality and the length of playtime(from 3 to 15 minutes a side).(Sterling&Kittross,1978,p.98).The Great Depression also brought many innovations in radio production largely in the area of cutting costs(id,p.125). Far more importantly,in the early 1930s,a drastic change occurred:crystal sets were replaced by valve receivers with loudspeakers,whose price was approximately £5 or £6,a relatively high price since as a general rule,radios could not be afforded by the working class.However as output increased and technical advances were made ,the price gradually decreased.
In the 1940's,there were new technological improvements in the area of sound recording which originated in Germany,but a revolution of the radio industry was caused in 1947 by the manufacture of the first transistor(Bell Laboratories)replacing the old costly and large wireless valve(transistors were much smaller and had a longer duration). Mass production of transistors developed first in the United States during the early1950's[…]In 1957 production of transistors was started in Britain,at Southampton by the Mullard company,which for a generation had produced valves and wireless receivers"(Briggs,1995,p.819).The late 1950's were also marked by

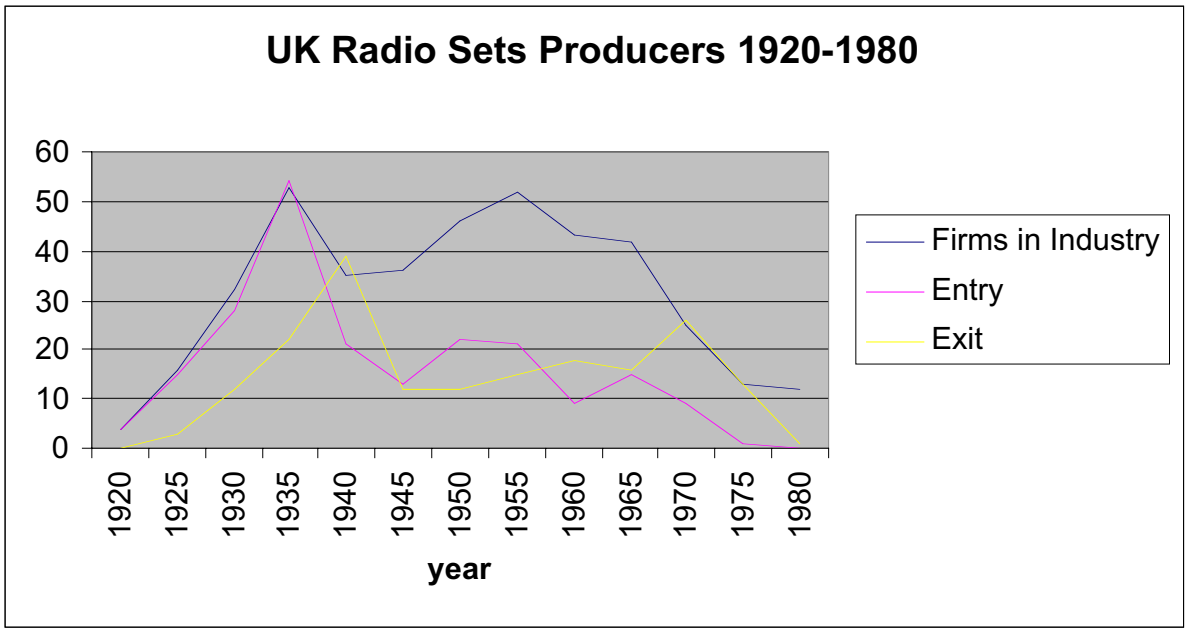
important improvements in the quality of transmission and the development of stereophonic sound.Most receivers could not adequately receive the higher and lower ends of the radio spectrum.The invention of FM radio by Edwin Armstrong radically eliminated this imperfection.The first two VHF-transmitters at Wotham in Kent in1955 one using also frequency modulation(FM) “provided listeners with freedom of interference” and “made possible the extensive development of local radio” while “the first test transmissions in stereo took place in 1958,the first regular broadcasts in 1966” (Crissel,1986,p.31).
In the mid 1960’s final improvements were made on transistor design and integrated circuits were commercialized.This had key consequences for the radio industry,which was seriously thraetened by the television industry:although radio clearly lost leadership against television,it has been able to resist and keep its role as an important medium of information.
So in summary ,the radio industry presents some interesting aspects:
the history of this industry is characterised by the remarkable tight interplay between 2 mutually interdependent industries ,namely the broadcasting industry and the radio manufacturing industry and by the critical role played by independent innovators like Marconi,De Forest,Flemming,Fessenden or Armstrong.
Moreover some basic discoveries gave birth to this entirely new industry whose technology was primitive at the beginning.Then the industry went through a number of successive important inventions and innovations both of the evolutionary and revolutionary type(invention of new components:valve,transistor and gradual improvements in sound quality).Hence technological change(both sustaining i.e continuous and disruptive i.e revolutionary)appears to play an important part in this industry. However this conclusion should not be drawn immediately since the radio receiver industry is essentially an assembly industry: “a radio […] receiver is primarily the product of the mass-assembly of purchased component parts .These purchased components such as tubes ,resistors,capacitors,speakers,and hardware items have been standardized by suppliers to function in a variety of basically similar sets”(Graham,1952,p.1).Therefore the important inventions of components probably have an external uniform effect on radio sets firms rather than give advantages to some particular firms. Consequently one can suggest that innovations affecting the different firms are rather related to continuous process innovations and improvements in ‘simplification and specialisation of operations[…]and mass production by line methods’(id.,p.2).

Now that we have emphasised the basic characteristics of the radio industry,let us resort to a specific data set in order to study competitive processes in this industry.
_Data consisting of the entire inventory of firms that entered,survived and exited within the radio receiver industry are compiled from the time of birth of the product(1920) to 1980 at an interval of 5 years from the Kelly’s Directory of Merchants,Manufacturers and Shippers of the World ,an annual,complete and detailed Trade register which lists separately manufacturers in London versus Provinces(the rest of England,Scotland,and Wales) over the years studied.
_Data on unit sales of domestic radio receiving sets (including car radios) in the UK from 1930 to 1968 are a production of the government statistical service (Historical record of the Census of production:1907-1970;Business Statistics Office,198,pp.364).

_Data on the number of radio receiver patents published over time was obtained via a patent search at the patent database at “http:gb.espacenet.com”by entering “radio receiver “in the title.

By finding the number of firms in the industries,the number of entrants and exiting firms for each of the year studied,we can graph the number of firms as well as the level of entry and exit over time:

year	Firms in Industry	Entry	Exit
1920	4	4	0
1925	16	15	3
1930	32	28	12
1935	53	54	22
1940	35	21	39
1945	36	13	12
1950	46	22	12
1955	52	21	15
1960	43	9	18
1965	42	15	16
1970	25	9	26
1975	13	1	13
1980	12	0	1

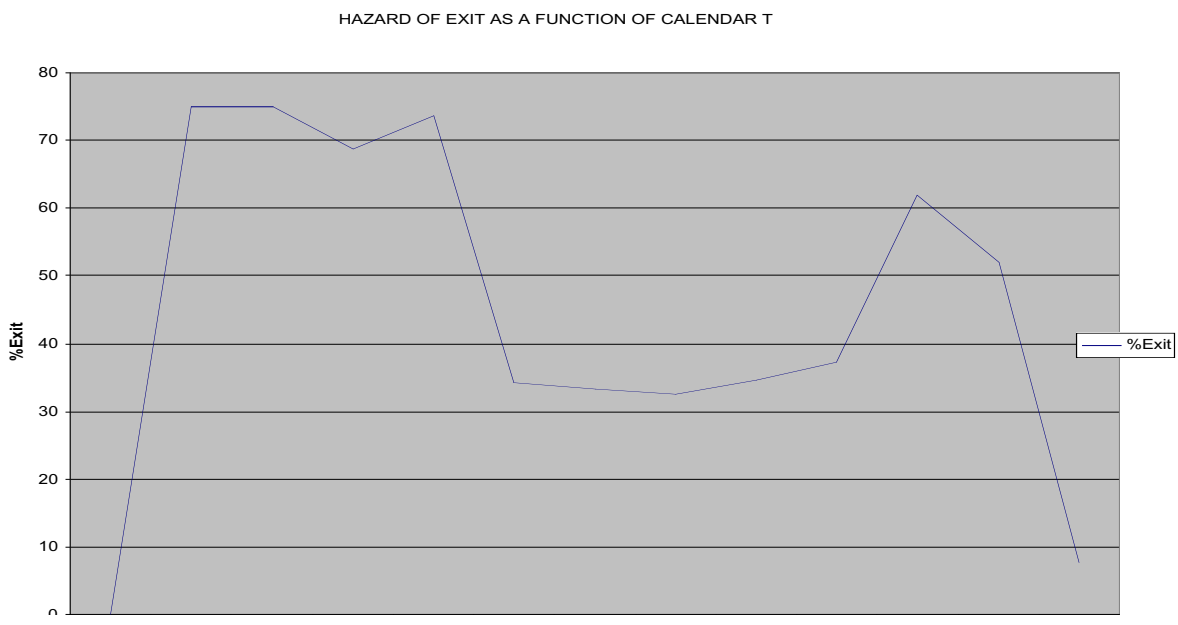


We can see a recurrent pattern of an initial large increase in the number of producers followed by a severe fall in the number of producers.This phenomenon is called a shakeout and is characterised by a rapid substantial rise of the number of firms (and entry in the industry) until it reaches a peak,followed by a dramatic drop of the numbers of firms and a significant fall in entry. Naturally as a result of the decline in the number of firms ,the number of exits decreases accordingly soon after the peak year.

Hence the radio industry underwent 2 clearly identifiable shakeouts and a third final one that was much less strong.

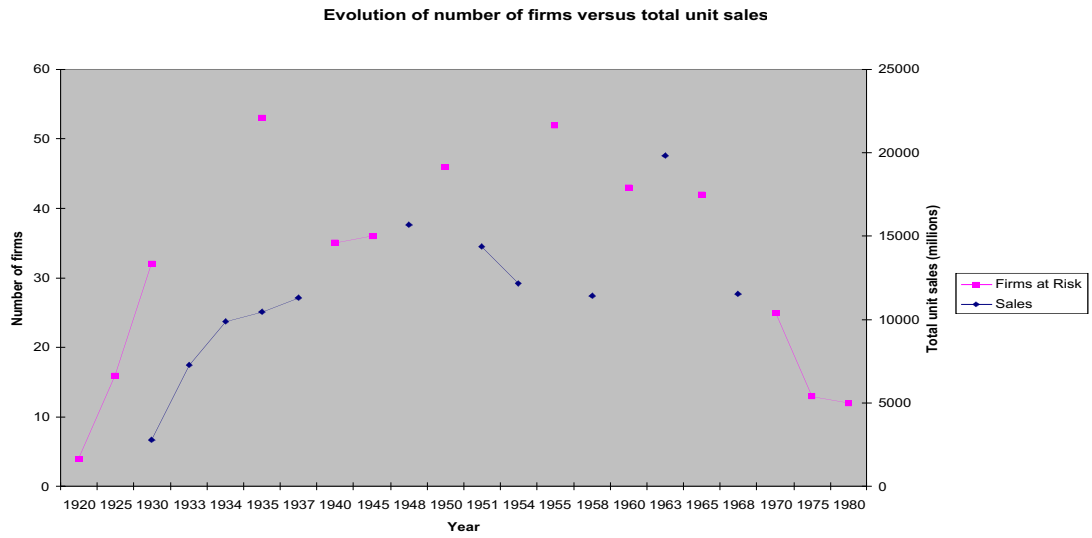
The most important shakeout happened around 1935 ,the year of the peak number of firms and entrants both in relative and absolute terms(53 and 54 respectively)and the only year of the sample when the number of entrants actually exceeded the number of firms in the industry. The second shakeout happened around the peak year 1955 and although weaker than the first one is still quite significant .The last shakeout around 1965 is less marked ,since it does not show an initial increase in the number of firms ,which rather stayed constant or more precisely even slightly decreased before collapsing after 1965 down to 12 in 1980.
Nevertheless like in the pattern of the first two shakeouts entry reached a peak in 1965 and then gradually fell down to 0 in 1980.
We can also examine how the probability of exit changed over time in order to check one of the main usual features of shakeouts.We calculate the % exit rate for each of our sample years,by dividing the number of exits for the given year by the total number of firms in the industry in the previous period studied i.e 5 years before.We are then able to graph the % exit over time:

	Firms in Industry	Entry	Exit	%Exit
1920	4	4	0	0
1925	16	15	3	75
1930	32	28	12	75
1935	53	54	22	68.75
1940	35	21	39	73.58491
1945	36	13	12	34.28571
1950	46	22	12	33.33333
1955	52	21	15	32.6087
1960	43	9	18	34.61538
1965	42	15	16	37.2093
1970	25	9	26	61.90476
1975	13	1	13	52
1980	12	0	1	7.692308

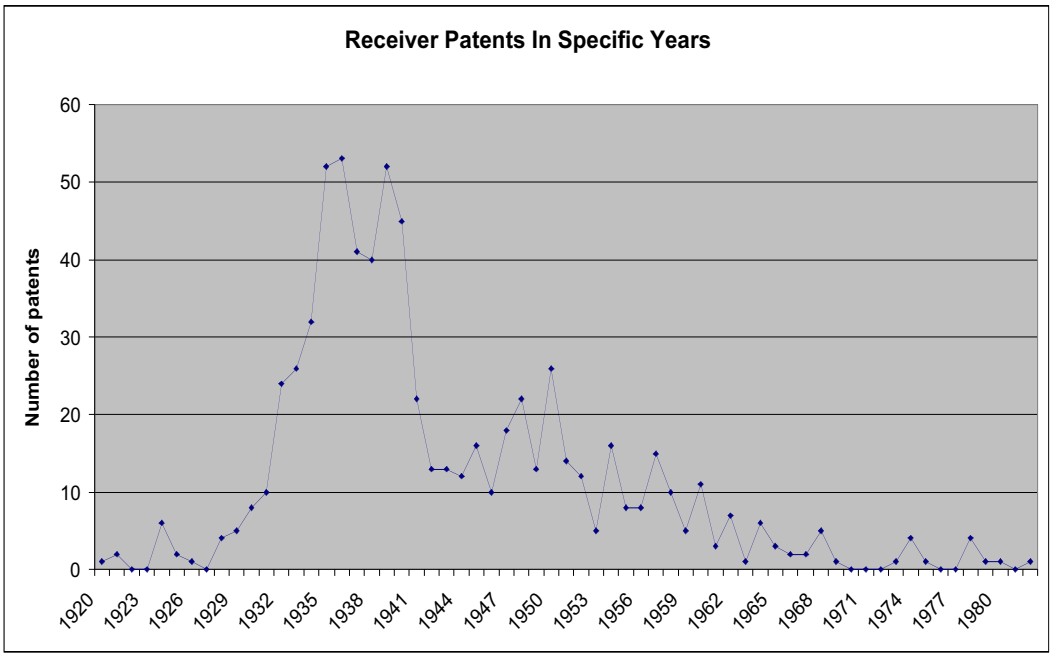


We do not observe a rise in the % exit rate during the time of the first two shakeouts but rather a stable % exit rate (it is increasing during the third shakeout).This fact is consistent with the findings of shakeout empirical analysis.We can infer the cause of the shakeouts is not a rise in the chance of exit since the hazard of exit remains constant but rather a radical fall in the level of entry:as the number of entrants falls,it becomes inferior to the number of exiting firms and as a result the number of firms starts declining.
Additionally ,if we graph the number of producers versus unit sales over time,we can conclude the first two shakeouts in the radio industry are not caused by Demand for the product drying up:

Years available	Number of firms	Entry	Exit	Sales
1920	4	4	0	-
1925	16	15	3	-
1930	32	28	12	2770
1933	-	-	-	7282
1934	-	-	-	9876
1935	53	54	22	10463
1937	-	-	-	11325
1940	35	21	39	-
1945	36	13	12	-
1948	-	-	-	15655
1950	46	22	12	-
1951	-	-	-	14382
1954	-	-	-	12152
1955	52	21	15	-
1958	-	-	-	11418
1960	43	9	18	-
1963	-	-	-	19810
1965	42	15	16	-
1968	-	-	-	11556
1970	25	9	26	-
1975	13	1	13	-
1980	12	0	1	-



As a matter of fact during the first two shakeouts in the radio industry,although the number of firms fell substantially, sales kept paradoxically rising at an increasing rate:from 1935 to 1948 sales increased from 10463 units to 15665 units. And from 1958 to 1963 they increased from 11418 to 19810.
On the contrary during the period of third more obscure shakeout, sales decreased sharply from 19810 units in 1963 to 11556 units in 1968.This suggests that the third shakeout was indeed due to a fall in Demand for radio sets.
Since sales dropped only in the case of the third skakeout ,there must obviously exist other reasons than a fall in demand that account for the first two shakeouts.
If we graph the number of radio receiver patents issued over time,we can observe a definite rise in the number of patents over the period of the first shakeout(around 1935) and a second less pronounced rise at the time preceding the second shakeout(around 1950):



So we may conclude that each of these shakeouts was caused by some important technological change regarding radio receivers.
Actually, if we refer to the technological development of radio we can identify the first shakeout with the replacement of crystal sets by valve receivers in the early 1930's ,and the second one with the replacement of valves by transistors in the late 1940's.As for the third shakeout, it could also be explained by some particular innovations:the development of stereophonic sound(1958) and of VHF-transmission and frequency modulation (1955).
Consequently one could argue that these revolutionary technological innovations that preceded the shakeouts stimulated Demand for radio sets(the new sets were of a better quality) which in turn led to a rapid increase in the number of entrants ,willing to take advantage of the benefits of the new technology on the market for radio sets. We can make the hypothesis that these "late" entrants were subsequently eliminated by the more skilled early entrants.

Thus we are given the impression that technological factors seem to have been the source of the first two shakeouts in the radio industry and hence are crucial in explaining the survival of firms over time. The third shakeout was more presumably brought about by the standardisation of radio sets and their maximum level of performance reached,leading to a saturation of the market:after the establishment of the solid state equipment(transistors), there was little scope for further basic improvement and as a result the incentive to buy a new radio set was clearly reduced (radios generally lasted very long).In fact after 1960, the number of radio receiver patents issued became nearly negligible and hence presumably crucial product innovations ceased .One can therefore speculate that by 1960 radio sets had reached a "dominant design"(Utterback and Suarez,1993,p.1-21)i.e could not be made obsolete anymore .Other reasons for the fall in demand for radio sets have been offered such as "recession ,foreign competition and Government tax policy"(The United Kingdom market for domestic audio and TV equipment,1997,p.iii) and obviously the increasing success of television.

At this point in order to explain better the pattern of shakeouts in the radio industry,it may be useful to turn to some formal theories of shakeouts.

Many models have been developed on the causes and consequences of shakeouts especially since shakeouts have been identified as one of the major sources of concentration i.e the establishment of oligopolies , especially if the remaining firms are the early entrants because they had time to grow gradually over time.

Infact the natural result of the sequence of shakeouts the radio industry appears to have experienced was a permanent reduction in the number of competing firms (from a peak level of 53 in 1935 down to only 12 in 1980)i.e a high level of concentration in the industry.In effect, nowadays there are only 3 radio receivers manufacturers listed in the 2001 Kelly's Directory:AMS neve PLC, Bush Radio Plc and Marine Electronic Suppliers.These are huge companies producing a range of electronics products.The United States radio industry appears to have been characterized by a similar shakeout process and is also quite concentrated.Hence oligopoly in the radio industry is probably a natural market stucture which cannot possibly be avoided and results from the basic nature of the industry

We will now concentrate on a particular theory of shakeout developed by Klepper and Simons (1993,1997) and check if the empirical results obtained from our dataset match with the elements of this model. First let us discuss the main features of this model:

This model assumes firms enter fairly small,but then grow gradually . First many firms are attacted by the new market and are able to enter because prices are still quite high and even relatively incompetent firms can achieve positive profits.Over time the number of producers increases and existing firms expand so if the Demand function remains the same,the price(hedonic and inflation adjusted) falls.Then, as expected profits keep going down , only the most competent i.e a smaller and smaller proportion of the potential entrants decide to enter.As a result,the level of entry decreases until it reaches zero when no firm can enter profitably anymore.As exit continues normally and entry falls,the number of producers in the industry declines substantially. According to this model , early entrants have a significant advantage over later entrants in the industry and survive better in the long term because of their larger size and geater expertise.

This model argues that early entrants enter when the price of the product is still high and there is the opportunity to earn very high profits and then grow and gain experience over time so that they become the larger most skilled firms in the industry(since the growth rate is limited in practice as marginal costs of growth are increasing).Since both size and skills drive costs down and increase efficiency,the early entrants are generally more profitable firms and tend to survive longer and dominate the industry through reinforcing technnology,wiping out the late smaller less skilled competing firms which are not able to keep making positive profits as prices fall.So the positive role of early entry ,size and skills on survival are underlined in this model .
Some of the assumptions of this model are the following:
_Firms enter small.
Although in the radio industry "standardization of parts and relatively little use of highly trained workers have also enabled many assemblers to enter the industry with small amounts of capital"(,1952,p.1),which makes this assumption valid,there might have been some heterogeneity in entrants'sizes(some new entrants may have been large firms specialised in other products or based overseas).Yet it could still be said if we assume firms grow gradually over time that on the whole,early entrants are larger than later ones at any point in time.
_The demand function is stable.
This is a questionable assumption in the radio industry since the level of demand might have shifted over time, up when new innovations were introduced and improved considerably the quality of radio sets making them more attractive to consumers , or down when television was introduced and radios were not perfected anymore.
_Technology in the industry is essentially of the sustaining type(process innovation,improvements in production methods) thus reinforces the leadership of early entrants which can rely on their past relevant experience.
It could be argued that this may not exactly the case in the radio industry where ,although gradual continuous innovations were frequent and contributed to the success of some firms, a number of dramatic technological changes considerably transformed the initial product.
So these assumptions seem slightly problematic in the context of the radio industry. However the model may still accurately depict the evolutionary dynamics of this industry.
In order to check whether the Keppler&Simons model applies to the radio industry ,we will now test its hypothesis more formally .We also aim at evaluating the effect of a number of characteristics of firms on their survival, we will use the techniques of survival analysis applied to our data sample.
Our data set lists all the companies in the industry fom 1920 to 1980 .It contains 203 observations and each line has 7 variables i.e for each firm 7 corresponding variables are given :

1. "entryyr":its respective year of entry i.e the approximate date at which it began producing radio sets .Since we started collecting data from the year of the beginning of the industry,we can assume that all producers are 0 years old i.e have produced the product for 0 years , when they are first listed in the register.So no firm could have existed before 1920,the first year in our sample.Hence there in no problem of left-sample truncation.
2. "exityr":its year of exit (or 1985 ,if it still appears in 1980:right censoring) i.e its approximate last year of production.

3. Its "totalage" i.e the approximate number of years it remained in the industry.We calculated totalage as the difference between year of exit and year of entry since we collected data at a 5 year interval and we assumed that in practical terms the average company entered the industry 2.5 years before the year we found it first listed (i.e the theoretical ' year of entry') and exited 2.5 years before the first year we do not find it listed anymore(i.e the theoretical 'year of exit').
   When we found gaps in our data collection ,we assumed that the firms remained producers during the apparent gaps.

We have added 3 dummy variables that could have an effect on survival:

4. "London":this variable takes the value 1 if the firm is based in London,a 0 otherwise and is formed using the company's location.
5. "Ltd.":this variable equals 1 if the firm is a Limited company,a 0 otherwise and is simply directly inferred from the company's name.This variable should give us some rough idea of the firms'sizes since we would expect the group of limited firms to correspond to larger firms.
6. "TV prod".:this variable is given the value 1 if the firm also entered the TV industry ,a 0 otherwise and was derived by indentifying the radio sets firms in the list of all UK manufacturers of TV sets registered in the Kelly's Directory .Radio sets firms containing the word television in their name were also considered as TV producers.

Finally we tried to assess somehow the impact of technology on survival in the radio industry by studying the effect of the following variable:

7. " patents":average number of radio patents per year received by each firm.

The overall number of radio patents for each firm was determined by carrying out a patent search at the patent database at "http:gb.espacenet.com":we entered the firm's name under the category "Applicant" and the word "radio" under "title".This patent search is not quite a detailed one since we only looked for patents of firms which have survived at least 10 years(totalage>=10) and for patents containing the word radio in their title,which might have only yielded partial results. Moreover we have not estimated the relative values of the patents delivered. However we have accounted for the firms'distinct totalages: the approximate (average) annual number of radio patents granted to each company was worked out by dividing the total number of patents found for each firm by its totalage.The resulting value should provide a crude measure of the firm's technological activity or level of R&D undertaken in the specific radio field(some firms also issued other types of electronics patents but we did not include them in the total number of patents although these firms may have also benefited from these broader type of technology).

A summary of the data is given below,with the usual measures of central tendency(mean,min,max),and dispersion in the data(standard deviation, maximum range):

Variable	Obs	Mean	Std. Dev.	Min	Max
entryyr	203	1943.424	13.52401	1920	1975
exityr	203	1953.596	16.26283	1925	1985
London	202	.5	.5012422	0	1
Ltd	203	.7241379	.4480526	0	1
totalage	203	10.17241	10.3333	5	65
TVprod	203	.1871921	.39103	0	1
Patents	73	2.891808	18.31023	0	155

We make the following assumptions to analyse our data:
_As mentioned before,we consider that the firms with entryyear equal to 1920,the first year of our sample,did not produce radios in earlier years.This is reasonable since there is no section on radio receiving sets manufacturers in the Kelly's Directories before 1920.However these firms may have actually been present before 1920 as well-established manufacturers of other products but this does not represent a problem because exit and survival in our analysis are not defined in terms of existence but in terms of production of radio sets: a firm is said to exit when it ceases to produce radio sets pesumably because it is not competitive any more and makes negative profits.
_Given that we do not possess any information on acquisitions and mergers,we assimilate an acquisition or a merger as an exit of one of the firms and the survival of the other(the firm whose name has been kept , assuming that the firm formed is named after one of the two original producers).
First of all,we check for early-mover advantage by interpreting two-by-two tables of survival length versus time of entry.We can infer from these tables whether earlier entrants had better chances of surviving a particular number of years.This method involves the choice of an arbitrary dividing date separating early entrants from later ones and a precise duration of time for the survival age.We selected the year 1930 as the critical year between the early entry cohort and the late entry one:we generate early1=entryyr<1930 i.e we define early entrants as firms which began production before 1930 i.e either in 1920 or 1925 as we consider the period 1920-1930 or more precisely 1917.5-1927.5 to be the early stage of the industry when the number of producers was still relatively low.
To begin with ,we study survival over at least 10 years,exluding firms which entered after 1975i.e in 1980(we generate tenyear>=10 and usedata=entryyr<=1975) since it is impossible to determine from our data whether their totalage is at least 10 years.We obtain the following results:

early1	0	1	Total
0	117	67	184
	63.59	36.41	100.00
1	15	4	19
	78.95	21.05	100.00
Total	132	71	203
	65.02	34.98	100.00

Fisher's exact = 0.215
1-sided Fisher's exact = 0.138

We find how many firms belong to each category and the corresponding percentages,given below these numbers.So the late entrants correspond to 184 firms,67/184≈36.41 % of which survived at least ten years(67 firms) whereas only 4/19≈21.05% of the early entrants(4 over 9 firms) have a totalage equal or greater to 10.

These figures seem to indicate that later entrants performed better in terms of 10-years survival.The “p value” fom Fisher’exact test is equal to 0.215.This number implies that if the 2 categories of cohorts(early and late entrants) had exactly identical chances of surviving to age 10 then the probability of finding such a large difference between survival rates in each category(36.41-21.05=15.36) just as a result of random variation would be 21.5%,which is a rather small chance.Hence this apparent disadvantage of early entrants versus late ones cannot simply be attributed to some random events.

Now let us consider twenty years as the survival length(we generate twenyear>=20 and usedata entryyr<=1965):

	twenyear	
early1	0	1	Total
0	150	24	174
	86.21	13.79	100.00
1	17	2	19
	89.47	10.53	100.00
Total	167	26	193
	86.53	13.47	100.00

Fisher's exact = 1.000
1-sidedFisher's exact = 0.512

The fraction of late entrants surviving at least 20 years(13.79%)is very close to the faction of early entrants surviving at least 20 years (10.53%).As a result the Fisher’s exact is approximately 100%:survival rates will almost always be at least as far apart as 10.53% and 13.79% even if early and late entrants have the same chances of surviving 20 years.
Similarly for 30 years survival,the percentages for early versus late entrants are nearly equal(9.40 % and 10.53% respectively):

	thiryear	
early1	0	1	Total
0	135	14	149
	90.60	9.40	100.00
1	17	2	19
	89.47	10.53	100.00
Total	152	16	168
	90.48	9.52	100.00

Fisher's exact = 1.000
1-sidedFisher's exact = 0.565

For 40 years survival,the results lead to different conclusions:

	fortyear		
early1	0	1	Total
0	98	7	105
	93.33	6.67	100.00
1	17	2	19
	89.47	10.53	100.00
Total	115	9	124
	92.74	7.26	100.00

Fisher's exact = 0.627
1-sidedFisher's exact = 0.415

6.67% of late entrants managed to survive this long versus 10.53% of early entrants but the value of the Fisher'exact is 62.7%i.e it is larger than 50% so the results are not very meaningfull statistically and one should not draw conclusions from these results in terms of relative chances of exit for early entrants versus late ones.
Similarly in terms of 50 years survival,early entrants performed better than late ones:

	fiftyear		
early1	0	1	Total
0	71	2	73
	97.26	2.74	100.00
1	17	2	19
	89.47	10.53	100.00
Total	88	4	92
	95.65	4.35	100.00

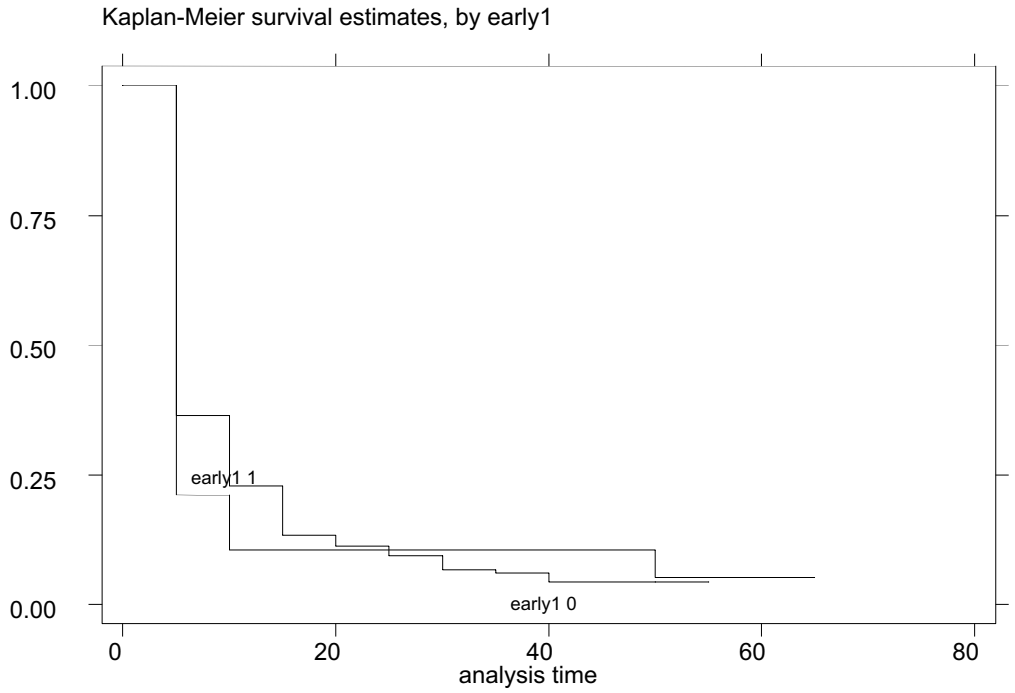
Fisher's exact = 0.188
1-sidedFisher's exact = 0.188

However in this case,not only is the difference between the percentage of early and late entrants having survived wider(2.74% for late entrants versus 10.53%for early entrants)but the Fisher'exact equals only 18.8%,making these results more valid in terms of relative probability of exit of the two entry cohorts.So at old totalages,the survival rates are high for early entrants and low for late ones .
We can also use a different approach to compare survival chances between the early and later entrants groups.We can plot Kaplan-Meier survival curves for the two groups and make comparisons.This is a more general method,which does not require the choice of an arbitrary dividing date for survival age and entry time.

The category survival time in the table below shows the totalage by which 25%,50% and 75% of firms had exited:

early1	timeat risk	incidence rate	no. of subjects	-- Survival time 25%	50%	75%	-----
0	1855	.0932615	184	5	5	10	
1	210	.0857143	19	5	5	5	
total	2065	.0924939	203	5	5	10	

Both survival curves are constructed by plotting the percentage of firms in the data that survived a given amount of time according to whether these firms are early entrants or not:



This graph gives the impression , as we found previously ,that early entry gave an advantage for survival not in the short run but in the long-run since the two curves intersect,the curve corresponding to early entrants going above the late entrants curve after a survival age of about 25 years(it is clearly above only starting from a totalage of 30 years).
So both the two-by-two tables and the Kaplan-Meier survival curves suggest the possibility of an advantage of early entrants for survival chances but only over a very long time period(more than about 30 years of participation in the industry).
It can be argued that this complete absence of competitive advantage of early entrants in the short and medium term i.e at relatively early totalages is consistent with the previous finding of a constant percentage exit over the time of the two first shakeouts in the radio industry:we may suggest that whenever the percentage exit (ratio of exits to the number of firms in the previous period) remains the same throughout the shakeout period then survival over that period has no tie in with any supremacy of old entry firms.

In fact,if that ratio stays constant while at the same time the level of entry first goes up and then comes down,it may be surmised that the propensity,as to say,to exit is the same for “old”,incumbent firms as for “new” firms,otherwise the average propensity would vary along with the level of entry(unless of course ,for the sake of the argument,one would imagine a complicated relationship where the two single propensities would vary according to the relative presence of the old and new entrants so as to keep the average equal).This is equivalent to saying that the difference between “old” and “new” is not a significant variable for survival over the shakeout and the entire process correlates with exogenous factors.An analogy may be given by a chemical reaction where the ratio between the product(exit) and the reactants in place varies only with the physical factors(temperatures,pressure etc…)because of course molecules are all the same.
Moreover the absence of early entry advantage found at relatively small totalages does not contradict the Keppler&Simons model since “the heterogeneity in potential entrants’capabilities” and the increased competence required to enter the industry in later stages can explain why survival rates do not differ between early and later entrants initially: in the early years of the industry,numerous incompetent firms might have stepped into the industry but as possible profits become very low in the late stages and if diffusion of technology is widespread and access to it not too difficult late entrants happen to be more skilled and knowledgeable than incumbent firms so that this superior competence of later entrants outweighs the advantage of early entrants related to size and as a result both types of firms will then have equal chances of exit since both size and competence play a role for survival.So the opposing effects of early entry and increased competence accompanying late entry tend to cancel each other out so that the probability of exit becomes independent of the time of entry(same percentage exit for early and late entrants).
Consequently the Keppler&Simons theory of shakeouts appears to fit well the evidence in the case of the radio industry.
However this theory primarily relies on a definite advantage of early entrants driving later entrants out of the market and contrastedly the theory of early mover advantage does not hold at all for small and medium totalages.Although this surprising result could be explained by some assumptions of the Keppler&Simons model,we would expect a apparent advantage of early entrants at younger totalages than 30 years.
It may be noted that in the very much reduced number of radio firms present in the market in 1980,all have entered the industry before or in 1950 ,whereas if early entrants had the same chances of survival than later entrants,we would have expected a very large proportion of later entrants among the censored firms(later entrants have more chances of surviving until 1980 ceteris paribus given that their totalage is lower for any exityear).
Therefore in order to clarify the role of early entry in the radio industry and maybe find a stronger advantage of early entrants,we should perhaps take into account the disruptive side of the radio technology and redefine the concept of early entry in terms of relative early entry at the beginning of each shakeout when a radical innovation has just taken place and profitability is maximum , or more simply change the critical year between early entrants and late entrants from 1930 to 1955
(i.e generate early 2=entyyr<1950)so as to include both early entrants at the time of the first shakeout and at the time of the second shakeout.
Then the results obtained do highlight an early mover advantage at younger totalages:

	twenyear		
early2	0	1	Total
0	43	4	47
	91.49	8.51	100.00
1	124	22	146
	84.93	15.07	100.00
Total	167	26	193
	86.53	13.47	100.00

Fisher's exact = 0.330
1-sided Fisher's exact = 0.186

15.07% of early entrants(by 1950)versus only 8.51% of late entrants have survived 20 years and the value of Fisher's exact(33%) is acceptable.
For the older totalage ,30 years,the advantage of early entrants appears as very marked:

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	thiryear		
early2	0	1	Total
0	22	0	22
	100.00	0.00	100.00
1	130	16	146
	89.04	10.96	100.00
Total	152	16	168
	90.48	9.52	100.00

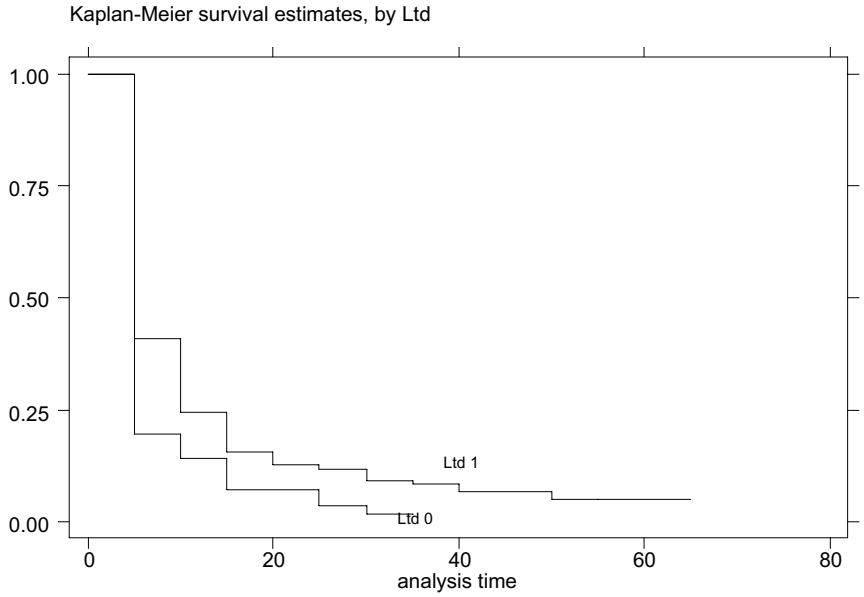
Fisher's exact = 0.134
1-sided Fisher's exact = 0.094

10.96% of early entrants have survived 30 years versus 0% of late entrants and the Fisher'exact is quite low:13.4%.
The new criteria for early entry yields far better results than before for the advantage related to early entry.So apparently it is not so much the very early entrants which have an advantage but rather the early entrants at the beginning of each shakeout.
Now let us verify the effect of some other firms'traits over their survival.
_Firstly to assess the role of size ,we use the proxi Ltd.Again we use 2-by-2 tables in order to compare firms'survival over at least 10 years depending on whether they were Limited companies:

	tenyear		
Ltd	0	1	Total
0	45	11	56
	80.36	19.64	100.00
1	87	60	147
	59.18	40.82	100.00
Total	132	71	203
	65.02	34.98	100.00

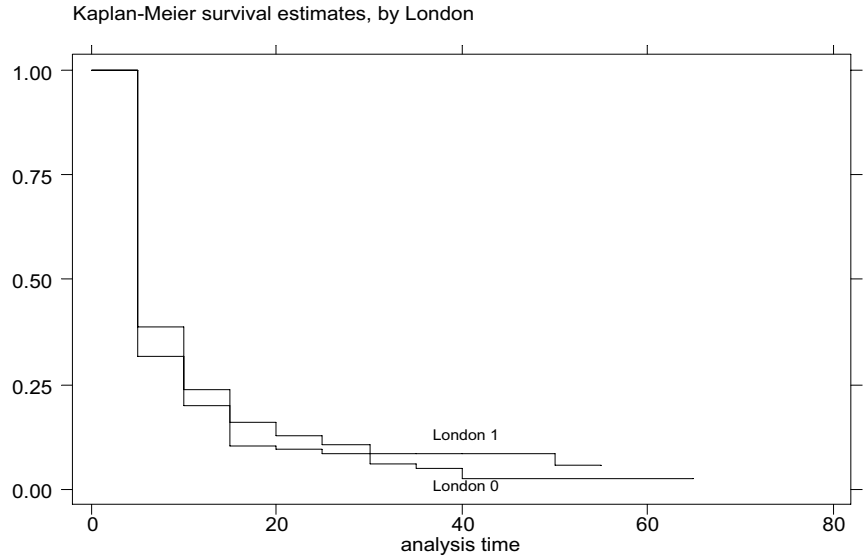
Fisher's exact = 0.005
1-sidedFisher's exact = 0.003

So the percentage of Ltd.firms which have survived at least 10 years is 40.82% compared to only 19.64% for non Ltd.firms.Fisher's exact test(0.5%) indicates that the results are reliable for general deductions about the role of Ltd.i.e size on survival:there is only a 0.5% chance to find such a disparity between survival rates just due to random factors.This advantage of Ltd.firms can be confirmed by plotting the proportion of firms surviving to each age for Ltd.firms versus non Ltd.ones:

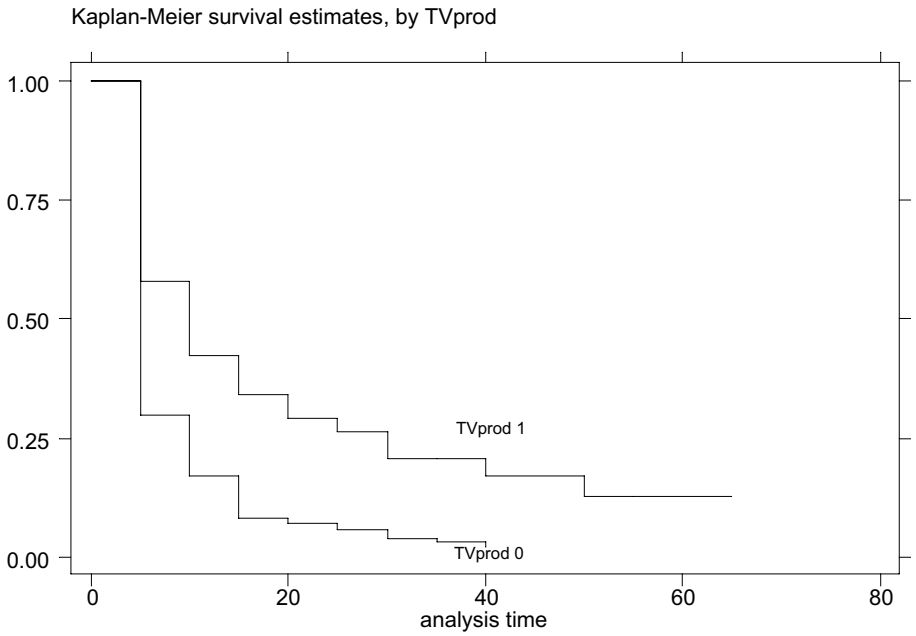


These Kaplan-Meier survival curves seem to indicate clearly far better survival rates for Ltd.firms : the Ltd.curve is markedly above the non Ltd.one and the log rank and Wilcoxon(Breslow) test for equality of survivor functions give a low probability (respectively 1.25 % and 0.64%)of this difference in the curve happening just by random chance if Ltd. and non Ltd. Firms had exactly the same chances of survival at different ages.
Thus Ltd.firms survive seemingly much better.We might infer that size and survival are tightly positively related .This result fits the Keppler&Simons hypothesis that larger firms perform better because they spread costs of R&D over more output and hence spend more on R&D,which leads to lower costs and a better product quality than smaller firms.Alternative reasons have been offered for the advantage enjoyed by

large firms:easier access to financial means,higher efficiency,economies of scale in production or methods(minimum efficient scale)or advertising cost spreading.
_Now let us examine the effect of the firms'location on their survival by using a Kaplan-Meier survival plot:



So we find that the firms based in London tend to survive better.This is probably due to the benefits from agglomerative networks&cities on the success of companies;firms in London dispose of a pool of information,suppliers,skilled personnel,contracts and financial means and of easier means of transport and infrastucture.
_The final dummy variable to analyse is TV prod.A study by Keppler&Simons (2000) found that survival in the TV industry was significantly better for firms which were previous radio producers since radio experience prooved very useful for TV manufacturing .We would like to determine if the converse is also true i.e if entering the TV industry caused a rise in radio firms'chances of survival. So we can graph Kaplan-Meier survival curves for radio firms manufacturing TVs and for radio firms which have not entered the TV market:



At first sight,ther appears to be a clear advantage of firms which have entered the TV industry(the TV prod.curve is well above the non TV prod. curve).
However television manufacturing started only around 1950 so including the firms whose entryyear is less than 1950 may be misleading:it introduces a bias in favour of an advantage of radio firms(all the firms which died before 1950 are considered as non TVprod,thus probably incresing the apparent hazard of exit of non TV prod).Therefore it would be more rigorous to consider only firms whose entryyear is greater than 1950.We can tabulate the variable TVprod versus ten years survival for firms wose entryyear is strictly between 1950 and 1975(usedata=1950<entryyr<1975) since we also exclude firms having entered in 1980(we ignore whether they survived 10 years):

	tenyear		
TVprod	0	1	Total
0	116	49	165
	70.30	29.70	100.00
1	16	22	38
	42.11	57.89	100.00
Total	132	71	203
	65.02	34.98	100.00

Fisher's exact =0.002
1-sided Fisher's exact =0.001

These tables show that among radio firms, 57.89% of TV producers survived 10 years versus only 29.70% of non TV producers.Moreover the value of Fisher'exact is low:0.2%.
Since this analysis is more precise and provides more trustworthy conclusions we may suggest that as a general rule radio firms benefited from entering the TV industry.The explanation might be that the usual success radio firms had in the TV industry,due to their know how enabled those firms to increase substantially their size,which has been identified as a plausible effective factor influencing survival .
At this point,in order to model the effect of the 3 dummy variables analysed previously on the hazard of exit,we suppose that these factors affect firms according to the following exponential hazard model:

By carrying out an exponential regression,we can determine the "maximum-likelihood estimates" of the constant terms $\beta 1$, $\beta 2$, $\beta 3$ and α :

Exponential regression -- log relative-hazard form

No. of subjects = 202 Number of obs = 202
No. of failures = 190
Time at risk = 2060
LR chi2(3) = 27.93
Log likelihood = -259.75651 Prob > chi2 = 0.0000

_t	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
London	-.1044826	.1461688	-0.715	0.475	-.3909683	.182003
Ltd	-.3142489	.1618375	-1.942	0.052	-.6314446	.0029468
TVprod	-.8021588	.1972402	-4.067	0.000	-1.188743	-.415575
_cons	-1.900418	.1541794	-12.326	0.000	-2.202604	-1.598232

The “maximum-likelihood estimates” are given in the column “Coef.”so:
α(“cons.”)= -1.900418
β1(“Ltd.”)= -0.3142489
β2(“London”)= -0.1044826
β3(“TV prod”)= -0.8021588
Therefore the estimated model is :

=exp(-1.90048-0.3142489Ltd.-0.1044826 London –0.8021588 Tvprod.)

The estimated hazard of firms which were not Limited nor in London nor TV producers is equal to exp(-1.90048)=0.149496844 per unit of time i.e approximately 15% per year,whereas h for firms which are Limited,based in London and TV producers is just equal to:
exp(-1.90048-0.3142489.-0.1044826 -0.8021588)=exp(-5.4404578)=0.004337497 (since Ltd=1,London=1 and TVprod=1),i.e about 0.4% per year,which is almost fourty times smaller than for non Ltd.radio firms in Provinces not producing TVs. Indeed,the values of β1,β2, and β3 are all negative numbers so that the variables Ltd.,London and TVprod.all appear to have a negative effect on the hazard of exit,i.e those characteristics of companies reduce the probability of exit as shown previously through survival curves.However the 95% Confidence Intervals for the coefficients of the variables London and Ltd contain zero,so at the 95% confidence level,we accept the null hypothesis that the real coefficients equal zero,i.e that the variables London and Ltd. are statistically insignificant.Yet the “p values”(found in the column P>z) indicate that if the true values for β1and β2 were equal to zero then there would be less than a 50 %(47.5% for β1,only 5.2% for β2) chance to find such large values of β1and β2.As for the variable TVprod.,it is significant(zero does not belong to the 95% confidence interval) and if β3 was equal to zero then there would be less than 0.1%chance to find such a large β3,but these results are likely to be biased given that TV production started only around 1950.
We can also use the Cox model to represent the effects of the variables Ltd.,London and TVprod.:

Given that in our case all firms did not enter at the same point in time,age is equivalent to time since the first year in our sample,1920.So f(age)=f(t).As we would also like to assess the effect of totalage on the hazard of exit,we can add the variable totalage:

By running a Cox regression,we find:

Cox regression -- Breslow method for ties

No. of subjects = 202 Number of obs = 202
No. of failures = 190
Time at risk = 2060
LR chi2(4) = 234.54
Log likelihood = -798.66533 Prob > chi2 = 0.0000

_d	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
Ltd	-.0181459	.1651291	-0.110	0.912	-.3417929	.3055012
London	-.0211275	.1469626	-0.144	0.886	-.3091688	.2669139
TVprod	.0107168	.2026144	0.053	0.958	-.3864002	.4078338
totalage	-1.398466	.1454856	-9.612	0.000	-1.683613	-1.11332

_t

This model gives different result for the coefficients of the dummy variables and in particular a positive coefficient for TVprod.
The “maximum partial likelihood estimate” for the factor totalage is $\beta 4 = -1.398466 < 0$, the absolute value of z is high(9.612) and the “p value” is less than 0.1% (totalage is a very significant variable) .Hence totalage seems to have a strong positive effect on survival.The hazard of exit appears to depend on the firms’totalage and to be smaller at old totalages i.e when firms have been in the market already for a number of years.Old firms have probably lower chances of exit because they have been able to grow and gain experience over time so they may be ahead of younger firms in terms of size and skills.
Finally let us evaluate the role of patents on survival.We have already shown the relevance of patents during shakeouts but the effect of patents on performance has not been qualified yet.
There is a wide diversity in the number of patents corresponding to firms whose totalages are equal.Some long lasting firms did not have any patent related to radio listed under their names whereas other firms received a high number of patents per year containing the word radio in the title(for example 155 for the Marconiphone Co.Ltd. and 22.45 for Bosch Ltd).Hence at first sight,one may have the impression that patents are not essential for success in radio manufacturing or that most of the patents received are of relative unimportance and easy to design around or perhaps that licensing is frequent and more crucial than patenting itself.
However, if we regress totalage on patents,totalage being the independent variable and patents the explanatory variable, we obtain the following results:

. reg totalage patents

Source	SS	df	MS	Number of obs =	73
				F(1, 71) =	16.61
Model	2337.90278	1	2337.90278	Prob > F =	0.0001
Residual	9993.6040771	140.754987		R-squared =	0.1896
				Adj R-squared =	0.1782
Total	12331.5068	72	171.270928	Root MSE =	11.864

totalage	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
patents	.3112228	.0763643	4.076		.1589568	.4634889
_cons	17.18478	1.405929	12.223	0.000	14.38144	19.98813

Since we have omitted the short lived firms(5 years totalage),there are only 73 observations available(130 missing observations).
We have the following regression line:
Totalage=17.18478 +0.311228 patents+(ε or u=disturbance term/residual).
Therefore, the coefficient on patents is strictly positive:a one unit increase in the number of patents received per year by a firm is associated with an increase in its totalage of 0.311228 years.
If we test the statistical significance of the parameters of the coefficient for the variable patents at the 95 % confidence level(5%level of significance):
Ho:$\beta=0$
H1:$\beta\neq0$
(where β is the true estimate for the slope),
we have tstatistics=4.075~t
The decision rule is that we reject Ho if t statistics > critical value tc.
Since tc=t $\approx$2.0 from t-tables,then 4.076>tc
So the variable patent is statistically significant i.e it has a significant effect on the dependent variable totalage(explanatory power of patents).
The value of the coefficient of determination r =0.1896 confirms that the variable patents is related to totalage i.e that the model explains partially the data:the proportion of the total variation in totalage which is explained by the regression line is 18.96%.
Thus the number of radio patents a company is assigned per year seems to have a definite positive influence on its survival.This implies that patenting is probably beneficial in terms of survival.
Furthermore,the firms which correspond to high numbers of patents per year(greater or equal to 1 per year) happen to be as a general rule the large players of the radio industry.As a matter of fact, they are all part of the “Big Names in Radio” i.e “a few major companies who took setmaking into mass production”and “whose names became truly “household words” as they led the industry towards putting a radio into every home”(Geddes&Bussey,1991):all of these firms (cole E.K.Ltd.,Cossor A.C.Ltd.,Decca Radio&Television,Marconiphone Co.Ltd.,Philco,Pye Radio

Ltd.)except the Burndept Ltd. And Bosch Ltd. ,are cited in the chapter “the big Names in Radio” and are identified as the major producers in the radio setmaking industry. Consequently the other radio long lasting firms have probably survived by buying licenses from the large main companies.
So we may conclude that the amount of patenting,which is probably a good indicator of the level of research undertaken is one of the major determinants of the firms’success regarding both expansion and survival.This suggests that patents in the radio industry give high benefits in practice,are well-enforced(difficult to get around) and/or represent a very operative protective barrier against competing firms and potential entrants.

Before drawing any conclusions fom our data analysis,we must not disregard the limitations of this analysis.
_Since our data was collected at a 5 years interval,it is discontinuous i.e it contains gaps so we have certainly omitted some short–lived firms in the industry.Moreover firms were not compelled to register on the directories and the smallest firms may not have been listed.
_We have no information on mergers and acquisitions so we might have considered some renamed merged firms as new entrants and some merging firms as exiting companies.
_As a whole radio sets firms were not specialized in manufacturing radio sets.Most produced other electronics products such as radio components and “ other sound reproduction equipment,television sets or record&tapes”(IPC Marketing services,1997,p.7).These other specific product industries undoubtedly affected the survival of radio sets firms.Thus the analysis for the individual industry segment of radio sets is not pure i.e it was most probably contaminated by the respective evolutions of those parallel industries and the role played by our variables in those industries.Therefore ideally we would consider only radio sets firms producing exclusively radio sets but such firms would be very difficult to find and anyway the study would not be representative anymore.
_Finally one serious problem in terms of interpretation is that even if we find by survival or regression analysis a variable to be significantly associated with a higher survival,we have no way to ascertain the direction of causation or even establish the existence of a cause-effect type of relationship.Indeed the variables could be interdependent (endogeneity bias) or worse both directy influenced by some other external variable responsible of the real effect on survival(spurious correlation).
So we cannot directly deduce from our analysis that large and patent holding firms survive better.A clarification of the causal relationship would require a finer statistical analysis of time series data tying individual firms previous size or number of patents to their subsequent success.A publication such as for example “The Setmakers,a history of the radio and telavision industry”by Geddes,K. & G.Bussey could assist us in undertaking this more detailed study.Probably the definition of the meaningfull parameters to be measured for success would be the most difficult task.
Although , as we have pointed out ,our analysis is rather appoximate, we can still discuss some possible conclusions regarding the patterns of exit and survival in the radio industry and their consistency with the theory expressed by Klepper&Simons.

In the model of Klepper&Simons ,it is assumed that the pattern of shakeouts is due to the advantage of skilled early entrants in the case of reinforcing technology.
A classical example offered is the automobile industry where a unique shakeout brought about the present oligopoly. On the contrary the radio industry is an example of a combination of continuous sustaining technology and disruptive technology,where rather than a unique shakeout,a sequence of multiple shakeouts did occur.We have tried to show that this multiplicity might be associated with disruptive innovations, whereas each shakeout taken separately is probably a result of sustaining technology.Since we do not find any early mover advantage in the industry,we can make the following hypothesis:the very early entrants ,or more precisely in each shakeout period the early entrants of the previous stage did not necessarily adopt the fundamental revolutionary innovations which marked the development of radio sets. In effect each innovation gave rise to a totally new product that was not produced using the same methods as before ,so that earlier firms already present in the industry at the beginning of the shakeout did not have necessarily an advantage,or even perhaps had a disadvantage versus entrants just entering at the beginning of the shakeout process i.e when the innovation had just taken place and profitability was at its highest level.Hence this technological explanation of shakeouts may relate more to turnover of corporate leadership (blindness of early entrants)rather than early mover advantage emphasized in the Klepper&Simons model.
However if we isolate each cycle of shakeout from the others,then the Klepper&Simons model appears to be validated : in each particular cycle ,the early entrants seem to have had an advantage relative to later entrants in terms of survival. Moreover even though very early entrants did not appear to have a significant advantage in terms of technology,their larger size must have been a definite asset versus later smaller competitors. In fact the 3 dummy variables London ,Ltd. and Tvprod,which were found by survival analysis to have an apparent significant positive effect on totalage, can all be associated with a large size:larger firms tend to be Limited ,based in London and diversified.Even if these variables had an effect on their own on performance then still size would matter as a result since these characteristics usually require a minimum size:London based companies face more costs (rental cost ,wages…)as well as Limited companies(higher income taxes) while entering a new industry such as the TV industry involves fairly important financial means(high fixed costs barriers of entry).Similarly, patenting,which was found by regression to affect positively the survival of firms is also linked with size:larger firms generally patent more as patenting incurs high financing.
Thus , as suggested by the Klepper&Simons model,size is very likely to play a crucial role for survival of individual firms in the radio industry.
In effect among the firms that have survived for a long time period or are still present in the industry in 1980,most are firms that have entered either around 1925 (at the beginning of the first shakeout period or around 1940(at the beginning of the second shakeout period)i.e firms which were able to adopt and patent early enough the new technologies which caused the shakeout and as a result gained a foothold in the industry and prevailed at least until the next shakeout ,suggesting that relative early entry plays a non negligible role for survival.There are only a few exceptions of late entrants still present in 1980 and these cases are probably due to to errors in the data or to the fact that these firms were already large at the time of entry,either specialized in other electronics areas or simply well-established overseas(such as Bosch).

Thus in general,it can be argued that the long term survivors in the radio industry are large and diversified firms able to resist to major changes in Demand for radio sets(like the drop in demand for radio sets in the late 1960's, fatal to numerous firms: 26/42≈62% of the firms present in 1965 exited before 1975) and to lead in terms of process innovations.One may wonder whether a new major radical innovation affecting radio sets would lead to another shakeout process and more interestingly whether these incumbent powerful firms would keep up with the innovation and manage to remain dominant or rather be outcompeted and even forced to exit by opportunistic competent new entrants.
As a final conclusion,one may suggest that both technological factors and size determine in great part survival of firms in the radio industry: firms able to implement themselves early enough to appropriate the benefits of a new fundamental technological change when profitability is at its highest level and patenting is still feasible have the possibility to grow and establish themselves as leading firms but may be at risk of loosing market shares or even of exiting the industry when the next drastic innovation occurs.
Hence one might surmise that oligopolies brought about by shakeouts and maintained through sustaining technological improvements are not pemanent in the radio industry.Indeed they might be broken up by disruptive innovations which start a new cycle and so on.However it may be important to note that in the case of the radio industry, major disruptive innovations would not really be expected since there is seemingly little scope left for further basic variations in the present solid state design of radio sets and that in addition,the last and most concentrated oligopoly was apparently not brought about by a classical shakeout caused by technology but rather happened as a result of a drastic drop in demand for radios. Consequently, one may doubt that such a concentrated oligopoly might ever be dismantled as a result of a new revolutionary innovation.

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