Schumpeterian Dynamism or Socialization: Persistence of Firm Dominance*

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Abstract

Schumpeter published his account of the rise and fall of companies as a process of creative destruction in 1943. In the same publication, he expressed concerns that the dynamism would disappear through a process he termed socialization, meaning that the government would take over control of productive resources. This paper endeavors to assess whether the persistence of firm dominance can be characterized by dynamism or socialization employing three measures: turnover, turbulence and Kaplan-Meier survival analysis. A cross-country comparison encompassing North America, Europe and Asia using the Forbes Global 2000 reveals comparable levels of dynamism despite varying institutional backgrounds. The evolution over time is examined for the United States based on Compustat and the Fortune 500, finding an increase in dynamism since 1950. An analysis of the Brussels stock exchange since 1830 shows that the survival probability has remained stable for Belgium. Generally, survival functions exhibit scale independence and firms that have been present longer in the top set of firms have a slight advantage for persistence. The empirical fit of the exponential and the Weibull distribution suggests a (generalized) Poisson process to model large firm dynamics. In combination with geometric Brownian motion, the exponentially distributed time in the top leads to power-law behaviour in the tail of firm size.

JEL Codes: C41, D22, L11, L16, O5. **Keywords:** Firm dynamics, superstar firms, business dynamism.

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1. Introduction

In times when physicists debate whether the laws of nature themselves have evolutionary origins (Hertog, 2023), the rise and fall of companies returns to the foreground in economics. The first thorough description of this process was arguably given by Joseph A. Schumpeter in his book 'Capitalism, socialism and democracy' (Schumpeter, 1943/2008):

> "The opening up of new markets, foreign or domestic and the organizational development from the craft shop and factory to such concerns as U.S. Steel illustrate the same process of industrial mutation –if I may use that biological term– that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism."

Schumpeter characterizes the capitalist engine as a dynamic process, a history of revolutions, where old products and methods are replaced by new ones. But Schumpeter was not convinced that the dynamism would go on indefinitely.[1] Instead, he thought that what he saw as the essential characteristic of capitalism, the entrepreneurial function of creative destruction, would grind to a halt in the future and disappear in a socialistic system, a process he termed socialization. Socialism is defined in his writings by government control of productive resources, thus ending the process of one company overtaking another one.

In this paper, I will shed light on the question if the story of large firms has been one of dynamism or socialization. I employ three different measures of dynamism to that end. Turnover measures the yearly amount of companies moving in or out of the top, while turbulence measures the yearly changes among the companies in the top. I also estimate survival probabilities of companies in the top using the Kaplan-Meier estimator to get a long-run view on dynamism.

First, I benchmark dynamism across countries. The analysis starts from the Forbes Global 2000 since 2008 and considers the top 50 in the eight countries with the largest amount of companies in the list, the United States, China, Japan, United Kingdom, South Korea, Canada, France and Germany. I examine the histories of those companies on Wikipedia to correct for name changes and mergers and acquisitions. The measures show a nuanced image of differences between countries, where e.g. France seems to emerge as the least dynamic economy. However, the findings also show a similarity, especially in the survival probabilities, across countries with different institutional backgrounds. Second, I benchmark dynamism over time for the United States. I utilize two different data sources, Compustat and the Fortune 500, to get a view on dynamism since 1950. The results show that turnover and turbulence have been increasing over time, while the survival probability has decreased. These trends have seen a partial reversal since 2000. A dataset on the Brussels stock exchange since the inception of Belgium in 1830 provides a longer term perspective on dynamism. While turnover and turbulence have fluctuated over time, the survival functions have remained remarkably stable.

[1] One just needs to read the first sentence of the prologue of part II 'can capitalism survive?' to be convinced of this point (Schumpeter, 1943/2008).

I also characterize the estimated survival probabilities statistically, and explore two properties of the rankings of firms, scale independence and memorylessness. The paper concludes with a discussion on how the findings can be translated into statistical modelling. The exponential and Weibull distribution used in the statistical characterization point towards a (generalized) Poisson process of replacements in the set of large firms. The exponentially distributed time in the top set of firms allows for an application of the argument by Reed (2001) that in combination with geometric Brownian motion, power-law behaviour appears in the tail of the firm size distribution.

The reader might have noticed a jump in the argumentation above. Schumpeter usually discusses the replacement of goods and services, methods of production and transportation, forms of organization and the opening up of new markets, while this paper deals with the replacement of firms. New firms do not map one-to-one to the other elements. They can be seen as a sufficient but not necessary condition. The presence of new firms is sufficient, because firms become larger than their incumbents by having a competitive edge of some sort, by doing things differently, thus constituting an innovation. Therefore, higher turnover among the large firms generates more dynamism.

New firms are however not necessary, because the largest incumbents can also innovate themselves. It has been argued that large firms have an advantage stemming from economies of scale and more capabilities for risk spreading and finance to conduct R&D and management changes (Nelson & Winter, 1982).[2] A counterargument is that the bureaucracy of large firms may offset these advantages. Moreover, market power can be inducive to innovation, as it allows the incumbents to grasp the returns from their innovations. One example is patent protection, where firms are granted a transient monopoly to reward innovations. In this sense, the decrease in static efficiency due to market power would lead to an increase in dynamic progressiveness.[3] A counterargument is that the drive to innovate disappears with the absence of potential competitors. In conclusion, lower turnover can generate more dynamism, but the argumentation seems less clear-cut.

Related literature The persistence of dominance of firms has received fairly limited attention in the literature so far, partially due to heavy data requirements. Sutton (2007) characterizes the debate on the persistence of leadership by contrasting Schumpeter's view of transience with Chandler's view of persistence (Chandler, 1990). He compares the duration of industry leadership with a Markovian benchmark and finds a 'Chandlerian' bias towards longer durations for a 23-year dataset in Japan. Geroski and Toker (1996) found similar results for the five top ranked firms by industry in the United Kingdom over the period 1979-86. Comin & Philippon (2005) documented an increase in the turnover of the largest firms within industries for the United States over the preceding 30 years. Marlow and Wright (1987) is an early example advocating for the development of metrics assessing the dynamic structure within leading firms. A recent report

[2] The highly productive firms that take a large share of the market have been coined 'Superstar firms' (e.g. Autor et al., 2020), such that the discussion in this paper has also been referred to as superstar versus shooting star firms (Kehrig & Vincent, 2021; Satterthwaite & Hamilton, 2017).

[3] Generally, the trade-off between static efficiency and dynamic progressiveness has been termed the Schumpeterian trade-off (Nelson & Winter, 1982; Schumpeter, 1943/2008).

by the OECD on measuring market competition echoes the need for dynamic measures of competition and notes that rank stability may be an interesting measure to analyse whether there have been changes in the top firms (OECD, 2021), referring to an application by the UK competition authority (CMA, 2020).

This paper can be seen as a combination of two strands of literature burgeoning in recent years, namely on the importance of large firms and on business dynamism.

Recent research has revealed that the impact of the set of largest firms on the aggregate can be substantial, even explaining an important part of aggregate fluctuations (Carvalho & Grassi, 2019; Gabaix, 2011). Firm size has heavy tails so the mere size of companies can lead to visible effects in the aggregate numbers (Gabaix, 2009). Furthermore, through network effects, the fluctuations among large firms can propagate throughout the economy (Acemoglu et al., 2012).

There is a tendency in economic literature contending that business dynamism is on the decline in many countries. In terms of static measures, claims have been made for instance that concentration has been rising, notably in the United States (Kwon et al., 2023). Mark-ups have also been increasing, even globally (De Loecker & Eeckhout, 2018). In terms of dynamic measures, entry and exit of firms have for example decreased for the United States (Decker et al., 2014), and the same is true for reallocation between firms.

The remainder of this paper is structured as follows: In section 2, the three measures of dynamism are introduced. Section 3 provides the comparison across countries, while section 4 looks at the evolution of dynamism over time in the United States since 1950. Section 5 takes a longer time horizon and tracks dynamism throughout the entire existence of Belgium. Section 6 delivers some general statistical characterizations of the survival functions, which then serve as the basis for the statistical models in section 7. Section 8 concludes.

2. Three Measures of Dynamism

The object of interest is the evolution in the ranking of top firms. A certain amount of top firms N is considered based on comparability requirements of the dataset at hand, for example the top N=50 by country or industry per year.

The first measure of turnover is the most straightforward one. Turnover measures the amount of firms entering (e) or exiting the top of the ranking. There is a symmetry between entry and exit because the number of top firms remains fixed.

$$Turnover_t = e_t/N$$

While turnover measures the movement on the extensive margin, the second measure of turbulence is informative on the intensive margin. Turbulence measures how different the ranking within the top is from the past. It can be computed by the complement of the Spearman rank correlation (ρ), the correlation between the rank in size in period t and a period before. The default choice throughout the paper is to calculate turbulence over a three-year period.

$$Turbulence_t = 1 - \rho_{t-3,t}$$

The third and final measure is the firm's survival probability in the top of the ranking. The survival probability at year one boils down to the complement of turnover. When considering the survival probability over multiple years for a certain time period, one runs into the problem of right-censoring. For the firms that survived up until the end of the time period, it is not observed how long they will stay in the top of the ranking afterwards. Therefore, the Kaplan-Meier estimator is used, the non-parametric maximum likelihood estimator in the presence of right-censoring (Kaplan & Meier, 1958). The probability S(t) that a firm survives longer than a time t can be estimated as:

$$\hat{S}(t) = \prod_{i:t_i \leq t} (1 - \frac{d_i}{n_i})$$

with d_i the number of firms that have dropped out at time t_i and n_i the firms known to have survived up to that time. The estimate at time t is therefore made up by all firms that are not yet censored at time t. The survival probability has an intuitive statistical interpretation. S denotes the survival function of the time variable T indicating the top in the ranking. The survival function thus constitutes the complement of the cumulative distribution function of T, as the probability that the time in the top exceeds t ($S(t) = P(T > t)$).

3. Dynamism across Countries

3.1 Data

To be able to analyse the evolution in the top firms, two elements are necessary: a definition of a firm and a definition of the size of a firm. A firm can be seen as an intersubjective reality that performs a set of economic activities. The existence of a firm is normally formalized in a legal entity. It is hard to pin down objectively, as many aspects can evolve. Employees can go work for another firm, owners can sell their share, the name can change and a firm can even decide to divert their activities. Furthermore, there is the question of how to deal with mergers and acquisitions (M&A). The closest object defining the firm as a legal entity is the registration number of the firm with the state, although that is also sometimes subject to alterations. Multiple size metrics can be used to compose a ranking of firms. For each dataset used in this paper, the explanation of the data handling process will therefore be transparent to what constitutes a firm and what constitutes a large firm.

The starting point to compare dynamism across countries is the Forbes Global 2000 list. In this list, Forbes Magazine attempts to rank the largest publicly traded companies in the world. The ranking is based on four equally weighted size metrics: sales, profits, assets and market value. All figures refer to the consolidated accounts. First, a separate top 2000 is constructed based on each of the size metrics. A firm needs to appear in at least one of them to be eligible for the final list. Then, the firm receives four separate scores based on the rankings, and an equally weighted composite score determines the final ranking. Further detail can be found on the Forbes website (Forbes, 2023). The Forbes Global 2000 list has been composed since 2003, of which I am able to analyze the years 2008-2023.

Firms in the Forbes Global 2000 are subject to name changes and mergers & acquisitions. Therefore, a standardized procedure is followed to keep track of firms over time. Briefly summarized, the history of the firms under analysis is manually investigated on their Wikipedia page for name changes, history of mergers and acquisitions and potential reasons why the firm entered the list in a certain year. Partially due to the public nature of the firm, its history is mostly well documented, to the point that sometimes the year of entrance into the Forbes list is mentioned. The different steps of the procedure are formalized for a consistent treatment of all firms, as elaborated upon next.

The following procedure is applied for all firms based on the chronological order they appear in the list. When a firm is present from the start, no corrections are necessary. When a firm joins the list afterwards, the Wikipedia page is scrutinized. If a firm is found to have changed names, the name is corrected to the latter name. In the case of a merger between two firms in the list, the name of the largest firm –highest in the list– is corrected to the name of the merged firm, so it is considered as mainly a continuation of the largest firm. A spin-off is considered a new firm, usually distinguished from a simple name change because the original company also stays in the list. In the rare occurrence of an equal split into two firms, the original name is corrected to the name of the firm with the core activities because this firm often retains the name in general.

When no predecessors are found for a firm, explanations are sought for the entrance in the list. The appearance of a firm can be rationalized as seamlessly following its documented growth path, often as a result of a history of acquisitions and sometimes coinciding with an initial public offering (IPO). A final check is performed when the reason for the entrance is not directly clear. The particular industry and country of the firm is scanned to search for companies that drop out of the list shortly before, which are then googled for a link with the new firm. The result is a dataset where the confounding effect of name changes and M&A is eliminated as much as possible, thus where the entrance of a firm means the replacement of an incumbent by a new firm.

There are eight countries that consistenly have more than fifty firms in the Forbes Global 2000 over the time period 2008-2013. The United States top the list with approximately 600 companies during the entire time period. China has seen an increase of less than 100 companies in the list towards more than 300 companies. Japan was the second largest, but became third with a decline from 300 to below 200 companies. The United Kingdom, South Korea, Canada, France and Germany complete the set of countries with between 50 and 100 companies in the list. See appendix A for the full evolution of countries. The analysis will focus on the top fifty across these countries to establish a common ground for comparison. Appendix A also contains the top 50 for each country in 2023 to get a grasp on the firms present in the

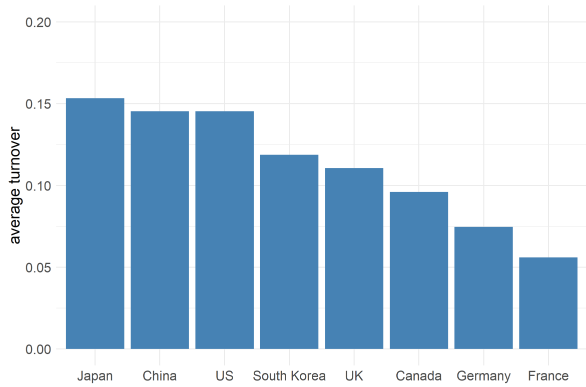

Figure 1: Average turnover over 2008-2023 of the top fifty by country in the Forbes Global 2000.

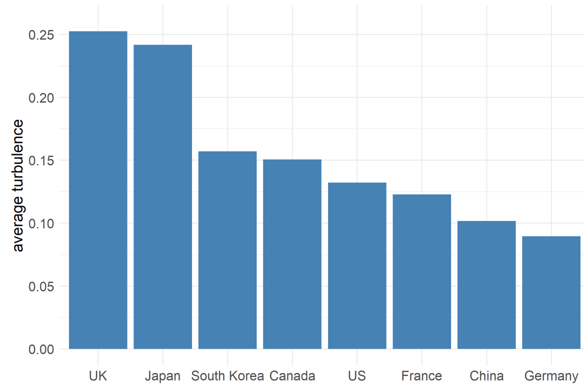

Figure 2: Average turbulence over 2008-2023 of the top fifty by country in the Forbes Global 2000.

Forbes Global 2000.

A final choice in the data transformation concerns the Kaplan-Meier survival analysis. Survival is defined as the period from the first year a firm is present in the top until the last year it is present. When a firm drops out for a certain amount of years and re-enters later, it is not counted as two seperate entities. The rationale behind this choice is that the accounts of a firm are only a temporary conjecture of the intrinsic value of the company. A few lesser years in terms of e.g. profits or sales does not allow for the interpration of the re-entrance as a new firm.

3.2 Analysis

Figures 1 and 2 depict the average turnover and turbulence respectively for the top fifty in the countries under analysis over a time period 2008-2023. A couple of observations can be made. Japan seems to be highly dynamic, in terms of both turnover and turbulence. China and the United States have a turnover at the high end of the spectrum, but below average or average turbulence, which means a lot of movement of new firms coming into the top fifty but less movement among the incumbents in the top fifty. The United Kingdom exhibits the opposite combination of average turnover and high turbulence. The other European countries, Germany and France, are on the lower side of the spectrum on both measures, suggesting lower dynamism. South Korea and Canada lie in the middle.

The survival analyis can shed more light on a long-run perspective. Figure 3 shows the survival functions of the top fifty in the different countries based on the Kaplan-Meier estimator. Confidence intervals are left out not to obfuscate the figure, but the survival functions with confidence intervals can be found in appendix B. One notable feature at first glance is the similarity of survival functions across different nations. For many countries, the survival probabilities evolve very closely over the recent time period spanning 16 years.

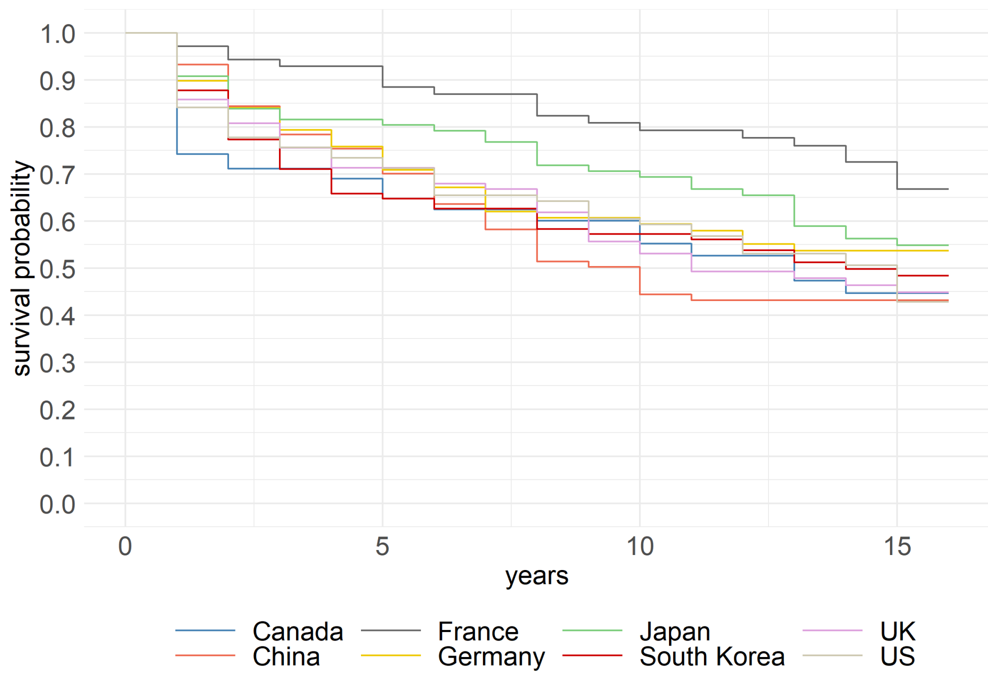

Figure 3: Kaplan-Meier survival function over 2008-2023 of the top fifty by country in the Forbes Global 2000.

France stands out as a country with a high survival probability. The chances that a company stays in the top fifty of a country is thus the highest in France. Together with the results on turnover and turbulence, France could be characterized by a form of dirigism, a term that fittingly has a French origin. Japan also has a rather high survival probability for a long period. There seems to be a paradox with the high turbulence and turnover in Japan. However, these findings could be reconciled by the observation that a high turbulence means that there is considerable movement among the incumbents. This movement leads to a large turnover of the same firms dropping in and out. Since survival is defined from the first to the last period a firm appears in the top fifty, the survival probability can still be high. A similar reasoning can be applied to the case of China, where a small amount of turbulence combined with a large turnover results in the lowest survival probability for a long period of time. One caveat applies here. Contrary to the other countries, the Wikipedia page of Chinese companies does not hold plenty of information on company histories, such that some links may have been missed between firms because of a name change or merger. It is possible that there is a slight ’Wikipedia bias’ downwards. One explanatory factor for the low survival probability and the recent large increase of Chinese firms in the Forbes global 2000 in general, could be the many IPOs in the recent wave of privatization.

Figure 4 shows the survival probability after 16 years with confidence intervals. The survival probabilities over the time period 2008-2023 range from 45% to 65% but can only be claimed to be different with statistical significance between France on the one hand and China and the United States on the other hand.

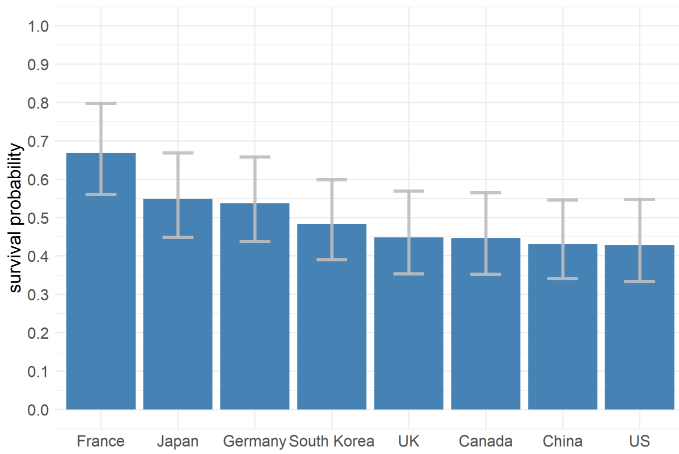

Figure 4: Kaplan-Meier survival probability from 2008 to 2023 of the top fifty by country in the Forbes Global 2000. Grey brackets denote 95% confidence intervals.

The analysis so far has focused on the differences between countries. It is however noteworthy that the remarkable aspect of these results is the similarity across countries from different parts of the world, with different institutional contexts and different economic histories. All countries under analysis demonstrate some dynamism based on our measures, suggesting a new element to corroborate the thesis proposed by Milanovic (2019) that the world at present is dominated by one economic system, capitalism.

4. Evolution of Dynamism in the United States since 1950

4.1 Data

Schumpeter wrote down his hypothesis that the world was moving towards socialization in the 1940s. The question thus arises how dynamism has evolved since then. While the Forbes global 2000 facilitates a comparative study across countries, it does not allow to go back beyond the 2000s. Therefore, the focus shifts to the United States, the country with arguably the largest economic heft over the last century. To study the evolution of dynamism in the United States, two data sources are used, the Fortune 500 and Compustat.

The Fortune 500 is similar to the Forbes global 2000 in the sense that it is also composed by a business magazine, Fortune. The benefit of a business magazine list is that they are widely known, publicly discussed and seen by companies as a goal to attain and advertise around. The list ranks the 500 largest United States companies based on total revenue, including publicly held companies and privately held companies for which revenues are publicly available (Fortune, 2024). I apply the data transformation procedure elaborated upon above in the context of the Forbes Global 2000 to account for name changes and M&A. The Fortune 500 list was first published in 1955 and consistently put together annually since then.

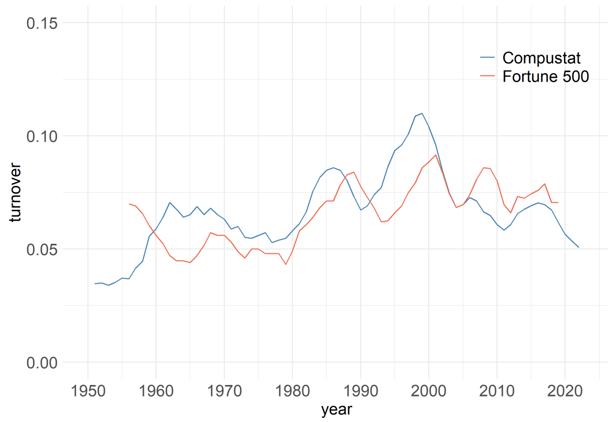

Figure 5: 5-year moving average of turnover of the top 500 for the United States based on Compustat (in terms of employment) and Fortune 500. Turnover is not included in the average for Fortune 500 in 1995 and for Compustat in 1960 to account for the breaks.

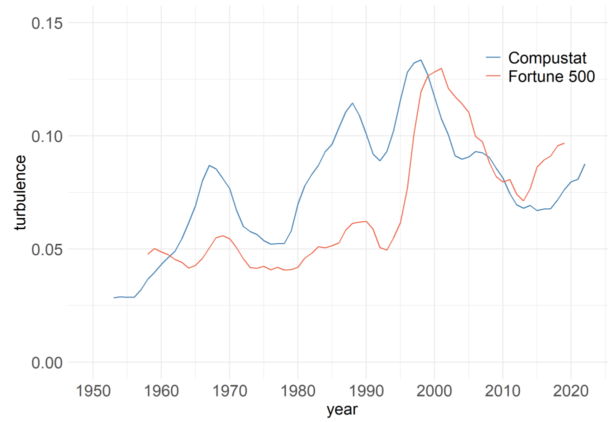

Figure 6: 5-year moving average of turbulence of the top 500 for the United States based on Compustat (in terms of employment) and Fortune 500.

There was one break in the methodology, in 1995, when the list was retooled from only manufacturing companies to include service companies as well. The analysis will where necessary take the break into account and discuss the impact.

Compustat provides standardized financial statement and market data for all publicly traded companies in the United States. It is monitored by Standard & Poor's and can be accessed through the Wharton Research Data Services (2023). The benefit is that it allows to define the size measure on which the ranking is based. Companies are defined by their global company key at the consolidated accounts level. The baseline analyis considers the top 500 for a common ground of comparison with the Fortune 500 and employment as a size measure because of its intuitive nature for a company's size and as a complement to earlier analyses. The results for Compustat are not corrected for M&A as I do not have access to the data, but they are not subject to name changes because of the identification with the global company key. The Compustat database has been maintained from 1950 onwards. The number of companies has afterwards smoothly increased from 641 companies to over 8000 companies, except for almost doubling in 1960, a break that will again be taken into account in the analyis where necessary.

4.2 Analysis

A first indication on the evolution of dynamism is given by figures 5 and 6 in terms of turnover and turbulence. The average turnover and turbulence for the United States in the cross-country comparison of before were close to 15%, while the turnover in the later years here lie below 10%, a fact that can be attributed to the higher volatility of market value and profits on which the Forbes Global 2000 is partially based. The figure on turnover disregards the break points in the data because of their large impact. The figure on

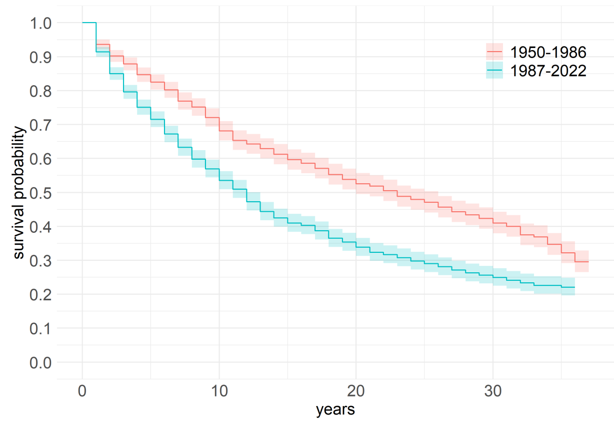

Figure 7: Kaplan-Meier survival probability of the top 500 for the United States in terms of employment based on Compustat. Comparison of two time periods 1950-1986 and 1987-2022. The lighter areas denote 95% confidence intervals.

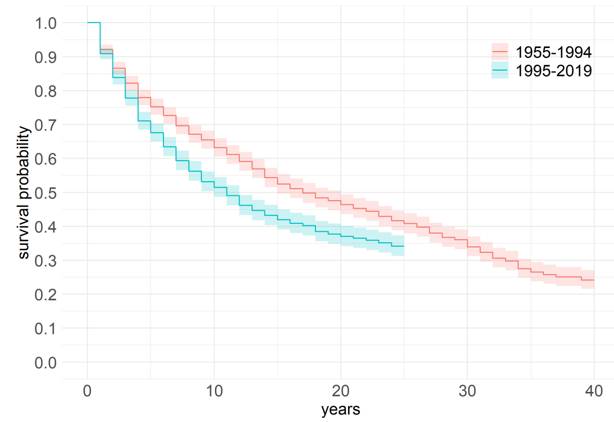

Figure 8: Kaplan-Meier survival probability of the top 500 for the United States based on Fortune 500. Comparison of two time periods 1955-1994 and 1995-2019. The lighter areas denote 95% confidence intervals.

turbulence is unaffected, because it looks at the changes among the firms that remain. Both turnover and turbulence seem to have been rising over time. The increase is somewhat more pronounced for turbulence. Moreover, for both measures the peak has been reached just before 2000 and a decline has set in since.

One might look for a relation to the business cycle. The results do not however seem to allow for a general conclusion regarding cyclicality. The financial crisis of 2008-09 has hardly caused a blip in the figures, potentially due to its systemic character. The surges in turnover and turbulence of the late 1990s could be related to the Dot-com bubble and crisis which is in contrast linked to certain sectors of the economy. Next, the increase in dynamism until 2000 and the partial reversal thereafter will be tested further using the survival probabilities in different periods.

Figures 7 and 8 depict the survival functions in two different periods. The country comparison based on Forbes Global 2000 resulted in a survival probability of 43% after 16 years for the United States. The figures show very similar numbers for both Compustat and Fortune 500 in the later period. After 30 years, 30% of the top 500 is still part of the top 500 for Compustat in the later period. The Fortune 500 dataset is split on 1995 to account for the inclusion of service companies. The survival probabilities for the earlier period are consistently higher for both datasets, with statistical significance. Therefore, chances that a firm stays in the top 500 for a long time have decreased over time, again pointing to an increase in dynamism.

The results on turnover and turbulence showed a reversal in trend in the last two decades. Figure 9 confirms this by depicting the survival function in three distinct 21-year periods. The survival probability in the top 500 has first decreased drastically with around 20% after 20 years, and reversed partially with around 10% afterwards. The longer the time period under consideration the more the survival probability has increased again.

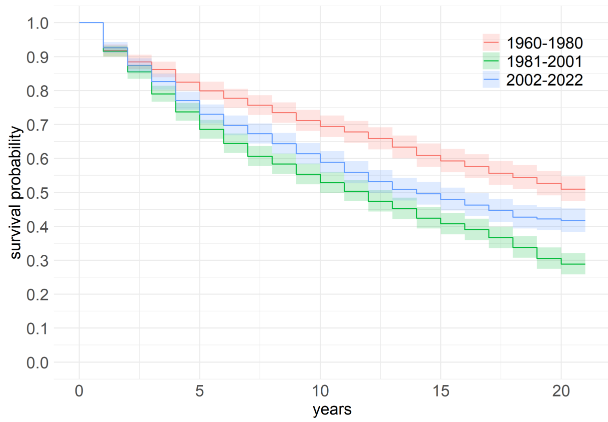

Figure 9: Kaplan-Meier survival probability of the top 500 for the United States in terms of employment based on Compustat. Comparison of three time periods 1960-1980, 1981-2001 and 2002-2022. The lighter areas denote 95% confidence intervals.

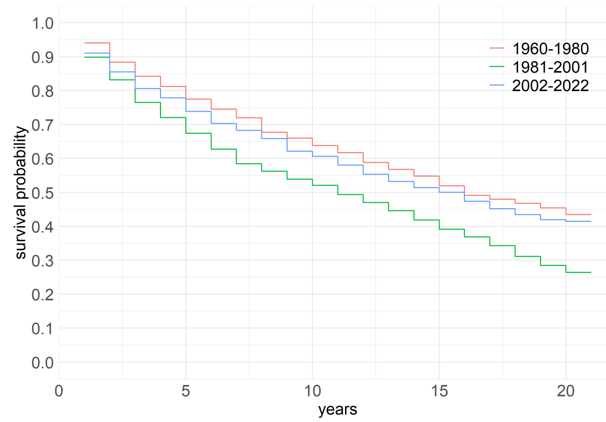

Figure 10: Average Kaplan-Meier survival probability of the top 50 by sector for the United States in terms of revenue based on Compustat. Comparison of three time periods 1960-1980, 1981-2001 and 2002-2022. Included sectors are SIC codes B, D, E, F, G, H, I.

The trends in dynamism can be explained by two margins, changes within sectors or changes between sectors. To test which margin is decisive, figure 10 shows the average within-sector survival function. Total revenues are used as a size measure to make sure that multiple sectors have more than 50 companies over the entire time period. Survival probabilities are then computed within the top 50 of a sector, and averaged across sectors. The within-sector survival function resembles closely the overall survival function. The drop of 20% from the 1960s-'70s towards the 1980s-'90s is also apparent within sectors. The survival function for the 2000s-'10s lies closer to the one of the 1960s-'70s than before. The reversal in the overall trend has thus partly been mitigated by changes in sectoral composition.

Schumpeter's concerns that dynamism would degrade in the future seem unjustified in the case of the United States. If anything, the measures of turnover, turbulence and survival probabilities point to an increase in dynamism since 1950. Next, I explore the Brussels stock exchange for a more historically detailed perspective on dynamism.

5. Evolution of Dynamism in Belgium since 1830

5.1 Data

A few of the earliest predecessors of modern stock exchanges were found during medieval times in the Low Countries in Antwerp and Bruges, cities that are now part of Belgium. When the Low Countries fell apart into Belgium and the Netherlands in 1830, the Brussels stock exchange was established. The dataset available contains all Belgian companies and colonial companies active in Congo that have been listed on the Brussels stock exchange (now Euronext Brussels). The heydays of the Brussels stock exhange lie in the

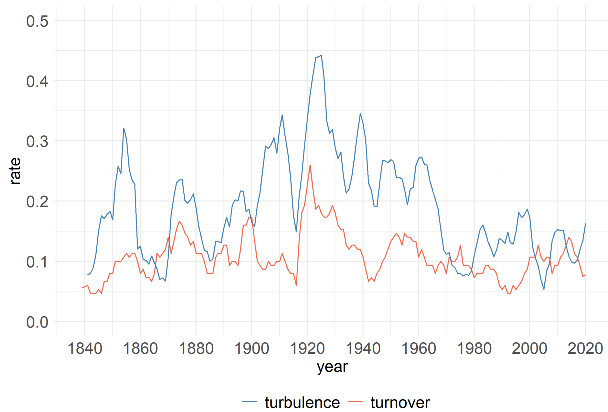

Figure 11: 5-year moving average of the turnover and turbulence rate of the top 30 for Belgium in terms of market value based on the Brussels stock exchange for 1838-2020.

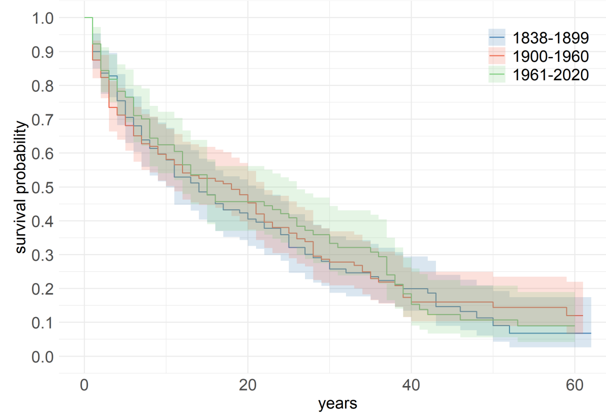

Figure 12: Kaplan-Meier survival probability of the top 30 for Belgium in terms of market value based on the Brussels stock exchange. Comparison of three time periods 1838-1899, 1900-1960 and 1961-2020. The lighter areas denote 95% confidence intervals.

early twentieth century when it was among the top 10 most important stock exchanges worldwide (Annaert et al., 2007). At its peak in 1929, the exchange contained almost 900 Belgian and colonial companies, which lately declined to approximately 120 companies.[4]

I will examine the top 30 of companies such that the stock exchange contains enough companies from 1838 onwards. As a size measure, total market value is used, summed over all classes of stocks outstanding for a company. The firms are defined by their identification number. The number is not altered when a company changes names, so the evolutions reported below are robust to name changes, but can still be subject to the effect of mergers and acquisitions. The Brussels stock exchange constructs since 1991 a yearly index with twenty leading stocks, the BEL20. The top 30 set of companies tracked in this paper contains approximately 86% of the companies in the BEL20 index for the overlapping period.

5.2 Analysis

Figure 11 depicts the evolution of turnover and turbulence. Both measures are marked by fluctuations, with especially high values in the period 1900-1960. The end of the first world war led to the highest values in turnover and turbulence, while the effect of the second world war was less pronounced. Figure 12 shows the survival functions for three periods. The period 1900-1960 does not demonstrate different survival probabilities than the period before or after. The combination of high turbulence and high turnover allows for the interpretation that the same companies are moving in and out of the top 30.

[4]The full evolution of the number of listed companies can be found in appendix A.2

6. Benchmarking Dynamism

The analysis has up to this point benchmarked dynamism across countries or across time. This section is dedicated to some general statistical characterizations. The main dataset under analysis will be the Compustat database as described in section 4.

The first aspect that has been concealed so far is scale dependence. The results for Compustat in the United States showed the evolution in the top 500. Figure 13 show how they compare to the results for different amounts of top companies. Remarkably, the survival functions can almost not be distinguished. The sole exception being the top 20 with the widest confidence intervals, which drops below the others the last ten years. The probability that a top firm prevails in the top set of firms, does not differ along the ranking up to a time period of sixty years, attesting to the property of scale independence.

The property of scale independence can be related to Gibrat's law, which states that the expected value of the increment to a firm's size in each period is proportional to the current size of the firm (Gibrat, 1931; Sutton, 1997). So in other words, the law states that the expected growth rate of a firm is independent of its size. In this context it can be restated as: The probability that a firm remains at or above a certain ranking is independent of the current ranking. A principle that seems to hold at least for the largest set of firms.

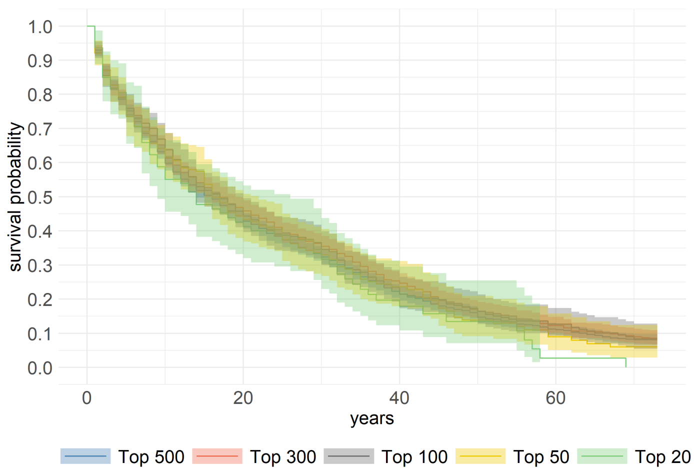

Figure 13: Kaplan-Meier survival probability from 1950 to 2022 for the United States in terms of employment based on Compustat. Comparison of top 500, 300, 100, 50, 20. The lighter areas denote 95% confidence intervals.

The second aspect relates to the 'memory' of rankings. The fitness of different statistical distributions can provide insights. Figure 14 shows the maximum likelihood fit of the exponential distribution for the Kaplan-Meier survival function of Compustat for the United States discussed before. The estimated exponential seems to capture the survival function quite well. The exponential distribution function is the sole continuous distribution having the property of being memoryless.[5] In this context, that would translate

[5]The geometric distribution is the discrete analogue of the exponential distribution and thus also exhibits memorylessness. I opt to work with the continuous distribution function here.

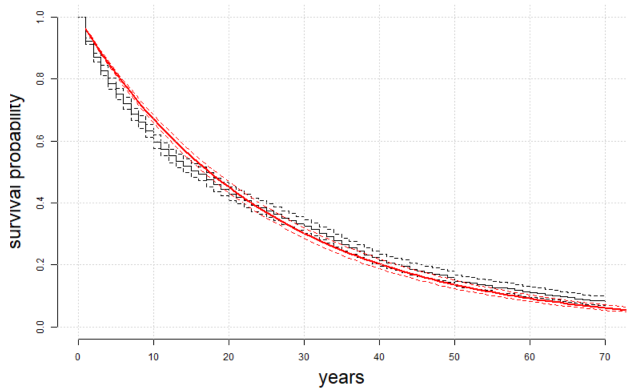

Figure 14: Exponential maximum likelihood fit for the survival function of the top 500 for the United States in terms of employment based on Compustat. Black lines indicate the Kaplan-Meier survival function and red lines the estimated exponential function. Outer lines denote 95 % confidence intervals.

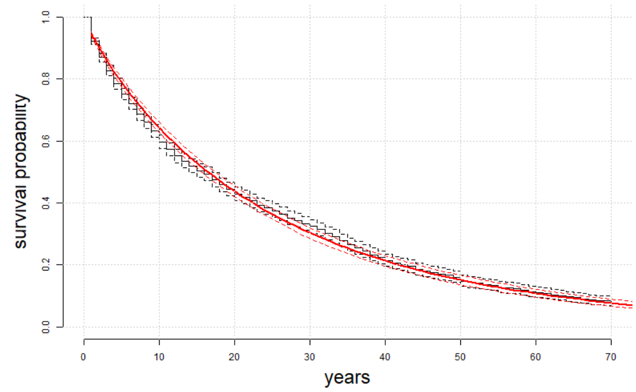

Figure 15: Weibull maximum likelihood fit for the survival function of the top 500 for the United States in terms of employment based on Compustat. Black lines denote data and red lines the estimated Weibull function. Outer lines denote confidence intervals.

into: The probability of survival in the top set of firms only depends on the present ranking, and is independent of previous rankings conditional on the current ranking. The fact that a company has been present for a long time in the ranking would in that case not convey an advantage compared to firms that just recently achieved a similar ranking. The estimated rate parameter is equal to 0.04, from which the expected time in the top can be derived as $1/0.04 = 25$ years. The rate parameter of the exponential distribution could serve as a first statistical measure of creative destruction.

The exponential distribution does seem to overestimate the survival probability a bit in earlier years and underestimate it slightly in later years. Therefore, another statistical distribution widely used in survival analysis is fitted to the Kaplan-Meier survival function, the Weibull distribution. Figure 15 shows visually that the Weibull distribution has a somewhat better fit. In essence, the Weibull distribution is a generalization of the exponential distribution where the memorylessness property is given up. The shape parameter or Weibull modulus determines the discrepancy with the exponential distribution. When the shape parameter is equal to one, the Weibull boils down to the exponential. The estimated shape parameter for the United States in Compustat is 0.9, differing from 1 with statistical significance. A shape parameter below one indicates that firms that have been present for a longer time in the top also have a higher chance to remain there. The shape parameter could serve as a second statistical measure of creative destruction.

7. Statistical Model

7.1 Poisson Process

The question remains how the empirical analyis of the evolution of large firms could be translated into a model of firm dynamics. The discussion on the underlying statistical distributions of section 6 provides a starting point. Recall that the Kaplan-Meier estimation of the probability that a firm will survive longer in the top than a time T, gives an estimate of the survival function of the random variable t, denoting the time in the top.

$$S(t) = P(t > T) = 1 - P(t \leq T) = 1 - \text{cumulative distribution function of t}$$

The exponential distribution presented a relatively close fit for the survival function. Both the probability density function f and the survival function S of the exponential distribution are (scaled) exponential functions. As negative time values have no meaning in this context, they are omitted from the equations below. The exponential density function and survival function are given by:

$$\begin{cases} f(t) = \lambda e^{-\lambda t} \\ S(t) = e^{-\lambda t} \end{cases}$$

where λ is the rate parameter and $1/\lambda$ the expected value of the time in the top.

The time in the top t could also be seen as the inter-arrival time between two entries of firms into the top. Or because of the symmetry between entry and exit, of two exits of firms. Taking the exponential distribution as a model for t, allows for the stochastic process of large incumbent firms being replaced by new firms to be modelled as a Poisson Process N_t. The Poisson process derives its intensity λ from the exponential distribution. The expected value of arrivals (replacements) in the Poisson process N_t is then equal to λt. A Weibull inter-arrival process necessitating a generalized Poisson process quickly proves computationally intractable, which can for instance be counteracted by deriving the Weibull count model using a polynomial expansion (Adrian et al., 2008).

7.2 Power-law Behaviour

The empirical results can also create credence in an argument developed by Reed (2001) for explaining power-law behaviour in the tail of a distribution. It is part of a larger strand of literature investigating theoretical mechanisms that lead to power-laws for size distributions (for an overview see e.g. Gabaix, 2009; Newman, 2005). The application of the argument of Reed (2001) to the context of large firms proceeds as follows.

The building block is the concept of geometric Brownian motion. Brownian motion was first introduced in economics by Bachelier (1900) in modelling stock market prices. Subsequently, it has become the most widely used model for the continuous-time stochastic process of stock prices, and arguably for firm size in general. Firm size X evolves through two components in a geometric Brownian motion. On one hand there is a systematic component μdt, containing a percentage drift. On the other hand there is a random component σdW_t, where dW_t is the increment of a Wiener process or white noise, containing a percentage volatility. Firm size is said to follow a geometric Brownian motion if it satisfies the following stochastic differential equation:

$$dX_t = \mu X_t dt + \sigma X_t dW_t$$

The size of a set of firms evolving according to geometric Brownian motion follows a lognormal distribution after a fixed time T. More specifically, when firms start at initial state X_0, the size at time T follows the lognormal distribution:

$$Y_T = log(X_T) \sim N(X_0 + (\frac{\mu - \sigma^2}{2})T, \sigma^2 T)$$

The variance increases with T and even becomes infinite when T goes to infinity. At low variance, the lognormal distribution behaves statistically like a Gaussian, while at high variance, it appears to have the behaviour of a Cauchy of sorts (Taleb, 2023). The properties of the firm size distribution thus highly depend on the choice for time T.

The crux of the argument is that we never observe firms all at the same time T in their evolution. Instead, T could be seen as a random variable itself, the time since a firm started at initial size X_0. If we look at the top set of firms (the tail of the distribution), the analysis above has indeed shown that there are large differences between the time durations firms have been present in the top. When the time T is assumed to follow an exponential distribution, there exists a closed form for the firm size distribution. The analyis has given an empirical ground for the approximating nature of the exponential distribution.[6]

The outline of the derivation of the firm size distribution goes as follows. Further detail can be found in appendix C. Y_T defined above as the logarithm of firm size X_T, has the moment generating function:

$$M_{Y(T)}(s) = exp(X_0 s + ((\mu - \frac{\sigma^2}{2})s + \frac{\sigma^2}{2}s^2)T)$$

Instead of a fixed time T, time now gets randomized based on an exponential distribution. Since the moment generating function of the exponential distribution $M_T(s) = \frac{\lambda}{\lambda - s}$, the moment generating function of Y transforms into:

$$E_T[M_{Y(T)}(s)] = e^{X_0 s} \frac{\lambda}{\lambda - (\mu - \frac{\sigma^2}{2})s - \frac{\sigma^2}{2}s^2}$$

The moment generating function is uniquely defined and corresponds for Y to the asymmetric Laplace distribution. The resulting probability density function for X is:

$$f_X(x) = \frac{\alpha\beta}{\alpha+\beta}(\frac{x}{X_0})^{-\alpha-1}, \ x \geq X_0$$

[6]There is a slight tension between the argument here concerning the entrance among the large firms that is based on an initial size and the analysis before concerning the entrance that is based on the number of firms. The tension disappears when size is relatively defined and concentration remains constant over the time span under analysis.

where α and $-\beta$ are the two roots of the characteristic quadratic equation $\frac{\sigma^2}{2}s^2 + (\mu - \frac{\sigma^2}{2})s + \lambda$. In conclusion, firm size is expected to follow a Pareto distribution exhibiting power-law behaviour.

8. Conclusion

Studying the rise and fall of companies means studying competition, innovation and economic development. Schumpeter saw the dynamic process as essential for innovation and economic progress. The concerns he raised that creative destruction would slowly die out, turned out to be unwarranted. Instead, the United States have seen an increase in dynamism among the largest companies. Furthermore, countries with a formerly large state capacity in productive resources, such as China, have become as dynamic as other economic powerhouses.

The analysis is limited by its concentration on publicly traded companies. It can be argued that the public offering is a step in the growth process of a firm into a large mature company, but this is not always the case. There may be a variety of reasons to keep a company private even when becoming very sizeable, or a sizeable company might remain fully government-owned. It would therefore be interesting to investigate if the empirical results hold among the privately- or state-owned large firms. In general, the measures of dynamism if deemed interesting could spur research into several more detailed country or industry cases.

The survival probability of companies in the top is characterized by scale independence. The exponential distribution provides an approximate fit, ameliorated by a Weibull distribution with a benefit for firms who have been present longer in the top. These distributions point towards a (generalized) Poisson process of arrival of firms into the top. The exponential distribution for the time in the top combined with a geometric Brownian motion translates into a power-law distribution, so the laws of nature have company in potentially having evolutionary origins.

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A. Data

A.1 Forbes Global 2000

Figure 16 shows the evolution of the number of companies in the Forbes Global 2000 for each country with consistently more than fifty companies across the time period 2008-2023.

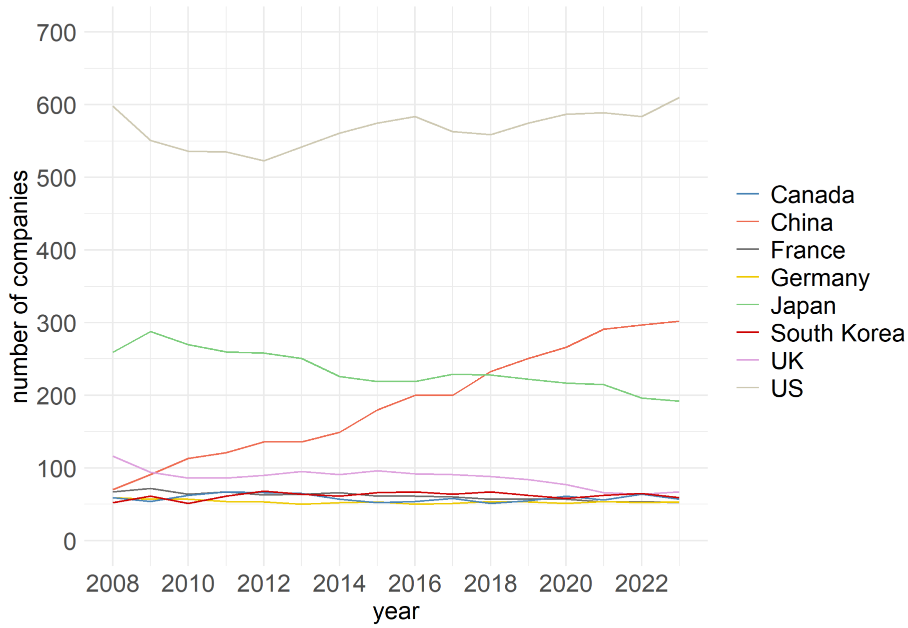

Figure 16: Number of companies in the Forbes Global 2000 list.

Tables 1-4 list the top fifty of the Forbes Global 2000 for the eight countries under analysis in 2023.

A.2 Brussels Stock Exchange

Figure 17 shows the evolution of the number of Belgian and colonial companies listed on the Brussels stock exchange over the time period 1832-2020.

B. Dynamism across Countries: Analysis

Figure 18 shows the survival functions with confidence intervals of the top fifty in the different countries of the Forbes Global 2000 based on the Kaplan-Meier estimator.

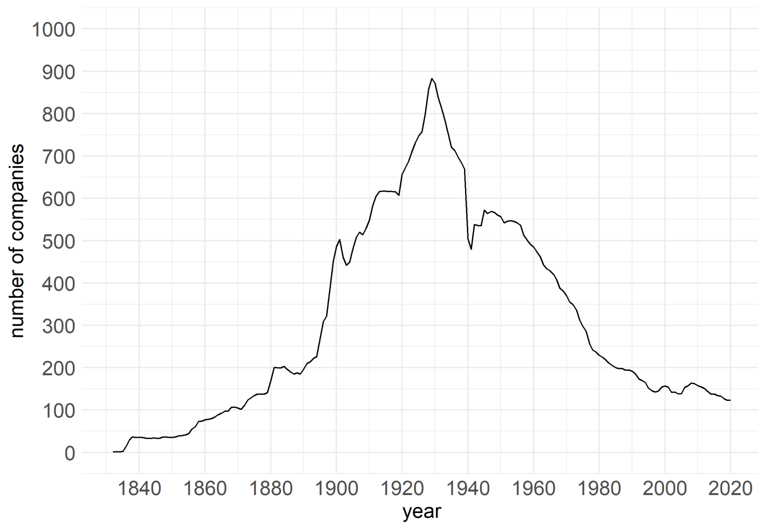

Figure 17: Number of Belgian and colonial companies listed on the Brussels stock exchange.

C. Statistical Model: Power-law Behaviour

This section elaborates on the derivations of the firm size distribution emerging from a geometric Brownian motion after an exponentially distributed time (Reed, 2001). Firms start at initial state X_0, such that the size after a fixed time T follows the lognormal distribution:

$$Y_T = log(X_T) \sim N(X_0 + (\frac{\mu - \sigma^2}{2})T, \sigma^2 T)$$

The moment generating function of Y is given by:

$$M_Y(T)(s) = e^{X_0 s + ((\mu - \frac{\sigma^2}{2})s + \frac{\sigma^2}{2}s^2)T}$$

Then, time T is randomized following an exponential distribution, which has probability density function $f_T(t) = \lambda e^{-\lambda t}$ for $t \geq 0$. The moment generating function of the exponential distribution is $M_T(s) = \frac{\lambda}{\lambda - s}$. The randomization leads to a new moment generating function for Y:

$$\begin{aligned} E_T[M_Y(T)(s)] &= E_T[e^{X_0 s + ((\mu - \frac{\sigma^2}{2})s + \frac{\sigma^2}{2}s^2)T}] \\ &= e^{X_0 s} E_T[e^{((\mu - \frac{\sigma^2}{2})s + \frac{\sigma^2}{2}s^2)T}] \\ &= e^{X_0 s} \frac{\lambda}{\lambda - (\mu - \frac{\sigma^2}{2})s - \frac{\sigma^2}{2}s^2} \end{aligned}$$

Denote by α and $-\beta$ the two roots of the characteristic quadratic equation $\frac{\sigma^2}{2}s^2 + (\mu - \frac{\sigma^2}{2})s + \lambda$ from negating the denominator in the equation above. The product of α and β can thus be written as $\alpha\beta = \frac{-\lambda}{\frac{\sigma^2}{2}}$. The

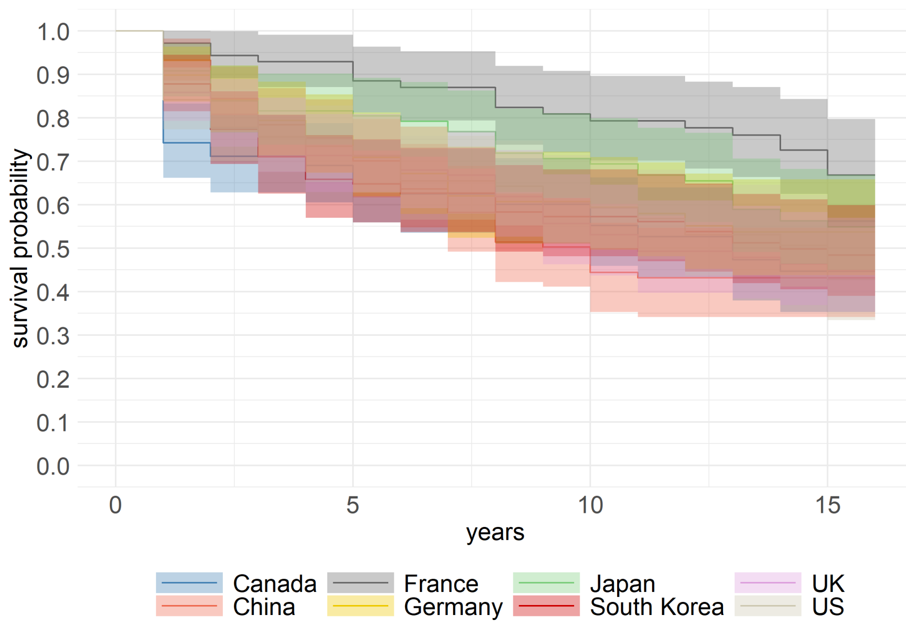

Figure 18: Kaplan-Meier survival function over 2008-2023 of the companies in the top fifty by country in the Forbes Global 2000. The lighter areas denote 95% confidence intervals.

moment generating function can be simplified based on the roots as:

$$M_Y(T)(s) = e^{X_0 s}\frac{\alpha\beta}{(\alpha - s)(\beta + s)}$$

This moment generating function belongs to the asymmetric Laplace distribution, which has probability density function:

$$f_Y(y) = \begin{cases} \frac{\alpha\beta}{\alpha+\beta}e^{\beta(y-Y_0)},\ y < log(X_0) \\ \frac{\alpha\beta}{\alpha+\beta}e^{-\alpha(y-Y_0)},\ y \geq log(X_0) \end{cases}$$

Finally, the probability density function can be transformed back into the probability density function of X as:

$$f_X(x) = \begin{cases} \frac{\alpha\beta}{\alpha+\beta}(\frac{x}{X_0})^{\beta-1},\ x < X_0 \\ \frac{\alpha\beta}{\alpha+\beta}(\frac{x}{X_0})^{-\alpha-1},\ x \geq X_0 \end{cases}$$

which characterizes a double-Pareto distribution exhibiting power-law behaviour in the tails. The power law coefficients containing parameters α and β depend on the parameters μ and σ of the geometric Brownian motion process and the parameter λ from the exponential distribution.

	United States	China	Japan	United Kingdom
1	JPMorgan Chase	ICBC	Toyota Motor	Shell
2	Bank of America	China Construction Bank	Nippon Telegraph & Tel	HSBC Holdings
3	Alphabet	Agricultural Bank of China	Sony	BP
4	ExxonMobil	Bank of China	Mitsubishi	Rio Tinto
5	Microsoft	Ping An Insurance Group	Sumitomo Mitsui Financial	Unilever
6	Apple	PetroChina	Mitsubishi UFJ Financial	British American Tobacco
7	UnitedHealth Group	China Merchants Bank	Mitsui	AstraZeneca
8	Wells Fargo	Postal Savings Bank Of China (PSBC)	Honda Motor	Lloyds Banking Group
9	Chevron	Sinopec	Itochu	Linde
10	Verizon Communications	Tencent Holdings	Hitachi	Barclays
11	Walmart	Bank of Communications	Japan Post Holdings	GSK
12	Citigroup	Alibaba Group	Mizuho Financial	NatWest Group
13	Morgan Stanley	Industrial Bank	KDDI	National Grid
14	Meta Platforms	China Life Insurance	Tokio Marine Holdings	Vodafone
15	Goldman Sachs Group	China State Construction Engineering	Seven & I Holdings	Anglo American
16	Amazon	Shanghai Pudong Development	Takeda Pharmaceutical	Standard Chartered
17	Pfizer	Contemporary Amperex Technology	Sumitomo	Diageo
18	Johnson & Johnson	China Shenhua Energy	Marubeni	LyondellBasell Industries
19	Comcast	China Citic Bank	Dai-ichi Life Insurance	Reckitt Benckiser Group
20	Procter & Gamble	China Telecom	Nippon Steel	BAE Systems
21	American Express	PICC	Denso	BT Group
22	General Electric	China Pacific Insurance	Shin-Etsu Chemical	Tesco
23	CVS Health	BYD	Japan Tobacco	London Stock Exchange
24	The Home Depot	China Everbright Bank	Panasonic	CNH Industrial
25	Cigna	China Railway Group	Orix	Imperial Brands

Table 1: Top 1-25 of Forbes Global 2000 in 2023 by country.

	United States	China	Japan	United Kingdom
26	Tesla	Midea Group	Daikin Industries	Compass Group
27	General Motors	China Minsheng Bank	MS&AD Insurance	Haleon
28	Merck & Co.	JD.com	Mitsubishi Electric	Coca-Cola Europacific Partners
29	AbbVie	China Vanke	Toyota Tsusho	Ferguson
30	Elevance Health	Poly Developments & Holdings Group	Bridgestone	Legal & General Group
31	Raytheon Technologies	Cosco Shipping	ENEOS Holdings	SSE
32	Oracle	SAIC Motor	Nissan Motor	RELX
33	PepsiCo	China Railway Construction	Canon	Prudential
34	ConocoPhillips	Zijin Mining Group	Komatsu	Associated British Foods
35	Walt Disney	Kweichow Moutai	Softbank	WTW
36	Cisco Systems	Power Construction Corporation of China	Daiwa House Industry	WPP
37	United Parcel Service	Longfor Group Holdings	Toyota Industries	Ashtead Group
38	Coca-Cola	Bank of Ningbo	Fast Retailing	Amcor
39	Costco Wholesale	Bank Of Jiangsu	Recruit Holdings	3i Group
40	Deere & Company	Huaxia Bank	Mitsui Fudosan	Rolls-Royce Holdings
41	Bristol Myers Squibb	Gree Electric Appliances	Inpex	International Airlines
42	Marathon Petroleum	Citic Securities	Suzuki Motor	J Sainsbury
43	Thermo Fisher Scientific	China Communications Construction	Central Japan Railway	Antofagasta
44	Caterpillar	Bank of Beijing	Fujitsu	Centrica
45	Charles Schwab	Shaanxi Coal Industry	Fujifilm Holdings	Aviva
46	Visa	Baoshan Iron & Steel	Nintendo	Investec
47	American International Group	Haier Smart Home	Tokyo Electron	Liberty Global
48	Ford Motor	Wanhua Chemical Group	Sumitomo Mitsui Trust	Bunzl
49	US Bancorp	Bank Of Shanghai	Nippon Yusen	Mondi
50	Broadcom	China Yangtze Power	Asahi Group Holdings	St. James's Place

Table 2: Top 26-50 of Forbes Global 2000 in 2023 by country.

	South Korea	Canada	France	Germany
1	Samsung Group	RBC	TotalEnergies	Volkswagen Group
2	Hyundai Motor	TD Bank Group	BNP Paribas	Allianz
3	KIA	Bank of Montreal	LVMH Moët Hennessy Louis Vuitton	Deutsche Telekom
4	KB Financial Group	Bank of Nova Scotia	AXA Group	Mercedes-Benz Group
5	SK Hynix	Brookfield Corporation	Sanofi	BMW Group
6	Posco	Canadian Imperial Bank	AIRBUS	Siemens
7	Shinhan Financial Group	Enbridge	Credit Agricole	Munich Re
8	LG Chem	Suncor Energy	VINCI	Bayer
9	Hana Financial Group	Canadian Natural Resources	L'Oréal	Deutsche Post
10	Hyundai Mobis	Sun Life Financial	Schneider Electric	Deutsche Bank
11	Samsung C&T	Nutrien	Air Liquide	Porsche Automobil Holding
12	Woori Financial Group	Manulife	Orange	E.ON
13	Samsung Life Insurance	Power Corp of Canada	EssilorLuxottica	RWE Group
14	Samsung SDI	Cenovus Energy	Saint-Gobain	SAP
15	SK	Couche Tard	Société Générale	Merck
16	Industrial Bank of Korea	National Bank of Canada	Kering	Daimler Truck Holding
17	Hanwha	BCE	EDF	EnBW-Energie Baden
18	SK Innovation	Canadian National Railway	Carrefour	Fresenius
19	Korea Gas	Fairfax Financial	Danone	Talanx
20	HD HYUNDAI	TC Energy	Pernod Ricard	Infineon Technologies
21	LG Electronics	Intact Financial	Michelin Group	Commerzbank
22	Korea Electric Power	George Weston	ENGIE	Henkel
23	Samsung Fire & Marine	Canadian Pacific Kansas City	Veolia Environnement	BASF
24	HMM	Teck Resources	Capgemini	HeidelbergCement
25	GS Holdings	TELUS	Bouygues	Deutsche Boerse

Table 3: Top 1-25 of Forbes Global 2000 in 2023 by country.

	South Korea	Canada	France	Germany
26	KT	Rogers Communications	Hermès International	Deutsche Lufthansa
27	Meritz Financial Group	Fortis (Canada)	Thales	Siemens Energy
28	Db Insurance	Pembina Pipeline	Publicis Groupe	ThyssenKrupp Group
29	E-mart	Thomson Reuters	Safran	Continental
30	S-Oil	Barrick Gold	Eiffage	Adidas
31	Korean Air	Magna International	Renault	Brenntag
32	CJ Corporation	Agnico Eagle Mines	Sodexo	Vonovia
33	Hyundai Steel	CGI	Air France-KLM	Evonik Industries
34	Naver	Waste Connections	Legrand	Beiersdorf
35	SK Telecom	Restaurant Brands International	Dassault Systemes	Salzgitter
36	Hyundai Glovis	Lululemon Athletica	Financiere de l'Odet	Wacker Chemie
37	CJ Cheiljedang	iA Financial Corporation	Dassault Aviation	Schaeffler
38	LG	First Quantum Minerals	Finatis	Sartorius
39	Korea Investment Holdings	Hydro One	Alstom	Covestro
40	LG Display	Metro	Scor	Metro Group
41	Hyundai Marine & Fire	Tourmaline Oil	Faurecia	Wuestenrot & Wuerttembergische
42	BNK Financial Group	Emera	Rexel	BayWa
43	Samsung SDS	Canadian Tire Corporation	Vivendi	Aurubis
44	LG Innotek Co	Constellation Software	Valeo	TUI
45	Lotte Chemical	Franco-Nevada	Arkema	Ceconomy
46	Korea Shipbuilding & Offshore Engineering	Shopify	Aeroports de Paris	K+S
47	Mirae Asset Financial Group	ARC Resources	Teleperformance	Knorr-Bremse
48	Lotte Shopping	Wheaton Precious Metals	Covivio	Deutsche Pfandbriefbank
49	Doosan	Empire	Unibail-Rodamco-Westfield	Delivery Hero
50	Daou Data	TFI International	Worldline	Rheinmetall

Table 4: Top 26-50 of Forbes Global 2000 in 2023 by country.