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A replication study on growth paths of young firms: Evidence from German administrative data

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ABSTRACT

This replication study contributes to the lively debate about firm-specific growth paths of new firms. Utilizing rich German administrative panel data (i.e., 895,459 young firms that submitted a turnover tax preregistration form between 2001 and 2011), the study empirically revisits new firms' growth paths as documented in the JBV Insights paper of Coad et al. (2015). In line with their results, the empirical findings of this study corroborate that (a) growth paths of young firms are erratic, meaning that such growth paths cannot be easily sorted into a meaningful taxonomy and (b) young firms rarely persistently experience comparably high growth in sales over time. In addition, an analysis of the characteristics of persistently growing firms suggests that these tend to invest more in their founding period and are typically founded in the manufacturing industry.

1. Introduction

Research literature tends to address the quantity of firm growth or describes the determinants of the few firms that win the race to the top of the firm size distribution, usually without asking the question of how firms grow over time. The basic question of how firms grow is rarely addressed (McKelvie and Wiklund 2010). Until now, most studies have concentrated either on the stochastic nature of firm growth (e.g., the analysis of Gibrat's law of proportionate growth) or on the identification of significant determinants of firm growth. Through this, it has become common knowledge that young firms tend to grow faster than older ones (e.g., Haltiwanger et al., 2013; Lawless 2014). It seems that politicians might therefore have gained the impression that because young businesses grow comparatively quickly, they transform whole economic regions, generate innovation, and create a large number of jobs (Shane 2009). Typical small business owners, however, have low growth aspirations (Shane 2009; Hurst and Pugsley 2011), and transformational entrepreneurship rarely occurs (Schoar 2010; Schneck 2020).

In this context, the study at hand sheds light on the nature of new firms' growth by examining their growth paths over time. The persistency of firm growth has recently attracted considerable interest in empirical research (Garnsey et al., 2006; Stam et al., 2008; Coad et al. 2013, 2015; Derbyshire and Garnsey 2014/2015). Stam et al. (2008), for example, investigated the employment growth of new ventures during the decade from 1994 to 2004 in the Netherlands and found that continuous growth is rare, which contradicts the widespread belief that young firms grow continuously. As these results also document, most young businesses seem to experience growth setbacks or reach a plateau – a maximum firm size. In line with this, Derbyshire and Garnsey (2014) analyzed the employment growth paths of young businesses in the UK over five years and found that many firms stagnate after a short period of growth, some

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even stagnating from their foundation onward.

The purpose of this study is to contribute to the lively debate about growth paths of young firms. The replication study at hand was specifically motivated by the lively discussion between Derbyshire and Garnsey (2014) and Coad et al. (2015) about methodology, growth indicators, and data issues with regard to firms' growth types. More precisely, the objective of this study is to contribute to their ongoing debate about the measurement of firm growth and methodological issues. The aim of this paper is not to generate any new hypotheses, but rather to shed light on the generalizability of the results presented in Coad et al. (2015) to deepen the understanding of firm growth paths. We see an important need for this because the Coad et al. (2015) study relies on the Barclays data set, which consists of a random sample of 2,176 new ventures in England and Wales. In contrast, the replication study at hand is based on administrative data, which is representative of all firms in Germany (i.e., 895,459 young firms that submitted a turnover tax preregistration form between 2001 and 2011). In addition, Coad et al. (2015) – as well as Derbyshire and Garnsey (2014) – only consider one single start-up cohort. This study aims to gain a more holistic picture by examining different cohorts of new ventures over time and relating growth paths to absolute sales growth. In addition, the study at hand also contains regressions to identify factors associated with persistent high growth of firms.

In line with the results of Coad et al. (2015), the results show that the growth paths of young firms are erratic, which means that growth paths cannot easily be sorted into a meaningful taxonomy and, consequently, young firms rarely experience comparably high growth in sales persistently over time. Moreover, our paper identifies some general characteristics of persistently growing firms in Germany: our regression analysis indicates that persistently growing firms invest a comparably high share of their sales in intermediate goods in the early phases of their existence and are usually founded in the manufacturing industry.

In sum, our paper contributes to the literature in two ways: Firstly, this is the first study to examine the growth paths of newly founded microenterprises in Germany by adopting (and enhancing) the methodology described in Coad et al. (2015) and applying sales as the central measure of growth. Secondly, our results confirm that young firms' growth is unlikely to skyrocket, although this can happen occasionally.[1]

2. The Coad et al. (2015) study and its critique

The phenomenon of firm growth has attracted a huge body of literature from the fields of management, economics, and sociology. A considerable part of this literature has considered firm growth as a stochastic process (see, e.g., the discussions about Gibrat's law of proportionate growth; Sutton 1997; Santarelli et al., 2006), making firm growth hard to predict. In line with this, Marsili (2001, p. 18) indicates, "the empirical evidence suggests that although there are systematic factors at the firm and industry levels that affect the process of firm growth, growth is mainly affected by purely stochastic shocks."

A recent contribution to this body of research literature is the study by Coad et al. (2013). The authors generalize the Gibrat's random growth model and make predictions about firm growth as well as survival. The authors draw on the Gambler's Ruin model (Wilcox 1971) and utilize the analogy of a ring of gamblers gathered around a gambling table, playing a game of chance. All players in this game are over-optimistic and confident about their winning chances. However, in reality, the players have little or no control over the outcomes. Applying this analogy to business, chance refers to the entry or innovation of competitors, changes to the regulatory environments (e.g., the start of a tariff war or the introduction of trade agreements), or changing consumer tastes. Consequently, firm growth is comparable to a game of chance (Gambler's Ruin model) and can be best modelled by a "random walk," which implies that growth rates are independent of prior success. In the study of Coad et al. (2013), this leads to the hypothesis that firm growth paths are close to random and cannot be sorted into a meaningful taxonomy.

After a critique by Derbyshire and Garnsey (2014) – which we comment on below in detail – Coad et al. clarified the meaning of their hypothesis in their 2015 study (p. 6): "[…] to be absolutely clear; we do not argue that N[ew]V[enture] growth paths are entirely random, but that they are close to random, and that randomness is a considerably better approximation than determinism." Our study was strongly inspired by the lively and controversial discussion between Derbyshire and Garnsey (2014) and Coad et al. (2015). Derbyshire and Garnsey (2014) critically discussed the Coad et al. (2013) study with a focus on methodology as well as growth indicators and data issues. In this replication study, the focus is on Derbyshire and Garnsey (2014) two central points of criticism of Coad et al., 's 2013 study.

Critique 1: The binary distinction between growth and decline in Coad et al. (2013) caused the potential randomness of growth paths.

In their study, Coad et al. (2013) distinguished only between growth and decline, and their distinction was based on the median of growth. That is, firms with growth above the median were defined to be growing in specific periods of time, while the remaining firms were defined to be declining. This point was criticized by Derbyshire and Garnsey (2014). However, Coad et al. (2015) responded by including a third category: stasis. The thresholds for these three groups were defined by the distribution of growth: the third of firms with lowest growth were defined as declining, the third of firms with highest growth were categorized as growing, and the remaining third of firms was defined to be in stasis.

Thus, growth, stasis, and decline of the firms' growth rates were defined in relation to the growth rates of the other new ventures in the data. This definition seems to align with perceptions about firm development – entrepreneurs tend to compare themselves and their firm's performance to others (see also the literature on interdependent preferences, e.g., Frank 1985). That is, according to prospect

[1] Primarily those firms serve as examples for entrepreneurship in the media. The majority of new firms however are highly unlikely to be addressed by the mass media.

theory, an entrepreneur "weathering a slump with greater success than his competitors may interpret a small loss as a gain, relative to the larger loss he had reason to expect" (Kahneman and Tversky 1979, p. 286). In contrast, entrepreneurs achieving smaller gains than their peers perceive their comparatively small increases as losses. Therefore, decline does not necessarily imply absolute losses in sales, but also lower growth when compared to others.[2] An additional advantage of this definition of firm growth is that it is more flexible than other definitions for quickly growing firms, which define fixed threshold values (e.g., growth must exceed 20% per year, cf. OECD 2010). Such definitions, however, do not account for business cycles, and therefore impose some bias. A large number of firms might pass the threshold values in an economic boom, while only few manage to achieve the required growth rates in downturns.

Critique 2: Sales is an ambiguous measure of performance.

As indicated above, the debate about young firms' growth paths is still in its infancy and fragmented. This is partially caused by the lack of consensus about how to measure growth. Stam et al. (2008) and Derbyshire and Garnsey (2014) apply growth in the number of employees as the main indicator; Coad et al. (2015) suggest utilizing sales growth rates to illustrate firm-specific growth paths. While we agree with Derbyshire and Garnsey (2014, p. 9) and Coad et al. (2015, p. 7) that each performance indicator has weaknesses, we consider it very unlikely that businesses maximize the numbers of employees. Instead, we think that businesses rather tend to focus on profits or sales (e.g., Baumol 1962; Achtenhagen et al., 2010; Daunfeldt et al., 2014; Coad et al., 2015).[3] Hence, in line with Coad et al. (2015), we argue that focusing on sales is more in line with the profit maximization focus of firm owners, managers, and shareholders.

3. Data and methodology

3.1. Data set

We utilized German census data, the *Umsatzsteuerpanel* (The German Turnover Tax Statistics Panel) provided by the German Statistical Office (Destatis), to analyze the firm-specific growth path of young firms. The data consist of panel information on all German firms that submitted a turnover tax preregistration form between years 2001 and 2011. We specifically concentrated on all firms with sales (deliveries and other performances) of at least 17,500 Euro. According to §19 (1) of the sales tax legislation (Umsatzsteuergesetz), firms submit the tax form when sales exceeded 16,620 Euro in 2002 and 17,500 Euro from 2003 onwards. In this paper, we restricted the minimum sales threshold to 17,500 Euro in all periods to avoid any bias due to the threshold. More details about the data and the legal background can be found in Vogel and Dittrich (2008).

New businesses were identified via a unique firm identification number in the data. A firm that was observable in year t but not in t-1 was defined as an entrant (Schneck and May-Strobl 2015). These firms might have been founded earlier, but we referred to the first appearance in the data as the period of start-up. In addition, we focused on newly founded microenterprises with maximum sales of €2,000,000 in their very first period. This restriction was imposed to reduce the likelihood of considering new firms arising from merger & acquisitions or spin-offs, which we could not identify otherwise (for details about potential changes in the firm identifier, see Vogel and Dittrich 2008, p. 668). Due to the sales threshold or potential business breaks, not all firms can be observed continuously over time. This can cause problems due to multiple entries and exits and can prevent the calculation of growth between two consecutive years. Therefore, we restricted the data to firms that were observable consecutively over time (Schneck and May-Strobl 2015). We then focused only on those new firms we could observe in each of the first five years (also see Coad et al., 2015). Put together, we focused on a balanced panel of firms, which could be observed during their first five years after their first occurrence.

We left the agriculture and forestry sectors unconsidered because firms in these sectors are likely to be exempt from submission of the sales tax preregistration form (Vogel and Dittrich 2008). We also excluded private households with service personnel and extraterritorial organizations from the analysis. Further details about the data and variables are presented in Vogel and Dittrich (2008).

3.2. Measurement and growth paths

We followed Coad et al. (2015) and examined sales growth for the determination of growth paths among young firms. That is, we replicated the methodology applied in Coad et al. (2015) and defined the growth of firm i in period t as shown in equation (1):

$$growth_{i,j,t} = \ln\left(sales_{i,j,t}\right) - \ln\left(sales_{i,j,t-1}\right) \quad (1)$$

Subscript j describes the start-up cohort. A firm of cohort j declines (d) when $growth_{i,j,t}$ is strictly lower than the 33.33rd percentile in a particular year. Decrease does not imply that sales in period t are necessarily lower than sales in t-1. This definition implies that these firms grew at a slower rate than 66.67% of the remaining firms of that cohort. Growth (g), in turn, is identified when the corresponding growth rate exceeds the 66.66th percentile. Finally, stasis (s) defines all growth rates from the 33.33rd percentile to the 66.66th percentile.

[2] Analogously, the same holds for the individual assessment of growth and stasis.

[3] A potential weakness of using sales as an indicator of firm performance is that sales are affected by price effects, productivity effects as well as exchange rate effects (Brenner and Schimke 2014). Sales hence tend to fluctuate more than other indicators of firm growth, such as employment levels.

3.3. Methodology

We applied sequence analysis (Scherer 2001; Brüderl and Scherer 2004; Brzinsky-Fay 2007) with the three states *g*, *s*, and *d*. Sequence analysis was conducted for market entrants that could be observed for five consecutive years. This is analogous to the time horizon in Derbyshire and Garnsey (2014) as well as Coad et al. (2015). With our three states – *g*, *s*, *d* – and a period of five years, a maximum of $3^4 = 81$ combinations were possible. In sum, we consecutively analyzed the first five years' data of firms newly founded between 2002 and 2007.

4. Results

4.1. Replication

In this chapter, we firstly compare the results of our replication study to the results presented in Coad et al. (2015). A striking difference between the studies is the number of observations. While the seminal study is based on 2,176 observations, our study consists of 895,459 observations (see Table 1). Table 1 only presents growth paths that are more likely than by a uniform distribution – that is, growth paths with a propensity above 1.235%.[4] With exception of few outliers, our results corroborate previous findings and indicate that sales growth paths are distributed in an almost random manner. In addition, more than three quarters of positive (negative) deviations from the uniform distribution in Coad et al.'s study are also positive (negative) in our replication study (Fig. 1). This lends further credit to the generalizability of the results presented in Coad et al. (2015).

In line with the results presented in Coad et al. (2015), we also find that stagnation from foundation onwards is a more likely growth path for a firm than other growth paths. Firms that grow outstandingly – that is, firms that are among the first third in each period (growth path *gggg*) – occur with a slightly greater likelihood than random chance. However, the ranking of the growth paths differs substantially from Coad et al. (2015). Only 3 profiles are among the 10 most common profiles in both studies. The growth path *gsss* is ranked third in this study, but occupies the 28th place in Coad et al.'s study (2015). The propensity of occurrence, however, differs by less than one percentage point (0.739%). Such differences could be caused by differences in the underlying data sets or random instances.

In sum, our replication study corroborates that growth paths seem to be distributed in an almost random manner. In other words, growth sequences cannot be sorted into a meaningful taxonomy of growth paths. This view is validated by the fact that we were largely unable to replicate the ranking of the sequences. The studies by Derbyshire and Garnsey (2014) and Coad et al. (2015) rely on a single cohort of firms.[5] Our analysis by cohort corroborates the findings established above. Profiles are distributed close to a uniform distribution (see Table 2). However, there is evidence for a remarkable stability among the leading profiles. Market entry followed by a period of decrease – as defined here – and then followed by periods of stasis is the most prevalent cohort. The second most common profile suggests stasis from the beginning onwards. The prevalence of this sequence is much lower than the one reported in studies on growth paths that concentrate on employment growth (e.g., Derbyshire and Garnsey 2014). The ranking of the other profiles changes by cohort. This finding lends further credit to the hypothesis that a meaningful classification of growth paths is difficult to achieve.

4.2. Extension 1: cardinal growth and growth paths

Existing literature has addressed growth paths, but the associated growth rates of young firms are also of special interest for management and policy. Therefore, we added descriptive statistics on the growth rates of young firms. Specifically, we calculated a firm's growth by dividing sales in the fifth period by sales in the base period. The average firm more than tripled its sales during its first five years (3.634, see Table 3). Furthermore, permanent growers achieved comparatively large sales increases, amounting to about seven times the average growth rate.

Our results on firm growth rates might be biased by the fact that sales often do not cover the entire twelve months of the corresponding year of entry. As a robustness check, we therefore excluded very small firms in the base period and only considered firms with sales larger than the median in the start-up period. The results reveal lower growth rates, but in general, the results are qualitatively robust to the full sample. On average, firms tripled their size, while firms that grew outstandingly in each year exhibited a similar growth rate when compared to those in the complete sample. In general, the high growth rates might be explained by survival bias and an "up-or-out dynamic" among young firms (Haltiwanger 2012; Schneck 2020). Note that firms with one single period of growth exhibited, on average, annual sales growth of almost 20% per year ($2.067^{0.25} = 1.199$). We would thus define the average young firm – which survives for five years and is just once among the set of growing firms – as a fast growing one if we adapt the OECD (2010) definition for sales growth. This average growth rate over time, however, is due to just one period of extreme success. When examining growth sequences over time instead of average growth rates over time, one might categorize such firms differently and therefore obtain different results.

[4] Of course, Tables with detailed numbers will be provided upon request.

[5] Derbyshire and Garnsey (2014) examined a cohort of firms, which were founded in the fourth quarter of 2005. The data set of Coad et al. (2013/2015) "comprises a randomly-selected sample of all new business current accounts opened with Barclays between March and May 2004" (Coad et al., 2013, p. 620).

Table 1
Sequence analysis of firm growth paths.

Rank (ordered by frequency)	All cohorts (Data source: Umsatzsteuerpanel)			Coad et al. (2015) (Data source: Barclays dataset)		
	Growth path	No. Of firms	Share (in%)	Growth path	No. Of firms	Share (in%)
1	dsss	36,290	4.05	ssss	103	4.73
2	ssss	23,750	2.65	sssg	55	2.53
3	gsss	18,967	2.12	dggd	46	2.11
4	gggg	18,653	2.08	dgdd	44	2.02
5	dgdg	17,454	1.95	dddg	42	1.93
6	sdgd	16,644	1.86	gggd	41	1.88
7	gdgd	16,599	1.85	ddgg	40	1.84
8	sgdg	15,050	1.68	dgdg	40	1.84
9	ggdg	14,996	1.67	gggg	40	1.84
10	gdgg	14,648	1.64	gddd	38	1.75
11	gddg	14,532	1.62	ddgd	37	1.70
12	gddd	14,429	1.61	sddd	37	1.70
13	ggdd	14,423	1.61	ddss	36	1.65
14	dggd	14,338	1.60	sdss	36	1.65
15	gggd	14,217	1.59	ggdd	35	1.61
16	ddgd	14,033	1.57	sdgd	35	1.61
17	sdgg	13,836	1.55	gdgd	34	1.56
18	sddg	13,214	1.48	gddg	33	1.52
19	ddss	13,159	1.47	ssgs	33	1.52
20	sggg	13,013	1.45	dddd	32	1.47
21	dgdd	12,737	1.42	gdgg	32	1.47
22	sdss	12,433	1.39	sddg	32	1.47
23	sggd	11,937	1.33	dgss	31	1.42
24	sgdd	11,765	1.31	dsss	31	1.42
25	dggg	11,666	1.30	sgdg	31	1.42
26	ddgg	11,242	1.26	ddgs	30	1.38
27	sddd	11,146	1.24	gggs	30	1.38
28	dssd	11,084	1.24	gsss	30	1.38
29	dsds	11,070	1.24	dggg	28	1.29
30			1.22	dsdg	28	1.29
31			1.20	gsgg	28	1.29
32			1.18	gsdd	27	1.24
33			1.14	sssd	27	1.24
Total		895,459	100.00		2176.00	100.00

4.3. Extension 2: characteristics of permanently growing firms

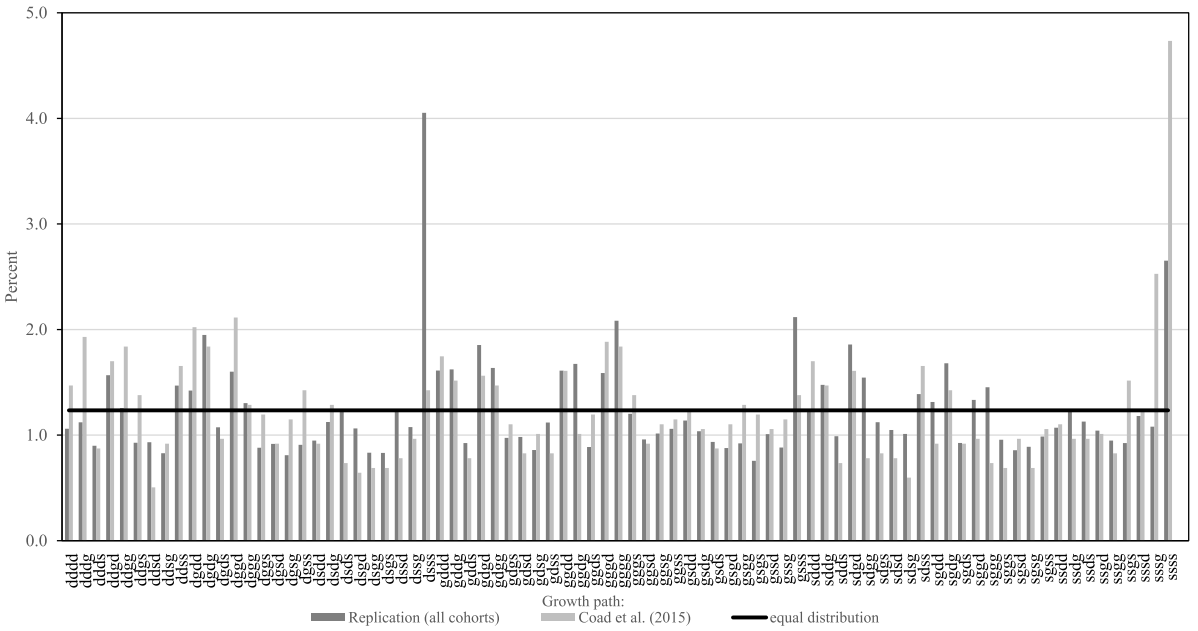
Coad et al. (2013) discuss that firms have differing access to resources at their inception, which affects firm survival over time. Here, we assess whether different resources at the time of market entry affect the likelihood of being a permanently growing firm (growth path *gggg*).

We generated a dummy variable that was coded with value 1 if a firm exhibited growth profile *gggg* and 0 otherwise. To distinguish the permanently growing firms from the other firms, we conducted probit estimation to identify characteristics promoting continuous growth. Our probit estimates show that firms with greater investments and intermediate consumption[6] are more likely to be among continuously growing firms (see Table 4). For this reason, we identify a systematic factor at the firm level that affects the process of firm growth. However, this does not contradict the claim that growth might also be affected by stochastic shocks.

Our estimates also suggest that permanently growing firms are typically small at time of start-up. The negative coefficient of firm size in the first period suggests that larger firms are less likely to grow continuously. This indicates that small firms are more likely to achieve comparably higher growth rates over five years. Concerning sector, growth path *gggg* occurs more often in the manufacturing industry and the transport, storage, and communication sectors compared to the other industries.

Our results suggest that significantly more continuously growing firms were founded in the earlier periods under analysis than in the later ones. This might be attributed to the severe effects of the financial crisis starting in 2008. While the cohorts of 2002 and 2003 were generally unaffected, all later start-up cohorts suffered from the consequences of the crisis, which might have induced higher levels of market turbulence. Therefore, compared to a descriptive inspection of the growth paths, the multivariate analysis provides deeper insights into cohort-specific effects – descriptive inspection of the growth paths did not lead to conclusions about significant differences upon first inspection.

[6] Intermediate consumption describes firm-specific needs for services as well as inputs to set up the business, to produce, to stay on the market, and to grow (cf. Schneck and May-Strobl 2015, pp. 235, 238).



*Note: Decline (*d*) describes cohort-specific growth strictly lower than the 33.33th percentile in a particular year. Growth (*g*) describes cohort-specific growth strictly above the 66.66th percentile in a particular year. In case of stasis (*s*), growth lies in between the mentioned percentiles. The probability in case of uniform distribution is equal to 1.235%. Number of observations: Replication (all observations): 895,459 observations; Coad et al. (2015): 2,176 observations.

Fig. 1. Deviations from uniform distribution.

5. Discussion

5.1. Overview

This paper successfully replicates the findings reported in Coad et al. (2015) with administrative German panel data. We confirm that firm growth paths cannot easily be transformed into any meaningful taxonomy. We furthermore corroborate that new firm growth paths are not entirely random, "but that they are close to random" (cf. Coad et al., 2015, p. 6). However, some firm growth paths occur more often than what would be suggested by chance or a uniform distribution. Nevertheless, the deviations are usually qualitatively small and amount to less than 0.5 percentage points in more than 90% of sequences. Our extensions suggest that growth paths might also provide a useful robustness check in the identification of quickly growing firms and that systematic factors at the firm or industry levels affect the process of firm growth.

5.2. Constraints on generalizability

Our data covers the entire set of firms that submit a tax preregistration form and obtain sales of at least 17,500 Euro per year. Firms in the agricultural and banking sector are frequently exempt from submitting the form and such firms remain unconsidered. We also excluded firms in the sectors of private households with service personnel and extraterritorial organizations from our analysis. All interpretations are conditional on firms surviving for at least five years.

5.3. Theoretical implications

The study at hand replicates the results of the Coad et al. study and should be understood as data-driven empirical research that confirms that growth paths cannot easily be sorted into a meaningful taxonomy. This will hopefully contribute to subsequent theory building. As Coad and Srhoj (2020) for example point out, especially in the context of this result, the shift in research should move away from seeking determinants of the average high growth firm with the focus on time-invariant predictors. Moreover, as firm growth is an erratic and time-varying process, theory building should concentrate on "high growth episodes" rather than "high growth firms" (Grover Goswami et al., 2019). Also in the context of the replicated results that growth paths cannot easily be sorted into any meaningful taxonomy, it should be discussed in more detail that neither employment growth nor sales may be sufficient indicators of success. The success of a young firm depends strongly on how the business founder understand and perceive success personally. Recent literature in entrepreneurship has therefore criticized the narrow focus on firms' growth as the dominant success factor entrepreneurs strive for. This young stream of entrepreneurship literature emphasizes the need for growth to be "placed within a broader context of reasons, purposes, and values for why and how entrepreneurship emerges" (Welter et al., 2016, p.311).

Table 2
Sequence analysis of firm growth paths by cohort (2002–2007).

Rank (ordered by frequency)	2002			2003			2004			2005			2006			2007		
	Growth path	No. of firms	Share (in%)	Growth path	No. of firms	Share (in%)	Growth path	No. of firms	Share (in%)	Growth path	No. of firms	Share (in%)	Growth path	No. of firms	Share (in%)	Growth path	No. of firms	Share (in%)
1	dsss	5,924	4.14	dsss	5,477	3.92	dsss	5,689	3.73	dsss	6,810	4.19	dsss	6,166	4.02	dsss	6,224	4.31
2	ssss	4,016	2.81	ssss	3,736	2.68	ssss	4,604	3.02	ssss	3,769	2.32	ssss	3,834	2.50	ssss	3,791	2.63
3	gsss	3,173	2.22	gggg	3,175	2.27	gggg	3,364	2.20	gdgd	3,281	2.02	gsss	3,415	2.22	gggg	3,033	2.10
4	gggg	3,071	2.15	gsss	2,990	2.14	gsss	3,111	2.04	gsss	3,258	2.01	dgdg	3,183	2.07	gsss	3,020	2.09
5	dgdg	2,807	1.96	dgdg	2,686	1.92	dgdg	3,025	1.98	sdgd	3,101	1.91	ggdg	2,995	1.95	gdgg	2,954	2.05
6	sdgd	2,716	1.90	sdgd	2,500	1.79	ggdg	2,788	1.83	gggg	3,029	1.87	gggg	2,981	1.94	gdgd	2,828	1.96
7	gdgd	2,691	1.88	gdgd	2,467	1.77	sdgd	2,747	1.80	dgdg	3,026	1.86	gddg	2,894	1.89	sdgd	2,801	1.94
8	gdgg	2,639	1.85	dssd	2,437	1.75	gdgd	2,679	1.76	gggd	3,023	1.86	sgdg	2,782	1.81	dgdg	2,727	1.89
9	sgdg	2,437	1.70	gddd	2,348	1.68	ddss	2,629	1.72	ggdd	2,913	1.79	sdgd	2,779	1.81	gddg	2,549	1.77
10	ggdg	2,424	1.70	gggd	2,284	1.64	sgdg	2,615	1.71	sgdg	2,685	1.65	gdgd	2,653	1.73	sdgg	2,489	1.72
11	sdgg	2,419	1.69	sgdg	2,205	1.58	gggd	2,606	1.71	dssd	2,655	1.63	gddd	2,583	1.68	sddg	2,336	1.62
12	ddgd	2,320	1.62	ddgd	2,172	1.56	ggdd	2,519	1.65	ddss	2,631	1.62	ggdd	2,559	1.67	sgdg	2,326	1.61
13	gddd	2,272	1.59	sggg	2,155	1.54	dssd	2,454	1.61	sdgg	2,529	1.56	ddss	2,502	1.63	ddgd	2,307	1.60
14	gddg	2,227	1.56	gdgg	2,116	1.52	gddd	2,452	1.61	gddg	2,517	1.55	dssd	2,474	1.61	gddd	2,267	1.57
15	ggdd	2,161	1.51	ggdg	2,111	1.51	ddgd	2,425	1.59	gddd	2,507	1.54	ddgd	2,413	1.57	ggdg	2,203	1.53
16	sggg	2,158	1.51	ggdd	2,101	1.51	sdss	2,325	1.52	gdgg	2,484	1.53	sdss	2,302	1.50	ggdd	2,170	1.50
17	dssd	2,150	1.50	sdgg	2,076	1.49	sggg	2,306	1.51	ggdg	2,475	1.52	sddg	2,302	1.50	dssd	2,168	1.50
18	dgdd	2,076	1.45	sddg	2,075	1.49	gddg	2,286	1.50	dgdd	2,439	1.50	sdgg	2,225	1.45	gggd	2,101	1.46
19	sddg	2,065	1.44	gddg	2,059	1.48	gdgg	2,272	1.49	ddgd	2,396	1.48	gdgg	2,183	1.42	dssd	2,082	1.44
20	gggd	2,032	1.42	dggg	2,027	1.45	sdgg	2,098	1.37	sddg	2,361	1.45	gggd	2,171	1.41	sggg	2,060	1.43
21	dssd	1,957	1.37	sdss	2,014	1.44	sddg	2,075	1.36	sggd	2,303	1.42	dgdd	2,167	1.41	dgdd	2,032	1.41
22	ddgg	1,912	1.34	ddss	1,996	1.43	dgdd	2,064	1.35	sdss	2,262	1.39	sggg	2,149	1.40	dsds	1,991	1.38
23	sddd	1,885	1.32	dgdd	1,959	1.40	sggd	2,063	1.35	sgdd	2,256	1.39	sgdd	2,109	1.37	sgdd	1,968	1.36
24	dggg	1,882	1.32	sggd	1,949	1.40	dggg	2,037	1.33	sggg	2,185	1.35	ssdg	2,015	1.31	ddgg	1,944	1.35
25	sdss	1,876	1.31	dsds	1,929	1.38	sddd	1,969	1.29	dsds	2,126	1.31	dggg	2,006	1.31	sssd	1,861	1.29
26	sgdd	1,797	1.26	sddd	1,844	1.32	sgdd	1,935	1.27	sssg	2,072	1.28	sggd	1,995	1.30	sggd	1,849	1.28
27	sggd	1,778	1.24	ssds	1,729	1.24				ssdg	2,071	1.28	dssd	1,960	1.28	ssds	1,810	1.25
28										dggd	2,069	1.27	sssd	1,939	1.26	ggss	1,789	1.24
29													ddgg	1,907	1.24			
Total		142,996	100.00		139,567	100.00		152,610	100.00		162,406	100.00		153,502	100.00		144,378	100.00

* Note: Replication of Table 1 in Coad et al. (2015). We present all paths, which exceed the propensity of random growth paths (1.235% = 100%*1/81). Growth paths below that threshold are not presented. Decline (d) describes cohort-specific growth strictly lower than the 33.33rd percentile in a particular year. Growth (g) describes cohort-specific growth strictly above the 66.66th percentile in a particular year. In case of stasis (s), growth lies in between the mentioned percentiles.

Table 3
Descriptive statistics on growth rates by growth path.

Growth path	Number of observations	Percentage (cumulated)	Average sales growth	Median sales growth	Variance
All firms					
Not one single period of growth	201,835	22.540	0.929	0.935	0.113
One single period of growth	327,036	59.061	2.067	1.308	1,513.197
Two periods of growth	251,284	87.123	3.969	2.173	3,292.438
Three periods of growth	96,651	97.917	10.182	4.248	53,078.010
Four periods of growth	18,653	100.000	21.941	9.018	13,094.900
Total	895,459		3.634	1.473	7,492.437
Firms with sales above the median in the start-up period					
Not one single period of growth	118,251	26.411	0.885	0.907	0.135
One single period of growth	167,989	63.932	1.835	1.235	662.788
Two periods of growth	112,784	89.122	3.633	2.069	4,219.920
Three periods of growth	40,681	98.208	8.776	4.043	25,201.640
Four periods of growth	8,023	100.000	19.267	8.359	12,869.630
Total	447,728		2.980	1.319	3,841.665

*Note: Sales Growth: $\frac{sales_{i,T}}{sales_{i,t0}}$, sales deflated 2010 = 100.

Table 4
Probit estimation results presenting marginal effects describing permanent growth of firms within a five year time horizon.

Variables: Permanent growth (gggg) = 1; All other growth paths = 0	Coef.	Std.Error	
Logarithmic sales in first period (deflated, 2010 = 100)	-.00486	(.000)	***
Intermediate consumption$_{i,t0}$/sales$_{i,t0}$ [a]	.00002	(.000)	**
Sector			
Manufacturing	Reference category		
Electricity, gas and water supply	-.00886	(.001)	***
Construction	-.00711	(.001)	***
Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods	-.00331	(.001)	***
Hotels and restaurants	-.01631	(.000)	***
Transport, storage and communication	.00079	(.001)	
Financial intermediation	-.01025	(.001)	***
Real estate, renting and business activities	-.01246	(.000)	***
Public administration and defence; compulsory social security	-.01313	(.001)	***
Education	-.01072	(.001)	***
Health and social work	-.01312	(.000)	***
Start-up cohort			
2002	Reference category		
2003	.00099	(.001)	
2004	.00024	(.001)	
2005	-.00334	(.000)	***
2006	-.00251	(.000)	***
2007	-.00083	(.001)	
Observed Probability $\bar{y}$:	.022		
Predicted Probability $E[y\|\bar{x}]$:	.020		
Number of observations	843,338		
Pseudo R^2	.016		
Wald chi^2	2,600.350		

*Note: a Values deflated, 2010 = 100; negative values of intermediate consumption are set to 0; For details about this variable see Schneck and May-Strobl (2015, pp. 235, 238). Significance levels: *p < .05, **p < .01, ***p < .001. Standard errors (in parentheses).Śectors coded in accordance with the German Classification of Economic Activities, Edition 2003 (WZ 2003) offered by the federal statistical office.

5.4. Practical implications

In general, we find that the growth paths of young firms seem to be close to random and that the rank order of growth sequences seems to be rather volatile. Most firms experience growth setbacks or reach a plateau within the first five years. We think that researchers should investigate these surviving firms further, rather than focusing on the very few "superstar" firms. In this regard, we encourage further research on organizational challenges or the growth ambitions of entrepreneurs. However, much of the growth process might be due to chance – entrepreneurs have little or no control over outcomes in a variety of dimensions (e.g., policy interventions or customer tastes). Besides, some entrepreneurs may only be extremely successful because they adopt ideas of others who were in the wrong place at the right time or in the right place at the wrong time.

Few firms manage to be among the third of fastest-growing firms over five years. Only one in fifty firms grew persistently per our definition. This relatively small subsample of firms, however, receives considerable attention in public, media, policy, and research. However, the negative effects of fast growth are rarely examined. An exception is the study by Daunfeldt et al. (2015), which showed that high-growth firms frequently achieve low profits and are therefore not necessarily healthy. In addition, permanent high growth also causes organizational and resource-related challenges (see, e.g., Garnsey et al., 2006, who discuss prior work of Edith Penrose).

5.5. Limitations and future directions

Despite its advantages and merits, the examination of growth paths is also subject to some limitations. For example, there is a lively debate about learning processes of firms and entrepreneurs (e.g., Penrose 1959; Nelson and Winter 1982; Jovanovic 1982; Geroski and Mazzucato 2002; Frankish et al., 2013). We observe that one in three firms entered the third of fastest-growing firms in the direct aftermath of a period of comparably slow growth (status "decline" in our empirical investigation).[7] Before attributing this to learning processes in organizations, potential fallacies must be checked. All firms were categorized into one of the three considered states; there was equal likelihood for each state. The basic prediction that one in three firms is growing after a period of decline thus might simply reflect the random nature of firm growth. In addition, regression to the mean (see, e.g., Kahneman 2011, chapter 17) might be evident. In other words, an average firm might be outstandingly unsuccessful in one single period, but might be very average in the remaining periods. As a result, stasis or growth is likely to occur in the aftermath of decline. Another explanation for growth in the aftermath of a severe decline might be for mathematical reasons – we related current sales to unusually low sales in the previous period. Therefore, still open-minded discussions and alternative concepts in the debate about firm growth (paths) are necessary.

We show that newly founded, permanently growing firms are usually smaller at the time of start-up and invest a comparably large amount in their very first period. One limitation was that we were not able to analyze managerial decisions or other forms of restructuring measures. A basic advantage of subsequent estimation procedures after the identification of growth paths might be the application of selection models, which might account for the survival bias. We did not calculate selection models because we could not identify a variable that was highly correlated with firm survival, but uncorrelated with its growth path.

A multivariate analysis of stagnation after periods of growth might open promising avenues for research on obstacles to growth. In this regard, growth ambitions might be a powerful predictor of stagnation after periods of growth (Welter 2001; Stam and Wennberg 2009). The analysis of growth paths contributes to literature in the economics and business fields: economists and managers alike need studies that identify managerial measures or other determinants of persistent high growth. However, as the growth paths of firms seem to be close to random, it is important to be open-minded about how organizations grow due to ad hoc managerial artefacts and processes. Economic, political, and societal influences might exhibit stronger effects.

6. Conclusion

We would like to conclude with Derbyshire and Garnsey (2015, p. 10) and agree with their statement that although growth paths occur in an approximately stochastic fashion, "we do not feel that this detracts from our argument that gambling analogies are not likely to provide a useful lens through which to consider entrepreneurship." However, we add further evidence to the literature, lending credit to the view that entrepreneurial success also features inherent random features, which are hard to predict.

Declaration of competing interest

The authors whose names are listed immediately below certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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[7] Our examination of the complete sample and 81 growth paths shows that growth follows immediately after a period of decline in one third of all cases (26 paths, 34.564% of firms). Further decline occurs less likely in the aftermath of periods of decline. Nevertheless, each fourth firm is characterized by at least two periods of decline in series (25.435% of firms).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jbvi.2021.e00246.

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Stefan Schneck: Conceptualization, Methodology, Data analysis (incl. Formal analysis and data curation), Writing and Reviewing. **Arndt Werner:** Conceptualization, Visualization, Writing, Reviewing and Editing. **Hans-Jürgen Wolter:** Conceptualization, Writing and Reviewing.

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