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ANALYZING NON-LINEAR DYNAMICS OF ORGANIC GROWTH: EVIDENCE FROM SMALL GERMAN NEW VENTURES

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ABSTRACT

This paper links theories of growth models with the literature on serial autocorrelation of growth. We study the serial autocorrelation of tendencies of growth trajectories of employment and sales for German new ventures over a nine-year period using mosaic plots as a conceptual framework. The autocorrelation of growth tendencies provides important information on firms growth processes. We find that growing new ventures are subject to negative autocorrelation of tendencies of growth trajectories making sustained growth a very rare occurrence. This indicates that the growth of new ventures is non-linear, prone to interruptions, amplifying forces, and setbacks. Therefore, we interpret the commonly used term 'stages of growth model' in a different manner. A stage cannot be defined as a time span but rather as a sort of conditions of circumstances that are all present at a point in time and that are conditionally linked to a preceding sort of circumstances.

INTRODUCTION

Growth of businesses is one of the central topics of entrepreneurship research (McKelvie & Wiklund, 2010). Stages of growth models dominate this literature on the growth of businesses and are based on three main assumptions (Greiner, 1972; Levie & Lichtenstein, 2010). First, distinctively different stages of development can be identified. Second, the sequence and order of development is predetermined and thus predictable. Third, all ventures develop according to prefigured rules. In recent years, scholars began to criticize the linear models of business growth (Levie & Lichtenstein, 2010) and suggest replacing assumptions of these models with principles from complexity science, such as complex adaptive systems (Anderson, Meyer, Eisenhardt, Carley, & Pettigrew., 1999; Holland, 1995; McKelvey, 2004) and the non-linear dynamics of economics and management (Chiles, Bluedorn, A., & Gupta, 2007; Meyer, Gaba, & Colwell, 2005;).

By drawing on these studies criticizing stages of growth models and the resource-based view, we examine the serial correlation of growth for small new ventures that do not have neither innovative nor technology-based business concepts and are run as full-time businesses. We chose to study the relationship between measures of growth of this type of new venture for the following reasons. First, this type of new venture is typical of many entrepreneurial activities in Germany in terms of size, business model, or legal type (Lambertz & Schulte, 2013). Second, so far the focus has been on research of new ventures in the manufacturing sector (Bottazzi, Coad, Jacoby, & Secchi, 2009; Coad & Hölzl, 2009; Daunfeldt & Halvarsson, 2015). To validate the theory of negative autocorrelation of growth other sectors than the manufacturing sector need to be investigated. Third, established theories originating from economics, sociology or management may be well suited for explaining the creation of innovative ventures. However, empirical results show that for imitative new ventures a different conceptual framework is required to build models that have the same explanatory power than models that include innovative new ventures (Samuelsson & Davidsson, 2009).

We suggest that small firms typically are subject to negative serial correlation of annual growth rates (Daunfeldt & Halvarsson, 2015). Put differently, we theorize that recent growth is more likely to lead to negative growth, and conversely, that a recent negative growth raises the probability of a subsequent growth. The findings of our analyses based on longitudinal data obtained from the Start-Up Panel of the German state of North Rhine-Westphalia support our hypotheses.

Our study contributes to the literature in the following ways. First, our findings provide new insights concerning growth measures by focusing on tendencies of growth trajectories instead of average growth rates. Empirical analysis often prefers a method that measures trajectories in terms of average size or average growth rates for prolonged periods. However, this approach says little about the individual economic growth over time. Second, we add to the literature that shows that measures of growth are not interchangeable. Growth of sales and the growth of employment are not equivalent measures of the performance of new ventures and lead to different results (Chandler, McKelvie, & Davidsson, 2009). Third, our results support the findings of critics of stages of growth models. We show that recent growth is more likely to lead to negative growth, and conversely, that a recent negative growth raises the probability of a subsequent growth. Therefore, traditional growth models that assume a linear development over time cannot be validated by our data. Fourth, we add to the literature on drivers of the successful establishment of imitative, subsistence-oriented businesses. Similar to other new ventures, imitative, subsistence-oriented new ventures have negative serial correlation of growth. Thus, growth in period t can be a rather good predictor for growth in period t+1.

In the remainder of this paper, we present our theory, hypotheses, methodology, and results, followed by a discussion of the implications and limitations of our study.

EXISTING THEORIES OF GROWTH MODELS

Business growth theories can be classified into four groups (O'Farrell & Hitchens, 1988) and are summarized in Table 1: (1) industrial economics, (2) stochastic models, (3) management perspective and (4) stages of growth models. The group of industrial economics research is represented by Penrose (1959) who argues that unused productive services facilitate the introduction of new combinations of resources in a firm: ''The new combinations may be combinations of services for the production of new products, new processes for the production of old products, new organization of administrative functions'' (Penrose, 1959:85). This approach recognizes the importance of periods of stability because growth is seen as episodic and occurring in spurts (Derbyshire & Garnsey, 2014).

Second, stochastic models of business growth explain that the process of random growth leads to a skewed size distributions of companies, which means that few large and many small companies exist (Gibrat, 1931). However, the view that business growth is predominately random is criticized because if this were the case entrepreneurs would not be able to influence the outcomes of new ventures (Derbyshire & Garnsey, E., 2014). Thus, there would be little room for government policy stimulating business growth. Empirical evidence shows mixed results if Gibrat's law can be rejected or not. The industry context matters for whether Gibrat's law holds or not (Daunfeldt & Elert, 2013).

Third, the management perspective argues that the growth and development of businesses depend on the internal and external environment of entrepreneurs and how quickly they can adapt to these circumstances (Milne & Thompson, 1982).

Fourth, there are stages of growth models. These models distinguish different stages of venture growth (Tatikonda, Terjesen, Patel, & Parida, 2013), and the change from one phase to another depends mainly on time. Greiner (1972), Christensen and Scot (1964), Lippitt and Schmidt (1967) and Norman (1977) are foundational theoretical sources for the literature on stages of growth models (Levie & Lichtenstein, 2010). The core assumption of these stages of growth models is that 'Organizations grow as if they are developing organisms' (Tsoukas, 1991, p. 575). From this basic statement, three assumptions are made about the growth of ventures (Kimberly & Miles, 1980): First, distinctively different stages of development can be identified. Second, the sequence and order of development is predetermined and thus predictable. Third, all ventures develop according to prefigured rules. Taken together, there is a need for models of growth that reflect the non-linearity dynamic of development over time.

Table 1
Existing Theories of Growth Models (O'Farrell & Hitchens, 1988)

Theory of growth	Definition	Author name (year)
Industrial economics	Unused productive services facilitate the introduction of new combinations of resources in a firm.	Penrose (1959)
Stochastic models	The process of random growth leads to a skewed size distributions of companies, which means that few large and many small companies exist.	Gibrat (1931)
Management perspective	The growth and development of businesses depend on the internal and external environment of entrepreneurs and how quickly they can adapt to these circumstances.	Milne & Thompson (1982)
Stages of growth models	Three assumptions are made about the growth of ventures: First, distinctively different stages of development can be identified. Second, the sequence and order of development is predetermined and thus predictable. Third, all ventures develop according to prefigured rules.	Greiner (1972), Christensen & Scot (1964), Lippitt & Schmidt (1967), Norman (1977)

THEORY DEVELOPMENT AND HYPOTHESES

Non-linearity of growth of new ventures

Although stages of growth theories have different shortcomings, it could be empirically shown that businesses tend to operate in some definable state for some period of time (Levie & Lichtenstein, 2010) and then change. This change is sometimes gradual (Churchill & Lewis, 1983) and sometimes dramatic (Romanelli & Tushman, 1994). In their 'Terminal Assessment of Stages Theory' Levie and Lichtenstein (2010) develop a framework that pays attention to this empirical outcome but is not limited by the assumptions of stages of growth models. They suggest replacing assumptions of these models with principles from complexity science, such as complex adaptive systems (Anderson, Meyer, Eisenhardt, Carley, & Pettigrew, 1999; Holland, 1995; Lichtenstein, 2010; McKelvey, 2004) and the non-linear dynamics of economics and management (Chiles, Bluedorn, & Gupta, 2007; Meyer, Gaba, & Colwell, 2005). This so-called dynamic states approach is also influenced by Penrose (1959) who argue that new combinations of resources need to be introduced into the company, and by Milne and Thompson (1982) who define success of a new venture as its ability to adopt quickly to the internal and external environment of the entrepreneur. Businesses are not predetermined by an unchangeable genetic program, and there is no way to predict how many stages a company will go through during its lifecycle. The main assumption of the dynamic states approach is that each state represents an entrepreneur's attempt to most efficiently and effectively match internal resources with external ones.

The dynamic states approach focuses on the growth of new ventures without accepting assumptions of life cycle models (Furlan, Grandinetti, R., & Paggiaro, 2014), for example continuous or linear growth (Brännback, Carsrud, & Kiviluoto, 2014; Davidsson, Achtenhagen, & Naldi, 2010; Hamilton, 2011). Stages of growth models link the age and size of a firm to its stage of development. However, not all ventures grow and multiple potential stages for ventures of all ages and sizes exist (Wales, Monson, & McKelvie, 2011). Storm (2011), as one of the few scholars to do so, empirically operationalizes the dynamic states approach to establish a link between drivers of individual behavior and complexity theory. His results validate the use of complexity theory in entrepreneurship research. These alternatives to the stages of growth models show theoretically and empirically the non-linear dynamics of growth trajectories and are summarized in Table 2.

Autocorrelation of growth rates of new ventures

The growth of new ventures is considered to depend on past events (Barney & Zajac, 1994; Dierckx & Cool, 1989). Heterogeneity of findings regarding the serial correlation of growth rates can be found in the literature. Positive autocorrelation has been found in studies for UK quoted firms (Chesher, 1979; Geroski, Machin, & Walters, 1997), for manufacturing firms in Germany (Wagner, 1992), for Austrian farms (Weiss, 1998) or for US manufacturing firms (Bottazzi & Secchi, 2003). Negative serial correlation has been shown for German firms (Boeri & Cramer, 1992), for quoted Japanese firms (Goddard, Wilson, & Blandon, 2002) for Italian and French manufacturing firms (Bottazzi, Cefis, Dosi, & Secchi; 2009).

Other studies failed to find any significant autocorrelation in growth rates, e.g. for selected Italian manufacturing sectors (Bottazzi, Cefis, & Dosi, 2002) or for the US automobile industry (Geroski & Mazzucato, 2002). Therefore, it seems that overall there is no clear pattern emerging regarding the autocorrelation of firm growth rates. However, this changed with the findings of Coad (2007) and Coad and Hölzl (2009). They show that small firms typically are subject to negative serial correlation of annual growth rates (Daunfeldt & Halvarsson, 2015), whereas larger firms exhibit positive serial correlation. Consequently, the inconclusive results of the research on serial correlation of growth rates can be explained that previous studies have used databases that include both small and large companies. In addition, serial correlation is strongly negative for small firms that have just experienced a large growth event in the recent past (Coad, 2013).

Table 2
Alternative Theories of Growth Models

Theory of growth	Definition	Author name (year)
Dynamic states approach	The main assumption is that each state represents an entrepreneur's attempt to most efficiently and effectively match internal resources with external ones. Growth is defined as a convergence to a resource stock that fits to market optimally.	Levie & Lichtenstein (2012)
Trigger points	Bursts of rapid growth of new ventures often occur after important events, so called trigger points. They have the potential to turn moderately performing businesses into high-performing ones.	Brown & Mawson (2013)
Complexity science	Agent models explain order creation, i.e. non-linear outcomes resulting from (1) rapid phase transitions caused by adaptive tensions and (2) coevolutionary processes.	McKelvey (2004), Derbyshire & Garnsey (2014), Dooley & Van de Ven (1999)

In line with this empirical finding, we hypothesize that employment growth proceeds in batches, where expansion follows contraction, and contraction follows expansion. A positive incremental, point-to-point growth is rather followed by zero or negative growth and a negative or zero incremental growth is rather followed by positive growth.

Employment growth in new ventures proceeds in batches because of indivisibilities, uncertainty and adjustment costs. In contrast, fine-grained adjustment to actual capacity needs are made for instance by temporal work overtime of given staff, contract workers, outsourcing to freelance staff, etc. Indivisibilities of employment result from individual employment contracts. In Germany, these contracts need to be scaled or portioned in a given frame of regulatory boundaries, set by law. Moreover, some responsibilities are subject to inseparability. Staff-related measures require regularity of capacity needs and a well predictable increase in demand. Because termination options are limited, careful restraint caused by uncertainty guides implementation of an additional unit. Therefore, new ventures need to align additional capacity and increase in demand step-by-step. Staff recruitment and termination cause cost of information and search, cost of reorganization, cost of contract design, etc. (Hall, 2004; Hamermesh & Pfann 1996, Cooper & Haltiwanger 2003).

Therefore, oscillating fluctuations in growth of new ventures can be expected, independent from the assumption that long term growth is subject to certain stages, consistent trajectories or development trends. That means incremental growth of new ventures is lumpy and batch-like. After an initial growth spurt, there is little expectation of an immediate subsequent further growth but rather remaining the level yielded, or even a decrease. This applies in reverse as well: After decrease or stagnation growth can be expected to follow.

Concerning sales, although being an output measure, contrarily to employment as an input measure of new ventures, there is a corresponding argumentation not only because of the interrelation of sales and workforce. Change of sales structures calls for adjustment costs, such as personnel training in or recruitment for new distribution channels, new customers or change in the service range. Moreover, sales processes are subject to indivisibilities caused by product range or sales personnel because sales directly depend on the value chain, which in turn is subject to indivisibilities given by production and procurement. Therefore, sales of new ventures are not supposed to change continuously but in incremental batches as well as employment.

Following these argumentation line and in line with the findings that growth rate autocorrelation varies with firm size we propose the following hypotheses 1 and 2.

> ***Hypothesis 1****: After a period of positive growth, a given small venture is more likely to enter a period of negative growth in a subsequent period.*

> ***Hypothesis 2****: After a period of negative growth, a given small venture is more likely to enter a period of positive growth in a subsequent period.*

Derbyshire and Garnsey (2014) consider stable periods in the growth trajectories of new ventures. They show that the typical state for a firm is neither growth nor decline but stability. 99.5% of all UK firms included in their dataset have at least one period of stability over the period under analysis. Penrose (1959) explains stable periods with adjustment costs. These costs of growth consist of the time and effort required to adapt managers and operations to the expansion of activities of a given venture. The development of managerial resources takes time, which influences the growth of new ventures (Lockett, Wiklund, Davidsson, & Girma, 2011). To address the importance of stable periods in the growth process of new ventures we propose the following hypothesis

> ***Hypothesis 3****: A given small venture experiencing zero growth is more likely to experience more zero growth than either negative or positive growth in a subsequent period.*

Towards a new measure of growth

Employment and sales are the most commonly used indicators to measure average business growth (Delmar, 2006; Gilbert, McDougall, & Audretsch, 2006). In our study, we compare the growth of sales to employment. Employment data offers standardized, comparable data on the rate and direction in which new ventures have been expanding (Garnsey, Stam, Heffernan, & Hugo, 2006). In contrast, sales are influenced by price effects, productivity effects, exchange rate effects, and taxes (Brenner & Schimke, 2014). For further discussion of the advantages and disadvantages of each indicator we refer to Coad (2009). So far, growth measures have been used interchangeably, although correlations between the indicators growth of sales and growth of employment are relatively small. Delmar, Davidsson, & Gartner (2003) find a very weak correlation of .09 between absolute growth of sales and employment, and Weinzimmer, Nystrom, & Freeman (1998) show a correlation of .57 between the relative growth of sales and employment. Thus, the growth of sales and the growth of employment are not equivalent measures of the performance of new ventures (Chandler, McKelvie, & Davidsson, 2009; Coad & Guenther, 2014).

Empirical analysis often prefers a method that measures trajectories in terms of average size or average growth rates for prolonged periods. However, we define the growth of new ventures as the comparison of date-related tendencies of growth indicators between two consecutive periods. Our understanding of constant growth is that the total number of employees or the total amount of sales did not change from one year to the other. We will explain this approach in more detail in the following chapters. Measuring growth in terms of average size says little about the individual economic growth over time. First, static comparisons cannot explain whether a particular development was achieved with constant, decreasing, or increasing growth rates. Different growth trajectories can lead to the same average trajectory. Second, assuming that a cohort includes both fast-growing ventures and ventures that are close to market exit due to stagnation (Garnsey, Stam, Heffernan, & Hugo, 2006) one could argue, the average growth rate masks tremendous differences between these two groups. We argue that the average trajectory cannot be used especially when it comes to the early-development of new ventures. Therefore, we will provide a conceptual framework to overcome these shortcomings.

Cross-sectional data

'Little evidence is available on the growth paths of firms over time' (Garnsey, Stam, Heffernan, & Hugo, 2006, p. 9). Cross-sectional designs may be able to identify some of the variables of growth trajectories of new ventures. A meta-analysis of studies of firm growth published between 1992 and 2006 shows that 'rarely did a study use two or more time spans for calculating growth' (Shepherd & Wiklund 2009, p. 108). After 2006, only few longitudinal studies on dynamics of new ventures in general (Federico & Capelleras, 2015; Lejárraga & Oberhofer, 2015; Triguero, Córcoles, & Cuerva, 2014) and particular on growth trajectories (Anyadike-Danes, 2015) were published. This shows that the literature on growth trajectories of new ventures is quite sparse (Brenner & Schimke, 2014). However, more robust empirical studies to develop theories for entrepreneurial growth (Blackburn, Hart, & Wainwright, 2013) or to explain how internal and external factors contribute to sustainable growth in SMEs are necessary (Gupta, Guha, & Krishnaswami, 2013). We argue that a longitudinal research design is crucial to trace growth trajectories of new ventures.

RESEARCH AND METHODOLOGY

Data

One limitation of the existing literature about new ventures is that much of it focuses on the manufacturing sector (Neumark, Wall, & Zhang, 2011). We use data from the Start-Up Panel of the German state of North Rhine-Westphalia (NRW) which annually monitors young enterprises in the skilled crafts sector. We define a new venture as an economic enterprise that is eight years or younger

(Fackler, Schnabel, & Wagner, 2013; Jennings, Jennings, & Greenwood, 2009; Miller & Camp, 1985; Pellegrino, Piva, & Vivarelli, 2012; Short, McKelvie, Ketchen, & Chandler, 2009).

We only use data from the skilled crafts sector, which is typical of many entrepreneurial activities in Germany in terms of size, business model, or legal type (Lambertz & Schulte, 2013). Furthermore, this sub-sample adheres to Davidsson and Gordon's (2012, p. 19) call for 'better theorizing and modeling of the drivers of the successful establishment of imitative, subsistence-oriented businesses.' Hence, we focus on 'ordinary entrepreneurs' that do not have neither innovative nor technology-based business concepts (Lambertz & Schulte, 2013).

Table 3 provides response rates ranging from 39.5 to 52.7 percent, which correspond to rates which allow valid and reliable results (Baruch, 1999). In addition to start-ups, the panel covers successions as well as active participations. The data set is not biased by part-time businesses because it contains data solely on full time entrepreneurship (Lambertz & Schulte, 2013). In general, part-time businesses cannot be compared with full-time ventures because they are often created only for auxiliary income. Thus, single-person enterprises, which have become a very important part of contemporary's economies (Kessler, 2009), are only covered as far as they are run as a full-time business.

Table 3
Response Rates

Panel wave	Survey period	Number of questionnaires distributed	Number of responses	Response rate
5	Summer 2004	6,881	3,627	0.527
6	Summer 2005	8,153	3,978	0.488
7	Summer 2006	9,149	3,610	0.395
8	Summer 2007	9,751	4,014	0.412
9	Summer 2008	7,265	3,231	0.445
10	Summer 2009	7,322	3,316	0.453
11	Summer 2010	7,880	3,272	0.415
12	Summer 2011	8,443	3,447	0.408
13	Summer 2012	8,805	3,653	0.415

The conceptual cornerstone of the Start-Up Panel NRW is a periodical survey based on standardized questionnaires that pave the way for the long-term monitoring of a large number of young entrepreneurs and their enterprises, which are either newly created or acquired. This survey has no survivorship bias: As all new ventures in our data set are required to report to a governmental authority (Landes-Gewerbeförderungsstelle), we can monitor and control for the survival of these new ventures within the first two years after foundation. Therefore, we can exclude survivorship bias for first this time span (Lambertz & Schulte, 2013). For a longer time period, literature shows that the mortality of new ventures in the craft sector is much lower than in other sectors (Paulini 1999, Albach & Hunsdiek, 1987).

The questionnaires of the annual panel wave always contain the same questions with regard to corporate development (sales volume, number of employees, investment volume, expected corporate earnings, corporate profits, utilization, and achievement of profit goals) as well as questions focusing on specific topics that differ from panel wave to panel wave (counseling, entrepreneurial marketing, motivation, etc.) (Lambertz & Schulte, 2013).

Our study is based on data that includes nine waves of the Start-Up Panel NRW, and begins with Wave 5. The first four waves are excluded because the survey period changed from six months to one year. The survey is conducted once a year in summer, and if the business is established in spring of the same year, it still does not have one complete year in business. For this reason, the time span between the establishment of the new venture and the first survey is defined as Year 0. This time span, therefore, is shorter than twelve months. Year 1, therefore, marks the first full year of business activities within the panel waves. We assume that the total number of employees of a given new venture in Year 0 equals the total number of employees at the foundation of a given venture. Because this study investigates up to eight years of a given new venture, it covers Year 0 and eight years, which are numbered 1 to 8 and are equal to an entire year of business activity following Year 0. For example, 1 refers to the age of a given new venture, e.g. this new venture is at least one year (min.) and up to one year and eleven months (max.) old. It is important to mention that we distinguish between periods and point in time. In general, we relate absolute numbers of employment or sales from one date to absolute numbers in the preceding date. For Period 0, we relate the total number of employees or the total amount of sales of Year 0 to Year 1. This allows us to define state changes, e.g. if the total number of employees or the total amount of sales increases, decreases or grows constantly in a given Period. We will explain the concept of state changes in more detail below.

We merge the data into one set of pooled cross-sectional data. Utilizing pooled data, we reduce potential biasing effects of different economic business cycles, cohorts, and outliers. As it is important to distinguish growth through acquisition (Burghardt & Helm, 2015; Gilbert, McDougall, & Audretsch, 2006; Lockett, Wiklund, Davidsson, & Girma, 2011) from organic growth (Delmar, Davidsson, & Gartner, 2003), we do not analyze acquisition or active participation. Our dataset contains information on 4,880 newly established ventures between 2003 and 2012 (Table 4). 78 percent are sole proprietorships, and 79 percent are owned by men. The dataset contains information about the sector for 3,977 new ventures. Out of these 3,977, 1,465 (37 percent) new ventures work in the building and interior finishing trades, 1,178 (30 percent) in the electrical and metalworking trades, 953 (24 percent) in the health and body care trades as well as the chemical and cleaning sector, 250 (6 percent) in the woodcrafts and plastic trades, and 55 (1 percent) in the food crafts and trades. There are 76 (1 percent) new ventures representing other trades. On average, the new ventures start up with 2.77 employees (including the entrepreneur). We compare these data with official data from the Register of Craftsmen (Müller, 2014) to analyze if our data set is representative for new ventures in the German craftsman sector. This analysis shows that the numbers are comparable, for example in 2009 the average size of German new ventures was 2.1 employees (including the entrepreneur), 85 percent of all new ventures were sole proprietorships, and 79 percent were male.

Data-related tendencies

Our literature review shows that the field of new venture growth is still fragmented. However, more and more researchers agree that the stages of growth models do not adequately describe the growth trajectories of new ventures. We enter the debate by focusing on the empirical analysis of growth trajectories, and not on an empirical test for a specific model. To do so, we analyze the growth of new ventures by focusing on what we call date-related tendencies. Based on the work on the development of new ventures in terms of development tendencies, we examine long-term developments divided into state changes between time points.

Table 4
Descriptives

Variable	**Mean**	**Standard deviation**
Number of employees (including entrepreneur, at foundation)	2,77	3.140
Gender: male	0.79	0.407
Form of organization		
Unlimited private company	0.08	0.270
Sole proprietorship	0.78	0.414
Limited liability company	0.14	0.348
Age (in years)		
Age of new venture (in 2012)	5,80	2.489
Age of entrepreneur (in 2012)	41,79	8.332
Sector		
Building and interior finishes trades	0.37	0.482
Electrical and metalworking trades	0.30	0.457
Woodcrafts and plastic trades	0.06	0.243
Clothing, textiles and leather crafts and trades	0.01	0.107
Food crafts and trades	0.01	0.117
Health & body care trades and chemical & cleaning	0.24	0.427
Others	0.01	0.087

This approach allows us to define state changes, e.g. date-related tendencies, and to identify the trajectory of a given venture's development. We exemplify this approach in Figure 1: V_i represents different new ventures with individually specific growth trajectories over time. In our example, we explain the approach of state changes by four different new ventures ($V_{1\ to\ 4}$). The transition from Year 1 to Year 2 is in this case for all $V_{1\ to\ 4}$ non-negative. During the transition from Year 4 to Year 5, half of $V_{1\ to\ 4}$ have a positive rate of change, while the other half has a negative or stable one. It is possible to consider individual temporal interdependencies of development and to discern patterns of growth. In line with Derbyshire and Garnsey (2014), we argue in favor of an empirical model that also considers stable periods in the growth trajectories of new ventures. We define the growth of new ventures as the comparison of date-related tendencies of growth indicators between two consecutive periods.

Residual analysis and mosaic plots

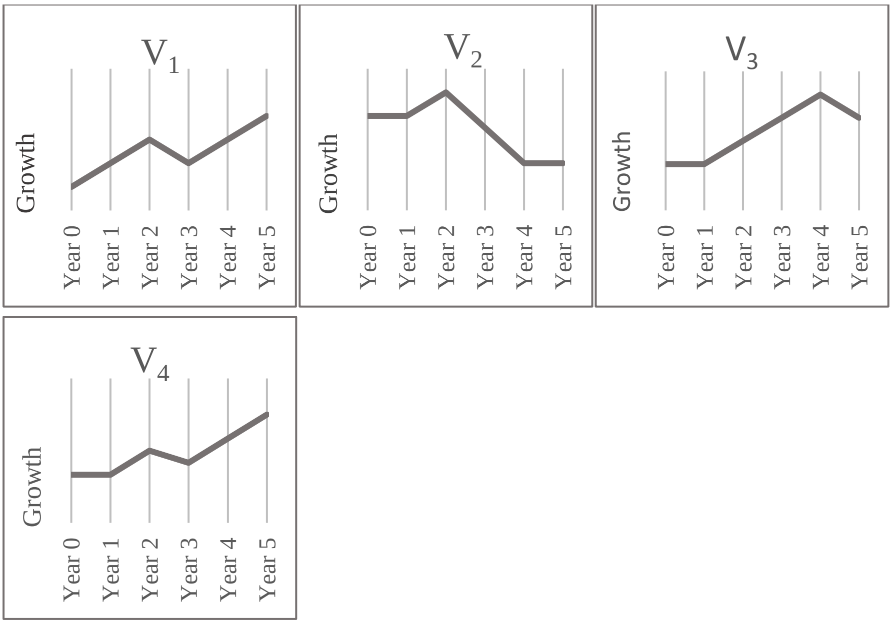
We apply a residual analysis to test our hypotheses. We identify categories relevant for a significant Chi-square statistic. This approach involves calculating the standardized residual for each cell of the contingency table of date-related tendencies and adjusting it for its variance (Haberman 1973):

$$d = \frac{\mathrm{e}}{\sqrt{(1-\frac{n(\mathrm{row})}{n(total)})(1-\frac{n(col)}{n(total)})}}$$

Where d is an adjusted residual and e a standardized residual corrected for expected cell size (Tredoux & Durrheim 2002 p. 375).

Figure 1.

Individual growth trajectories of four new ventures (V_1 to V_4)



The normal distribution is used to find the probability of the adjusted residual using a two-tailed test of significance. A significant adjusted residual indicates that the cell made a significant contribution to the Chi-square statistic (Agresti, 2013).

Under the null hypothesis that is the assumption that variables are independent, the adjusted residuals will have a standard normal distribution. An adjusted residual larger than 1.96 indicates that the number of cases in that cell is significantly larger than would be expected if the null hypothesis were true, with a significance level of .05. An adjusted residual less than -1.96 indicates that the number of cases in that cell is significantly smaller than would be expected if the null hypothesis were true (Agresti, 2013).

To illustrate the results of our residual analysis we use mosaic plots, which graphically show percentages of cross-classified categorical variables (Friendly, 2002; Hofmann, 2000). The areas of rectangular tiles are proportional to the percentages in the cells of the contingency table (Cox, 2008).

RESULTS

Descriptives of non-linear growth

Table 4 briefly describes the merged data of the 4,880 new ventures between 2003 and 2012. We use date-related tendencies regarding employment and sales to explain how these newly established ventures grow within the first eight periods. All results of the Chi-square test are significant throughout the bivariate analysis. In Period 8, more than twenty percent of the expected counts are less than five for both growth measures and, thus, the Chi-square test may be invalid (Wildemuth, 2009). Therefore, we focus on date-related tendencies for periods 0 to 7.

The numbers given on the horizontal axis at the very bottom of Figures 2 to 4 refer to the periods explained above. ‘0 and 1’ means that we compare the date-related tendencies in Period 0 with the ones in Period 1. Thus, the columns of Figures 2 to 4 show growth trajectories considering the conditionality of date-related tendencies of preceding periods. In Figure 2, the 33 per cent of Periods ‘0 and 1’ of the left table about employment can be read as follows: 33 percent of all new ventures that increased their employment in Period 0 reversed their decision and decreased their total number of employees in Period 1.

From our analysis we derive the following results: First, the growth of new ventures is not as positive, as suggested by the stages of growth models. For both growth measures, the probability that a new venture continues to grow in a period following an earlier period of growth varies between 29 and 53 percent (Figure 2). Second, the growth of new ventures is uneven, and distinct stages cannot be identified as claimed by stages of growth models. Third, different measures of growth lead to different results. The tendency that sales or employment of new venture increases in period t+1 after it decreased in period t is, for the sales measure, between 3 and 14 percentage points higher than for the employment measure (Figure 3). The probability of a new venture to remain at the same size after a period of constant growth is between eleven and thirty percentage points higher for the employment measure than for the sales measure (Figure 4).

To highlight the differences in the measurement of growth of new ventures, we define increase-decrease-ratios (IDRs). Let IDR be the increase-decrease-ratio of a given part of the growth trajectory with:

IDR = date-related tendency of positive growth / date-related tendency of negative growth For the left table of Figure 2, we exemplify this ratio. We relate the 42 percent to the 33 percent to receive an IDR of 1.27.

After an increase in period t (Figure 2), at period t+1 four out of seven IDRs of employment are less than 1 indicating that the percentage of negative growth is larger than the percentage of growth in these periods (Figure 2, table on the left side). In contrast, for sales in period t+1 all periods, except the comparison between Period 3 and 4, show a IDR value larger than 1 indicating that the percentage of growth is larger than the percentage of negative growth (Figure 2, table on the right side). After zero growth in period t (Figure 4), in period t+1 IDRs of sales range from 1.34 to 3.24, which means that the percentage of increase is always larger than the percentage of decrease. Constant growth in period t is followed by a range of fluctuating sales figures throughout the periods (Figure 4, table on the right side). In period t+1, the IDRs of employment vary even more between 1.05 and 5.25 (Figure 4, table on the left side).

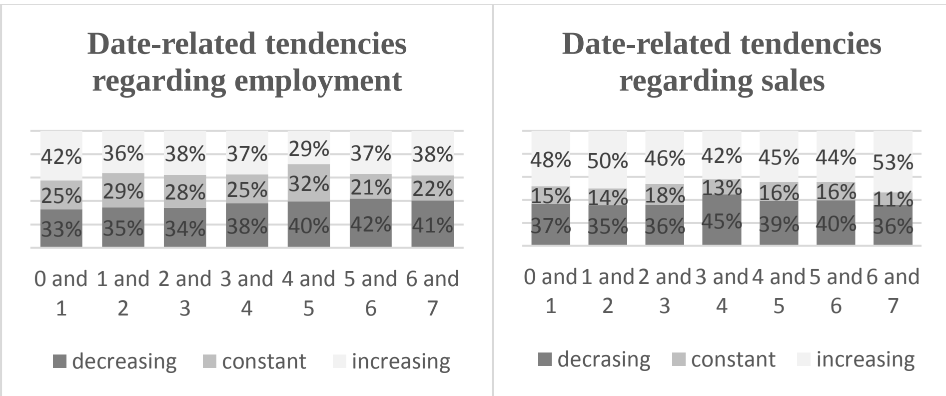


Figure 2. Date-related tendencies regarding employment (left figure) and sales (right figure) conditional on positive growth in period t.

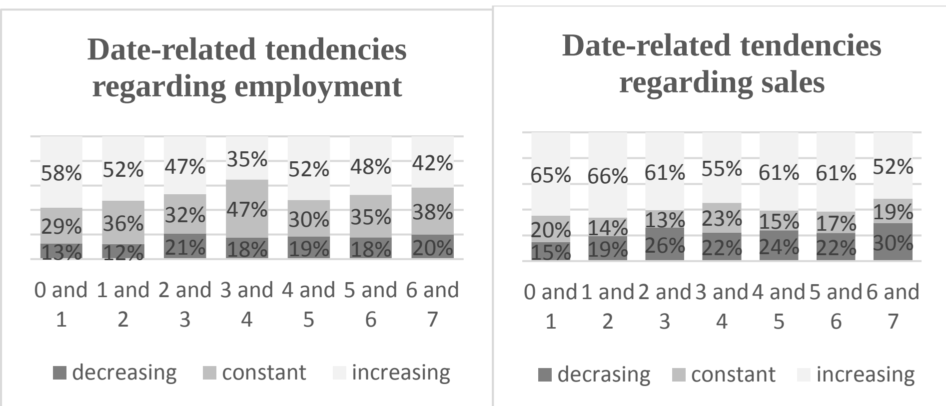


Figure 3. Date-related tendencies regarding employment and sales conditional on negative growth in period t.

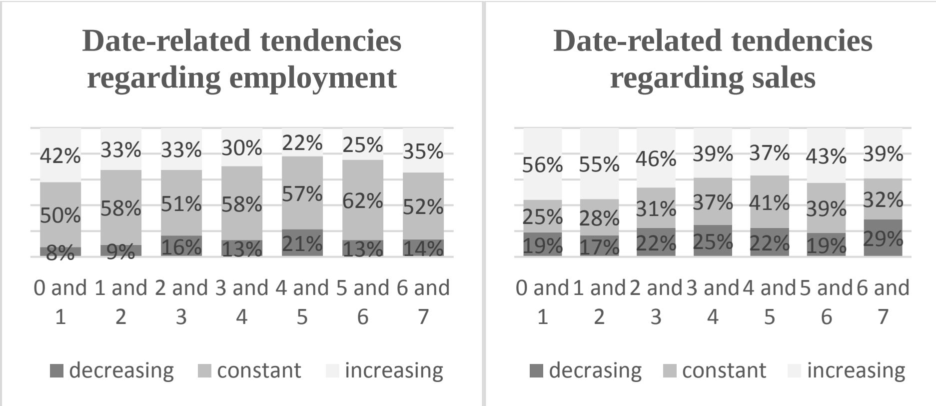


Figure 4. Date-related tendencies regarding employment and sales conditional on zero growth in period t.

Mosaic plots

As we introduce mosaic plots as a new approach to test hypotheses of growth trajectories, we exemplify how to read Mosaic plot 1 regarding employment (Figure 5, first table on the left side). The percentages on the horizontal axis refer to the percentages of new ventures that decreased, increased, or hold their number of employees constant in Period 0. Similarly, the numbers on the left side (0, 25, 50, etc.) refer to the percentage of new ventures and its change in employment in Period 1. As date-related tendencies in Period 1 are conditional on date related-tendencies in Period 0, the results can be read as follows: Out of all new ventures that decreased their number of employees in Period 0, 12.9 percent continue to decline their total number of employees in Period 1.

The number in parenthesis and the colors refer to the residual analysis. White refers to adjusted residuals larger than 1.96, grey to the ones between -1.96 and 1.96, and black to adjusted residuals smaller than -1.96. In our example, the adjusted residuals have a value of -1.2 and the cell is, therefore, grey. This means that the number of cases in this cell is not significantly larger or smaller than expected and, thus, this result does not provide evidence for our hypotheses.

As illustrated in Figure 5, mosaic plots show evidence for Hypothesis 1. The value of adjusted residuals shows that observations for growth of employment in period t and decline in period t+1 are, as shown in the bottom right corner of the mosaic plots in Figure 5, overrepresented within the entire period under observation. In addition, all periods which see an increase in period t and constant development in period t+1 are underrepresented. We find a similar result for growth of sales.

As shown in Figure 5, mosaic plots show partly evidence for Hypothesis 2. The value of adjusted residuals shows that observations for decline of employment in period t and increase in period t+1 are, as shown in the upper left corner of the mosaic plots in Figure 5, overrepresented for mosaic plots 2, 3, 5, and 6. For mosaic plots 1, 4 and 7 we do not find evidence that the number of cases in that cell is significantly larger than would be expected. For growth of sales we find statistical evidence for our hypothesis for mosaic plots 2, 3, and 5.

As presented in Figure 5, mosaic plots provide evidence for Hypothesis 3. The value of adjusted residuals shows that observations for constant growth of employment in period t and constant growth in period t+1 are, as shown in the rectangle in the middle of the mosaic plots in Figure 5, overrepresented within the entire period under observation. Except mosaic plot 1, we find a similar result for growth of sales.

Multivariate analyses

We run a pooled OLS regression to support our findings of the residual analysis and show which variables influence the growth of new ventures. To facilitate comparability with other studies related to growth of new ventures (Bottazzi, Coad, Jacoby, & Secchi, Coad 2009; Federico & Capelleras 2015), our measure of growth rates is calculated by taking the differences of the logarithms of size, exemplified on employment:

$$GROWTH_{it}=\log(SIZE_{i,t})-\log(SIZE_{i,t-1})$$

where $SIZE_{it}$ is measured by employment for firm i at time t.

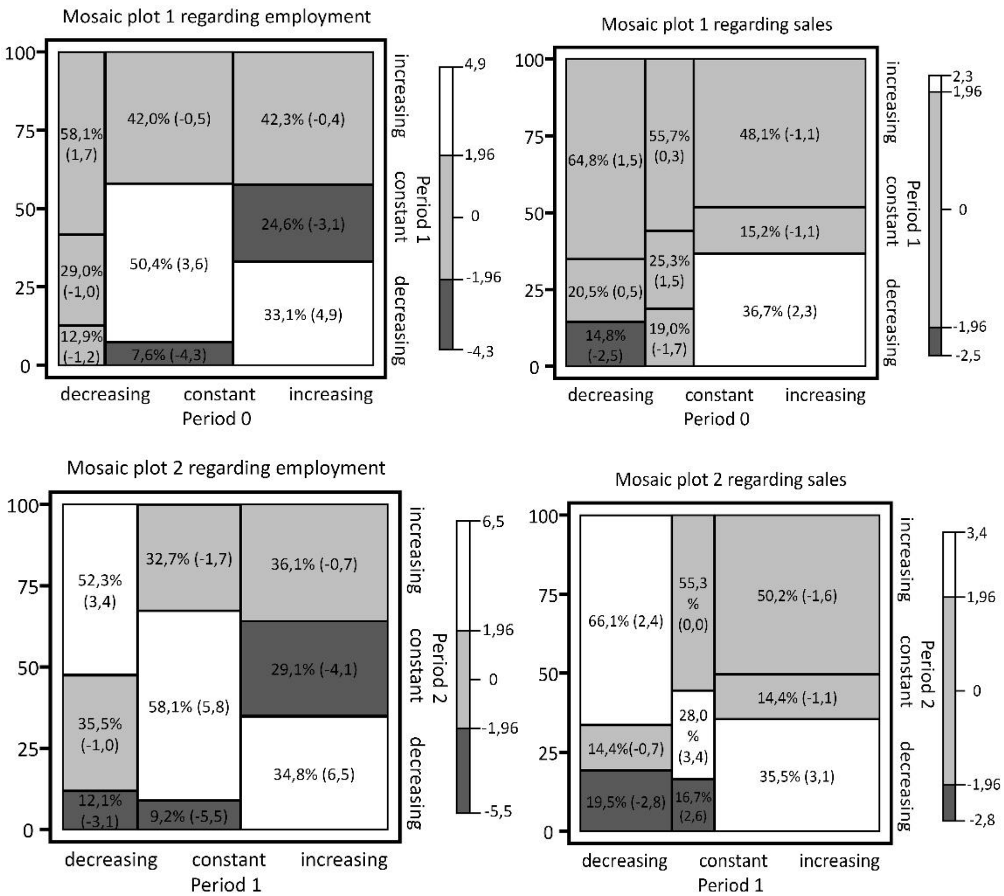


Figure 5. Mosaic plots regarding growth of employment and sales (please refer to p. 50 left side for the explanation of the colors).

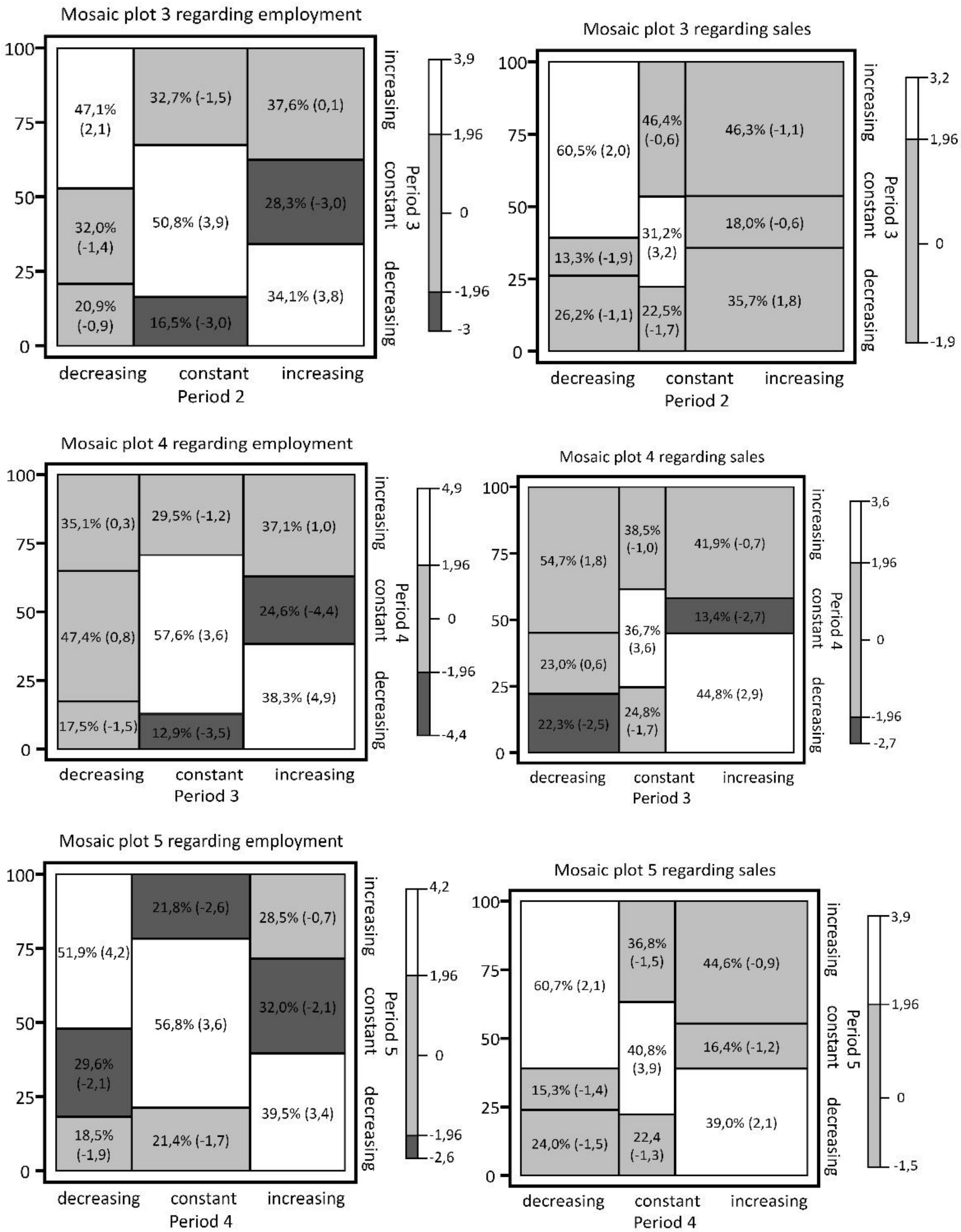


Figure 5 continued

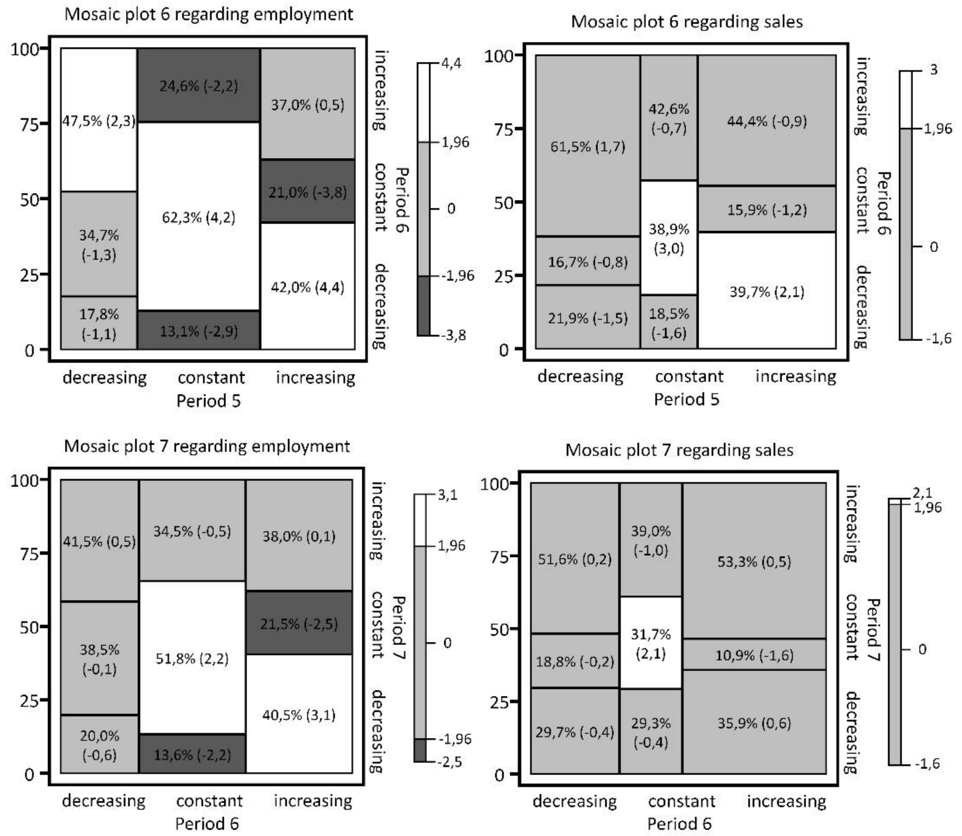


Figure 5 continued

In order to analyse the autocorrelation between growth of new ventures, we estimate the following equation with Cluster-robust Huber/White standard errors (Rogers 1993; Williams 2000). It allows controlling for intraclass correlation between the new ventures in the data set:

$$(\log(empl_{i,t})-\log(empl_{i,t-1})) = \alpha_0+\alpha_1 1Lagloggrowthempl + \alpha_2 2Lagloggrowthempl + \alpha_3 Legalform + \alpha_4 Age + \alpha_5 Sex + \alpha_6 Performance + \alpha_{7\text{-}8} IndustryDummy + \varepsilon$$

This equation represents our GROWTH model, where current growth is estimated using a set of lagged values of growth of employment to test for the autocorrelation of growth rates. Table 5 shows that the serial correlation of the growth of new ventures is consistently significant for t-1 and t-2. Adding further lags will also reduce critically the number of observations and may not imply an improvement in the explanatory power of the model. The approach of lagged variables is different to our analysis of the mosaic plots, where we compare t and t+1 instead of focusing on all past growth rates.

As control variables we add firm age, legal form of new ventures, sex and industry dummies. In addition, we add the total number of employees and profit achievement as independent variables. Firm age is observed to have a negative effect on growth, as a large number of studies have shown, for example Evans (1987a,b) for US manufacturing firms, Variyam and Kraybill (1992) for US manufacturing and services firms, Liu, J, M., Tsou, J., & Hammitt, K. (1999) for Taiwanese electronics plants, Geroski and Gugler (2004) for large European companies, and Yasuda (2005) for Japanese manufacturing firms. Harhoff, D., Stahl, K., & Woywode, M. (1998) examine the growth of West German firms and observe that firms with limited liability have significantly higher growth rates in comparison to other ventures. However, these firms also have significantly higher exit hazards. These results are in line with theoretical contributions that emphasize that the limited liability legal form provides incentives for managers to pursue projects that are characterized by both a relatively high expected return and a relatively high risk of failure (Stiglitz & Weiss, 1981).

Table 5

Correlation Between Growth of Employment (p-values in parentheses)

	log_emp	lag_log_empl	2lag_log_empl	3lag_log_empl	4lag_log_empl	5lag_log_empl	6lag_log_empl	7lag_log_empl
log_empl	1							
	-0.2806							
lag_log_empl	(0.0000)	1						
	-0.0620	-0.2775						
2lag_log_empl	(0.0000)	(0.0000)	1					
	-0.0049	-0.0502	-0.2814					
3lag_log_empl	(0.8016)	(0.0019)	(0.0000)	1				
	0.0041	-0.0090	-0.0546	-0.2801				
4lag_log_empl	(0.8654)	(0.6525)	(0.0012)	(0.0000)	1			
	0.0160	0.0070	-0.0205	-0.0630	-0.2785			
5lag_log_empl	(0.6080)	(0.7783)	(0.3346)	(0.0005)	(0.0000)	1		
	-0.0001	0.0210	0.0307	-0.0173	-0.0839	-0.3046		
6lag_log_empl	(0.9981)	(0.5160)	(0.2601)	(0.4615)	(0.0000)	(0.0000)	1	
	-0.0347	-0.0113	-0.044	0.0250	-0.0127	-0.1104	-0.3532	
7lag_log_empl	(0.5994)	(0.8017)	(0.9077)	(0.4421)	(0.6540)	(0.0000)	(0.0000)	1

Firms in mature industries are likely to have lower average growth rates because of the lower level of opportunity in mature industries. In contrast, firms in new sectors may have high growth rates due to the rapid pace of technological progress and the emergence of new products (Coad, 2009). To address these industry-related differences we add industry dummies to the equation.

Current total number of employment and performance of a new venture are supposed to be a major influence for incremental growth. A top performing business is much more able to add size than an underachieving one, because profit enables the new firm to fund additional staff. Therefore, the profit situation is a major prerequisite for incremental growth. For this reason, we add ‘profit situation’, proxied by profit achievement as an independent variable for performance into the regression.

Regression results are reported in Table 6. We observe a negative autocorrelation for the first lag and a smaller autocorrelation for the second lag. These results highlight some important features. First, the results of the pooled OLS regression support the results of the mosaic plots that firm growth rates are not random and non-linear. Second, in line with Coad and Hölzl 2009, Coad 2007, Fotopoulos and Giotopoulos 2010 and, Hölzl 2014, we show that small firms are subject to negative serial correlation of growth rates. For new ventures experiencing high dismissal of employees at time t, the negative coefficient implies that in the previous period t-1 these new ventures were probably experiencing positive above-average growth. Similarly, for those fastest-growing firms at time t, the negative coefficient indicates that these firms probably performed relatively poorly in the previous period t-1.

An explanation for the negative autocorrelation could be that new ventures hire more than the required number of employees with the expectation of keeping only top performers. This may lead to a mechanical effect of negative autocorrelation. We analyze micro and small new ventures, thus these types of firms do not have the necessary resources to apply such a forward-looking strategy.

Table 6

OLS Regression Results for Growth of Employment with Industry Dummies, Taking 2 Lags (Standard Errors in Parentheses)

	log_empl
	-0.3079***
lag_log_empl	(0.0040)
	-0.1211***
2lag_log_empl	(0.0358)
	-0.0281
legal_form	(0.0396)
	0.0195***
firm_age	(0.0061)
	0.0267
Manufacturing	(0.0177)
	-0.0187
Services	(0.0152)
	0.0132
Sex	(0.0379)
	0.0166**
Total employment	(0.0077)
	0.0306***
Profit achievement	0.0107
Constant	-39.12
R-squared	0.15
Obs	1583

*p ≤0.1, **p ≤0.05, ***p ≤0.01

The significance and the positive sign of the founding year mean that the younger the firm the higher the growth rate of employment. This negative dependence of growth rate on age appears to be a robust feature of industrial dynamics in our data set. Sole proprietorships have the expected negative sign but the results are not significant. In addition, total number of employment and profit achievement are positive and significant.

DISCUSSION AND CONCLUSION

Our study of German new venture development over time highlights the importance of longitudinal data to trace the growth of new ventures. Growth is non-linear, prone to interruptions, amplifying forces, and setbacks (Garnsey, Stam, Heffernan, & Hugo, 2006). Therefore, our results support Penrose's (1959) view that growth is episodic and occurs in spurts. However, the literature so far seldom focuses on non-linear phenomena. Instead, the growth of new ventures is modeled as if it were linear. Dynamic processes, such as resource problems or shifts in terms of opportunities, result in variations in the timing, magnitude, duration, and rate of change of growth (Derbyshire & Garnsey, 2014). Our article supports scholars such as Levie and Lichtenstein (2010), Brown and Mawson (2013) or Davidsson, Steffens, & Fitzsimmons, (2009) who have challenged traditional stages of growth models. In line with scholars who introduce complexity science to the literature on growth of new ventures (Derbyshire & Garnsey, 2014; Dooley & Van de Ven, 1999; McKelvey, 2004), we argue for theoretical models that capture complex and non-linear dynamics of growth (Steffens, Davidsson, & Fitzsimmons, 2009). Future research on new venture growth should focus on a more flexible approach, such as the dynamic states approach, to understand the dynamics of hyper-growth companies (Cassia & Minola, 2012). This study also seeks to complement the existing literature on growth rate autocorrelation by focusing on the dynamics of new ventures. After a period of growth, more than 29 percent of the new ventures investigated here seem to enter a phase of consolidation because they may not want to grow further or even decide to reverse their decisions. These results are in line with Penrose's focus on the adjustment costs of further growth. Consecutive periods of constancy or negative growth can be explained by the need of a new venture for consolidation. Indivisibility, potential sunk costs, and size adjustment costs prevent firms from growth at certain stages of development (Lockett, Wiklund, Davidsson, & Girma, 2011). Even growing firms devote more than 65 percent of their time to consolidation (Hamilton, 2011).

In contrast to Coad, Frankish, Roberts, & Storey, (2013), who do not consider stable periods, our results show that stable periods exist and, therefore, need to be considered. This is indicates that periods of growth are not necessarily followed by periods of growth, as suggested by the findings by Garnsey, Stam, Heffernan, and Hugo (2006) for the UK, Netherlands, and Germany. We agree with Garnsey, Stam, Heffernan, and Hugo (2006), however, that an important determinant of year-to-year growth seems to be the growth in the preceding year.

Data and findings add a new and different view to the assumption of a staged development of new ventures. When creating new combinations of resources and adapting to their environment, new ventures do not generally contradict staged development presumptions. But stages, if existent, are not constant or steady. Development is not continuously incrementing but intermitted, lumpy and not always in line with a steady state stages assumption. Moreover, findings question the determination and inevitability of stage sequences in a typical new venture setting.

Consistent with other work on growth measures (Delmar, 2006; Shepherd &

Wiklund, 2009), we argue that it is important that scholars clearly explain why they use a certain growth measure because results depend on this decision. Standard cross sectional measures and average growth rates fail to describe important dimensions of the course of growth of firms (Garnsey, Stam, Heffernan, & Hugo, 2006).

Our findings have the five following implications: First, it makes sense to study growth trajectories in a non-linear way and not constrained by the concept of stages, highlighting point-to-point changes to identify development patterns. We introduce mosaic plots as a new approach to visualize growth tendencies and evidence for our hypotheses.

Second, our data shows that recent positive growth is more likely to lead to negative growth, and conversely, that a recent negative growth raises the probability of a subsequent positive growth. Therefore, traditional growth models cannot be validated by our data. To put it differently, the commonly used term 'stage model' has to be interpreted in a different manner. Stage would not be defined as a time span, but rather as a sort of conditions of circumstances that are all present at a point in time and that are conditionally linked to a preceding sort of circumstances. In this sense, our understanding of stages reveals the opportunity tension between stability and change identified by Levie and Lichtenstein (2010).

Third, growth in period t can be a rather good predictor for growth in period t+1. This suggests that variables for growth need to be included as lagged variables in models predicting growth. Our suggestion implies further research on growth determinants. While the vast majority of previous findings have relied on cross-sectional designs, our longitudinal design leads to more nuanced results. It also shows that large-scale longitudinal data is crucial for future research because it can generate more reliable results.

Fourth, the different findings concerning sales and employment growth call for some reflections on their distinctions. Business founders have an effect on the growth of their firms due to their intentional behavior, but do not affect employment and sales in the same manner. While growth in terms of employment is directly affected by the intentional behavior (Bingham, Eisenhardt, & Furr, 2007), growth in terms of sales depends on market demand. As Delmar and Wiklund (2008) point out, the latter reflects market-driven output gains while the former is related to adjustments of the resources available for a firm (Penrose, 1959).

Fifth, a more practical implication of this paper's findings is that the management of new ventures and consultants need to consider growth trajectories in terms of the extent and timing. Because growth is subject to indivisibility, potential sunk costs, and size adjustment costs, options of continuous, incremental growth are limited, and this situation may lead to dramatic changes. This challenge, in turn, may lead to a loss of crucial resources. In light of these potential dangers, new ventures have to respond to internal and external changes in a measured manner. New venture management and consultants can help entrepreneurs to achieve this difficult balancing act.

This article has some limitations. We do not have data on growth intensions, and, therefore, we cannot distinguish between ventures that cannot grow, do not have to grow, or do not want to grow (Autio & Acs, 2010). We analyze new ventures predominately in the skilled crafts sector. These new ventures cover different occupations and sectors but a precise breakdown into certain sectors (for example as defined by NACE code) is not possible.

A more panel-specific limitation results from decreasing case numbers with longer periods. As shown above, the case number of ventures analyzable decreases with venture age. Therefore, the period of observation is limited to the first eight years of early development. Because consolidation periods of new ventures go up to five years on average (Lambertz & Schulte 2013), this is supposed to be an adequate period of time. However, as panel mortality can lead to successor bias, meaning that more successful ventures are more likely to report their development, later period estimations might be overestimated because of underperforming non-respondents. However, this issue seems to be negligible as respondents do not report growth but current size. Another problem in this respect can be survivorship bias because only ventures still in business can be surveyed. However, the data set allows controlling for exits for at least the first two years of business activity of each firm because of respective notations in the central state government data base. Afterwards, exit rate of these full-time businesses is demonstrably lower than average. The results of the mosaic plots focus on the sign of the autocorrelation.

Future research could shed light on attractive alternatives to organic growth of new ventures. One of these alternatives to discuss may be acquisitions because it may enable a firm to take advantage of growth opportunities by accessing resources that are complementary in nature to the resources that the new venture already controls (Lockett, Wiklund, Davidsson, & Girma, 2011). Further empirical research on the value creation process could also provide new insights into the heterogeneous growth trajectories of new ventures and the validation of Levie and Lichtenstein's (2010) dynamic states approach.

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