

## **New Venture Investing Trajectories - A Large Scale Longitudinal Study**

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**New Venture Investing Trajectories - A Large Scale  
Longitudinal Study**

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# ***New Venture Investing Trajectories - A Large Scale Longitudinal Study***

*Reinhard Schulte*

## **Abstract**

*Investment trajectories of new enterprises are a largely neglected but important issue of new firms' business behavior. This paper debuts in showing robust evidence of new venture investment time patterns by using investment time series of 4.733 new businesses. Based on a fixed effects nonlinear panel regression approach, the study models the trajectory of new venture asset acquisition in the first years after market entry. The results unveil durations and levels of investment patterns. Showing a first investment peak at market entry and a second peak years later, an initial new venture investment cycle is bimodal. Its peak-to-peak duration yields approximately nine years on average. New venture investment can be staggered into three stages, namely an initial, a plateau, and a replacement and expansion stage.*

**Keywords:** new ventures, start-up, investment pattern, investment trajectory, fixed effects model, panel data

**JEL classification:** D92, G31, L25, M13, M21

## INTRODUCTION

While investing *in* new firms always has been a key issue in research on new businesses, the investing *of* new firms into tangible assets has not drawn much attention. Hordes of scientists put funding topics such as motives, risk perceptions and investment behavior of investors under the microscope and examine major financiers like venture capitalists or banks for their role in new business formation and performance and their investment behavior regarding new and small firms (for example, see Pollinger et al. 2007; Robinson and Cottrell 2007 or Berger and Frame 2007 for the latter issue).

This paper is different because it intends to unveil the investment behavior *of* new firms when acquiring tangible assets. It explores the use of available funds independently from the sources and structure of funding. Hence, this approach is straightforwardly geared at the recipient side of new venture funding.

The content is original because time series analyses of new venture investments in tangible assets have never been conducted before. This is especially true as this study utilizes a large sample of new enterprises with full-time self-employed business founders, based on a novel and rich time series dataset about western German private firms. This complements the literature, which typically had to be content with cross-sectional data.

The topic is important because the initial investment of a new venture is a precondition for its further development and hence has strategic relevance. Initial investing establishes operational readiness and serves to generate or enhance value. Doing business is not possible without initial investments in most cases. In addition, early development and subsequent establishing of the venture calls for additional investing. Long-term usage and irreversibility of implementation emphasize the strategic importance of new venture investments (NVI), which is especially true for producer goods (Bertola and Caballero 1994; Gelos and Isgut 2001; Nilsen and Schiantarelli 2003). Industry dissimilarities are quite evident within this framework and generate a broad spectrum of NVI levels, ranging from employee capacity-based service enterprises with very few investment needs to manufacturing companies, which need a lot more hardware to get ready for business operations. Therefore, it might be reasonably assumed that initial and early investing is of extreme importance for growth and development of a new venture.

A highly relevant issue in this context is capital stock, which NVI sets out to adjust (Cooper and Haltiwanger 2006). Every investment changes capital stock, so that the investing of different periods is exposed to temporal interdependencies. This is why it is not appropriate to analyze NVI only at a particular point in time but in the long term. Therefore, studying NVI imperatively requires time series data. The NVI theorem proposed by Schulte (2015) sets a theoretical background that is suitable for stating hypotheses to be examined using empirical evidence. The aim of this paper is therefore twofold: It serves to explore time patterns of NVI behavior empirically and to test NVI time series for the NVI theorem.

Timing, dynamics and extend of investment at the level of the firm has not always been a viable option for research. For long, empirical research on the topic has been impeded by the practical impossibility to access firm level investment data. This is especially true for new venture investment data.

Investment of new businesses can only be studied in an explicitly dynamic setting because of long term utilization of investment goods and its interdependence with aggregate capital stock.

By introducing the conceptual outline of the NVI and the NVI theorem based on the most relevant previous literature, we derive a testable framework for testing the NVI theorem. Advancing our argument, we then explore time series of newly founded businesses for investment trajectories by using a rich and novel dataset of German new enterprises. Utilizing a fixed effects nonlinear panel regression model, we then statistically test for evidence of the theorem. We will provide some empirical evidence suggesting that new venture real investments follow an s-shaped course over time. To emphasize the practical relevance of the phenomenon, different stages of NVI are derived from the data. Finally, we explore implications for future research, policy and new business counselling.

## LITERATURE REVIEW AND HYPOTHESES

Investment is supposed to be a major economic measure, accounting for macroeconomic output, income, and long-run economic growth. However, understanding actual investment behavior on a micro level is more than just difficult (Abel 1980; Abel and Blanchard 1986). It is a well-known fact that firm level investment, which is lumpy and intermittent, highly differs from aggregate investment, which is much more regular and highly serially correlated over time. These differences in investment dynamics have led to the assumption that aggregate investment is prone to convex adjustment costs, whereas firms face non-convex adjustment costs. Evidence from firm-level and aggregate-level investment data has confirmed these assumptions (Nilsen et al. 2009; Bachmann et al. 2013; Del Boca et al. 2008).

Research has already produced some substantial findings on plant level investments. Van Reenen and Bond (2005) delivered an overview of major investment issues like lumpiness, capital adjustment cost and convexities of capital adjustment, the role of irreversibilities, uncertainties, and demand shocks, as well as their linkages to employment. Besides, there is research linking investment to firm performance and to drivers of investment like financial constraints or financial terms. To place some structure on this vast literature and to sketch a systematic overview of research on investment, which is relevant on enterprise level at least to some extent, one has to point out roughly four streams of literature, which we will discuss briefly in the following. Figure 1 depicts this crude corresponding segmentation.

The *first stream* of literature is dedicated to features of investment, its optimality, capital adjustment and investment aggregation. It examines these features under different macro conditions and with special regard to irreversibility and uncertainty.

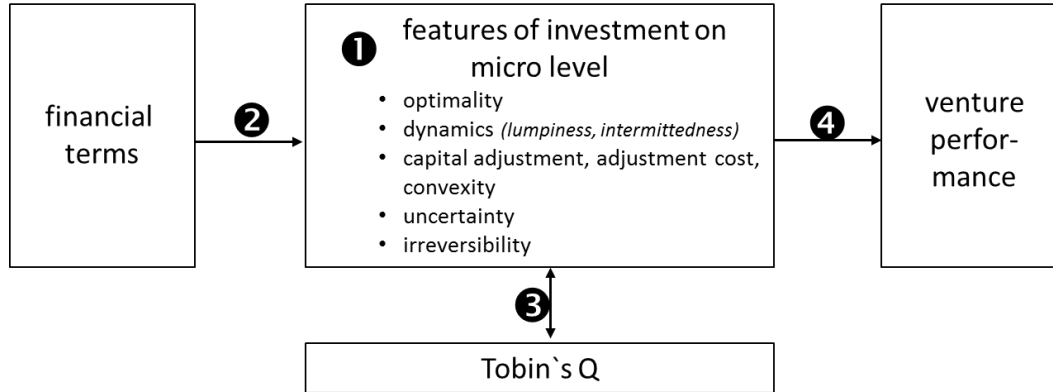
Inter alia, one dominant issue of this research stream is investment dynamics, indicating some important characteristics of investment. According to this thread and as already sketched above, firm level investments are lumpy and intermittent (Geylani 2015; Bachmann et al 2013; Nilsen et al 2009; Chaddad and Reuer 2009; Whited 2006; Sakellaris 2004; Thomas 2002). Another most often addressed issue characterizing firm level investment is capital adjustment, with regard to capital adjustment cost and convexities of investment (Wang and Wen 2012; Bayer 2006; Del Boca et al 2008; Caballero et al 1995). Accordingly, there is evidence for non-convex capital adjustment cost on firm level. Bontempi et al (2004) studied determinants of investment decisions on firm level with heterogeneous capital goods and found evidence for convexities with equipment, non-convexities with structures, meaning buildings where the production process takes place. A likewise major issue of this research stream is uncertainty (Kellogg 2014; Carruth et al 2000; Leahy and Whited 1996). It states conditions for optimal sequential investment under uncertainty (Bertola and Caballero 1994; Bloom 2009; Doms and Dunne 1998; Caballero 1991),

controlling for labor (Lee and Shin 2000; Nakamura 1999). Micro level investments are affected by uncertainty, which causes cautionary effects. Bloom et al (2007) found evidence for the assumption that the responsiveness of firms to policy stimuli are weaker in periods of high uncertainty. On industry level, Caballero and Pindyck (1996) found entry behavior of firms to be affected by uncertainty of investment and by features of industry equilibrium. According to Whited (1992), asymmetric information causes debt finance problems and impacts the firms investment behavior over time. Empirical evidence suggests that family firms' investments are significantly more sensitive to uncertainty than nonfamily firms (Bianco et al 2013). Finally, irreversibility tackles real investment of firms (Pindyck 1991, 1988). Most major investment expenditures are at least partly irreversible, as the firm cannot disinvest without heavy discounts, so the investment entails sunk costs. The irreversibility problem usually shows up because investment is firm specific or at least industry specific, so that capital goods supplied cannot be used by other firms or can sold only at a much smaller amount than invested. Moreover, disinvestment usually comes along with a considerable markdown of net value due to transaction costs and second hand devaluation. Unsurprisingly, firm level capacity is smaller (Pindyck 1988, 969) in view of investment irreversibilities. A general conclusion that can be drawn from this literature is that increasing uncertainty leads to lower investment rates on both industry and firm levels, and therefore an irreversibility effect can be presumed.

A *second thread* is dedicated to the impact of financial terms on investment. It analyzes the relevance of cash flows, sales, profit terms and financial constraints on investment in general (Yang et al 2015; Bond et al 2003; Bokpin and Onumah 2009), and gives evidence for the role of financial intermediaries in the investment process and suggests that investment on firm level is affected by information and incentive problems with banks (Whited 1992; Hoshi et al 1991).

The relationship between investment and Tobin's Q features a *third stream* in firm level investment behavior research (Abel and Eberly 2008: for a basic theory approach see Chung and Wright 1998). Jovanovic and Rousseau (2014) studied the impact of Tobin's Q on firm investment and found investment to respond to Tobin's Q, but in a much different manner, depending on firm incumbency: While established firms react negatively, new businesses respond positively to Q. This research is one of very rare papers dealing explicitly with new ventures in regard to investment timing. However, timing refers to the business cycle, which is an aggregate view and as such differs to early venture development intended to investigate here.

The *fourth strand* of research, the relation between investment and economic growth is well established in the macroeconomic theory, but has been tested on micro level as well, using firm performance and profitability as dependent measures (Grazzi et al 2013; Cooper and Haltiwanger 2006; Erickson and Whited 2000; Lang et al 1996). Deviating from the topics already referred to, investment is used as an independent variable in this thread of research. Given this research, there is evidence for impact of investment on firm growth.

**Figure 1** Extant foci of research on firm level real investment

As could be seen, none of these streams of literature research done so far is dedicated to new ventures explicitly in a manner that

- considers initial development on micro level
- and includes evidence from time series data of small and not publicly traded businesses, which represent the vast majority of start-ups in almost every major economy.

Remarkably, a considerable research stream on corporate investing is directed at the study of investment dynamics in specific industries (e.g., Geylani 2015, claiming that lumpy investment at the plant level is evident in the food manufacturing industry as well). On the other hand, new ventures as an at least equally important and very specific subpopulation are rarely taken into consideration. With the exception of Jovanovic and Rousseau (2014), who claim that investment of new firms responds positively and elastically to  $Q$  because new firms do not face compatibility costs and step up their investment in response to a rise in  $Q$ , none of the contributions presented so far incorporate the idiosyncratic case of new ventures. The Jovanovic and Rousseau paper does, but unfortunately, it is restricted to companies that provide a firm's asset values and market value and therefore regularly need to be publicly traded. Entrepreneurial investment issues have also been tackled by linking Entrepreneurial investment and self-efficacy (Cassar and Friedman 2009). However, their study did not analyze investments of a newly created firm, but rather personal investments of an entrepreneur to enter the market.

In connection to new venture investing, it might be obvious to expand considerations to the well explored research field of VC funding. However, the median new business venture does not stand on VC. Only a negligible proportion of start-ups is VC backed. In Germany, a share of 5.6% of new ventures exhibits outside equity capital (Ripsas and Tröger 2014, 41). Within equity funding, commercial VC only represents a tiny proportion of equity capital, which mainly comes from private investors such as family members or corporate investors (Metzger 2015, 18). Therefore, the percentage of new businesses utilizing VC can be estimated to be significantly lower than 1%. This paper can be categorized under section 1 (investment dynamics on the micro level). Deviating from extant literature of this section, it is focused on new ventures and their particular investment idiosyncrasy and uses the comparatively rare methodology of panel regression.

As obviously no study has been conducted on NVI so far, does this mean that NVI is not relevant? We argue that NVI is actually highly relevant, as it basically concerns the development

and growth of new ventures. However, just that is a major issue of new venture research (McMullen and Dimov 2013; Dimov 2011; McKelvie and Wiklund 2010, 281; Blackburn and Kovalainen 2009, 132), serving to explain developmental dynamics and define impact factors of growth. Against this backdrop, doing something nobody else does means that there must be good reason for this disregard, which most likely is twofold: the collection of comparable longitudinal data on new firms is difficult and expensive (Ployhart and Vandenberg 2010, 95; Lance et al. 2000), and the lack of appropriate micro-level panel data hinders secondary research. Moreover, the awareness of new venture peculiarities might still be low in investment research.

In this setting, we argue that new ventures are special and very different from publicly traded firms and firms that publish financial statements regularly, which are listed in public databases. Why are findings on established enterprises not applicable to new ventures? Additionally, why does firm newness justify an idiosyncratic view and analysis of investing behavior? Differentness results from new ventures' specific features. Newness means that initial development is not finished. Because the organizational structure is not finalized, the enterprise is not established to its customers and potential target groups. It was not a demand shock that triggered the initial capital set up but an individual business opportunity that led to the start-up of the company. Therefore, newness is usually linked to the need for development. However, newness often coincides with smallness. Most new ventures need to grow to achieve long-term viability. To set up an operational level adequate for business survival and profitability, they need to adjust, in particular in terms of capital, employment, sales, financial means and real economic processes. That is why smallness comes with limitations concerning market power, access to the market and financial resources. This leads to limited risk spreading, relatively strong dependence on a few products and customers, and a high market exit risk.

Therefore, one can doubt the validity of data and findings on firms with observable market values for ventures being in their initial development stage that immediately follows market entry. An approach like this requires a listing of new ventures in public databases (such as Compustat) and relies necessarily on published financial statements. However, asset values and market values usually are not available for start-ups, which are not publicly traded and not required to produce a balance sheet. To overcome this limitation, we will make use of an original novel panel survey dataset of new enterprises in this study.

This paper refers to the New Venture Investment-Theorem (Schulte 2015) and tends to test its propositional logic. The NVI Theorem (NVIT) detects stages of investment and claims NVI to be bimodal over time.

To explain investment into tangible assets by business start-ups, literature provides some fundamental arguments (Schulte, 2015; Cassar and Friedman, 2009; Forsfält, 1999). Two of them are applicable to new businesses:

First, investment into tangible assets is driven by opportunity. In this sense, investment happens in case of a profitable investment opportunity. For start-ups, an entrepreneurial opportunity offering future added value is a key requirement of starting the venture. Without any prospect of value adding and of economic viability, entrepreneurs have to reject to start the business and to invest. Second, real investment is driven by capital markets and interest rates. In this sense, new businesses are influenced by cost of capital in their decision to invest. Rationalized by net present value, enterprises in general can be assumed to invest more with lower lending interest rates (Samuelson and Nordhaus, 2010: 652ff). For potential new entrants, lower interest rates can ease the decision to enter the market by more favorable interest rate conditions and better access to



capital. So the opportunity threshold is the main investment driver of new businesses, possibly supported or hindered by cost of capital considerations. Besides, real investment basically is driven by resource availability. Excess liquidity seeking for profitable use needs to be invested. Investment is forced by former profit insofar. But former profit is not an issue of new businesses because of the very lack of internal self-financing in early business development.

Following NVIT, an initial investment peak can be expected as the business starts because implementation of operational readiness requires asset buildup. After this initial peak, investment is supposed to drop in the following years, while capital is in use and gets depleted continually. Later in time, and triggered by capital adjustment and replacement needs, investment rises to a second peak, which is expected to be lower than the first one. The NVIT then proposes a second decline afterwards, altogether forming a bimodal, s-shaped investment time series for start-ups. For clearness and unambiguity, we now will call these stages ‘first peak stage’, which comes soon after market entry, ‘second peak stage’, which marks the later local maximum of investing after some years, and ‘valley stage’, which is located between the two maxima. To simplify notation, we will label stages in chronological order from 1 to 3.

Following the NVIT, we now can conclude that amounts invested in the ‘first peak stage’ (stage 1), which starts at market entry, should be higher than in the ‘valley stage’ (stage 2) following the first peak, and higher than the ‘second peak stage’ (stage 3), which in turn follows the ‘valley stage’. Moreover, ‘valley stage’ investments should be lower than those of the ‘2nd peak stage’.

Applying this approach, we now can state three respective hypotheses:

H1a/b: New venture investment is higher in stage 1 than in stage 2 and in stage 3.

H2: New venture investment is lower in stage 2 than in stage 3.

Please note that we do not make any a priori settings concerning the length of stages at this point. Therefore, data analysis cannot be based on predefined stage durations necessary for methods such as stage-specific comparisons of means. To test within this approach, we rather will perform alternative curve fitting procedures to determine the pattern that fits investment time series of new ventures best and to determine an average peak-to-peak duration.

## DATA AND METHODS

The dataset in use is obtained by employing a unique German panel survey specialized in full-time entrepreneurship and comprising business start-up as well as business succession and active business participation: The Start-up Panel NRW (SPNRW) is a standardized written survey conducted annually since 2000 by the Centre for Entrepreneurship in Theory and Application (ceta) using a new business database held by LGH, a governmental authority dedicated to the promotion of commerce and trade. cetra runs the panel for long-term monitoring of independent full-time entrepreneurship activities, addressing a quantity of enterprises large enough to produce robust findings on early venture development. The panel survey covers more than 17,000 business start-ups in North Rhine-Westphalia (NRW), Germany’s largest federal state in terms of population and area. Annual response rates range from 35.0 to 70.0 percent (Lambertz and Schulte 2013, 374). The SPNRW, among other data, provides information on firms’ annual investment behavior using micro-level time series data from more than 7,000 enterprises. The SPNRW database is the most detailed and comprehensive source of data on this type of firms in Germany. This database exhibits several strengths. First, data on sample firms are significantly more comprehensive than public trade registers and allow for a rich set of variables that can be

used for economic estimation. Second, the dataset provides information on longitudinal development of firms and is not only restricted to cross-sectional data. This is a strong advantage compared to studies about entrepreneurial dynamics that use data gathered retrospectively by one-time surveys only (Rauch, Rijsdijk 2013, Hmieleski, Corbett, Baron 2013). Third, MGP does only include full time self-employment, but no lifestyle firms and firms that are purely created for tax-saving or purchasing advantage purposes.

For this study, we only make use of investment data from newly founded ventures, for a total of 4,733 enterprises, because in cases of successions and participations, businesses are already established and do not have to initially invest.

In addition to provision of the investment time series data required, the panel features several key benefits compared to trade register-based panels. First, it contains small and micro businesses as well, even those not subject to registration. With this feature, it achieves better representation of common business venturing activities than data preselected by registration obligations. Second, it excludes sideline enterprises, dependent entities, group subsidiaries and corporate venturing. With this feature, it targets full-time independent entrepreneurship and thereby excludes bias in size and behavior from part-time businesses generating just auxiliary or sporadic income, as well as corporate group venturing. Third, it is monitored for survival bias by LGH for at least three years after market entry. Therefore, enterprises not taking part in the annual surveys because of market exit can be determined and explicitly considered.

In line with typical (German) business venturing evidence, the panel dataset includes businesses of all sectors. Given the panel features presented above, this study focuses on common business starters, which in the majority of cases do not have innovative, technology-based or venture capital-based business concepts. Significant in shaping this common evidence is the crafts business sector, constituting a major part of the panel, which is a rather typical representation of entrepreneurial activities in Germany in general, i.e., in terms of size, business model, and legal type.

In the period examined, the exit rate of the ventures under examination caused by economic problems accounted for less than 2 percent. A comparison of surviving and outgoing ventures revealed, according to amount, some recognisable, but not highly significant differences. Exits performed worse in terms of investments, profit situation, occupancy and employment. To control for survival, exits were excluded from further analysis. The findings gathered therefore necessarily refer to the surviving population, which is inevitable for a longitudinal analysis. Insofar, there inevitably is a ‘survivor bias’ in every longitudinal study – in the same manner as with growth curves of newborns, *exempli gratia*, which only comprise survivors.

The panel wave questionnaires are composed of recurring questions on corporate development (e.g., sales volume, employment and corporate profit situation), supplemented by selected nonrecurring items on current issues of early business development (e.g., risk perception, recruiting, or controlling). The annual investment amount was surveyed by dedicated panel questionnaires that asked the business owners for the amount invested in the past business year (EUR thousands). Although a self-declaration of the actual investment amount may be subject to bias risks because of misunderstanding, ignorance, embellishment or downplay, we decided to prioritize them over financial statement data because of very limited availability of accounting data from firms not registered in the German trade register. However, even in cases of availability, data taken from financial statements are less valid because of accounting policy bias. Moreover, actual investments cannot be directly read from financial statements, which only

present stock size but not change in capital stock. Thus, further information would be necessary to extract annual investing from financial statements. Summarizing these considerations, financial statements seem to be less appropriate to determine annual investment of new ventures.

This paper analyzes enterprise level time series that have been merged into one set of pooled data. Pooling is necessary here to set an equal reference point in chronological development for all ventures, namely the start of business activity. This pooling provides a beneficial and welcome side effect: influences of different economic business cycles on investment are compensated for by using pooled data, and thus, respective biasing effects are filtered out.

The SPNRW investment surveys deliver an unbalanced panel of 4,733 newly founded ventures over the period 2003–2012, as shown in Table 1.

**Table 1** Founding year cohorts of sample

<b>year of foundation</b>	<b>no. of cases</b>
before 2005	1,547
2005 - 2008	2,134
2009 - 2012	1,052
<b>total</b>	<b>4,733</b>

To secure a sufficient time series and an adequate development picture of every single enterprise, ventures with only one or two observations were dropped out of the sample. This selection results in 2,381 new ventures with 10,756 observations and thus in 4.52 investment observations per start-up.

This study makes use of the annual investment amounts of ventures providing at least three measured points per unit within the inspected period. Three measured points are necessary for a minimum representation of a supposedly nonlinear development over time (Ployhart and Vandenberg 2010, 97; Chan 1998). For a single unit, only two measured points would be limited to a linear estimation, and only one would not show development at all.

Investment time series were pooled along the age of the ventures to make them comparable concerning their year of foundation. With this step, possible impacts of different cyclical economic business environments were filtered out. To test investment trajectories over time, data analyses and estimations are thus restricted to investment and age.

The dataset contains companies aged 0-9 years with a size of 4.08 (resp. 5.78) employees on average after 2 (resp. 5) years of business operation. Table 2 briefly describes the main features of the sample under inspection.

As Table 2 shows, the data set is characterized by new individual companies, which are, as typical for start-ups, rather small and still growing. Annual investments cover a range of Zero up to several 100,000€, but the major portion remains on a moderate level. The firms analyzed reported annual investments between roughly 14,000€ and 32,000€ on average. The mean time series starts with the maximum mean amount in the trunk year and drops to its lowest average level in year 7. Thereafter, mean investments increase again up to around 24,000€. Net sales per month average 22,750€ after two years and 38,510€ after five years of business operation. Female business founders are a minority, as expected founders are mainly male. The sample contains a variety of industries, but is dominated by the manufacturing sector. Sole proprietorships represent about 78% of the sample.

**Table 2** Sample description

Variable	n	Mean	StdDev	Median	SE	Min.	Max.
Legal: Ltd. Liability Company <sup>1</sup>	4,731	.125	.331	0	.006	0	1
Legal: Sole Proprietorship <sup>1</sup>	4,731	.781	.414	1	.006	0	1
Gender: Female <sup>1</sup>	4,733	.206	.404	0	.006	0	1
Industry: Manufacturing <sup>1</sup>	3,859	.596	.443	1	.007	0	1
Industry: Services <sup>1</sup>	3,859	.219	.443	0	.007	0	1
Investment trunk year <sup>2</sup> (€'000)	1,266	31.92	.914	25.0	32.51	0	220
Investment year 1 (€'000)	3,300	29.12	.754	19.0	43.33	0	480
Investment year 2 (€'000)	2,636	14.31	.415	7.0	21.32	0	210
Investment year 3 (€'000)	2,013	14.83	.554	6.0	24.84	0	248
Investment year 4 (€'000)	1,665	15.34	.724	5.0	29.55	0	260
Investment year 5 (€'000)	1,221	18.10	1.104	5.0	38.59	0	315
Investment year 6 (€'000)	912	13.86	.889	4.0	26.85	0	202
Investment year 7 (€'000)	663	23.98	1.912	6.0	49.24	0	500
Investment year 8 (€'000)	409	22.94	2.133	9.0	43.13	0	360
Investment year 9 (€'000)	135	23.16	3.584	10	41.64	0	250
Net sales per month after 2 yrs (€'000)	2,521	22.75	.845	12.0	42.45	0	975
Net sales per month after 5 yrs (€'000)	1,102	38.51	2.76	19.0	91.75	1	1,650
FTE after 2 years <sup>3</sup>	2,768	4.08	.097	3.0	5.12	1.0	112.0
FTE after 5 years <sup>3</sup>	1,311	5.78	.275	4.0	9.95	1.0	190.0

<sup>1</sup>yes=1, no=0.<sup>2</sup>< 12 months<sup>3</sup>full time employees (including owner)

Cross-tabulation of data can detect that sole proprietorships and service industries are more frequent among smaller enterprises. Smaller enterprises are younger than bigger ones, because most firms are in their early development stage, meaning that they still grow in terms of employment and sales. As already stated, all enterprises are full time independent ventures. Featuring firms characterized by newness, full time employment and heterogeneity (concerning industry, legal, sex and size issues), the sample seems to be appropriate for the given research question.

Because pooled data in use here comprise cases of different age and founding date, and each subsequent year new entrants were to be incorporated into the data set, the sample includes a larger amount of shorter period cases than other. On the other hand, with growing duration of panel surveys, respondents increasingly reject to answer repeatedly. That's why case numbers vary over time and decrease with length of period. To control for possibly different investment behavior between drop outs and repetitive respondents, we compared both groups in terms of their pre drop out-behavior and in respect to basic business features such as legal form, size and industry. We didn't find significant differences in this subject.

The features of the data set imply that the sample is not only in line with german foundation activities, but also with other western industrialised countries. To check for possible biases, the data set was compared to secondary data from the Federal Statistical Office and the federal sales-tax statistics for all of Germany, in fact concerning legal status, industry and sales volumes. In the course of this, highly significant correlations ( $>.99$ ,  $\alpha<.001$ ) and chi-squares ( $\alpha<.001$ ) between the data set and the respective reference values became apparent. So this sample appears to give an adequate representation of the population of German start-ups, by sector, size and legal form.

To approximate investment behavior of new ventures, namely to estimate new venture investment trajectories, linear and cubical curve fitting procedures were employed. Because theory implies a descending investment tendency in general while early business development proceeds, a linear estimation of NVI time series was run at first to check for an overall trend and to set a benchmark for model fit indicators. Testing of the hypotheses proposed then was performed by a cubic curve fitting (Arlinghaus 1994), which allows to estimate bimodal trajectories and to check for different stages.

A highly relevant issue in modelling NVI trajectories is outlier treatment. Because of the variety of ventures and business models under inspection, NVI necessarily are highly dispersed and spread. Moreover, the lumpiness and intermittence of investments are in the nature of investment. That is why a wide divergence of investment sums cannot only be ruled out but is acceptable. However, extremely high investments of single units lead to inhomogeneous and strongly spread distributions that moreover tend to bias related estimations.

To cope with this challenge, the literature (Wilcox 2003; Wilcox and Keselman 2003) recommends trimming or winsorizing the affected data. We decided to winsorize data because trimming not only excludes cases but cuts off valuable evidence on extreme investment behavior as well. Winsorizing is not connected to the assumption of completely wrong measured points, which have to be omitted, but adopts the view that exaggerated amounts have to be limited to a level adequate for the sample. The potential error of this type of data revision is much lower because extreme declarations do not have to be excluded.

In line with Wilcox and Keselman (2003), winsorizing was set to 0.2 for this study. With this adjustment, dispersion can be reduced to an appropriate level without changing the idiosyncrasy of time series data. Data intervention at the lower end of the distribution is limited to years showing less than 20% of zero investment. Because a vast fraction of zero investment can be expected following initial equipment at market entry, the winsorizing adjustment is limited to a largely noninvasive level.

Curve fittings were based on the fixed effects model computed from the winsorized investment data, based on a centering on individual, unit-specific means (Allison 2009, 17-18). Fixed effects panel regressions are particularly suitable for investment time series because they allow for consistent estimates despite unobserved heterogeneity of cases by avoiding individual effects of error terms for time invariant third variables (Allison 2009, 1-2). Non-observable heterogeneity denotes firm-specific effects that cannot be measured because of non-observability. It is associated with features of the individual firms making up the panel that are constant in time. Heterogeneity can be eliminated by centering within individuals because it does not have any temporal variation. The opportunity to control for unobserved heterogeneity is a strong argument for fixed effects modeling here. Utilizing a random effects model would contradict the motive for studying panel data. Time invariant third variables such as industry, gender or legal status especially justify the use of panel data, while random effects modeling is based on the problematic assumption of having no correlated time invariant third variables (Halaby 2004).

Testing was performed using linear and cubic curve panel regressions over years, yielding annual investment, which can be expressed as

$$(y_{it} - y_i) = c + \beta t + e_{it} \text{ (linear model),}$$

and

$$(y_{it} - y_i) = c + \beta_1 t + \beta_2 t^2 + \beta_3 t^3 + e_{it} \text{ (cubic model),}$$

where  $(y_{it}-y_i)$  is the dependent variable, denoted as a difference because of the centering performed for panel regression purposes.  $c$  is the estimation constant, representing the intercept of the curve,  $\beta_i$  are regression coefficients that indicate investment slope over time,  $t$  is investment years, and  $e_{it}$  is the remaining error term of the curve estimation.

To test for robustness of estimations, unit-specific *median* centerings were additionally conducted.

Note that the time variable  $t$  is centered deliberately on the date of the business start-up, not on the unit-specific mean point of time, because adequate pooling of data (see above) requires timeline adjustment to make early development behavior comparable for all units.

## RESULTS

### Modeling the NVI trajectory

Table 3 shows the results of linear and cubic curve fitting. The linear model, implemented as a base benchmark, already delivers highly significant evidence for the presumption of descending investments while early business development proceeds. The results show a positive intercept of approximately 2,500€, representing an estimation of mean investment deviation in year 0, and a negative linear slope around -1,200€. Please note that these figures do not represent absolute amounts of investment but unit-specific mean deviations, which are caused by the fixed effects approach utilized here.

However, the base model necessarily blanks out possible nonlinearities in NVI behavior. To test for the nonlinear and presumably bimodal trajectory stated by theory, a cubic curve fitting was performed, showing highly significant results as well and for all variables included (all  $\alpha < .001$ ). With the cubic model, an intercept of approximately 10.000 € (year 0) was estimated. Model fit rises by  $\Delta R^2 = .2$ , from a proper  $R^2 = .134$  to a remarkable model fit of  $R^2 = .334$ .

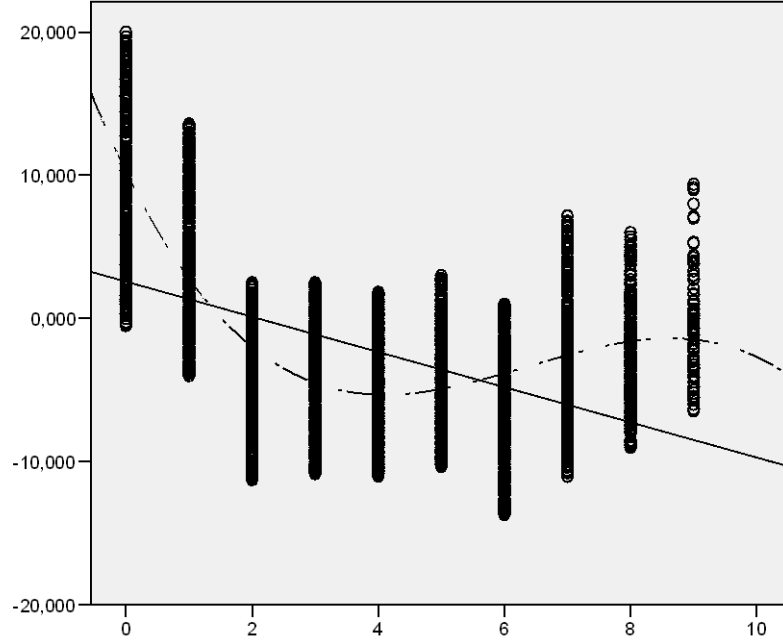
Both models are highly significant, and both show a highly significant time variable. Cubic modeling considerably increases model fit. Stronger requirements for the number of measured points ( $>3$ ) do not improve model fit.

**Table 3** Annual investment observations (0.2-winsorized, mean-centered)

	linear Model	cubic Model
year	-1.229***	-9.018***
year <sup>2</sup>		1.620***
year <sup>3</sup>		-.085***
const.	2.574	10.257
N	2,381	2,381
std.err.	7.000	6.139
F	1,666.3***	1,799.3***
R	.366	.578
R <sup>2</sup>	.134	.334
adj. R <sup>2</sup>	.134	.334

Figure 2 depicts the fixed effects trajectory estimations based on the concurrent models. The dotted s-shape represents cubic fitting, while the solid line shows linear fitting. The tiny circles stand for single median-centered observations.

**Figure 2** Annual investment observations (0.2-winsorized, mean-centered)



### Robustness tests

To test for robustness of the findings, we compared them to alternative specifications and estimations. In case of fixed effects models, the literature recommends replacing the mean with the median, to avoid mean-biased centering when doing fixed effects regression (see Wagner 2011, 23). We did so to test the robustness of the results.

Table 4 shows the tests for robustness of the regressions performed above to the replacement of individual means by individual medians. The results are quite identical concerning models, variables and estimation errors. The cubic estimation of the curve trajectory is nearly equal to the base model. Model fit measures (F statistic,  $R^2$ ) confirm an equally strong validity of estimations. However, the model intercepts are approximately 3,600 € higher than those of the two corresponding models, which is an interesting shift caused by median replacement of means. The intercept represents the deviation of the amount invested from a utilized measure of central tendency in year 0. As usual with skewed distributions, in this study, median deviations top mean deviations and thereby cause the difference in intercepts. Unsurprisingly, the difference between mean and median in year 0 (16,231 to 11,474€) yields roughly the same amount as the difference in intercepts between models. Therefore, the models introduced for robustness checks face a parallel shifting of the corresponding curves.

**Table 4** Robustness test (median-centered panel regressions)

robustness test	linear Model	cubic Model
year	-1.236***	-9.009***
year <sup>2</sup>		1.651***
year <sup>3</sup>		-.089***
const.	6.341***	13.893***
N	2,381	2,381
std.err.	7.000	6.195
F	1,687.4***	1,711.5***
R	.368	.568
R <sup>2</sup>	.136	.323
adj. R <sup>2</sup>	.136	.323

### Hypotheses testing and interpretations

Linear fixed effects panel regression confirms the presumption of a generally descending NVI behavior. A much more appropriate model fit can be achieved by an s-shaped curve fitting as proposed by the NVI theorem. A bimodal path like that can be described by an (at least) 3<sup>rd</sup>-degree polynomial, a cubic function. As assumed according to the NVI theorem, coefficients for  $t$  and  $t^3$  are negative, while  $t^2$  results are positive. All of them are highly significant.

Therefore, both models and all of their coefficients are highly significant. However, compared to the linear approach, the cubic fitting delivers a much better model fit in terms of standard errors, F-statistics and especially concerning variance explanation, expressed by  $R^2$ . The cubic panel regression yields a surplus of  $\Delta R^2 = .20$ .

The extreme significance of the model underlines the three hypotheses stated at the outset. The variance explanation yielded shows early development as being a highly relevant phenomenon for explanation of NVI behavior. The age variable already explains more than one-third of the trajectory.

The constants computed depict the average initial mean investing difference of a startup. Within the linear model, this intercept averages approximately 2.500 € above unit-specific means. Each year, this amount decreases by approx. 1.230€. Within the cubic model, the intercept averages approximately 10.300 € above unit-specific means, combined with a more intensely negative slope and a second peak, which in total leads to a distinctive s-like shape.

Moreover, the models deliver estimations of the time of peaks and valleys. Given the estimation curve of the s-model, which is

$$(y_{it} - y_i) = 10.257 - 9.018x + 1.620x^2 - 0.085x^3, \text{ for } 0 \leq x \leq 9,$$

we can determine the peaks and valley as follows:

*first peak:  $x = 0$ , valley:  $x = 4.118$ , second peak = 8.588*

Year 4 marks the valley of the curve, and the second peak is located between years 8 and 9. To ensure significance of differences on the level of annual means, T-testing was additionally performed, comparing pairwise means of relevant years 0, 4, 8 and 9. Table 5 shows all differences as being highly significant.



**Table 5** Mean differences between peaks and valley

		year 0	year 4	year 8	year 9
T-test (pairwise)	year 0		17.35*** (26.278) n=455	17.99*** (12.114) n=97	./.
	year 4			-2.84*** (-4.989) n=285	-3.64*** (-3.621) n=98

(./ no valid pairs. *t*-statistics in parentheses. \*\*\*  $\alpha < .001$ )

However, T-testing calls for normal distribution, which is violated by winsorized data. The results of significance testing may cause false conclusions in this case. Therefore, Wilcoxon Rank-Sum tests for paired samples were performed to ensure the findings obtained as shown in Table 6. This type of nonparametric testing does not require any assumptions of the underlying statistical distribution and, furthermore, carries the advantage of not being subject to outlier burdened mean values.

**Table 6** Wilcoxon Rank-Sum tests for paired samples of investment in years 0/4/8/9

		year 0	year 4	year 8	year 9
Z-value (paired years)	year 0		16.780*** n=455	7.398*** n=97	./.
	year 4			-5.051*** n=285	-4.362*** n=98

(./ no valid pairs. \*\*\*  $\alpha < .001$ )

Wilcoxon Rank-Sum tests confirm all results already obtained by *t*-statistics. In fact, all three hypotheses can be sustained. As panel regressions verify, initial investments exceed those of stages 2 and 3, while stage 3 investments are higher than those of stage 2, which is confirmed by comparison of means based on a yearly perspective.

## Discussion

The linear model verified a decreasing NVI pattern in a first instance of estimation. However, this masks nonlinearities, which have to be presumed following the NVIT. According to this theorem, a bimodal trajectory is more appropriate than a linear one. This pattern can be validated by a more elaborate estimation.

These findings indeed are astonishing considering the fact that the presumed s-shape can be confirmed without further distinctions, such as controlling for industry, size, legal type or other business features. This might be traced to the powerful panel approach, which is especially capable of coping with unobserved heterogeneity much better than cross-sectional approaches of all types. Of course, there are significant differences in the sizes of investments that can be read directly from non-centered NVI distributions. This implies special specifications of the s-curve for subcategories, resulting in different categorical amplitudes, but does not notably change the pattern itself and its longitudinal stretch.

The significant model fit gives strong evidence for the interpretation that time frames and stages do not differ substantially. Thus, strongly divergent estimations for subcategories on the level of a stretch on the time axis of the curve cannot be expected.

## CONCLUSIONS

This paper complements the literature presented above by following a completely different approach. To our best knowledge, it is the first time that new venture investment behavior is inspected in such a direct way and based on micro-level time series on new ventures.

The model applied fits the data reasonably well using German pooled data since 1995. We derived robust predictions of NVI behavior by fitting data to a cubic fixed effects panel regression. Thus, from a technical perspective, the findings are useful. However, why are they relevant, apart from just giving the first evidence of NVI? The relevance is related to more reasons than just exploring a new research area.

First, the study offers new venture theory validation, which has been largely missing so far, within a specific field of research. Second, it contributes to early business development research, as investment opens up an alternate type of access to new venture progress and organizational build-up. As capital stock is a measure of productive size, NVI, which builds up and adjusts capital stock, most presumably correlates to growth. Linking growth research to NVI may gain a so far unseen knowledge potential. Thus, only with a closer understanding of NVI and by using time series data provided by panel approaches can future research on new business growth be advanced significantly. Third, the study offers initial insights into intertemporal issues of development. Former, current and future investments are largely interdependent because investment goods are intended for long-term use. Fourth, NVI data allow for linkage to the funding side of the start-up and its respective figures, which might contribute to deeper insights into early stage funding demands and behavior. Altogether, these issues can contribute to a better understanding and more appropriate counseling of start-ups and new ventures.

*Limitations* of these findings are twofold, namely method specific and panel specific.

Winsorizing centered data, performed here to handle extreme outliers, induces the risk of cutting off important information on particular but nonetheless relevant cases. As already noted above, the impact of winsorizing to a large extent is limited to the upper end of distributions. However, the remaining revision of data may contribute to a cutoff of some heavy investment behavior. Taking into account the possibility of such cases calls for differentiation and possibly classification into subcategories or clusters, respectively. This might be an area for future research.

A more panel-specific limitation is given by the trunk year feature of new venture panel data, resulting from the fact that there is a time span of less than 12 months between foundation date and the first subsequent panel survey wave in most cases. Trunk years represent time periods ranging from a few days to nearly a whole year. However, this limitation seems to be tolerable, as most significant amounts are invested at the very beginning of a venture anyway and therefore do not bias investment trajectories over time. Despite a relative underestimation of first observations in the time series, trunk year investments are still higher than those of the first full reported year in the sample, independent from trunk duration and even in cases of very short trunks. Thus, the initial decrease in investments is not biased by trunk years. Obviously,

preparation of operational readiness is more important for periodic investment figures than trunk year duration.

Another panel-specific limitation results from decreasing case numbers with longer periods. As shown in the tabulation of descriptives in Table 2, the case number of ventures analyzable decreases with venture age. Therefore, the period of observation is limited to less than 10 years of early development. Because consolidation periods of new ventures go up to 6 years on average (Lambertz and Schulte 2013), this is an appropriate period of time. However, as panel mortality can lead to successor bias, meaning that more successful ventures are more likely to report their investments, later period estimations might be overestimated because of low investing non-respondents. Still, this issue seems to be negligible as investment usually is not considered as a classic performance indicator. Another problem in this respect can be survivor bias, after which only ventures still in business can be surveyed. However, unlike success factor investigations, where viability correlates to success and underachieving enterprises are excluded from observation by market exit, the limitation to surviving ventures is appropriate here because the study targets long-time investment patterns of ventures sustainably active in their market.

The evidence shown drives some *implications* for policy, management, and particularly for future research.

From an entrepreneur's point of view, the findings are useful for new venture counseling and to locate and relativize their own investment patterns and developments. For entrepreneurs, an understanding of the relation between investment and development is required to control investment-driven growth. Additionally, the findings can serve as a benchmark to assess enterprise-specific behavior. The results obtained can contribute to counseling of new ventures as well.

Implications for theory and future research are even more extensive. First, the findings provide evidence for the presumption that the investigation of NVI is an appropriate and fertile ground for research on early venture development. It seems crucial in this context to mold initial development by chronological sequence to unveil nonlinearities in venture progress over time.

Second, because NVI at best are subject to cross-sectional inspection, the conclusion of a specific temporal pattern of investment suggests further and more detailed longitudinal analyses. The differentiation of subcategories divided by industry, legal form or sex, for example, might be especially promising.

Third, further investigation of NVI time series is supposed to contribute to a better understanding of growth and its patterns on a temporal axis. Better than just static variables could do, time series of growth and investment are much more suitable to reflect dynamics and changes that new businesses have to undergo. Taking the quite obvious assumption that past growth as well as past and current investments contribute to *further* growth, an integrative look at these four factors makes sense. It also follows that past investments can contribute to an explanation of subsequent investments.

This insight in turn is tangent to a fourth issue. It illustrates and clarifies that the amount of annual investments is not a development indicator comparable to periodic indicators such as sales, as it represents change (of capital stock), not annual performance. It is much more related to workforce and its change over time, which also represents stock size. If there is change like that, the starting position of the subsequent period, and of course all following periods, changes as well. Investment induces long-term effects, and that is why there are temporal interdependencies between investment amounts of subsequent periods. Thus, it is advisable to establish

accumulated capital stock for future investigations of investment and links between investment and growth. In turn, the decline of capital stock, caused by depletion and adjustment, also requires explicit future research attention. This might be negligible at the very beginning of the business but applies increasingly with advancing venture age and development. This investment-development connection also questions whether earlier investments impact later ones, and how outcomes of earlier investments affect investments of subsequent periods. In this context, the link between an enterprise's financing decisions and investment decisions, where both are not separable in the case of new firms, deserves to be considered carefully (Tsai 2005). More generally speaking, the relation of NVI to determinants and effects of investment needs to be analyzed in a framework of the chronological logic of a cause-effect chain.

Finally, besides aiming at a better understanding and explanation of early growth, there are many more issues of interest within the framework of NVI, such as investment and economic viability of the business, investment and change of strategy and structure, or personality features and decision-making behavior of the people investing. A special task for future research is the question, whether investment data can challenge the assumption of liability of newness. One weakness of the respective literature is that it focuses on resources such as employee size, which is used partly as a proxy for financial capital, but do not stand on financial data directly.

It is hoped that future research will address, deepen and answer one or other of these questions.

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