International Review of Entrepreneurship, Article #1527, 14(1): pp. 85-102.
© 2016, Senate Hall Academic Publishing.

Explaining Investment Dynamics: Empirical Evidence from German New Ventures

Harald Habermann[1]
Leuphana University of Lueneburg, Germany

Abstract. So far, empirical evidence regarding investment patterns has focused almost entirely on established firms, and mainly in the manufacturing sector. No theory for investment has been empirically tested for new ventures. Using pooled panel data of 7,028 German new ventures, the present article documents the importance of zero-investment episodes and applies a cluster analysis to investigate if different investment patterns can be distinguished. The empirical results support the presence of both convex and nonconvex components of adjustment costs, implying that both neoclassical and newer investment theories have practical validity.

Keywords: convex adjustment costs; investment pattern; panel data.

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

1. Introduction

Students in business schools are taught that an investment should be made if the present value of the expected cash flow is at least as large as its cost. This is the standard neoclassical investment theory, which ignores the irreversibility and uncertainty of investment. An alternative approach, highlighted in the work of Doms and Dunne (1998), Cooper et al. (1995), Abel and Eberly (1996), Caballero et al. (1995) and Bachmann et al. (2013), argues that nonconvex adjustment costs, irreversibility and indivisibility of investment play an important role in the investment process (Cooper and Haltiwanger, 2006). In the present article, this alternative approach will be called newer investment theory. Empirical evidence shows the importance of infrequent and large investment activities. Gelos and Isgut (2001) and Caballero et al. (1997) urge for further examination of data from different countries to ascertain the general validity of such a newer investment theory. So far, little empirical research that focused exclusively on established ventures (Bigsten et al. 2005, Bloom et al. 2003, Caballero et al. 1995, Cooper et

1. Department of Start-up Management, Leuphana University of Lueneburg, Scharnhorststr. 1, D-21335 Lueneburg, Germany, E-mail: harald.habermann@leuphana.de, Tel: + 49 4131 677-1951.

© 2016, Senate Hall Academic Publishing. All Rights Reserved

al. 1995, Doms and Dunne 1998, Gelos and Isgut 2001, Nilsen and Schiantarelli 2003) followed. One reason explaining the small amount of research conducted so far could be that few data sets at the micro-level, which are required to analyze investment decisions, exist. Another reason could be that the net present value concept is more appealing because, based on its assumptions, it is easier to apply. The present article reemphasizes the need for more micro empirical research and uses for the first time panel data from Germany to examine the investment patterns of new ventures in different skilled crafts trades. The skilled crafts sector in Germany includes over 100 occupations, such as bricklayer, carpenter, etc., in different trades. Empirical investigation into investment patterns of new ventures could be interesting for both practical and theoretical reasons. Firstly, knowing the investment dynamics of new ventures would support the design of new policies for the development of a firm. Secondly, investment is seen as relevant important variable that spurs growth (Cooper et al., 1994, Geyani and Stefanou, 2012). Therefore, knowing how investment develops over time seems to be an information that supports the prediction of the growth of new ventures. Thirdly, finding evidence for certain investment patterns has practical relevance for consultancy and management of new ventures because it supports the optimization of early business performance. Fourthly, analyzing investment patterns helps to find differences between the investment of established firms and new ventures. Research into why differences in the investment patterns of these two groups exist could support the general validity of investment theories.

The present article contributes to the investment literature by answering the following questions: What is the nature of the investment process for new ventures at the micro-level? Does the data provide evidence that supports the neoclassical and/or the newer investment theory? What are the aggregate and policy implications of the results?

The article proceeds as follows. In the first part, the assumptions of the neoclassical models and newer investment theory are explained. In the second part of the article, using data from a German Start-Up Panel, the investment patterns of the new ventures described by this data are empirically examined. Third, the empirical analysis identifies five clusters of firms with different investment patterns. Two clusters behave more in accordance with neoclassical investment theory, and two clusters behave more in accordance with newer investment theory. The present article concludes that both neoclassical and newer investment theory can be applied to explain certain investment patterns of new ventures.

2. State of Research

Issues of adjustment have been addressed in the economic literature, and scholars have mainly distinguished between frequent and infrequent adjustment (Bertola

and Caballero, 1990). Theory of infrequent adjustment can be applied to the marketing of a product (Baldwin and Krugman, 1989), the durable goods consumption (Grossman and Laroque, 1990), the Operations Research literature (Bather, 1966), or the capital stock (Arrow 1968, Dixit and Pindyck 1994, Bertola and Caballero 1990). The costs of adjusting the stock of capital reflect a variety of interrelated factors that are difficult to measure directly or precisely (Cooper and Haltiwanger, 2006). Therefore, the present article analyzes the capital adjustment costs indirectly through studying the dynamics of investment itself. Dixit and Pindyck (1994:1) define investment as an "act of incurring an immediate cost in the expectation of future rewards." In line with this definition and the difficulty to measure the stock of capital, the present article understands investment as a change in capital stock over a period. Therefore, investment is used as a synonym for capital adjustment.

The neoclassical model of investment is seen as the orthodox theory of frequent adjustment of investment. Before the neoclassical model, no framework existed for investigating the determinants of investment. In this model, the firm maximizes the discounted flow of profits over an infinite horizon (Chirinko, 1993). It assumes that capital depreciates at a geometric rate, while delivery lags and vintage effects are absent. A delivery lag is the time between the ordering of new capital goods and their installation. The vintage effect states that new capital is more productive than old capital due to technological improvement. The neoclassical model of investment also assumes that adjustment costs are convex, investment is reversible and indivisibility does not exist (Jorgenson, 1963). Chirinko (1993) as well as Abel and Eberly (1996) provide an extended review on neoclassical investment theories. A growing literature on investment models has criticized these three assumptions. Abel and Eberly (1996), Doms and Dunne (1998), Caballero et al. (1995), Dixit and Pindyck (1994), and Cooper and Haltiwanger (2006) develop an alternative theory highlighting the importance of irreversibility and indivisibility. In the present article, the literature that criticizes the neoclassical assumptions is called the newer investment theory. The main differences in the assumptions of both theories are as follows:

Adjustment costs

Investment models of infrequent adjustment can be divided into models with fixed adjustment costs and models with adjustment costs kinked at zero. Kinked adjustment costs mean that the adjustment cost for the first unit of positive investment is less than the adjustment cost for the first unit of disinvestment. Adjustment costs arise in addition to the direct cost of buying new capital goods and can be divided into internal and external ones. Internal adjustments costs arise when the new capital is installed or workers are retrained to operate the new machines (Bigsten et al., 2005). Assuming a perfectly elastic supply of capital, external adjustment costs arise where the price of capital goods relative to other goods adjusts so that firms do not wish to invest or disinvest at infinite rates

(Foley and Sidrauski, 1970). The neoclassical investment model assumes convex adjustment costs, i.e. firms respond to external shocks by making continuous, small investment because large and rapid changes are extremely costly. In this model, zero-investment is very difficult to explain. The marginal adjustment cost is increasing in the size of adjustment (Hayashi, 1982).

Empirical evidence, however, seems to indicate that firms do no continually invest every time conditions change. This means that zero-investment in particular periods can be optimal in models with either fixed or kinked adjustment costs. Adjustment costs seem more likely to have a large fixed and infrequent, also called lumpy or decreasing cost component (Bigsten et al., 2005). Therefore, the newer investment theory assumes nonconvex adjustment costs and can explain zero-investment.

Irreversibility and indivisibility of investment

Irreversible investment acknowledges that the value of capital may not be fully recoverable when resold. This is partly caused by a lack of secondary markets for capital goods. Irreversibility changes the dynamics of investment by creating a threshold level of returns for positive investment. Below this threshold, investment is zero which means lumpy rather than continuous investment. If a firm does not invest, it retains the possibility of keeping its capital stock low, which means that a reverse of the investment, i.e. disinvestment, is less costly. If a firm invests, it commits itself to a high capital stock and possibly high costs of suspension (Dixit and Pindyck, 1994). While the neoclassical investment theory assumes the reversibility of investment, the newer investment theory acknowledges irreversible investment. The newer investment theory also assumes indivisibility, which leaves firms with a choice of making a large investment or no investment at all (Bigsten et al., 2005). This could also lead to lumpy investment.

Small firms could be faced with problems of indivisibility and irreversibility of investment and, therefore, investment of this type of firm could be assumed to be lumpy in nature. In contrast to established firms, new ventures do not have an existing portfolio of capital stock that has to be rearranged or adjusted to an optimal level or size. Therefore, one has to be cautious to predict certain investment patterns of new ventures by analyzing investment of small but established firms. New ventures only face positive changes in capital stock alignments and ordinarily do not disinvest (Schulte, 2015).

Micro data is required to truly understand the dynamics within new ventures (Doms and Dunne, 1998) and to test the theoretical models. So far, the focus has been on established firms. For example, Doms and Dunne (1998), Cooper et al. (1995) and Caballero et al. (1995) provide evidence from the U.S. manufacturing sector that plant-level adjustments tend to occur at discrete times and that long spells of inactivity are followed by bursts in capital expenditure. These findings suggest the existence of indivisibility, irreversibility, and increasing returns in the

adjustment cost function. Nilsen and Schiantarelli (2003) report similar findings for the Norwegian manufacturing sector, although their evidence for nonconvexities is weaker. Dunne and Mu (2010) find 74 percent of investment in the U.S. petroleum refining industry to be non-zero. Bigsten et al. (2005) find empirical evidence for zero-investment episodes and lumpy investment at the firm-level for five sub-Saharan African countries. Bloom et al. (2003) show that uncertainty influences investment in the UK. Beyond these articles, the empirical evidence of capital adjustment patterns remains limited, and further examination of data from other countries and other business sectors is warranted to ascertain the general validity of investment theories.

3. Data and Methodology

Since 2000, the Start-Up Panel of the German federal state of North Rhine-Westphalia (NRW) has monitored annually young enterprises predominately belonging to the skilled crafts sector. The definition of age of new ventures varies from younger than eight years (Pellegrino et al. 2012, Miller and Camp 1985, Jennings et al. 2009) to younger than five years (Fackler et al., 2013). The present article defines a new venture as an economic enterprise that is not older than eight years. This definition provides a sufficient number of firms to run statistical analyses while still considering them as (relatively) new.

The skilled crafts sector can be seen as typical of many entrepreneurial activities in Germany in terms of size, business model, or legal type (Lambertz and Schulte, 2013). In line with Davidsson and Gordon (2012:19), who argue that "there is an obvious need for better theorizing and modeling of the drivers of the successful establishment of imitative, subsistence-oriented businesses", the present article focuses mainly on 'ordinary' entrepreneurs. These new ventures have neither innovative nor technology-based business concepts (Lambertz and Schulte, 2013). For example, a carpenter needs to invest in different circular saws, power drills or high-quality wood but does not need to invest in robots that lead to high industrial automation that is often required in technology-based new ventures.

Until 2013, this German panel data set, with response rates between 39.5 and 52.7 percent (Table 1), has observed more than 19,000 new ventures. In addition to de novo start-ups, the panel covers successions as well as active participations.[2] Active participation means the entry of an entrepreneur into an existing company. The data set is not biased by part-time businesses because it contains data solely on full time entrepreneurship (Lambertz and Schulte, 2013). Part-time businesses cannot usually be compared with full-time ventures because

2. I recognize that successions and active participations are not new firms. However, the entrepreneurial activity in these businesses is new to the entrepreneur. The vast majority of firms in the sample (69.4%) are de novo start-ups though.

they are often created only for auxiliary income. Thus, single person enterprises, which have become a very important part of today's economies (Kessler et al., 2009), are only covered as far as they are run as a full-time job. The conceptual cornerstone of the Start-Up Panel NRW is a periodical survey based on standardized written questionnaires that pave the way for the long-term monitoring of a large number of young entrepreneurs and their enterprises, either newly created or acquired. This survey is defined by survivorship bias: No hidden market exit is possible because government authorities monitor the new ventures over a three-year period. Moreover, all exits can be verified by using a special crafts register, where all entries and exits have to be recorded (Lambertz and Schulte, 2013).

Table 1: 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

Source: Calculations based on the Start-Up Panel of the German federal state of North Rhine-Westphalia

The questionnaire of the annual panel wave always contains the same questions with regard to corporate development (sales volume, quantity of staff, investment volume, corporate earnings expectation, corporate profit situation, production activity, 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 and Schulte, 2013).

The research is based on data from nine waves of the Start-Up Panel NRW between 2004 and 2012, beginning with Wave 5. The first four waves are excluded because the survey period changed from six months to one year. It is not possible to compare the investment of six months, the number used in the first four waves, with investment of twelve months simply by multiplying by two. Investment by companies in general and entrepreneurs in particular are singular events that may occur throughout the entire year. Starting with Wave 5, the Start-

Up Panel NRW defines investment as the amount entrepreneurs have invested in the last twelve months.

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 first survey and the establishment of the new venture is defined as Period 0. This period, therefore, is shorter than twelve months. However, this does not affect the research on investment because investment is made selectively mainly in the establishment stage and not on a regular monthly basis. Because the present study investigates up to eight years of a given new venture, it covers Period 0 and eight periods, which are numbered 1 to 8 and are equal to a complete year of business activity following Period 0.

The data has been merged into one set of pooled cross-sectional data. Utilizing pooled data, potential biasing effects of different economic business cycles, cohorts, and outliers were reduced. Furthermore, the study utilizes a number of variables, such as the legal form of organization, skilled crafts trades, or gender to insure that the results are generally acceptable and not influenced by other effects (Lambertz and Schulte, 2013).

The merged dataset contains 7,028 German entrepreneurs comprising 4,880 (69.4 percent) entrepreneurs who were establishing a new venture, 1,872 (26.6 percent) who were taking over a company, and 276 (4.0 percent) who were actively participating in an existing business between 1995 and 2012. 1,828 (26.0 percent) new ventures work in the electrical and metalworking trades, 1,790 (25.5 percent) in the building and interior finishing trades, 1,582 (22.5 percent) in the health and body care trades as well as the chemical and cleaning sector, 393 (5.6 percent) in the woodcrafts and plastic trades, and 211 (3.0 percent) in the food crafts and trades. There are 141 (2.0 percent) new ventures that work in other trades and there is no information available from 1,083 (15.4 percent) businesses. 74.3 percent are sole proprietorships and 77.7 percent are owned by men.

4. Results and Implications

Table 2 shows the proportion of new ventures that make no investment during a period within the sample period. The share of new ventures in the entire sample that make no investment during a period varies between three and 15 percent (last column). In an analysis of selected manufacturing companies in several African countries, Bigsten et al. (2005) find that 58 percent of the firms have zero-investment episodes. According to a study by Gelos and Isgut (2001), where Mexican and Colombian manufacturing companies are analyzed, the number of zero-investment varies between 28 and 95 percent. These numbers are much higher than those presented in a study on manufacturing firms in Norway, according to which zero-investment varies between 20 and 61 percent (Nilson

and Schiantarelli, 2003). Cooper and Haltiwanger (2006) state that ten percent of British manufacturing firms that they analyzed have zero-investment, which closely resembles the results of the analysis, as shown in Table 2.

Table 2: Share of zero-investment of new ventures

	Cluster 1 (582 obs.)	Cluster 2 (4,856 obs.)	Cluster 3 (824 obs.)	Cluster 4 (601 obs.)	Total (7,028 obs.)
Investment Period 0	0.02	0.04	0.02	0.08	0.03
Investment Period 1	0	0.07	0.03	0.01	0.05
Investment Period 2	0.08	0.14	0.01	0.05	0.11
Investment Period 3	0.06	0.16	0.05	0.06	0.14
Investment Period 4	0.09	0.18	0.03	0.02	0.15
Investment Period 5	0.13	0.18	0.04	0.03	0.15
Investment Period 6	0.10	0.13	0.02	0.10	0.11
Investment Period 7	0.07	0.14	0.02	0.04	0.11
Investment Period 8	0.04	0.13	0	0.06	0.10

Calculations based on the Start-Up Panel of the German federal state of North Rhine-Westphalia

In contrast to the findings in the present article, Nilson and Schiantarelli (2003) and Bigsten et al. (2005) argue that zero-investment episodes appear to be more important for small firms. They argue that the indivisibility of capital goods forces especially small firms, which most of the new ventures are, to make a choice whether to make a large investment or no investment at all. Bigsten et al. (2005) show that small firms tend to face credit constraints, which could prevent firms from making any investment in particular periods.

However, the present article shows, on average, fewer cases with zero-investment than other scholarships. There exist several reasons why few observations with zero-investment could be found in the data. Firstly, the data set does not focus only on the manufacturing sector. At least 23 percent of the new ventures are in the service sector, where huge investment in machines is not required. It is easier for ventures to invest on a regular basis because the cost for investment is on average lower than investment in the manufacturing sector. Secondly, when the new ventures are founded, entrepreneurs may not have the

opportunity to decide whether to invest or not because they are forced to invest to establish the firm in the market. Thirdly, entrepreneurs may be trained to use the net present value as a decision tool to value their investment. This tool, however, does not account for irreversibility and uncertainty.

The present article proceeds by examining how new ventures invest once they decide to act. In contrast to other studies, due to lack of data the distribution of new ventures' investment rate or the capital growth rate is not analyzed. Firstly, an analysis of the investment pattern of the 7,028 new ventures is conducted. In a second step, a cluster analysis is applied because it allows describing, in a fairly nuanced manner, if the pattern of the median investment of the 7,028 new ventures can be distinguished into different investment patterns. Based on a dendogram and a distance matrix of the median investment five clusters are identified. For the cluster analysis the median investment in each period is chosen as dependent variable and variables on the organizational- and individual-level which are commonly used in entrepreneurship research (Carsrud and Brännback, 2014) are also included. These variables are the legal form of organization, gender, ownership status, and the skilled crafts trades. Both the median investment of the 7,028 new ventures and the clusters of the investment patterns are shown in Figures 1 to 4 and described in detail below. Having found that a relatively low percentage (between three and 15 percent) of new ventures decide not to invest at a certain time period is a first hint that the neoclassical investment theory could be applied for new ventures.

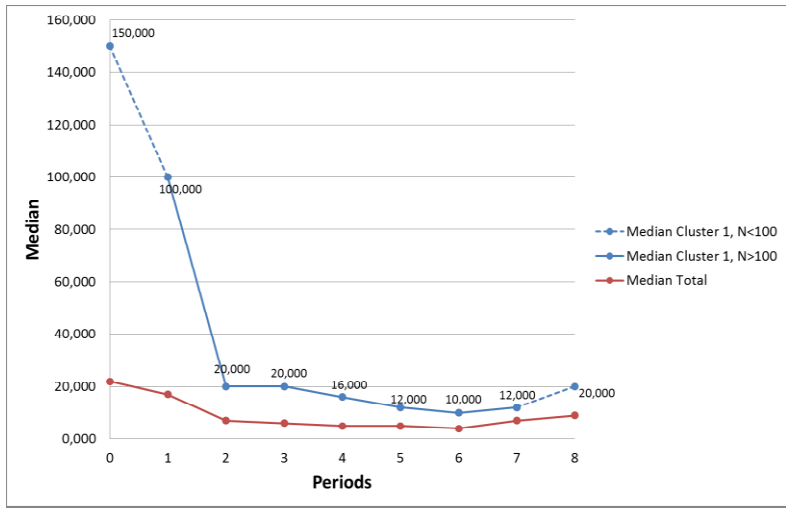
The pattern of investment of the entire data set shows that investment behavior in new ventures is nonlinear and happens by waves. A first (Periods 0 and 1) and a second wave (Period 8) of investment in the first nine periods after starting the business are identified. The ANOVA significance figures suggest that all clustering variables differ between clusters in the solution. The results of the Kruskal-Wallis one-way analysis of variance test lead to rejection of null hypotheses that median values for all characterization variables do not differ between clusters in the solution.

The clusters

The first cluster consists of 582 new ventures and represents a pattern with high investment in the beginning, which drops sharply in Period 2 (Figure 1). However, the median investment is higher than the median investment of the 7,028 new ventures for the first nine periods. The number of limited liability companies in the first cluster is nine percent points higher and the number of sole proprietorship is 15 percent points lower than in the survey sample of 7,028 new ventures. This difference in the legal form could explain the higher investment at the foundation of the new venture because in Germany at least 25,000 euro are required to set up a limited liability company. In this cluster, there are also eight percent points less than average of new ventures from the building and interior finishing trades and four percent points higher than average from the electrical

and metalworking trades. Over nine periods, the average total amount of investment for the new ventures in this cluster is more than four times higher than the average total amount of investment for the same time span for all new ventures in the data set. Almost 70 percent of the investment is made within the first two periods. Therefore, the investment seems to be lumpy within the first two periods. This result, however, has to be treated with caution because for Period 0, less than 100 observations are available.

Figure 1: Cluster 1: Median investment of new ventures (in euro)[3]

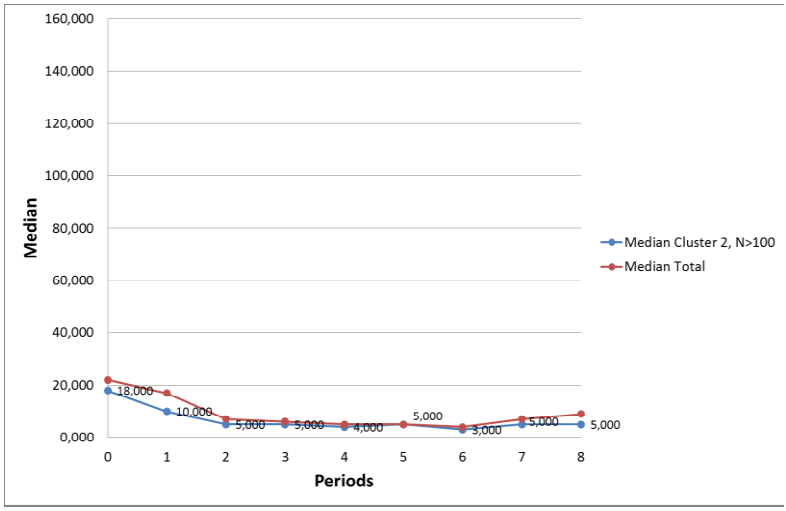


Calculations based on the Start-Up Panel of the German federal state of North Rhine-Westphalia

The second cluster consists of 4,856 new ventures, and at first sight closely resembles the average pattern of investment for all new ventures (Figure 2). Upon closer inspection, it turns out, however, that investment for a given period in this cluster is, on average, slightly lower than the investment of the 7,028 new ventures and the pattern is linear which is in line with neoclassical investment theory.

3. If a variable has less than 100 observations for a given period, a dotted line is used.

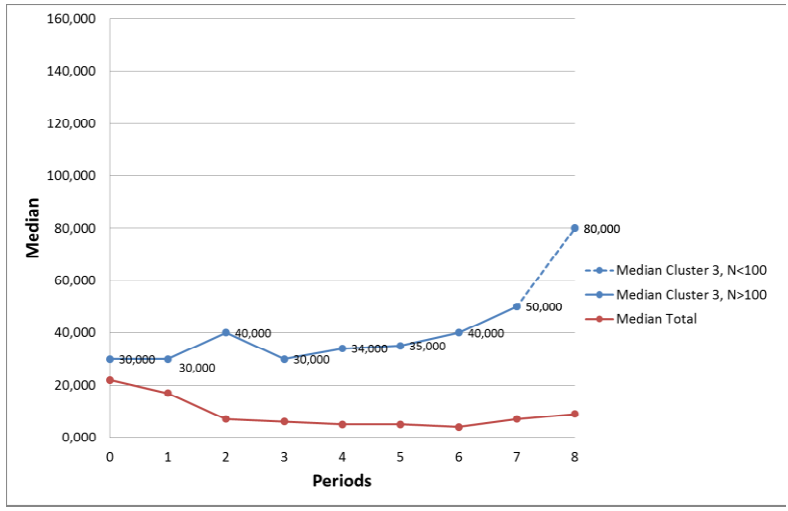
Figure 2: Cluster 2: Median investment of new ventures (in euro)



Calculations based on the Start-Up Panel of the German federal state of North Rhine-Westphalia

The third cluster consists of 824 new ventures and represents a pattern marked by higher-than-average investment in Period 0 and gradually increasing investment in subsequent periods (Figure 3). Although limited liability companies are, similar to Cluster 1, overrepresented, the initial investment is, compared to Cluster 1, around 120,000 euro lower. In contrast to the other clusters, the investment for a given period does not decrease after Period 3 but increases slowly but steadily. Over nine periods, the average total amount of investment for the new ventures in this cluster is more than four times higher than the average total amount of investment for the same time span for all new ventures in the data set. The average investment for a given period varies between 30,000 and 40,000 euro for Period 0 to 7. Hence, this pattern does not show any lumpiness. Only the last two periods have, on average, high average investment. Because less than 100 observations are available for the last period, this result has to be treated with caution.

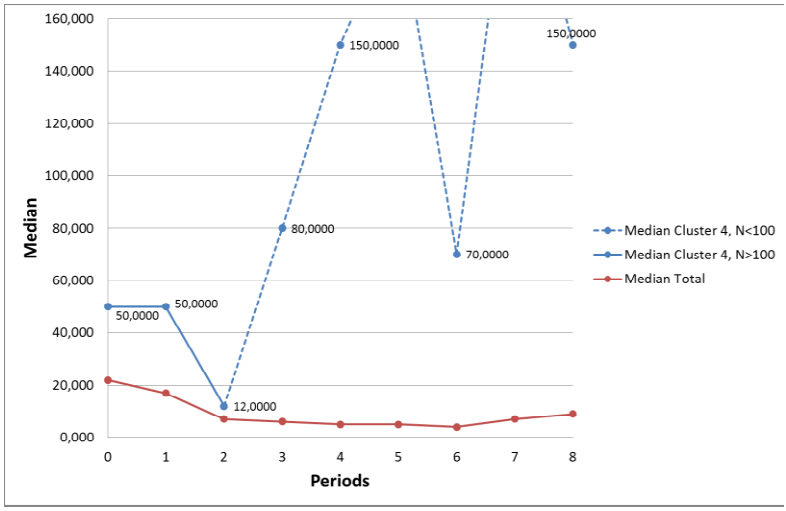
Figure 3: Cluster 3: Median investment of new ventures (in euro)



Calculations based on the Start-Up Panel of the German federal state of North Rhine-Westphalia

The fourth pattern consists of 601 new ventures and reflects a pattern with a higher than average investment at the beginning, which drops to 12,000 euro in Period 2 (Figure 4). After this period investment fluctuates heavily but after the first three periods the number of observations is less than 100 and, therefore, a trend for an investment pattern has to be made cautiously. Over nine periods, the average total amount of investment for the new ventures in this cluster is more than twelve times higher than the average total amount of investment for the same time span for all new ventures in the data set. Almost 60 percent of the investment is made within three periods. This result indicates the lumpiness of investment in this cluster. However, this result has to be treated with caution because for the Periods 2 to 8, less than 100 observations for a given period are available.

Figure 4: Cluster 4: Median investment of new ventures (in euro)



Calculations based on the Start-Up Panel of the German federal state of North Rhine-Westphalia

The fifth cluster consists of only 165 new ventures and, therefore, does not have enough observations to be included in the analysis.

The analysis of median investment of the 7,028 new ventures shows two waves of investment. The related cluster analysis reveals five different development patterns and, therefore, offers a nuanced analysis of investment patterns. Caballero and Engel (1999) argue that nonconvex capital adjustment costs help to explain certain nonlinearities in investment fluctuations. Due to the nonlinear development pattern of investment in the data, nonconvex capital adjustment costs seem to influence new ventures in Cluster 1 and 4. In these clusters, the adjustment costs seem to be fixed because lumpy periods exist. In contrast, Cluster 2 and 3 seem to reflect new ventures with convex adjustment costs because the pattern develops in a linear way. The data also shows that periods with zero-investment exist (see Table 2). One possible explanation could be that uncertainty increases the separation between the marginal cost of capital that justifies investment and the marginal product of capital that justifies disinvestment. This increases the range of inaction: Firms prefer to "wait and see" rather than undertaking a costly action with uncertain consequences. In short, investment behavior becomes more cautious (Bloom et al. 2003).

5. Conclusion

The present article is a first attempt to apply investment theories to the field of new ventures by examining the capital adjustment patterns of 7,028 German

entrepreneurs. Empirical studies of investment patterns have exclusively focused on established firms mainly in the manufacturing sector. So far, no theory for investment has been empirically tested for new ventures. Dixit and Pindyck (1994) argue that the neoclassical investment models ignore the interaction between irreversibility, uncertainty, and the choice of timing. Therefore, different scholars developed new investment theories that assume nonconvex adjustment costs and tested them empirically. Empirical evidence shows, for instance, that plant-level adjustments tend to occur at discrete times and that long spells of inactivity are followed by bursts in capital expenditure. Geylani (2015) and Bigsten et al. (2005) find evidence for both convex and nonconvex adjustment costs. The present article does not replicate earlier studies, in part because the data of this survey does not contain information on the return on investment. Instead, the focus is on the importance of zero-investment episodes and the identification of different investment patterns over time.

In a first step, the results show that between three and 15 percent of new ventures decide not to invest at a certain point of time. These numbers point to convexity of adjustment costs, in line with the neoclassical investment model which assumes continuous, small investment. In a second step, a cluster analysis is applied to show how certain investment patterns evolve over time. The analysis of median investment of the 7,028 new ventures shows two waves of investment. The related cluster analysis reveals five different development patterns and, therefore, offers a nuanced analysis of investment patterns. Caballero and Engel (1999) argue that nonconvex capital adjustment costs help to explain certain nonlinearities in investment fluctuations. Due to the nonlinear development pattern of investment in the data, nonconvex capital adjustment costs seem to influence new ventures in Cluster 1 and 4. In these clusters, the adjustment costs seem to be fixed because lumpy periods exist. In contrast, Cluster 2 and 3 seem to reflect new ventures with convex adjustment costs because the pattern develops in a linear way.

In line with Geylani (2015) and Bigsten et a. (2005), the present article finds evidence for both neoclassical and newer investment theory. This is partly surprising because it could be assumed that indivisibility and irreversibility influences the investment decision of new ventures. However, the majority of new ventures in the data set follow a linear pattern with a low percentage of zero-investment implying continuous, small investment. One explanation could be that for new ventures large and rapid changes are costly.

The present article suggests three major directions for further research. Firstly, as indicated above, the differences with regard to investment patterns have yet to be explained. Further research on variables, for example legal status or the impact of events such as the financial crisis, is needed to understand the differences with regard to the patterns. Secondly, research on how infrequent and large investment influences the growth of new ventures could link investment theories to discussions on resource-based growth models. Relating the nature of

investment to the growth of companies would be "extremely valuable" (Coad, 2009, p. 38). Analyzing the reasons why investment strategies between fast- and slow-growing new ventures are different could be a methodology to investigate this investment-growth nexus. One explanation for the differences could be that fast-growing new ventures have more resources to invest than new ventures that grow on a smaller scale. One challenge for this type of research is to define and identify fast- and slow-growing new ventures. Another option could be to distinguish between imitative, subsistence-oriented and innovative businesses.

Thirdly, small firms face problems of indivisibility and irreversibility of investment and, therefore, investment of this type of firm could be assumed to be lumpy in nature. However, the present article shows a mixed result and the investment patterns of the majority of new ventures are in line with neoclassical investment theory that does not assume lumpy investment. Therefore, further research on how investment behaviour of new ventures differs from that of established ventures is required.

Lack of relevant data will be one of the biggest challenges for future research. The current data, for instance, does not distinguish between initial, replacement, and extension investment, but each of these kinds of investment is likely to affect early business development in a different manner. A more comprehensive database that contains further information on the three different kinds of investment would be needed to gain a more nuanced perspective on investment patterns. The present article does not distinguish between start-ups, active participations and successions. Further research could focus just on start-ups to analyze if there are any differences to the results in the present article.

References:

Arrow, K. (1968), "Optimal capital policy with irreversible investment", in J. Wolfe (ed.): *Value, Capital, and Growth*, Edinburgh: Edinburgh University Press, p 1-19.

Abel A. and Eberly, J. (1996), "Optimal investment with costly reversibility", *The Review of Economic Studies*, 63(4): p 581-593.

Bachmann, R., Caballero, R., Engel, E. (2013), "Aggregate Implications of Lumpy Investment: New Evidence and a DSGE Model", *American Economic Journal*: *Macroeconomics*, 5(4): p 29-67.

Baldwin, R., and Krugman, P. (1989), "Persistent Trade Effects of Large Exchange Rate Shocks", *The Quarterly Journal of Economics*, 104(4): p 635-654.

Bather, J. (1966), "A continuous time inventory model", *Journal of Applied Probability*, 3(2): p 538-549.

Bertola, G. and Caballero, R. (1990), "Kinked adjustment costs and aggregate dynamics", *NBER Macroeconomics Annual,* 5: p 237-288.

Bigsten, A., Collier, P., Dercon, S., Fafchamps, M., Gauthier, B., Gunning, J., Oostendorp, R., Pattillo, C., Soderbom, M. and Teal, F. (2005), "Adjustment costs and irreversibility as determinants of investment: Evidence from African manufacturing", *Contributions to Economic Analysis and Policy*, 4(1): p 1-27.

Bloom, N., Bond, S. and Van Reenen, J. (2003), "Uncertainty and Company Investment Dynamics: Empirical Evidence for UK Firms", CEPR Discussion Paper No. 4025, London: CEPR.

Caballero, R, Engel, E., Haltiwanger, J., Woodford, M. and Hall, R. (1995), "Plant-level adjustment and aggregate investment dynamics", *Brookings papers on economic activity*, 2: p 1-54.

Caballero, R, Engel, E. and Haltiwanger, J. (1997), "Aggregate employment dynamics: Building from microeconomic evidence", *American Economic Review*, 87: p 115-137.

Caballero, R. and Engel, E. (1999), "Explaining Investment Dynamics in U.S. Manufacturing: A Generalized (S,s) Approach", *Econometrica*, 67: p 783-826.

Carsrud, A. and Brännback, M. (2014), *Handbook of Research Methods and Applications in Entrepreneurship and Small Business*, Cheltenham, UK: Edward Elgar Publishing.

Chirinko, R. (1993), "Business fixed investment spending: Modeling strategies, empirical results, and policy implications", *Journal of Economic Literature*, 31(4): p 1875-1911.

Coad, A. (2009), *The growth of firms: A survey of theories and empirical evidence.* Cheltenham, UK: Edward Elgar Publishing.

Cooper, A, Gimeno-Gascon, F. and Woo, C. (1994), "Initial human and financial capital as predictors of new venture performance", *Journal of Business Venturing*, 9(5): p 371-395.

Cooper, R. and Haltiwanger, J. (2006), "On the Nature of Capital Adjustment Costs", *Review of Economic Studies*, 73: p 611-633.

Cooper, R., Haltiwanger, J. and Power, L. (1995), "Machine replacement and the business cycle: lumps and bumps", NBER working paper no. 5260, Cambridger, MA: National Bureau of Economic Research.

Davidsson, P. and Gordon, S. (2012), "Panel studies of new venture creation: a methods-focused review and suggestions for future research", *Small Business Economics*, 39(4): p 853-876.

Dixit, A. and Pindyck, R. (1994), *Investment Under Uncertainty*, Princeton, NJ: Princeton University Press.

Doms, M. and Dunne, T. (1998), "Capital Adjustment Patterns in Manufacturing Plants", *Review of Economic Dynamics*, 67: p 117-145.

Dunne, T. and Mu, X. (2010), "Investment spikes and uncertainty in the petroleum refining industry", *Journal of Industrial Economics*, 58(1): p 190-213

Fackler, D., Schnabel, C. and Wagner, J. (2013), "Establishment exits in Germany: the role of size and age", *Small Business Economics*, 41: p 683-700.

Foley, D. and Sidrauski, M. (1970), "Portfolio choice, investment, and growth", *The American Economic Review*, 60: p 44-63.

Gelos, R. G. and Isgut, A. (2001), "Fixed Capital Adjustment: Is Latin America Different? ", *Review of Economics and Statistics*, 83(4): p 717-726.

Geylani, P. (2015), "Lumpy investments and capital adjustment patterns in the food manufacturing industry", *Journal of Economics and Finance*, 39(3): p 501-517.

Geylani P. and Stefanou, E. (2012), "Linking investment spikes and productivity growth" *Empirical Econonomics*, 45(1): p 157-178.

Grossman, S., and Laroque, G. (1990), "Asset pricing and optimal portfolio choice in the presence of illiquid durable consumption goods", *Econometrica*, 58(1): p 25-52.

Hayashi, F. (1982), "Tobin's marginal q and average q: A neoclassical interpretation", *Econometrica*, 50(1): p 213-224.

Jennings, J., Jennings, P. and Greenwood, R. (2009), "Novelty and new firm performance: The case of employment systems in knowledge-intensive service organizations", *Journal of Business Venturing*, 24: p 338-359.

Jorgenson, D. (1963), "Capital theory and investment behavior", *The American Economic Review*, 53(2): p 247-259.

Kessler, P., Korunka, C., Frank, H. and Lueger, M. (2009), "Wachstumsbedingungen von Ein-Personen-Gründungen–Eine Längsschnittbeobachtung über acht Jahre", *Zeitschrift für Betriebswirtschaft*, 79(12): p 1413-1435.

Lambertz, S. and Schulte, R. (2013), "Consolidation period in new ventures: How long does it take to establish a start-up?", *International Journal of Entrepreneurial Venturing*, 5(4): 369-390.

Miller, A. and Camp, B. (1985), "Exploring determinants of success in corporate ventures", *Journal of Business Venturing*, 1: p 87-105.

Nilson, O. and Schiantarelli, F. (2003), "Zeroes and Lumps in Investment: Empirical Evidence on Irreversibilities and Nonconvexities", *Review of Economics and Statistics*, 85: p 1021-1037.

Pellegrino, G., Piva, M. and Vivarelli, M. (2012), "Young firms and innovation: A microeconometric analysis", *Structural Change and Economic Dynamics*, 23: p 329-340.

Schulte, R. (2015), "On Real Investment by New Ventures", Discussion Paper No. 12, Lüneburger Beiträge zur Gründungsforschung, Lueneburg: Leuphana University of Lueneburg.