# *SUCCESS FACTORS OF FARM INVESTMENTS: THE EXAMPLE OF SWISS DAIRY FARMS*

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EXECUTIVE SUMMARY

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# EXECUTIVE SUMMARY

This scientific analysis aims to identify success factors of farm investments on the example of Swiss dairy barn investments, which are supported by interest free loans.

The data basis consists of data from the Farm Accountancy Data Network (FADN) from 2003 through 2014 from Switzerland, which is matched to data from the Meliorations- und Agrarkredit-Projekt-Informations-System (MAPIS), where all supported dairy barn investments in Switzerland are registered. This unique dataset allows for the definitive information if a farm has invested in a dairy barn. In addition, a Gini coefficient on the level of municipality is added, calculated from agricultural census data (AGIS). Farms of the type dairy farm and combined dairy/arable crops farm in the valley and hill region are used for the analyses. The final sample consists of 103 farms with almost 800 observations.

One of the main variables analysed is calculated profit, a figure that takes all opportunity costs into account. Another important variable, analysed in this work, is herd size. As a first step, the development of calculated profit and herd size change after investment are analysed by two separate fixed-effects panel regression models up to eight years after investment. The results show, that calculated profit is significantly and positively influenced by the amount of agricultural land of the farm and significantly reduced for the first three years after investment. From the fourth year onwards, no coefficients are significant anymore, which might either be caused by a divergent development of individual farms or by the diminishing number of observations. Herd size change is positive and significantly influenced by the amount of agricultural land. Also the period of quota phasing out affected herd size change positively. Dairy herds probably grew in the year before investment already and kept growing till five years after investment. Both dependent variables indicate that farms undergo an adjustment phase after investment.

For the analysis of investment probability, the data sample is extended by including observations of all dairy farms and combined dairy/arable crop farms in the valley and hill region. Observations after investment are excluded. A logit regression model of the pooled data reveals that among the financial variables, only equity and farm income have a small positive and significant effect on investment probability. Social characteristics show a larger effect. The investment probability increases with age, farm household size and the presence of a partner.

In order to analyse influencing factors of successful investments, investments that enable the farm to achieve the same or higher calculated profit as before, are considered successful. The year before investment is used as the basis and a Cox Proportional-Hazard-model is used to investigate those influencing factors. The model reveals that for farm having a higher calculated profit before investment, it is more difficult to restore that level after investment. Only equity shows a small positive and significant effect. Off-farm income and expenses for purchase of additional animals affect recovery of calculated profit significantly negative. The largest significant negative impact comes with more family labour. The results suggest that

family labour which is likely to be freed up by productivity gains, is not reallocated to off-farm income.

There is considerable evidence that availability of acreage is a restrictive factor in the implementation of economies of scale in dairy barn investment. Therefore, additional indicators for land competition on the level of municipality are used. Agricultural income per family working unit is analysed as financial measure. This is a precursor for calculated profit and reflects financial efficiency of the input of family labor. In addition, growth of the dairy herd is analyzed. A random effects model is used for both variables. For dairy herd growth, utilized agricultural area and milk quota abolishment have a positive effect. More subsidized projects within a municipality and a higher concentration of acreage have a negative effect. For agricultural income per family working unit, utilised agricultural area, number of subsidized projects within a municipality, valley region and equity have a positive effect while milk quota abolishment has a negative effect. Off-farm income, which has been used as off-farm income per full-time working unit, showed no statistically significant effect. Neighboring effects appear to be more important for dairy herd growth than for agricultural income.

Based on the derived definitions, success factors are identified. The overall results are in line with other European studies that found dairy herds only to increase slowly after investment. An adjustment phase is confirmed, while the productivity of family labour seems to be the most important influencing factor for recovering calculated profits of the pre-investment situation. This could partly be due to the different perception of opportunity costs and out-of-pocket costs or a rather inflexible nature of family labour. Structural influences seem most important for herd size growth. With regard to the negative effect of off-farm labour, off-farm labour might be seen as enabling farms with off-farm labour to accept a lower level of labour productivity. In general, the social characteristics of farms seem to have a larger impact on dairy farm investments than financial variables. For investment support, the results imply not only to put emphasis on financial characteristics. In addition, the adjustment phase must be considered with investment plans.

With such long lasting investments like dairy barns, strategic decisions by the farmer combined with family characteristics might be more important than financial indicators. Therefore, future research on dairy barn investments should incorporate a strategic component and social characteristics.

# ZUSAMMENFASSUNG

Diese wissenschaftliche Untersuchung hat zum Ziel die Erfolgsfaktoren von Investitionen landwirtschaftlicher Betriebe zu identifizieren am Beispiel von Investitionen in Milchviehställe Schweizer Milchviehbetriebe, die mit zinslosen Investitionskrediten unterstützt wurden.

Die Datenbasis besteht aus Schweizer Daten des Farm Accountancy Data Network (FADN) von 2003 bis 2014, die mit Daten des Meliorations- und Agrarkredit- Projekt- Informations-System (MAPIS), in dem alle geförderten Milchviehstallinvestitionen der Schweiz verzeichnet sind. Dieses einzigartige Datenset enthält die definitive Information, ob ein Betrieb in einen Milchviehstall investiert hat. Ergänzt werden diese beiden Datensets um einen Gini-Koeffizienten auf Gemeindeebene, der auf Grundlage des Agrarzensus berechnet wird. Es werden Verkehrsmilchbetriebe und kombinierte Betriebe Verkehrsmilch/Ackerbau in der Tal- und Hügelregion für die Analyse genutzt. Das finale Sample besteht aus 103 Betrieben mit knapp 800 Beobachtungen.

Eine der analysierten Hauptvariablen ist der kalkulierte Gewinn, der alle Opportunitätskosten berücksichtigt. Eine weitere wichtige Variable, die in dieser Arbeit analysiert wurde, ist die Herdengröße. In einem ersten Schritt wurde die Entwicklung von kalkuliertem Gewinn und Herdengröße untersucht mit zwei separaten Fixed-Effects Panel-Regressions-Modellen bis acht Jahre nach der Investition.

Die Resultate zeigen, dass der kalkulierte Gewinn signifikant und positiv vom Umfang der landwirtschaftlichen Nutzfläche beeinflusst wird und signifikant reduziert ist über die ersten drei Jahre nach der Investition. Vom vierten Jahr an sind die Koeffizienten nicht mehr signifikant, was durch eine auseinanderlaufende Entwicklung der Betriebe oder einer abnehmenden Anzahl von Beobachtungen liegen könnte. Die Veränderung der Herdengröße ist signifikant und positiv vom Umfang der landwirtschaftlichen Nutzfläche beeinflusst. Zudem zeigt die Phase des Quotenausstiegs einen signifikant positiven Effekt. Die Milchviehherde ist wahrscheinlich bereits im Jahr vor der Investition gewachsen und wuchs weiter bis fünf Jahre nach der Investition. Beide abhängigen Variablen deuten darauf hin, dass die Betriebe nach der Investition eine Anpassungsphase durchlaufen.

ZUSAMMENFASSUNG

Zur Analyse der Investitionswahrscheinlichkeit wird das Sample erweitert um alle Verkehrsmilchbetriebe und kombinierten Betriebe Verkehrsmilch/Ackerbau in der Tal- und Hügelregion. Beobachtungen nach einer Investition werden ausgeschlossen. Ein Logit-Modell der gepoolten Daten zeigt, dass unter den finanziellen Kennzahlen, nur Eigenkapital und Betriebseinkommen einen kleinen positiven und signifikanten Effekt haben. Soziale Charakteristika zeigen gröβere Effekte. Die Investitionswahrscheinlichkeit steigt mit dem Alter, der Haushaltsgröβe und dem Vorhandensein einer Partnerin oder eines Partners.

Um die Einflussfaktoren erfolgreicher Investitionen zu analysieren, werden die Investitionen als erfolgreich erachtet, die es ermöglichen den kalkulierten Gewinn von vor der Investition mindestens wieder zu erreichen. Ein Cox-Proportional-Hazard-Modell wird genutzt für die Analyse dieser Einflussfaktoren. Das Modell zeigt, dass es ein höherer kalkulierter Gewinn vor der Investition schwieriger macht, diesen danach wieder zu erreichen. Nur Eigenkapital zeigt einen kleinen signifikant positiven Effekt. Außerlandwirtschaftliches Einkommen und Ausgaben für zusätzliche Tiere beeinflussen das Wiedererreichen signifikant negativ. Den größten signifikant negativen Effekt hat der Einsatz von Familienarbeitskräften. Die Resultate deuten darauf hin, dass Familienarbeit, die wahrscheinlich durch Produktivitätsgewinne freigesetzt wurde, nicht für außerlandwirtschaftliches Einkommen umgewidmet wird.

Es gibt Hinweise, dass die Verfügbarkeit von landwirtschaftlicher Nutzfläche ein begrenzender Faktor ist in der Implementierung von Degressionseffekten bei Investitionen in Milchviehställe. Daher werden zusätzliche Indikatoren für den Wettbewerb um Fläche auf Gemeindeebene genutzt. Als finanzielle Größe wird das landwirtschaftliche Einkommen je Familienarbeitskraft genutzt. Diese Variable ist eine Vorstufe für den kalkulierten Gewinn und spiegelt die finanzielle Effizienz der eingesetzten Familienarbeitskräfte wider. Zusätzlich wird das Wachstum der Milchviehherde analysiert. Für beide abhängige Variablen wird ein Random Effects Modell genutzt. Auf das Herdenwachstum wirken die bewirtschaftete landwirtschaftliche Nutzfläche und der Milchquotenausstieg positiv. Mehr subventionierte Milchviehställe und eine höhere Konzentration der Fläche auf weniger Betriebe auf Gemeindeebene wirken negativ. Auf das Arbeitseinkommen je Familienarbeitskraft wirken die landwirtschaftliche Nutzfläche, Anzahl subventionierter Milchviehställe in der Gemeinde, Talregion und Eigenkapital positiv, während der Ausstieg aus der Milchquote negativ wirkt. Nebeneinkommen, das als Nebeneinkommen je voller Arbeitskraft einbezogen wurde, zeigte keinen statistisch signifikanten Effekt. Nachbarschaftseffekte scheinen bedeutender zu sein für das Wachstum der Milchviehherde als für das landwirtschaftliche Einkommen.

Basierend auf den abgeleiteten Definitionen einer erfolgreichen Investition, sind Erfolgsfaktoren identifiziert. Die allgemeinen Resultate sind im Einklang mit anderen europäischen Studien, die einen langsamen Anstieg der Herdengröße nach einer Investition festgestellt haben. Es zeigt sich eine Anpassungsphase, während die Produktivität der Familienarbeit der bedeutendste Einflussfaktor zu sein scheint, um den kalkulierten Gewinn vor der Investition wieder zu erreichen. Das könnte zurückgehen auf die unterschiedliche Wahrnehmung von Opportunitätskosten und pagatorischen Kosten oder eine eher unflexible Natur der Familienarbeit. Strukturelle Einflüsse scheinen bedeutender zu sein für das Herdenwachstum. Hinsichtlich des negativen Effekts der außerlandwirtschaftlichen Arbeit, könnte diese gesehen werden als Befähigung der Betriebe mit außerlandwirtschaftlichem Einkommen eine geringere Arbeitsproduktivität in Kauf zu nehmen. Generell scheinen die sozialen Charakteristika eines Betriebs einen deutlicheren Einfluss auf die Investition zu haben als finanzielle Kennzahlen. Zudem, sollte die Anpassungsphase bei Investitionsplänen berücksichtigt werden.

Mit so langfristigen Investitionen wie Milchviehställen, sind strategische Entscheidungen des Betriebsleiters zusammen mit den Familiencharakteristika möglicherweise bedeutender als finanzielle Indikatoren. Daher sollte zukünftige Forschung zu Investitionen in Milchviehställe auch eine strategische Komponente und soziale Charakteristika beinhalten.

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| | |
|---|---|
| AGIS | Agrarpolitisches Informationssystem |
| AI/FWU | Agricultural Income per Family Working Unit |
| AWU | Annual Working Units |
| BGBB | Bundesgesetz über das Bäuerliche Bodenrecht |
| CHF | Swiss Francs |
| EU | European Union |
| FADN | Farm Accountancy Data Network |
| FLU | Fertilizer produced per Livestock Unit |
| FSO | Federal Statistical Office |
| GDP | Gross Domestic Product |
| ha | Hectare |
| LN | Landwirtschaftliche Nutzfläche |
| LU | Livestock units |
| MAPIS | Melioratios- und Agrarkredit-Projekt-Informations-System |
| MSS | Musculoskeletal Symptoms |
| OECD | Organisation for Economic Co-Operation and Development |
| ÖLN | Ökologischer Leistungsnachweis |
| PSE | Producer Support Estimate |
| UAA | Utilized agricultural area |

LIST OF ABBREVIATIONS

| | |
|---|---|
| U.S. | United States of America |

# 1 GENERAL INTRODUCTION

*"Ever tried. Ever failed. No matter. Try again. Fail again. Fail better"* (Samuel Beckett)

## 1.1 INVESTMENT IN AGRICULTURE

The following sections give an overview over the literature and the theories of agricultural production and point out the particularities of agricultural investments.

### 1.1.1 Specifics of farm investments

In economic theory an investment is seen as putting funds into assets for a longer duration with the objective of achieving a profit. Under the broad range of business decisions on a farm, the decision of an investment plays a particularly important role. Investments are strategic, usually capital intensive and they bear a considerable level of risk and uncertainty (Doluschitz et al., 2011). When analysing farm investments, it has to be taken into account that farms differ in certain ways compared to the rest of the economy. These aspects are further discussed in the following sections.

#### *1.1.1.1 Family labour and opportunity costs*

One unique characteristic is that farms are mainly run as family farms. According to Lowder et al. (2016), the most widely used definition of a family farm is that they use family labour and are managed by family members. Worldwide, this definition applies to about 90 % of all farms. In Switzerland, the Swiss Federal Statistical Office (FSO) found in 2013 that 98 % of all farms were covered by this definition, with 80 % of the workforce being supplied by family labour and one third of them not being paid on a regular basis (FSO, 2014).

As early as in the seventies, Hoglund (1973) predicted that the survival of dairy farms is affected by the efficiency of labour utilization. At this point a trend was seen in the United States (U.S.), that in the future more cows will be held in the more efficient free-stall milking parlour system. Labour cost accounted for 15 to 30 % of the total cost, being the most expensive item (Hoglund, 1973). Also for Switzerland, labour is still the main cost factor, where in the mountain region more than 60 % of full costs are accounted for labour (Lips, 2014). The fact that a large proportion of labour input in Swiss dairy production is unpaid family labour highlights that a considerable proportion of production costs consists of opportunity costs (European Court of Auditors, 2016), since family labour could also be allocated to off-farm activities (Mishra et al., 2002). While unpaid family labour might help to maintain liquidity on the farm, the farmerin the role of an entrepreneur has the task of generating sufficient revenue to cover these opportunity costs in order to strengthen competitiveness. The power distribution of milk producers and milk buyers requires milk producers to improve efficiency and to minimize production costs (Drescher and Maurer, 1999). Since labour might get wooed away in the long run by other industries (Baur, 2000), opportunity costs of labour matter for dairy farms in the long run. Accounting for opportunity cost of labour is a challenging task for the entrepreneur, because opportunity cost is often perceived differently from out-of-pocket cost (Kahneman et al., 1991). The high percentage of family labour input could thus result in economically low-performing farms staying in business, since labour does not necessarily result in out-of-pocket costs.

#### *1.1.1.2 Farm household and off-farm income*

Several authors have taken off-farm work into account when analysing agricultural investments (Weiss, 1999; Foltz and Aldana, 2006; Hennessy and O'Brien, 2008; Olsen and Lund, 2009; Pufahl and Weiss, 2009; Salvioni and Sciulli, 2011). In agricultural economics, farms are often analysed at farm level in absence of farm household data (European Court of Auditors, 2016). However, the perspective of the farm household makes sense, as many farms generate their disposable income not from farm income only. Hennessy and O'Brien (2008) found that in 1995 only for 36.5 % of all Irish farm households, the farmer or spouse was employed in off-farm work. In 2004, this number had gone up to over 50 %. Lips et al. (2013) analysed a sample of Swiss dairy farms in 2008, were 40 % had no involvement in off-farm work at all and 16 % a minor involvement, leaving the remaining 44 % to allocate more than 0.2 full-time equivalent to off-farm work. Interestingly, 80 % of this sample earned a higher income per full-time equivalent off-farm than on the farm. In 2017, off-farm income for all individual farms in Switzerland accounted for almost 33 % of household income (Pfefferli et al., 2018). In an analysis of farms in the canton of Obwalden, Schmid et al. (2015) found on average 50 % of household income to be generated from off-farm activities, while farms differed considerably in size, natural conditions and specialisation. El Benni and Finger (2013a) found for Switzerland that farm income from 1990 through 2009 decreased, while off-farm income in the valley and hill region increased to hold household income stable. While farmers in the hill and valley region compensated this by off-farm income to keep household income stable, this was not achieved by farmers in the mountain region.

Hennessy and O'Brien (2008) use an agricultural household model, based on farm and off-farm income, to explain why investments in Irish dairy farms grew, while real farm incomedecreased. The theoretical rationale behind farm investments funded by off-farm income is postulated to be a substitution effect. As long as work efficiency in the farm can be increased with investments it might be reasonable to do so, if the released labour in the farm can be put to a better paying off-farm work, hence increasing total household income. However, Hennessyand O'Brien (2008) question the need of direct investment from off-farm income since Irish farmers have access to borrowed capital. However, borrowing conditions are not mentioned.

For the more general question of allocation of working hours to on- and off-farm work, without considering investment, O'Brien et al. (2007) use a time-allocation model described by Singh et al. (1986). In this model, the farmer optimizes his utility, derived from purchased goods and leisure, and is affected by age and environmental factors. In this framework, the individual chooses the hours of on-farm work, off-farm work and leisure time till the marginal utility of these hours are equal, while time is a constraint. The decision to participate in off-farm work is binary and depends on the question whether the reservation wage is met. Therefore, factors increasing the off-farm wage relative to the reservation wage are considered to increase the probability for participation in off-farm work (O'Brien et al., 2007). It was also found by Lips et al. (2010) for Switzerland, that the probability of off-farm work increases with the spread of on-farm and off-farm wages. Evidence in the literature suggests that better-educated spouses, smaller farms (Foltz and Aldana, 2006) and older farmers (Lips et al., 2010) increase the probability that off-farm income is obtained. However, the system of on-farm and off-farm work is not readily responsive to changes, since the current situation bears a strong influence on future situations (Weiss, 1997). Weiss (1997) found increasing probability of switching to part-time farming with increasing market wage but an asymmetry the other way around. Hence, with falling market wages the probability of switching into farming was different. When discussing the utility of the farm household, farm income and off-farm income might not be seen as equal substitutes. Carriker et al. (1993) observed that less volatile forms of income from off-farm work or government payments exhibit a larger propensity to be consumed than farm income. Over all farm types and all regions in Swiss FADN (Farm Accountancy Data Network) data, the average amount of direct payments from 2012 through 2014 was 64’000 CHF[1], which is about 50 % of the turnover from animal husbandry as a whole and slightly higher than agricultural income (Schmid and Hoop, 2015). Volatility of farm income as incentive for off-farm work was also found by Weersink et al. (1998). Furthermore, they found that volatility of farm income mainly affects the off-farm working decision of the farmer, while the off-farm working decision of the spouse is mainly affected by family demographics, education level and social support policy. In case of low farm income Weersink et al. (1998) see in off-farm work a way to provide basic necessities for the household while still being able to maintain the farm business. In addition, farming can to some extent be seen as voluntary work. Non-monetary incentives for farming are well established in literature. Mittenzwei and Mann (2017) even see farming more as a lifestyle- than an occupational choice. Strong non-monetary incentives among Swiss dairy farms were found by Lips et al. (2016).

### 1.1.2 Motivation for dairy farm investments

The motivation behind dairy farm investments is usually driven by different factors. Even from the perspective of a single farm, multiple aspects affect the decision. Moreover, factors influencing the sector as a whole can effect investment decisions of a single farmer, too. In the following sections, general drivers behind dairy farm investments are discussed in more detail.

#### *1.1.2.1 Investment goals of individual farms*

The literature provides different motivations for investments by farmers. Many authors have argued that the main motivation of investments in agriculture is to achieve a higher income (Bailey, 1997; Smith et al., 1997; Stahl et al., 1999; Bewley et al., 2001a; Bewley et al., 2001b;

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[1] average exchange rates 2018; 1 CHF = 0.87 Euro = 1.02 USD; https://data.snb.ch, accessed 2 April 2019

Hadley et al., 2002). Another driver for investments can be to improve working conditions (Stahl et al., 1999; Dirksmeyer et al., 2006; Sandbichler et al., 2013; Eidgenössische Finanzkontrolle, 2015b). Not only the farmer aims at a higher income, but also agricultural policy in general for the entirety of farming operations. This is rooted in Article 104 of the Swiss constitution that obliges policy to supplement agricultural income in order to achieve adequate remuneration for the services provided and allows for the subsidisation of investments (Bundesrat, 1999b). Investments often go along with an expansion (Dirksmeyer et al., 2006; Buysse et al., 2011) in order to decrease unit costs and improve competitiveness (Lehenbauer and Oltjen, 1998; Poppe and van Meijl, 2004; Gazzarin and Lips, 2008; Hüttel and Jongeneel, 2011; Wimmer and Sauer, 2016). Increasing farm size may help to reduce unit production costs since large farms are on average more efficient than small farms (Tauer and Mishra, 2006).

Besides the aforementioned motivations for an investment, there might be less tangible reasons. According to Baerenklau (2005), large capital-intensive investments are often linked to neighbourhood effects or peer-group effects. This is in line with Pulfer and Lips (2009) who state that the value set, carried by farmers, favours investments which can readily be seen from the outside.

#### *1.1.2.2 General role of technical progress*

Cochrane's treadmill (Cochrane, 1958) may represent a good explanation for general forces that influence investments in the agricultural sector as a whole. The basic idea behind this concept is that the profit of using a new technology wears away as more and more farmers switch to this new technology. At the beginning, early adopters can benefit from lower unit production costs. But as more and more farmers adopt the new technology, production goes upand prices down, diminishing the advantage of lower production costs. Laggard farmers who stick to the old technology face higher production costs and are inevitably driven out of businessin the long run, making room for other farmers who can take on more land from those who quit.While the initial theory was based on land, Levins and Cochrane (1996) state that expansion ofthe concept towards a technology treadmill is supported by much evidence. Transferred to dairyhousing, this means that farmers quickly need to switch from tied-stall housing to free-stall housing in order to obtain a profit from the utilization of new technology. The results of Wieckand Heckelei (2007) are in line with Cochrane's theory. They found that in the European dairy sector, farms with higher marginal costs dropped out, helping the sector to produce the same amount of milk at lower cost. The Swiss dairy farm sector is likely to fit into this concept, too.

#### *1.1.2.3 Technical progress in dairy farming*

When discussing innovations in agriculture in the more specific matter of dairy farms, the switch from tied-stall housing to free-stall housing represents a major innovation with several advantages. Like Pietola and Heikkilä (2005) observed for Finnish dairy farms, many dairy farms in Switzerland switched from tied-housing to free-stall housing. From 2003 to 2013, the capacity for number of cows held in a tied-housing system declined by around 200’000. Over the same period the capacity for number of cows held in free-stall housing systems grew about 200’000 (Meyre, 2016). The overall capacity in both systems was about 880’000 in 2013 (BFS, 2019b) with about 700’000 dairy cows being held at that point in time (BFS, 2019a). A part of the discrepancy between the capacity and the number of dairy cows held can be explained by the survey asking for capacity while not distinguishing between dairy cows and suckler cows before 2013. In 2013, 95 % of the capacity in tied-stall housing was dedicated to dairy cows. For free-stall housing the share was about 70 % (BFS, 2019b).

The switch to free-stall housing can be seen as substitution of labour through capital (Pietola and Heikkilä, 2005; Luder, 2006), since the reduction in required working hours per cow is considerable (Pfefferli et al., 1994; Bewley et al., 2001c; Schick and Hartmann, 2005; Mayer and Kammel, 2010). Weiss (1999) points out that technical change in agriculture displays a labour-saving bias which results in farms required to grow. However, the required amount of capital can be considerable. Hence, farms have to rely on borrowed capital, although preceding profits may alleviate the switch (Pietola and Heikkilä, 2005). Another advantage of free-stall housing is an improvement of production characteristics. Studies found a positive influence on milk yield (Bewley et al., 2001c; Erzinger et al., 2004), fertility (Bielfeldt et al., 2004) and animal health (reduced lameness) (Bielfeldt et al., 2005).

According to Purvis et al. (1995), dairy farmers switched to free-stall housing in expectation of higher yields. They describe the optimal moment of investment as the point in time when discounted profits exceed sunk costs. This means that even with a not fully depreciated barn, a switch to free-stall housing can be economically reasonable. This is an important aspect, since dairy barn investments have a time horizon of 30 years (Lips et al., 2007). Besides advantages in production, farmers in Switzerland receive 90 CHF of additional direct payments per cow if the cow is kept in a free-stall housing system (Bundesrat, 2013). In addition to these additional direct payments, free-stall housing is also favoured by investment aids. Barns which fulfil the requirements for the payments are granted a premium in subsidies (Bundesrat, 1998c). El Benni et al. (2012b) conclude that these additional direct payments for animals in free-stall housing prefer higher income farmers since they are able to invest in new stabling systems, required to receive those payments. The pressure on tied-housing systems might even build up further in the future. In Austria, several companies have stopped buying milk from farms who keep their cows all year long in a tied-stall system (Liste, 2018) and several companies in Germany pay lower prices for milk produced in such systems (Dorsch, 2021). From the arguments pointed out above it becomes clear, that dairy farms in Switzerland likely have used investments in the past to change their housing system.

#### *1.1.2.4 Economies of scale*

Economies of scale are well established in agricultural economics and might be another important general driver for investments. In the presence of economies of scale, herd size expansion is economically justified. According to Miranda and Schnitkey (1995), fix costs in dairy production account for about 40 % of total production costs of milk and are barely affected by the number of cows held in a barn. Hence, there is an economic incentive to operate a barn at its maximum capacity (Miranda and Schnitkey, 1995). Moser et al. (2015) report that for Austrian dairy farms, investments combined with expansion showed a better economic performance. Cost reduction per unit with economies of scale is well recognized in literature (Poppe and van Meijl, 2004; Hüttel and Jongeneel, 2011; Dong et al., 2016; Wimmer and Sauer, 2016) and can still be found in very large dairy herds (Krpalkova et al., 2016). Economies of scale are also found to be present in Swiss agriculture (Schmid et al., 2015) and are quite large for building costs in the range of a capacity from 30 to 50 cows (Gazzarin and Hilty, 2002). Figures from 70 recent dairy barn projects show building costs per cow-place in Switzerland of around 18’000 CHF (Meili, 2014; Ritter, 2014; Bucheli, 2016). Even if the variation in building cost per cow-place is quite large between same-sized projects, this cost generally decreases for larger sizes of dairy barns. Hence, economies of scale are important for Swiss dairy farm investments.

### 1.1.3 After-effects of the Investment

As pointed out before, forces affecting the farming sector as a whole also may influence the single farm decision for investment. Vice versa, a single farm investment affects the whole farming sector since farms operate on a limited size of land area. The following sections discuss the changes of a farm after investment.

#### *1.1.3.1 Farm growth*

Technical progress and economies of scale have been discussed in the previous sections 1.1.2.3 and 1.1.2.4. Both can be implemented on the farm with investments. Among German farmers with recent investments in farm buildings, Ebers and Forstner (2007) found that half of the farms pursued the target of farm growth. Despite considerable growth in the past, more than 70 % of the interviewed farm managers in West Germany would have preferred to enlarge the farm even more than was done by the investment.

A frequent measure of farm size in the literature is agricultural land. For Switzerland, utilized agricultural area (UAA) was found to be the main factor influencing earned income on farms (Ferjani and Köhler, 2007; El Benni et al., 2012b). The European FADN data system uses standard output to assess the economic size of a farm (European Commission, 2014; Renner et al., 2018). Like UAA, economic farm size in terms of standard output influences earned income in Switzerland (Roesch, 2015). However, Roesch (2015) calculated standard output based on livestock and UAA, since Swiss FADN data do not contain standard output as a variable. Livestock is another physical measure of farm size. In order to obtain a normalized measure, the number of livestock in agricultural statistics is measured in livestock units with livestock units being derived by means of conversion factors based on the number of animals held in each of several categories (Bundesrat, 1998a).

In investment literature, capital measures play a crucial role, since they are commonly used as an indicator for access to borrowed capital. A prominent measure is equity. According to Anastassiadis and Musshoff (2014), investments reduce financial flexibility since equity is usually at least partly used to finance investments. In addition, equity usually serves as collateral in securing borrowed capital. It should be noted, however, that borrowing for farms exhibits some differences in Switzerland compared to other countries. The maximum credit sum, granted by banks, is restricted to the earning value. This value is estimated for each farm individually based on a taxonomy issued by the government and will be described in more detail in section 1.3.2. Drawing on the borrowing restriction on initial farm size, this also limits the maximum growth step. Weiss (1999) tested for the presence of Gibrat's law of proportional growth in farms in upper Austria. According to Gibrat's law, growth rates are determined by random factors independently from initial size. Weiss (1999) found that besides initial farm size, also age, schooling, sex of the farm manager, family size and off-farm work influence farm growth rates. As mentioned before, investments in farm buildings very often coincide withan enlargement of the farm.

Moreover, investments are also strategic decisions (Kis Csatari and Keszthelyi, 2016). The investment decision could therefore be linked to size and future of the farm. Poppe and Vrolijk (2005) state that non-investing farms may over time become too small in relation to other farms and are more likely to be taken over. For Switzerland, Meier et al. (2009) state that larger farms are more likely to be taken over, small farms more likely to exit. Glauben et al. (2002) see the direction of cause and effect of small farms less likely to be taken over the other way around than Poppe and Vrolijk (2005). In their point of view, farmers without a successor lose motivation for further farm expansion. While a relationship inevitably exists, the direction of cause and effect might not be straightforward and rather depend on the individual situation. For example, in a situation where farm growth is not possible given the farm's environment, a successor might decline to take over the farm due to lack of promising prospects. In another situation, if the potential successor opts for a different career, the farmer might decline to expand the farm even if reasonable opportunities exist. In this respect, farm growth via investment would be a way to secure the farm's long-term survival.

#### *1.1.3.2 Herd expansion*

For dairy farming, farm growth is inevitably followed by herd size growth. The question arises if and why a considerable delay in herd expansion after investment might occur. Such delay is not evidenced in the U.S., where studies point to immediate increase in herd size (Hadley et al., 2002), partly based on purchased animals (Faust et al., 2001). Moreover, Faust et al. (2001) state that farmers who recently invested in a barn recommend to budget expenses for additional dairy cows. In a survey which formed part of their study, creditors and farm managers considered an immediate full utilization of the new dairy barn as a necessary condition to meet debt service requirements. Farm structure in Europe being quite different might help explain why European studies do find a delayed herd expansion after investment (Sauer and Zilberman, 2012; Kirchweger and Kantelhardt, 2015). Bierlen et al. (1998) found that livestock and high-debt farms are more sensitive to inventory investments when cash flow shocks occur. Transferred to investing dairy farms, this might indicate dependence on cash flow when the dairy herd is supposed to be expanded. According to Chavas and Klemme (1986), farms respond to high prices in the long term with increased herd size, while it is difficult to restrict over-supply once the capacity is reached.

A dairy herd is subject to a rather dynamic nature. Old cows are culled, while younger cows enter the herd. A change in herd size alters the established relation of entering and culled cows. Hence, an investment has an effect on the replacement rate. Usually, the peak of milkproduction is reached in the third or fourth lactation of a dairy cow (Miranda and Schnitkey, 1995). Profitability is thus likely to be hampered if the share of young cows in a herd increases. However, according to Miranda and Schnitkey (1995) there is a discrepancy between the optimal replacement rate, calculated by economists, and the replacement rates observed on practical farms. Balaine et al. (1981b) mention that profitability was found to be improved when herd life was increased beyond 4.3 lactations on average.

#### *1.1.3.3 Land mobility*

Structural change and the accompanied land mobility have been discussed in the literature (Hüttel and Margarian, 2009; Zimmermann and Heckelei, 2012). Kirchweger and Kantelhardt (2015) found increasing acreage of cattle farms after investment. Bewley et al. (2001b) found that their sample of U.S. dairy farms held more cows per ha after investment. Hence, herd size was expanded more rapidly than acreage. Because of roughage production, dairy farming is linked closer to acreage, since roughage is generally low in energy density. Therefore, it is not as suitable for transportation as concentrates. In addition, when farms in Switzerland apply for direct payments, they have to keep the maximum number of livestock per ha under a certain threshold (El Benni and Finger, 2013b). Hüttel and Margarian (2009) state, that farmers have to anticipate the strategies of the neighbouring farms in their strategic decisions. Therefore, the expected mobility of land might be important factor about the investment decision in general and the size of the investment in detail.

#### *1.1.3.4 Path dependence*

The concept of path dependence might not only be seen as the consequence of an investment but also its prelude. It has been applied to the persistence of several technologies (Theuvsen, 2004). According to Theuvsen (2004), path dependence is caused by positive feedback and a following locked-in effect which hinders a technology change due to prohibitively high costs. Yet, path dependence is not necessarily associated with inefficiencies and a certain path can be overcome by innovation. In the light of investments, the concept of path dependence is of importance since investment decisions produce different results when sunken costs are present (Balmann et al., 1996). According to Chavas (1994), sunken costs are already created with transaction costs that come with investment. Balmann et al. (1996) state that the gains of a new technology are at least to exceed the sunken costs of the technology used in order to represent an incentive for technology change. Otherwise, a locked-in effect occurs. They hypothesize that sunken costs of agricultural training alter the opportunity costs of labour. Since training already represents sunken costs, an investment decision later on can be economically favourable even if opportunity costs for labour are not remunerated for. Also Mann and Mante (2004) argue with sunken costs already being created with agricultural training and experience. These sunkencosts are offered by Balmann et al. (1996) as an explanation that structural change does not occur at a higher rate.

When costs are sunken, it is economically reasonable to stay in production as long as fixed costs are at least partly covered (Odening and Balmann, 2001). In addition, Bozic et al. (2012) state that farms decline to reduce production when margins are diminishing and herd size adjustment can only be a medium- or long-term reaction to price shocks.

An investment in a dairy barn in Switzerland should be considered as sunken costs since buildings with specific use are only of interest to a limited market. If the theory of path dependence is applied, this means that prior to an investment a junction exists where the fate of a farm could go into different directions. After the investment, farmers are forced to stick to their production even with low profitability since sunken costs represent a high burden to exit. This sheds light on the importance of an investment into a dairy barn within the life cycle of a dairy farmer. The implication for this work is twofold. When analysing the development of farms, the locked-in effect must be considered. The second implication is that investments in dairy barns are more likely to be carried out by farms that are already specialized in dairy farming to a large extent, i.e. to a lesser degree by more diversified farms.

## 1.2 DAIRY SECTOR IN SWITZERLAND

In the following sections the dairy sector in Switzerland is described in more detail. The market regime for dairy farming has undergone major changes in the last decades.

### 1.2.1 Structure of the Swiss dairy sector

In 2017, there were 20’357 dairy farms in Switzerland (Leuenberger, 2018). According to the Association of Swiss Milk Producers (SMP), one third of Swiss milk production is processed into cheese by 600 commercial cheese factories. The other two thirds are processed into different dairy products by 90 dairy plants, which comprise a share of 90 % of the milk which is processed to other products than raw milk cheese (Swiss Milk Producers, 2019). The process of selling milk is highly standardized, as payment is based on standard requirements of quality and ingredients with premiums or deductions for deviations from these requirements. Some product differentiation is possible through cheese production. Lehenbauer and Oltjen (1998) see dairy producers in the position of a price taker, since - as actors in a competitive market - they have limited possibilities to manage the selling price of milk. As a result, dairy producers seek to increase profit through expansion and improved production efficiency (Lehenbauer and Oltjen, 1998). This also holds true for the market environment of Swiss milk producers, which is governed by structural change and the total amount of milk produced. Expanding dairy farms more than compensated for the capacity of farms dropping out of dairying. The amount of milk produced by one farm on average doubled from 80'000 kg in 2000 to 160'000 kg in 2017 (Leuenberger, 2018). The total amount of milk produced in Switzerland grew from around 3.2 million tons in 2000 up to more than 3.4 million tons in 2010 and was kept rather stable from then on with a peak in 2015 (Leuenberger, 2018). Over the same period, the number of milk producers (i.e. dairy farms) kept declining, e.g. for the valley region from 20'771 farms in 2000 to 10'668 farms in 2017. The development of the Swiss dairy sector illustrates that investments of the remaining farms are important to expand production. Furthermore, investments in dairy barns might be necessary to meet the demand of food retailers for animal-friendly housing (El Benni, 2013). On this subject Balmann et al. (2016) argue that because of concentration processes, retailers are large enough to employ corporate social responsibility in order to contribute to their branding. As a side effect, increased quality requirements are passed onto producers who need to adapt to these requirements in order to stay in business.

### 1.2.2 Milk quota

Just like milk producers in the European Union, milk producers in Switzerland were restricted in their production by milk quotas. From 1999 on it was possible to lease or buy quotas which caused a considerable increase of milk production per farm (Hausheer Schnider and Schmid, 2011). For many producers, milk quotas represent a golden handshake (Richards, 1996) which sweetened the exit for farmers who were able to sell production rights they initially were granted by law for free. In Germany, milk quota abolishment was negatively perceived by farmers prior to quota phasing-out, while growth intentions were not exclusively expressed by large farms (Rothfuß et al., 2009). Anticipating an increasing supply, production expansion in order to reduce costs was mainly seen as the strategy to respond to quota abolishment (Doluschitz, 2009). In contrast to the milk quota in the European Union, the Swiss quota system was abandoned earlier on over a longer time span. Swiss milk quotas were tradeable between farmers from 2000 onwards, and the Swiss Parliament decided abolishment in 2003. Between 2006 and 2009 dairy farmers were allowed to exit the quota system by joining a producer organisation or a milk processor organization and enter a contract specifying price and quantity (El Benni and Finger, 2013b). This allowed farms to increase their production which caused an overall increase in Swiss milk production, as the time of phasing-out coincided with a boom in world milk markets with high dairy prices also in Switzerland (Mann and Gairing, 2011). Because of the voluntary phasing-out, 63 % of milk producers, representing 73 % of the milk produced, exited the system at the first opportunity. Although prices declined from the year 2009 onwards, production did not decrease (Finger et al., 2013). From a theoretical perspective, milk quotas impose structural rigidity since growing farms have to pay for quotas from exiting farms increasing their costs of growth. In contrast to this view, Hüttel and Jongeneel (2011) found no evidence of such rigidity when comparing German and Dutch farm structure from the pre-quota period to the quota-period. Milk-quota phasing-out in Switzerland has definitely been a crucial event for dairy farms. However, Mann and Gairing (2011) interpret the follow-up system of payments based on A- and B-prices as a hint that the protagonists still were thinking in terms of quotas.

### 1.2.3 Structural change

The declining number of farms has consequences for the farming sector as a whole. According to Baur (2000), agriculture in Switzerland has a small-scale structure and is labour- and capital-intensive because of slow structural change. The view of the structural change being too slow is shared by Baltensweiler and Erdin (2005). They argue that well-structured farms rather put labour into off-farm jobs than expand the farm. Structural change is closely linked to technical progress. Cross (2001) observed, that the number of Amish dairy farmers in Wisconsin is stable and attributes this to the fact that they decline to use labour-saving technology and do not aim at profit maximization. Drescher and Maurer (1999) interpret competitiveness as the ability to withstand structural change because it reflects the ability of a firm to protect or improve the position on the market in relation to its competitors. According to Balmann et al. (2006), structural change is not a win-win situation but rather the answer to the question who wins and can stay in business and who is pushed out of business. They argue that farms are locked in because of sunken costs leading to a ruinous competition with prices not covering the full costs of production. Investments interact with structural change since they influence competitiveness via the implementation of technical progress and growth.

## 1.3 FARM SUPPORT IN SWITZERLAND

The following section describes agricultural support in a general and agricultural investment support specifically. Decoupled agricultural payments play an important role for agricultural income (chapter 1.1.1.2) and in this context also for investments. Agricultural investment support is crucial for dairy barn investment. Because of these facts, both kinds of support are described in the following sections in more detail.

### 1.3.1 General level of farm support in Switzerland

Agricultural policy in Switzerland is enshrined in the most fundamental legal regulation, the Swiss constitution. As early as 1951, the constitution proclaimed with article 29 the policy goal of cost-covering prices for agricultural products in order to allow farmers a comparable income to other sectors. In 1996, a public initiative and the subsequent poll led to the new agricultural article 104, which is currently applicable (Popp, 2013).

Switzerland exhibits one of the highest farm support levels in the world. The Organisation for Economic Co-operation and Development (OECD) has defined different measures to compare agricultural support between countries, where agricultural support is defined as the annual monetary value of gross transfers to agriculture from consumers and taxpayers. The PSE indicator is defined as the agricultural support in terms of percentage share of gross farm receipts (OECD, 2018a). According to data from the OECD, the Producer Support Estimate (PSE) in Switzerland was three times higher than the average of OECD countries in the 2015-17 period, with 50 % of this support being direct payments (OECD, 2018b). The development of this indicator is presented in Figure 1.

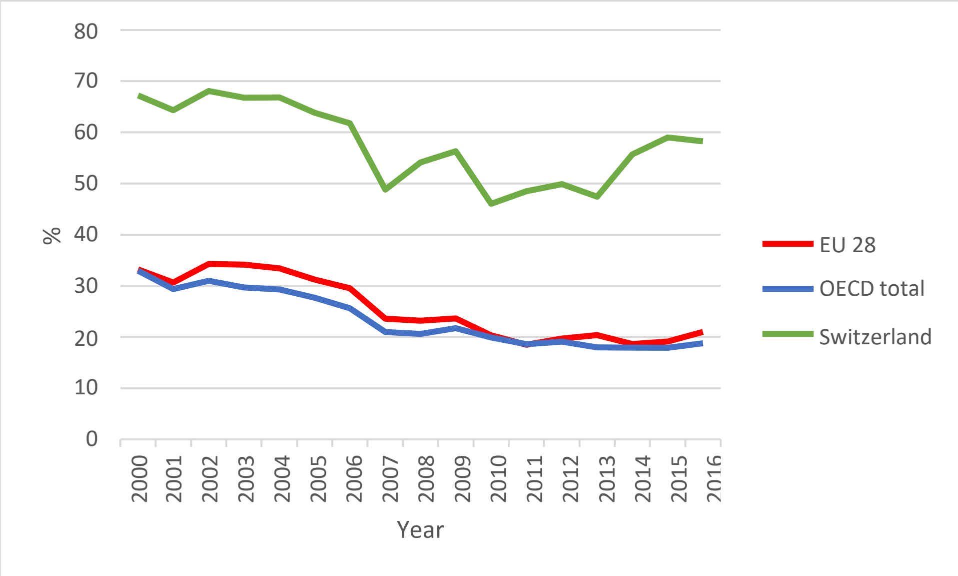


Figure 1: Development of Producer Support Estimate (PSE), Source: own visualisation based on data from OECD (2018b).

The PSE generally declined in Switzerland, the European Union (EU) and the OECD countries on average until about 2010, when EU and OECD countries reach a plateau. That the PSE increased later on for Switzerland might be caused by the abandonment of the fixed minimum exchange rate of the Swiss Franc (CHF) to the Euro by the Swiss National Bank in 2015 which causes border protection to be at a higher monetary value. Since PSE is expressed in relation to gross farm receipts, the index is influenced by commodity prices. Figure 1 emphasizes the substantially higher level of PSE in Switzerland compared to the OECD average and the geographic neighbours in the EU. From OECD countries, only Norway, Iceland, Japan and Korea show a similarly high level for the PSE index (OECD, 2018b).

Besides direct monetary transfers to agriculture, another major part of agricultural support consists of border control for agricultural products. Trade barriers for incoming products translate into higher prices for domestic producers if domestic market prices are above international market levels, which is generally the case in Switzerland. The OECD defines a coefficient of market price received by producers, measured at the farm gate, and international market prices. This measure has substantially declined in the early 2000s, shown in Figure 2.

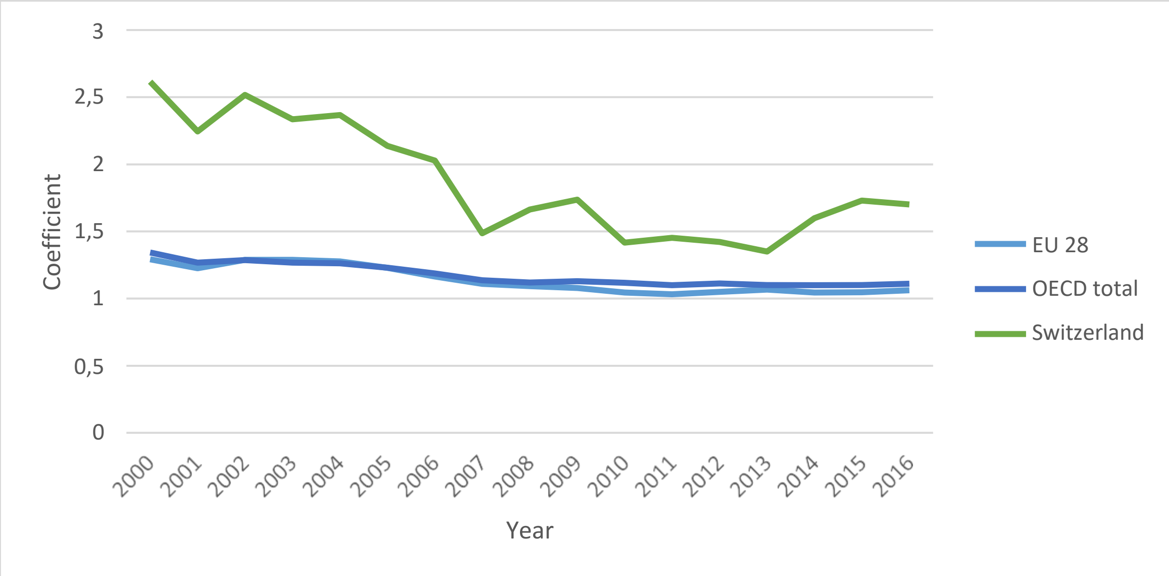


Figure 2: Producer Protection Ratio (domestic price to international price), Source: own visualisation based on data from OECD (2018b)

Although the border protection in Switzerland has been lowered, it is still considerably higher than the OECD or EU average. Yet, it becomes clear that also the role of agricultural policy is very important and decisive for a farm's strategy. The PSE above 50 % of farm gate prices implies a strong influence of agricultural policy on the future strategy of the farms. Agricultural policy in Switzerland is directed by a wealth of legal regulations. The most important ones for dairy farm investment are described in the following sections.

### 1.3.2 Agricultural investment support

Originating from article 104 in the Swiss constitution, a wider legal framework for investment support has been passed, the Agricultural Act, which describes investment support in greater detail. As instruments facilitating investments in agriculture, non-repayable loans or investment loans are provided (Bundesrat, 1998b). The Agricultural Act defines the goals of investment aids. The first two goals are to lower production costs through basic improvements to the farm and to improve living and economic conditions in rural areas. How to apply these instruments in practice is prescribed in the regulation for structural improvement (Bundesrat, 1998c). Non-repayable loans are only assigned to projects in the hill and mountain region. In addition to the non-repayable loans, investment loans can be approved in this area. For the valley region, only investment loans are applicable (Bundesrat, 1998c). The distribution of funds is organized by cantonal institutions (province level). Prior to the granting of the loan, the eligibility for investment support of the respective farm is examined. Legal regulations impose that farms meet several requirements, among them a business plan for the investment, adequate UAA for the amount of livestock held, and education of the farmer (Bundesrat, 1998c).

From 2003 through 2014, the investment loans granted per year for the whole country were on average on 123 million CHF, ranging from a low of 100 million CHF in 2006 to a high of more than 140 million in 2008. The numbers are visualized in more detail in Figure 3.

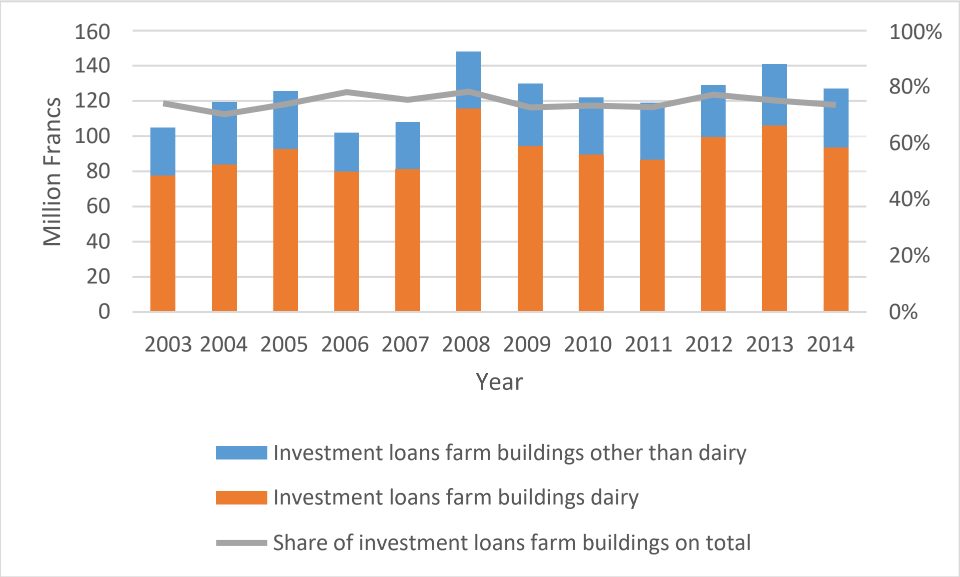


Figure 3: Million Swiss Francs (CHF) spent on investment loans on farm buildings in total for dairy farm buildings. Source: own calculations based on agricultural reports of the corresponding year and data from the Meliorations- und Agrarkredit-Projekt-Informations-System (MAPIS), where all investment loans are registered.

As can be seen from Figure 3, the vast majority of investment loans for farm buildings is granted for dairy buildings with an average share of 75 %. Some of the remaining 25 % could still be used up by dairy farms for other buildings, not necessarily linked to dairy production.

From the bare numbers, agricultural investment support seems negligible in Swiss agricultural budget compared to direct payments. With an average of 2’644 million CHF between 2003 and 2014 (BLW, 2003), direct payments were about twenty times larger than spending on investment support. Though, investment support can facilitate investment and therefore nudge farmers into the related decisions, hence it might contribute to decisions with long-term impact on farms. In addition, the total amount of investment support is directed towards a small proportion of farms, while direct payments apply to literally al farms.

Investment loans are – in contrast to non-repayable loans - available in all regions. The decisive advantage is that they come free of interest. This means that the value of this subsidy depends on the interest rates a farmer would have to pay in the capital market. Given that the cost of borrowed capital differs between farms, the value of this support instrument differs between farms, too. The ten-year interest rate could be used as proxy to derive an overall value for the subsidy. This interest rate declined from a high of more than 2.9 % in 2008 to a low of less than 0.7 % in 2012. The development from 2003 through 2014 is shown in Figure 4.

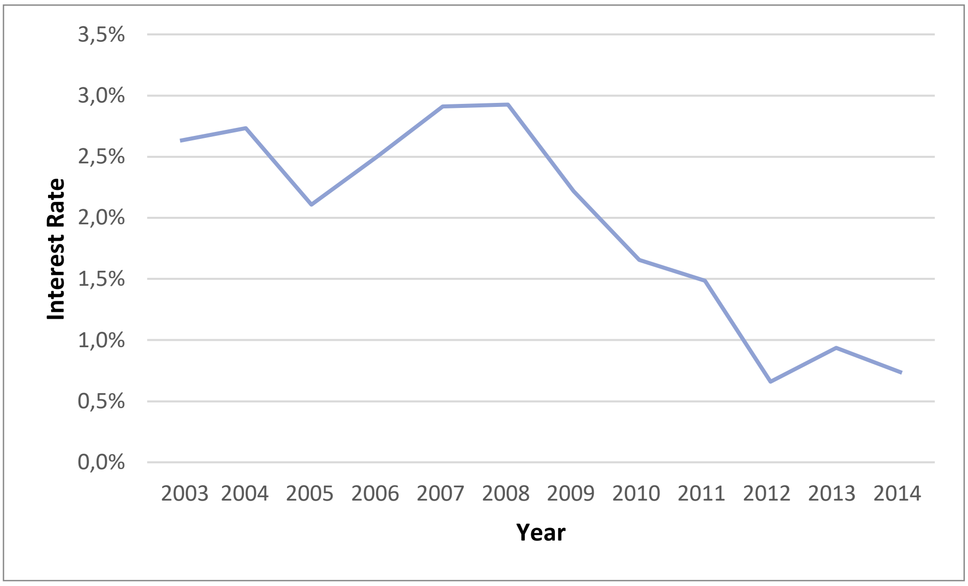


Figure 4: Interest rate of Swiss government bonds with a duration of ten years. Source: Own visualisation based on data from Swiss National Bank (SNB, 2018).

Despite the considerable decline in interest rates of 10-year Swiss government bonds over the 12-year period, this does not mean that it is concomitant with adverse selection of only farms applying with poor access to capital markets. Interest-free loans are economically favourable as long as interests are not negative. Besides low interest rates, investment loans are favourable because of legal regulation. Lending in Swiss agriculture is highly regulated by the Federal Act on Rural Land Law (Bundesrat, 1991). Mortgages are only allowed up to a certain limit in order to protect farms from excessive debt. According to Article 73 (BGBB), the amount of all mortgages on a farm is not allowed to exceed 135 % of the earnings value of a farm (Bundesrat, 1991). Investment loans are an exception, in that they are allowed to surpass this borrowing limit. These official earnings values underestimate the true earning values of a farm (Dieterle, 2019), hence also restrict borrowing capital from banks. According to verbal information from practitioners at the Swissmelio conference in 2017 (Personal Communication, 2017), the majority of all larger projects of dairy barns are at least partly financed by investment loans. In addition to the aforementioned advantages of investment loans, the expertise of the employees in the cantonal lending institutions might be very valuable for investments of dairy barns and for the farmer undertaking such investment.

## 1.4 RESEARCH MOTIVATION

It has been highlighted that investments in dairy barns interact with income- and other goals, strategic decisions, productivity growth, implementation of technical change, structural change, family characteristics and other factors. Based on the considerations of sunken costs as a result of specific investments, causing a locked-in effect (cf. Chapter 1.1.3.3 above), investments in dairy barns are a milestone in the life cycle of a dairy farmer and might even be seen as a fateful decision.

Existing studies on dairy investments are either considering a rather short-term period (Hadley et al., 2002) or not able to take into account the monetary side (Kirchweger and Kantelhardt, 2015) of consequences of the decision.

When discussing political measures for productivity increases in Swiss agriculture, Flury et al. (2016) attribute a larger leverage effect to investment support than to direct payments. Agricultural policy is mandated to improve competitiveness and the living situation for farm families. Policy makers therefore have a fundamental interest in the observation of the development of investing farms, since this could allow for conclusions on the success of political measures. Since dairy farms are price takers (Lehenbauer and Oltjen, 1998), a competitive edge comes from unit production cost reduction. A better living situation can result from a higher household income, resulting from higher farm or off-farm income. Either one requires a better work utilization as long as labor per household is restricted. Farm income is directly linked to production costs since in a price taker environment unit production costs must be lowered to achieve a higher income. This leads to the assumption that analysis of profitability as a central variable allows for meaningful conclusions.

The analysis of profitability is more complex than the analysis of pure farm income, since it considers all input factors. Swiss agricultural policy is mandated to create conditions which enable farmers to achieve an earned income comparable to the income in other sectors on the same qualification level (Bundesrat, 1998b). To monitor the success of agricultural policy in this respect, an evaluation frame was introduced which takes into account opportunity costs (Bundesrat, 1999a). This leads to the first research question:

1. Has the investment lead to an improvement in profitability?

Differences in profitability of different farms in Switzerland are quite large. For example, the earned income per full time worker for the 25 % highest-performing farms in 2017 was about 2.5 times the earned income in the 25 % lowest-performing farms (Pfefferli et al., 2018). Earned income per full time worker is directly linked to profitability with the distinction that the residual income is divided per full time worker without taking opportunity costs for labor into account. There is no reason to expect that differences between investing farms are substantially lower than for the totality of farms. For farmers as well as policy makers, it is of high importance to know what the success factors of investments in dairy barns are. Results could assist both groups and help to build a better ground for the profound decisions in their day-to-day operations. The second research question is formulated as:

2. What are the factors featuring a successful investment?

The following visualization gives an overview on the different chapters, included in this dissertation and which research question they seek to answer.


Figure 5: Visualisation of the assignment of different chapters to the respective research question. Source: Own visualisation.

The dashed line in Figure 5 indicates a relationship to both research questions. Chapter 2 deals with profitability and herd size change. The probability of investment (chapter 3) is a somewhat minor intermediate step between research question 1 and 2, which seeks to improve the understanding which farms are investing in dairy barns. Chapter 4 and chapter 5 aim at identifying the factors of success for a dairy barn investment, hence research question 2.

## 1.5 SAMPLE DESCRIPTION

This section gives an overview on the statistical background and advantages of Swiss FADN-data and describes the dataset. Furthermore, the supplemental data of the MAPIS dataset is described.

### 1.5.1 Statistical Background and Swiss FADN-Data

An advantage compared to FADN data from other European Countries is that Swiss data contains information on off-farm income (European Court of Auditors, 2016). For the analysis in this work, the twelve-year period from 2003 to 2014 is used. This period is used, since the data collecting system did not change over this time (Renner et al., 2018), making these years comparable to each other. About 3’000 individual farms are sampled each year, with a fluctuation from 2’395 to 3’376 individual farms. As some farms enter the panel, while others drop out, the number of farms is not constant (Hoop and Schmid, 2015). Attrition is a well-known phenomenon in panel data. With every year of duration, an individual’s propensity to continue participation decreases (Baltagi, 2013). Baltagi (2013) points to literature, which has analyzed panel data attrition with the result that even serious attrition did not affect the representativeness considerably. Although some statistical analyzing techniques are limited to a balanced panel, where each individual participates each year, a considerable number of techniques allows to analyze unbalanced panels.

The statistical acquisition of farm data in Switzerland distinguishes between six different production zones in respect to their natural conditions (Bundesrat, 1998d). Swiss FADN data assigns these six production zones into three regions; the valley, hill, and mountain region. Analyses in the following chapters are based on data from the valley and hill region, because the mountain region differs significantly in terms of natural conditions, which would require to control for those differences in the analysis. The largest number of farms in the FADN sample is in the valley region. For the period 2012-2014, on average 1’116 farms were located in the valley region, 832 in the hill region and the remaining 718 farms in the mountain region. The largest group in respect to farm type was dairy farming, accounting for 37 % or 998 farms in the 2012-2014 period. The fairly closely related dairy farms combined with arable farming were represented with 185 farms (Hoop and Schmid, 2015). Key characteristics of the farming type dairy farming in Switzerland are more than 75 % of all livestock units (LU) being cattle, of which more than 25 % being dairy cows and less than 25 % suckler cows. The same definition applies to combined dairy/arable crops farms except for the part of less than 25 % of the farmed UAA being allowed for crop production at a pure dairy farm, while for a combined dairy/arable crops farms the latter amount has to exceed 40 % (Hoop and Schmid, 2015).

### 1.5.2 MAPIS dataset

Detailed information on interest-free loans is not a part of Swiss FADN data. Only the balance of the current year in three different categories can be obtained, one of them being investment loans granted for farm buildings. No information is available on non-repayable investment aids, since the acquisition value is reduced for the amount of subsidies (Agroscope, 2014). While an increase of the balance for interest-free loans for farm buildings, if the farm is surveyed in two subsequent years, indicates that a new loan is granted, this does necessarily mean a dairy barn investment occurred.

All investment support that is granted to Swiss farms is registered in detail in the MAPIS dataset. Since the Swiss government grants subsidies for structural improvement and social support measures (Bundesrat, 1998b) information about them needs to be gathered for execution. Therefore, the cantonal lending institutions collect data on farm, farmer and finance, especially about the governmental support (Bundesrat, 2014). In more detail the datasetcontains information about the community where the farm is located, the year the subsidy wasgranted, type of subsidy, amount of subsidy and data on UAA, livestock units held. Based on our observations, data on livestock units and UAA differ considerably to the numbers in FADN. However, community, year and amount of investment year correspond well to each other in both datasets. Therefore, matches based on these three variables are very reliable farms, who have invested in a dairy barn.

### 1.5.3 AGIS dataset

To analyze and evaluate direct payments, Swiss administration uses a dataset that comprises data of structural variables of all farm which perceive direct payments. According to BLW (2015), 47,600 farms in 2014 were registered to meet the requirements of the “Ökologischer Leistungsnachweis”, which is a prerequisite for direct payments. From a total of54,046 farms in 2014, 5,615 farms were in the range of 0-3 ha. Therefore, AGIS data can be considered as reflecting the total Swiss farm structure. The AGIS dataset used, comprised dataon farm ID, municipality, acreage, animals, and work force on the farm.

### 1.5.4 Sample used for analyses

For the analysis, a unique dataset is constructed. For chapter 2 and chapter 4, FADN data and MAPIS data is matched. In contrast to other authors who employed a probabilistic matching (Eidgenössische Finanzkontrolle, 2015a), the reliance on only well responding variables in both datasets allows to identify farms that have definitely invested in a dairy barn. Furthermore, Swiss FADN data allows drawing conclusions on the interaction of dairy barn investment and off-farm income.

The sample on identified investing farms from FADN and MAPIS data, comprises 792 observations on 103 farms. On average, these farms participated in the sample for 7.7 years. 570 observations come from dairy farms, while 222 come from combined dairy/arable crops farms. Originating from the valley region are 401 observations and 391 observations from the hill region. Central variable in the analysis is years after investment,since the focus of research is on the development of these farms after investment. It is importantto consider that panel attrition causes the number of observations to decline with increasing periods of participation. This is decline is shown in the following Figure 6.

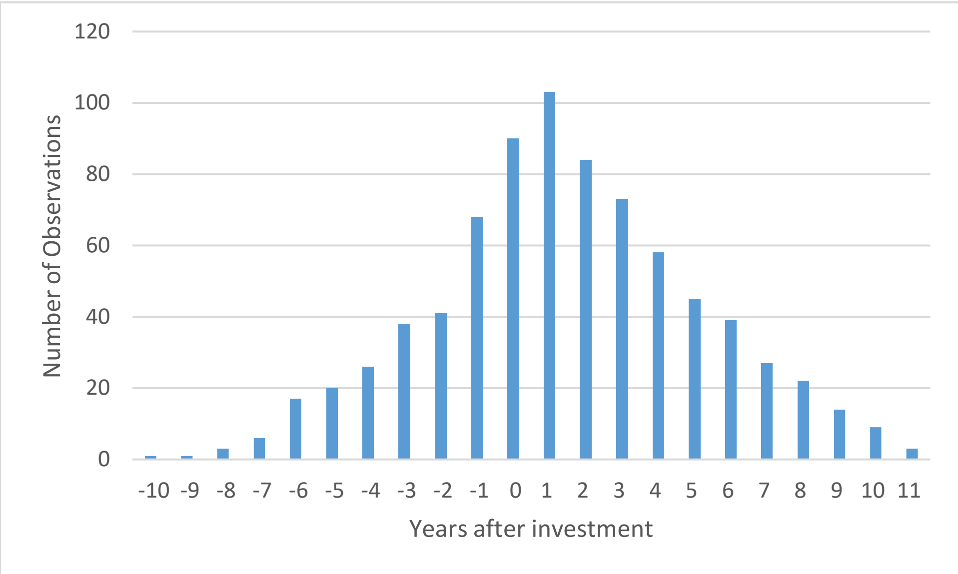


Figure 6: Number of observations in dependence of years after investment. Source: Own calculations based on the FADN data and MAPIS data used.

Year 0 is considered the year before investment, year one as the year of investment when the investment loan was granted. The number of observations in year 0 and year 1 differs slightly, since MAPIS allowed for a few investments being identified without the representation of a year 0 in FADN data. It is sometimes overlooked that the cut-off of the observation period in 2014 results in investment having occurred earlier in time the later the observation after investment is. For example, an observation in year 6 after investment implies that the investment has occurred in year 2008 the latest, since year 6 in this example can be no later than 2014, the latest year within the period considered. With each additional period of analysis, the number of observations decreases, causing results to be less robust. The larger the number of observations is, the smaller differences have to be in order to be found statistically significant and vice versa. Indeed, one has to distinguish between statistically and economically significant results (Rommel and Weltin, 2017). This can be done when analysing the periods close to investments with more observations.

With milk-quota phasing-out, the observation period comprises a drastic event which had an undoubted influence on dairy farming. The further away in the future the observation from investment, the more likely it is that investment occurred before quota abolishment. In order to prevent results from being biased by quota abolishment, it is important that investments occurred fairly evenly over time. Years of investments in the sample are shown in Figure 7.

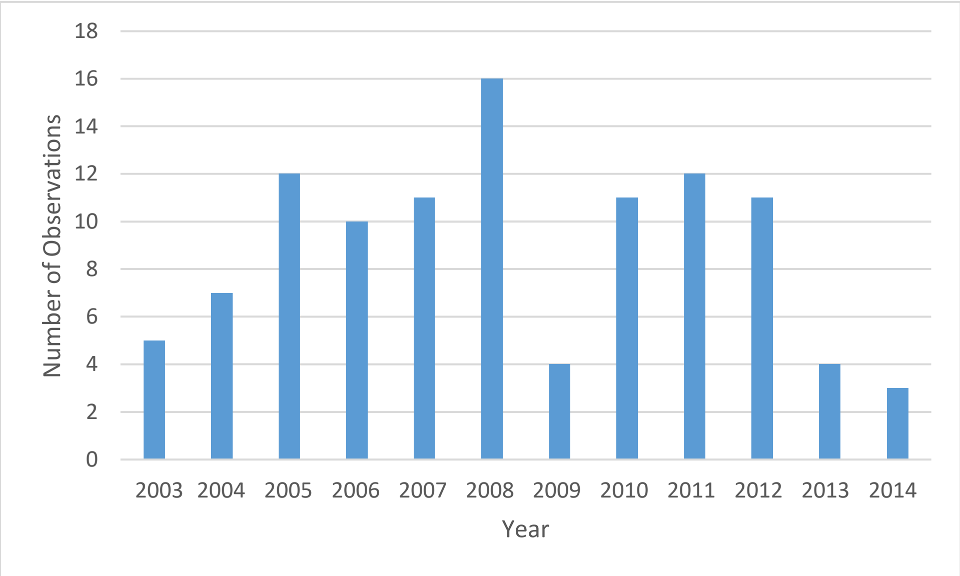


Figure 7: Number of investments in each year of observation. Source: Own visualisation based on the sample used.

As can be seen from Figure 7, fluctuations over different years occurred but they do not indicate a systematic difference between the period before quota phasing-out and after.

A central dependent variable in the analysis is calculated profit, since the development of profitability is of special interest because it allows for the incorporation of opportunity costs. Calculated profit is a variable that originates from the concept of assigning opportunity cost to all input factors (Bundesrat, 1999a). While opportunity cost for own land is valued as capital with interest rates derived from Swiss government bonds, family labor is assessed on the basis of the Swiss Earnings Structure Survey (Bundesrat, 1999a). This survey is a fairly detailed survey on the wage structure of the secondary and tertiary sector. Among other variables, education, working hours or region are surveyed (FSO, 2012), which serves as a robust basis for the construction of an agricultural reference wage.

For chapter 3 and chapter 5, the database is altered. For chapter 3, the sample is extended and rearranged. In order to characterize investing farms in respect to all farms in terms of investment probability, all dairy farms and combined dairy/arable crops farms the valley and hill region are included. Moreover, observations of investing farms after the investment are excluded. Several economic variables of a farm are severely influenced by a major investment like a dairy barn. This leads to a sample with an extreme distribution of the dependent variable. The implications for interpretation are discussed in detail in chapter 3.

For chapter 5, additional data from the AGIS dataset is used. Because of data privacy reasons, direct matching of AGIS data to the existing dataset is not possible. Therefore, the dataset is used to derive indices like a Gini-coefficient. In addition, the number of subsidized projects within a municipality over the observed period is possible. This allows for a unique dataset which takes the distribution of acreage between farms on the detailed municipality level into account.

# 2 SHORT AND MEDIUM-TERM IMPACT OF DAIRY BARN INVESTMENT ON PROFITABILITY AND HERD SIZE IN SWITZERLAND

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**Keywords**: farm growth, fixed-effects, investment support, opportunity cost quota abolishment

**Abstract**

Investing in larger barns and increasing herd size are crucial milestones in dairy production. Based on the Swiss Farm Accountancy Data Network and data on government-supported investments, we investigate the development of two key variables over the first eight years after investment: change in herd size and calculated profit, that is, farm income minus opportunity costs for family labor and capital. We apply a fixed-effects panel regression and test for autocorrelation present in the time series. Compared to the year before the investment, calculated profit decreases in the first three years, while in the remaining years no significant difference compared to the year before investment can be seen. Herd size increases slowly, predominantly in the second and third years after investment, to some extent explaining the less favorable development of profitability in these years. We conclude that investment in a dairy barn does not lead to improved profitability in the short and medium-term, pointing to the question of whether this picture changes in the long-term.

## 2.1 INTRODUCTION

Investing in larger barns and increasing herd size are crucial milestones in dairy production. Furthermore, in Switzerland the government supports such investment by providing interest-free loans.

In dairy farming, economies of scale exist (Hüttel and Jongeneel, 2011; Hoop et al., 2015;) and technical progress has led to a considerable improvement of labor productivity (Schick and Hartmann, 2005). As a result, investments in dairy barns usually lead to an increase in capacity compared to the pre-investment situation and therefore allow dairy herds to grow. In addition, technical progress and the obligation to increase animal welfare has triggered a comprehensive shift from stanchion to free stall barns, although these require more capital (Pietola and Heikkilä, 2005).

Farmers consider the full utilization of their barn capacity as necessary to meet loan repayment requirements (Faust et al., 2001), but while US farmers make use of their additional capacity immediately (Stahl et al., 1999; Faust et al., 2001), studies in Denmark and Austria have shown a rather slow and constant increase (Kirchweger and Kantelhardt, 2015; Sauer and Zilberman, 2012). Hüttel and Jongeneel (2011) found that under a quota regime, small dairy farms show a higher probability to stay in the smaller size class than without quota, hampering structural change. Samson et al. (2016) found low capacity utilization in Dutch dairy farms under their quota system. They assume two reasons underlie this observation. An increased milk yield per cow combined with the farm’s quota could have triggered a need for a reduction in cow numbers. Furthermore, farmers might have invested in surplus capacity to prepare for quota abolishment. In Switzerland, the milk quota was abolished between 2006 and 2009, a period that coincided with a peak in milk prices (Haller, 2014). There are also indications that farmers held idling capacity prior to quota abolishment (Jan et al., 2005; Gazzarin et al., 2008).

While some authors have studied economic indicators after farm investment (Salvioni and Sciulli, 2011; Spicka and Krause, 2013), no study has taken opportunity costs fully into account. Salvioni and Sciulli (2011) find an increase in profit per family working unit, though they do not divide between different production factors. We evaluate the calculated profitability after dairy barn investment. With slowly changing herd size, as indicated by the literature

(Kirchweger and Kantelhardt, 2015; Sauer and Zilberman, 2012), and capital being rather mobile, we hypothesize a low profitability after investment unless herd size is adjusted.

The novelty of this paper is the analysis of profitability of dairy barn investments on a single-farm basis, taking all opportunity costs into account instead of farm income only. In addition, we analyze dairy herd expansion after investment to provide insights into the cause of profitability changes. We are the first to combine data from the Swiss Farm Accountancy Network (FADN) with government data on investment-supported farms.

## 2.2 MATERIALS AND METHODS

### 2.2.1 Swiss FADN

Our analysis uses Swiss FADN data, where we focus on two types of farms: dairy farms and combined dairy/arable crops farms. Both types of farms specialize in dairy. They keep more than 75 % of livestock units (LU) in cattle, with at least 25 % of them being dairy cows, but differ in the usage of acreage. To be classified as a dairy farm, a maximum of 25 % of UAA may consist of open cropland, while for combined dairy/arable crop farms open cropland may make up more than 40% of UAA (Hoop and Schmid, 2015). Focusing on the years 2003 through 2014, farm observation of the valley and hill region are used.

### 2.2.2 Identification of investing farms

A major challenge of our analysis is the identification of dairy farms investing in a new barn. First, we identify farms in the FADN data showing an increase in an interest-free loan between consecutive years. Since the granting of these interest-free loans is organized at the cantonal level, no overall data exists about rejected loan applications. Given the attractiveness of interest-free loans, very few farms exist which have invested in dairy barns without this kind of support. Therefore, an increase in interest-free loans indicates investment in a farm building in general, but not necessarily in a dairy barn. To improve the accuracy of the sample in this respect, we use information provided by MAPIS[2] (Meliorations- und Agrarkredit-Projekt-Informations-System) which contains all government-supported investments. We match farm-level FADN and farm-level MAPIS data on municipal code, loan amount and year of investment. In this manner, we obtain a data set of farms with investments specifically aimed at dairy barns. The sample comprises 103 farms with 544 observations, corresponding to 5.3 observations per farm on average. The time span of observations per farm is between two and ten years.

### 2.2.3 Dependent and independent variables

Reliable information on the capacity of new barns is not available, but FADN data contains records on the number of cows $N_{i,t}$ on a farm *i* in each year *t*. To circumvent autocorrelation, we analyze the annual change of dairy cows, denoted as Δ LU cows and defined as follows:

$$\Delta\ LU\ cows_{i,t} = N_{i,t} - N_{i,t-1} \qquad (1)$$

Note that due to the use of Δ LU cows, some observations are lost, as opposed to using LU cows in absolute terms. As a second variable to explain, we use "calculated profit" as a measure of economic success of a farm. We compute calculated profit of farm *i* in the year *t* as farm income less opportunity costs of equity and labor. The use of the opportunity costs of labor is regulated by law (Bundesrat, 1998) stating that agricultural income has to be commensurate to the income achieved in other sectors of the regional economy[3].

[2] The ministry of agriculture maintains records of all loans granted, together with value and purpose.

[3] The wage of other sectors in the region is determined by the Federal Statistical Office. This is multiplied in FADN by the amount of labor input for each farm.

$$Calculated\ Profit_{i,t} = Agricultural\ income_{i,t} - Opporunity\ costs\ (labor, capital)_{i,t} \quad (2)$$

Interest rates to compensate equity capital are determined by the interest rate of government bonds, which is also applied to compensate own agricultural land. As opportunity costs are typically larger than the remuneration factor, calculated profit is negative on average.

Concerning explanatory or independent variables, an important determinant of the profitability and the herd size of a farm is its acreage (Hoop et al., 2015). First, dairy farming relies strongly on the availability of roughage, which is closely linked to acreage. Moreover, the number of LU per area is de facto restricted by the amount of manure per area. Direct payments, an important source of income in Swiss agriculture, are also linked to acreage. Due to its relation to herd size and income, acreage (in ha) is added as a first independent variable.

To control for the abolishment of the milk quota during the sample period, we introduce a dummy variable into our model indicating whether an observation is within the affected period (2006 through 2009).

### 2.2.4 Econometric model

Fixed-effects (FE) and random-effects (RE) models are typical models for performing a regression on panel data (Giesselmann and Windzio, 2012; Verbeek, 2012; Baltagi, 2013). It is criticized by Baltagi (2013, p. 24) and Giesselmann and Windzio (2012), that often only the Hausman test is used to decide between a FE or RE model. Giesselmann and Windzio (2012, p. 112) argue that this choice needs to be assessed with respect to the research question, the sample, and variables considered. The FE model is designed for the analysis of intra-individual effects, which requires intra-individual variation to obtain a coefficient (Verbeek, 2012, p. 379).

Coefficients of an FE model are an average of all single coefficients of the individuals. Since in our data set we focus on intra-individual effects, we use an FE model.

Panel data consist of individuals repeatedly measured in time. As a result, autocorrelation is a frequent challenge in panel data analysis. It must therefore be assessed whether error terms between different periods correlate (Verbeek, 2012, p. 373). If autocorrelation is present but ignored, estimates are still consistent, but inefficient due to biased standard errors (Verbeek, 2012, p. 389; Baltagi, 2013, p. 96). This increases the risk of wrong inferences. Although this problem in panel data is well known, Petersen (2009) finds that 42 % of 207 reviewed papers in finance journals do not adjust standard errors for possible autocorrelation. He however concedes that an appropriate correction of standard errors might be difficult, as the order of the autoregressive process needs to be known.

First-order serial correlation in an unbalanced panel can be assessed by a Wooldridge test (Drukker, 2003). We therefore use this test for our models and only retain them if the error probability exceeds 10%. Below this value, the null hypothesis of no first order serial correlation is rejected. In this case, we resort to analyzing changes of the dependent variable from one year to the next instead of its absolute value. In this way, autocorrelation can be ruled out, which is also confirmed by a Wooldridge test. However, results may be less sharp in terms of explanatory power and significance, and interpretation differs slightly. Compared to a wrong inference due to autocorrelation, this cost might be worthwhile.

Estimated models are as shown in equation (3):

$$X_{(i,t)} = \alpha + \sum_{j=1}^{8} \delta_j(i,t)\beta_j + ha_{(i,t)} * \beta_{ha} + \gamma_{(i,t)} * \beta_\gamma + \epsilon_{(i,t)} + \mu_i \tag{3}$$

$X_{(i,t)}$ denotes the dependent variable of farm *i* in year *t*, either Δ LU cows or calculated profit. The constant is given by $\alpha$ and dummies for year *j* after investment by $\delta_j$. We use the year before the investment ($\delta_0$) as a basis. We denote the dummy for quota abolishment as $\gamma$, the one for acreage as $ha$. To account for the panel structure, the model contains an unobservable individual specific effect $\varepsilon_{(i,t)}$ and the remainder disturbance $\mu_i$.

## 2.3 RESULTS

### 2.3.1 Descriptive statistics

Summary and descriptive statistics for the analyzed variables are given in Table 1. The sample comprises 544 observations, 290 observations from the valley region and 254 observations from the hill region.

Table 1: Descriptive Statistics for analyzed variables of the FADN-sample

| Variable | Observations | Mean | Standard deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| $\delta_0$ | 90 | | | | |
| $\delta_1$ | 103 | | | | |
| $\delta_2$ | 84 | | | | |
| $\delta_3$ | 73 | | | | |
| $\delta_4$ | 58 | | | | |
| $\delta_5$ | 45 | | | | |
| $\delta_6$ | 39 | | | | |
| $\delta_7$ | 27 | | | | |
| $\delta_8$ | 22 | | | | |
| LU cows | 544 | 31.572 | 11.815 | 8.98 | 74.89 |
| Δ LU cows | 503 | 1.474 | 3.364 | -11.12 | 18.92 |
| Acreage (ha) | 544 | 26.943 | 9.347 | 8.57 | 69.62 |
| Quota abolishment period (γ) | 544 | | | | |
| Calculated profit (CHF[4]) | 544 | -21'203 | 44'972 | -149'574 | 149'986 |

Our data set shows that the number of observations decreases as the number of years after investment increases. Regression coefficients in our models will therefore be based on fewer observations at later stages.

[4] average exchange rates 2017; 1 CHF = 0.90 Euro = 1.02 USD; https://data.snb.ch, accessed 29 January 2018

The farm size in terms of LU cows of our sample is above the average for FADN farms of the same type. Unsurprisingly, Δ LU cows (cf. Formula (1)) shows an average increase over all observations.

The sample includes 55 observations with an increase of more than five LU cows within one year, whereof 53 % occurred from 2006 to 2007.

The overall mean acreage for dairy farms in the hill region and valley region is around 21 ha per farm. Combined dairy/arable crop farms are large with an average of around 27 ha and 28 ha in the hill and valley region, respectively. Farms cannot compensate for their input on average and the overall mean over farm type and region is -32,278 CHF. This is still above average in the overall FADN sample.

### 2.3.2 Econometric estimations

Both model specifications (cf. Equation (3)) are tested on first-order serial correlation. For calculated profit, the probability level of the Wooldridge test is at 91 %. In contrast, for LU cows as a dependent variable, the Wooldridge test is highly significant, indicating that first order serial correlation is a problem in this specification. To amend this, we use Δ LU cows from one year to the subsequent year as a dependent variable. This in turn yields a probability level of 65% for the Wooldridge test, meaning autocorrelation can be excluded.

For easier comparison, regression results are shown in one table for the two different dependent variables and stated in Table 2.

Table 2: Regression Results of regressions with either calculated profit or Δ LU livestock as dependent variable;
p-value < 0.1 = *, p-value < 0.05 = **, p-value < 0.01 = ***

| | Calculated Profit in CHF | Δ LU cows |
|---|---|---|
| Prob > F | 0.0003 | 0.0000 |
| $R^2$ overall | 0.12 | 0.08 |
| $R^2$ within | 0.14 | 0.11 |
| $R^2$ between | 0.12 | 0.15 |
| | Coefficient (standard error) | Coefficient (standard error) |
| Constant | -103‘664*** (22’818) | -2.77* (1.49) |
| $\delta_1$ | -11‘930*** (3’338) | -0.02 (0.42) |
| $\delta_2$ | -16‘892*** (4‘757) | 0.99* (0.53) |
| $\delta_3$ | -14‘279*** (4‘548) | 1.19* (0.60) |
| $\delta_4$ | -4‘447 (5‘132) | 0.43 (0.54) |
| $\delta_5$ | -3‘123 (5‘008) | -1.63** (0.64) |
| $\delta_6$ | 1‘053 (5‘101) | -1.04* (0.59) |
| $\delta_7$ | 9‘385 (8‘294) | -1.39* (0.72) |
| $\delta_8$ | -1‘282 (8‘248) | -1.09 (0.78) |
| Acreage (ha) | 3‘280*** (896) | 0.15** (0.06) |
| Quota abolishment period | 3‘254 (3‘112) | 0.66** (0.33) |

For calculated profit, the coefficients of the first three dummies after investment are negative and highly significant, meaning that compared to the situation before investment, the calculated profit is clearly reduced. From the fourth year onwards, the dummies are no longer significant. Accordingly, the dairy farms have the same profit as prior to the investment.

Acreage of a farm shows a significantly positive contribution, increasing the calculated profit by CHF 3,280 per ha.

Regarding the change in the number of cows, there is no statistically significant difference in the first year after the investment. For the second and third year after investment, changes in LU cows are significant and positive. More prominent, though, are the negative values for dummies $\delta_5$ to $\delta_7$. This means that herd size changes were smaller in these years, compared to the basis, the left out dummy $\delta_0$. An increase of one hectare in acreage yields an additional 0.15 LU cows. Finally, quota abolishment period influences change in herd size of LU cows positively with a rate of 0.66 LU cows.

## 2.4 DISCUSSION

### 2.4.1 General picture

The results of our analysis question the economic rational of an increasing income due to the investment at least in the short and medium-term.

Three arguments may help explain this.

First, with an investment in a dairy barn, the factor allocation of a farm changes. To reflect this change, calculated profit is a suitable variable, since it reflects all production factors by using opportunity costs. Some authors argue that opportunity costs are very specific to a farm, and might be close to zero in some cases (Hüttel and Jongeneel, 2011), or they might not be perceived to be as high as they actually are (Kahneman et al., 1991). However, given that an investment in a dairy barn fixes the factor allocation for a significant time period, it is important to consider opportunity costs.

Secondly, investments in larger barns are fixing the input-output ratio for years (Sauer and Zilberman, 2012), not only in the short- and medium-terms, but in the long-term. A dairy barn investment might be seen as a tipping point were a farmer can decide between opting out of dairying and using the production factors differently, or investing and being tied to the production, even if it does not ultimately pay off. Therefore, it remains very important to address the long-term economic consequences of investing in a new barn. Due to the time covered by our data set, we are restricted from doing so.

As a third explanation, investments might be also inspired by non-monetary motives like attractiveness of the workplace (Olsen and Lund, 2009; Eidgenössische Finanzkontrolle, 2015) or non-monetary job preferences (Lips et al., 2016).

When assessing the development after the investment, the implications of the declining number of observations need to be considered. For calculated profit, the statistical insignificance of coefficients from the fourth year after investment onwards might stem from the fact that the variables show considerable variation and the number of observations is hardly sufficient. On the other hand, significant coefficients for dummies further away from the investment mean that the effect is quite clear. Another characteristic of our analysis is that larger time spans of observation stem from investments made earlier in time, that is, if observed eight years after investment, the investment would have been made in 2006 the latest.

### 2.4.2 Dependent variables

Even if the exact quantitative meaning of commensurability and other aspects leave room for interpretation, our manner of assessing opportunity cost is well established within Swiss agriculture. Although the farms analyzed show a better profitability on average than the remaining FADN farms, a clear drop in calculated profit occurs after investment. The fact that a significant increase in profitability does not occur at any point of time after investment contradicts the economic theory that investments aim at achieving higher income. However, there is no significant decrease either. As a result, an investment might be, at least for some farmers, just a way to keep up with structural change, as Olsen and Lund (2009) suggest. The large heterogeneity between single farms and the decreasing number of observations do not allow us to identify a clear trend by means of significant coefficients. The increasing standard errors with increasing distance in time from investment indicate a decreasing efficiency of the estimates.

Based on the increase in cows being kept in free stall houses (Meyre, 2016 we assume that a majority of farms in our sample used the investment to switch from stanchion to free-stall housing. In theory, this change in housing type allows for a substantial increase in labor productivity (Schick and Hartmann, 2005). Given the rather constant nature of labor input on farms (Hoop et al., 2014), labor input might be the production factor most difficult to adapt to the new system, suppressing profitability for several years.

While no clear long run conclusion can be drawn from the development of profitability, a clear indication exists of why profitability is suppressed. Given the literature that indicates ahesitance to increase herd size (Sauer and Zilberman, 2012; Kirchweger and Kantelhardt, 2015)and the perceived need of farmers for capacity utilization to fulfill financial requirements (Faustet al., 2001), there is a strong indication that idle capacity at least contributes to the suppressionof profitability. Maybe farmers in the United States manage their farms in a more business-oriented manner, since literature about substantial herd size increases after investments rely on data from U.S. farms (Stahl et al., 1999; Bewley et al., 2001b).

The constantly negative values for dummy $\delta_5$ through $\delta_7$ on $\Delta$ *LU* cows can be interpreted as herd size reaching a stable plateau. So, farms probably increased their herds in the year before investment, which is the reference basis for the other dummies. This raises the question of whether the farms had not been utilizing full capacity before investment, since it seems that they were able to increase herd size at that time. The major increase occurs in years two and three after investment, as indicated by the significant positive coefficients for $\delta_2$ and $\delta_3$.

### 2.4.3 Explanatory variables

Quota abolishment does not affect the two dependent variables in the same magnitude. It is only significant for change in LU cows. At first sight, this significant coefficient supports the finding from Jan et al. (2005) and Gazzarin et al. (2008) that dairy farms had idling barn capacity prior to quota abolishment. A significant influence, without further knowledge of the data, could be interpreted as evidence that farms were restricted by the amount of their milk quota. But the amount of time within our period of analysis when the quota system was effectively in place comprises only three years, a rather short period. The high number of large changes in LU cows during the period of quota abolishment indicates that during this period larger projects were realized. Farms with an opportunity to increase herd size by a large extent might have consciously delayed their investment until the quota system was abolished to avoid the obligation to buy quota. Thus, the positive and significant influence of quota abolishment on herd-size change may be due to the realization of larger projects during that time.

Acreage per farm as an influencing factor on profitability is comprehensively identified in the literature (Hoop et al., 2015). The availability of additional acreage in Switzerland is rather low. The significant effect of acreage on both calculated profit and change in LU cows might, however, be caused by different factors. Switzerland is subsidizing agriculture on a relatively high level. A considerable proportion of this support is transmitted via direct payments linked to acreage, which might explain the link between acreage and calculated profitability. For change in LU cows, restrictions on cows per ha and roughage production might be the most important considerations. The finding of Samson et al. (2016), that investing farmers rely on increasing acreage through leasing, supports this hypothesis.

## 2.5 CONCLUSIONS

We analyzed the development of profitability and herd size for Swiss dairy farms after their investment in a new barn.

The combination of FADN and governmental data allows us to investigate the short and medium-term effects by analyzing the first eight years after investment at the farm-level. The analysis confirms our hypothesis of an undesired profitability development after investment, questioning the investment to some extent from an economic point of view. During the first three years after investment, the farm faces a substantial loss of calculated profit, followed by a period in which the income situation resembles that prior to the investment.

An important reason for profitability change after investment is the herd size, which increases slowly. In our sample, it takes a dairy farm three years until the new proportion of allocated input factors no longer results in a decrease of profitability. The additional capacity is not used completely in the first years, and the aim of the investment, proposed by investment theory, an increased income, is not achieved. We conclude that the investment in a dairy barn does not lead to improved profitability in the short and medium-term, as postulated by the policy goals.

The question arises whether the governmental loans should be linked to a more detailed planning of herd development or more detailed financial planning in general.

Further research is needed in at least three matters. Firstly, having analyzed the short and medium-term, the question arises of whether the picture changes in the long-term. Secondly, it remains an open question why farms do not increase their herd size more quickly after investment. The under-utilized barn capacity clearly leads to depressed profitability. Finally, our results might point to non-monetary motives for investing in a dairy barn. There may be a substantial willingness to pay for a better work environment, lessening physical strain.

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# 3 WAHRSCHEINLICHKEIT VON INVESTITIONEN IN MILCHVIEHSTÄLLEN SCHWEIZER VERKEHRSMILCHBETRIEBE

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Logit-Modell, Investition, Milchvieh, Schweiz

**Zusammenfassung**

Die staatliche Unterstützung landwirtschaftlicher Betriebe in der Schweiz ist im internationalen Vergleich sehr hoch, auch in der Investitionsförderung. Zusätzlich ist die langfristige Wirkung auf die Landwirtschaft groß, da die Investitionsförderung die Agrarstruktur beeinflusst. So ist es wichtig, die Charakteristika geförderter Betriebe zu kennen.

Für den Zeitraum von 2003 bis 2014 werden anhand einer Logit-Regression die Charakteristika von geförderten Betrieben vor der Investition mit Betrieben, die nicht investiert haben, verglichen. Der geringe Anteil an Investitionsbetrieben erfordert besondere Beachtung bei der statistischen Analyse.

Ökonomische Kenngrößen wie Nebenerwerbseinkommen, Betriebseinkommen oder Eigenkapital haben einen deutlich kleineren Einfluss als soziale Charakteristika wie Alter, Anwesenheit einer Partnerin und Familiengröße. Das lässt darauf schließen, dass Investitionen stärker durch diese als durch ökonomische Faktoren bestimmt werden. Die Kanalisierung auf ökonomisch tragfähige Konzepte durch die Fördervorgaben macht sich damit nur schwach bemerkbar.

## 3.1 EINLEITUNG

Die Schweizer Landwirtschaft wird im Verhältnis zu anderen OECD-Ländern etwa viermal so stark unterstützt wie der OECD-Durchschnitt (OECD, 2017). In den Jahren 2012 bis 2015 entfielen rund 75% der direkten Unterstützung von 3,7 Mrd. CHF[5] auf Direktzahlungen (MEIER et al., 2016). Verglichen damit, ist der Anteil der à-fonds-perdu-Beiträge (verlorener Zuschuss, der nicht zurückbezahlt werden muss) im langjährigen Durchschnitt von 2003-2014 mit90,6 Mio. CHF (WEBER et al., 2015) sehr gering. Dennoch ist gegenüber anderen Staaten auchdieser Betrag in Relation sehr hoch. So gab Deutschland rund 129 Mio. Euro an Bundes- und Landesbeiträgen für einzelbetriebliche Förderung und Diversifizierung aus, die ebenfalls als verlorener Zuschuss gezahlt wurden (BUNDESMINISTERIUM FÜR ERNÄHRUNG UND LANDWIRTSCHAFT, 2015).

Die Schweizer Förderpolitik verfügt darüber hinaus über zinslose Investitionskredite, von denen kumuliert über die Jahre 2003-2014 insgesamt rund 1,5 Mrd. CHF für Ökonomiegebäude (Wirtschaftsgebäude) ausbezahlt wurden. Hinzukommen je nach Kanton noch weitere Beiträge. Die reduzierte Betrachtung auf öffentliche Mittel allein unterschätzt aber die Bedeutung der Investitionshilfen. So stellen WEBER et al. (2015) fest, dass 89,2 Mio. CHF an ausbezahlten Beiträgen des Bundes (verlorener Zuschuss) ein Investitionsvolumen von 482,5 Mio. CHF auslösten. Außerdem haben strukturrelevante Politikmaßnahmen wie Investitionsförderung laut OECD-Framework einen hohen Einfluss auf die Produktivität, während Direktzahlungen nur einen mittleren haben (FLURY et al., 2016). Der Investitionsförderung kommt daher eine große

[5] Durchschnittlicher Wechselkurs 2017; 1 CHF = 0.90 Euro = 1.02 USD; https://data.snb.ch, abgerufen am 29. Januar 2018

Bedeutung zu. Grundlage der Förderpolitik bildet Art. 87 a des Landwirtschaftsgesetzes, der die Politik beauftragt, mittels Investitionsförderung die Betriebsgrundlagen zu verbessern und damit die Produktionskosten zu senken.

Die Schweizer Landwirtschaft unterliegt einem Strukturwandel, der von der Agrarpolitik als sozialverträglich erachtet wird (BAUR, 1999; BUNDESAMT FÜR LANDWIRTSCHAFT, 2009). Nach Zahlen des BUNDESAMT FÜR STATISTIK (2017) ging die Anzahl der Vollerwerbsbetriebe von 2000 bis 2016 um 24,2 % zurück, die Anzahl der Vollzeitbeschäftigten um 28,5 %, was für eine Arbeitseinsparung durch den Strukturwandel spricht. Für die Substitution von Arbeit durch Kapital finden sich zwei Erklärungsansätze. Nach der Druck-Hypothese setzt der technische Fortschritt Arbeitskräfte frei, die dann abwandern müssen (BAUR, 2000). Nach der Sog-Hypothese wandern die Arbeitskräfte aufgrund zu schlechter Entlohnung ab und erzwingen so den technischen Fortschritt (BAUR, 2000; BOEHLJE, 1992). Nach HÜTTEL UND MARGARIAN (2009) äußert sich der Strukturwandel in schrumpfenden, stabilen und wachsenden Betrieben. Bei Milchviehbetrieben zeigt sich der Strukturwandel auch durch den Wechsel von Anbinde- zu Laufstallhaltung. Der Anteil der in dieser, arbeitseffizienteren, Haltungsform (SCHICK UND HARTMANN, 2005) gehaltenen Kühe hat im Zeitraum von 2003 bis 2013 deutlich zugenommen (MEYRE, 2016). Die Investitionsförderung hat daher eine sehr langfristige Wirkung und beeinflusst so auch den Strukturwandel.

Um einen zinslosen Investitionskredit zu erhalten, muss die Tragbarkeit der Investition mit geeigneten Planungsinstrumenten nachgewiesen werden und eine Risikobeurteilung erfolgen (BUNDESRAT, 1998b). Investierende Betriebe durchlaufen so einen Auswahlprozess, durch den sich die Fördermittel auf rentable Projekte und damit zukunftsfähige Betriebe kanalisieren sollen. Zwar gibt es keine bundesweite Statistik über den Anteil von abgelehnten Gesuchen nach Investitionskrediten, jedoch legen einzelne Geschäftsberichte nahe, dass kaum Gesuche abgelehnt werden (AARGAUISCHE LANDWIRTSCHAFTLICHE KREDITKASSE, 2016; GLIB, 2016). Um die Förderpolitik effektiv und effizient auszurichten, ist es wichtig zu wissen, wie sich geförderte Betriebe von nicht geförderten Betrieben unterscheiden.

In der Literatur finden sich einige Beispiele, die sich mit ähnlichen Fragestellungen zu Investitionen anhand unterschiedlicher Ansätze beschäftigt haben. WEISS (1999) untersuchte das Wachstum und das Überleben landwirtschaftlicher Betriebe in Oberösterreich mit Hilfe eines

Panels zu Haushaltsdaten. MANN (2003) untersuchte Entscheidungsgründe für Investitionen Schweizer Landwirtschaftsbetriebe mit einem Tobit-Modell basierend auf Testbetriebsnetz-Daten, auch Farm Accountancy Data Network (FADN) genannt. Ebenfalls Buchhaltungsdaten hatten HINRICHS et al. (2008) zur Verfügung. FOLTZ UND ALDANA (2006), HENNESSY UND O BRIEN (2008), LADUE et al. (1991) und OLSEN UND LUND (2009) stützten ihre Analysen zu Investitionen auf Ergebnisse von Umfragen unter Landwirten. Einige Autoren haben Wahrscheinlichkeiten und Investitionen im Rahmen von Propensity Score Matching untersucht (CIAIAN et al., 2015; PUFAHL UND WEISS, 2009; SALVIONI UND SCIULLI, 2011). Propensity Score Matching wird für die Konstruktion einer Kontrollgruppe in Experimenten verwendet. Allerdings sollte nach dem Matching eine große Stichprobe übrigbleiben (KING UND NIELSEN, 2016) und es können Verzerrungen aufgrund nicht beobachtbarer Variablen entstehen (CIAIAN et al., 2015; KING UND NIELSEN, 2016; PUFAHL UND WEISS, 2009; SALVIONI UND SCIULLI, 2011).

In der Praxis kommen bei abhängigen, binären Variablen meist Probit- oder Logit-Modelle zum Einsatz (VERBEEK, 2012). Mit diesen Modellen wird der besonderen Verteilung Rechnung getragen, dass die abhängige Variable nur Werte von 0 und 1 annehmen kann.

Verkehrsmilchbetriebe stellen die größte Einzelgruppe in den Schweizer FADN-Daten dar. Wir fokussieren daher auf diesen Typ, ergänzt durch die kombinierten Betriebe Verkehrsmilch/Ackerbau, da diese eine ähnliche betriebswirtschaftliche Ausrichtung haben. Mithilfe eines Logit-Modells analysieren wir die Charakteristika von Betrieben, die in einer nachfolgenden Zeitphase investieren (abhängige Variable =1) oder nicht (0). Mit den Erkenntnissen lässt sich darauf schließen, welche Bedeutung die Bedingungen haben, die an investierende Betriebe gestellt werden für den Erhalt eines Investitionskredites.

## 3.2 MATERIAL UND METHODEN

Im folgenden Kapitel wird auf die verwendeten Daten und die verwendete Analyse-Methode eingegangen.

## 3.3 DATENGRUNDLAGE UND VERWENDETE ERKLÄRENDE VARIABLEN

Zur Analyse dienen FADN-Daten der Jahre 2003 bis 2014 von Agroscope (HOOP UND SCHMID, 2015). Durch die Beschränkung des Samples auf Verkehrsmilch- und kombinierte Betriebe ist eine spezifische Analyse möglich, bei gleichzeitig großer Anzahl an Beobachtungen. Zusätzlich erfolgt eine Beschränkung auf die Tal- und Hügelregion. Die Bergregion wird nicht betrachtet, da sich dort die natürlichen Bedingungen deutlich von denen der anderen beiden Regionen unterscheiden.

Aus den FADN-Daten geht hervor, ob ein Betrieb einen zinslosen Investitionskredit neu aufgenommen oder aufgestockt hat, wenn der Betrieb über zwei aufeinanderfolgende Jahre im Panel war. Allerdings ist aus diesen Daten allein lediglich ein Rückschluss darauf möglich, ob der Investitionskredit für Ökonomiegebäude verwendet wurde. Darunter fällt jegliche Art von Wirtschaftsgebäude. Die genaue Art der Investition wird im Meliorations- und Agrarkredit-Projekt-Informations-System (MAPIS) geführt. Durch die Kombination von FADN- und MAPIS-Daten können Betriebe mit einer spezifischen Investition in einen Milchviehstall in den FADN-Daten identifiziert werden. In der MAPIS-Datenbank werden alle geförderten Investitionen in der Schweiz einschließlich der Höhe des Investitionskredits, der Gemeinde und dem Jahr der Investition geführt. Anhand dieser Variablen werden Investitionen in Milchviehställe den FADN-Betrieben zugeordnet. Aus 302 Betrieben, die während der Zeit im Panel einen Investitionskredit neu aufgenommen oder aufgestockt haben, konnten so 103 Betriebe ermittelt werden, die in einen Neu- oder Umbau des Milchviehstalles investierten.Bei den übrigen Beobachtungen handelt es sich entweder um Investitionen in andere Gebäude,oder die Beobachtung konnte nicht zugeordnet werden. Von Betrieben mit späterer Investitionliegen so 227 Beobachtungen vor, von insgesamt 11.004 Beobachtungen aller Betriebe im Sample.

Studien mit ähnlichen Fragestellungen verwendeten in ihren Modellen zwischen sechs und zwölf erklärende Variablen. Einen Großteil dieser Variablen können wir in Gruppen zusammenfassen. Sie sind in Tabelle 1 mit Literaturangaben dargestellt in absteigender Häufigkeit ihrer Verwendung.

Tabelle 1: Verwendete Variablen und Literaturangaben

| Variable | Literaturangaben |
|---|---|
| Alter | OLSEN UND LUND, 2009; WEISS, 1999; LADUE et al., 1991; HINRICHS et al., 2008; HENNESSY UND O'BRIEN, 2008, SALVIONI UND SCIULLI, 2011 |
| Region | LADUE et al., 1991; HINRICHS et al., 2008; SALVIONI UND SCIULLI, 2011; PUFAHL UND WEISS, 2009; MANN, 2003 |
| Nebenerwerb | OLSEN UND LUND, 2009; WEISS, 1999; HENNESSY UND O'BRIEN, 2008, PUFAHL UND WEISS, 2009; SALVIONI UND SCIULLI, 2011 |
| Umsatzgröße | OLSEN UND LUND, 2009; LADUE et al., 1991; HINRICHS et al., 2008; PUFAHL UND WEISS, 2009 |
| EK/FK Größe | OLSEN UND LUND, 2009; MANN, 2003; LADUE et al., 1991; HINRICHS et al., 2008 |
| Einkommensgröße | OLSEN UND LUND, 2009; CIAIAN et al., 2015; HENNESSY UND O'BRIEN, 2008; FOLTZ UND ALDANA, 2006 |
| Landwirtschaftliche Nutzfläche | MANN, 2003; HENNESSY UND O'BRIEN, 2008; PUFAHL UND WEISS, 2009; CIAIAN et al., 2015 |
| Größe Tierhaltung | MANN, 2003; FOLTZ UND ALDANA, 2006; PUFAHL UND WEISS, 2009; CIAIAN et al., 2015 |
| Zinsgröße | OLSEN UND LUND, 2009; LADUE et al., 1991; MANN, 2003 |
| Ausbildung | WEISS, 1999, LADUE et al., 1991; FOLTZ UND ALDANA, 2006 |
| Betriebstyp | LADUE et al., 1991; HENNESSY UND O'BRIEN, 2008; SALVIONI UND SCIULLI, 2011 |
| Variable Kosten | HINRICHS et al., 2008; PUFAHL UND WEISS, 2009 |
| Anzahl Familienmitglieder | WEISS, 1999; HENNESSY UND O'BRIEN, 2008 |
| Geschlecht Betriebsleiter | WEISS, 1999; SALVIONI UND SCIULLI, 2011 |
| Effizienzmaß | OLSEN UND LUND, 2009; CIAIAN et al., 2015 |
| Urbanisierung | LADUE et al., 1991; FOLTZ UND ALDANA, 2006 |
| Intensität Tierhaltung | HINRICHS et al., 2008; PUFAHL UND WEISS, 2009 |

Einige der dargestellten Studien verwendeten eine Variable, die den Umsatz darstellt. Damit wird die Unternehmensgröße abgebildet (LADUE et al., 1991; LAGERKVIST UND OLSON, 2001;

OLSEN UND LUND, 2009), die einen Einfluss auf die Investitionsentscheidung hat (PUFAHL UND WEISS, 2009; SALVIONI UND SCIULLI, 2011). In der Literatur herrscht Konsens, dass die Größe des Betriebs positiv auf die Investitionsentscheidung wirkt. Daher nehmen wir die Rohleistung, die sowohl Umsatz als auch Direktzahlungen umfasst, als erklärende Größe in unser Modell auf. Die Rohleistung wird auch deshalb verwendet, weil sie Bestandsveränderungen miterfasst.

Es finden sich Beispiele für Fremdkapitalanteil (HINRICHS et al., 2008; LAGERKVIST UND OLSON, 2001) und Eigenkapitalanteil (LADUE et al., 1991; MANN, 2003) als verwendete Variablen. Ein höherer Eigenkapitalanteil verbessert das Rating bei Kreditgebern, weshalb ein positiver Effekt der Eigenkapitalquote zu erwarten wäre. MANN (2003) stellte für die Schweiz allerdings einen negativen Zusammenhang von Eigenkapitalquote und Investitionsneigung fest, aber einen positiven des absoluten Eigenkapitals. Wir verwenden in unserer Studie das absolute Eigenkapital.

Für die Verwendung des Alters zur Erklärung von Investitionsentscheidungen spricht vor allem die Farm Life Cycle Theory (FOLTZ UND ALDANA, 2006; HENNESSY UND O BRIEN, 2008; LADUE et al., 1991; WEISS, 1999), die davon ausgeht, dass die Investitionsneigung ab einem gewissen Alter abnimmt. HINRICHS et al. (2008) begegnen diesem Phänomen dadurch, dass sie nicht das Alter selbst, sondern die absolute Abweichung vom Alter von 45 Jahren aufnehmen. Andere Autoren verwenden zusätzlich das Alter im Quadrat als erklärende Variable (HENNESSY UND O BRIEN, 2008; WEISS, 1999). In Anlehnung daran nehmen wir daher Alter, sowie Alter im Quadrat in das Modell auf.

Nebenerwerb wird teilweise als Einstieg in den Ausstieg betrachtet (WEISS, 1999). FOLTZ UND ALDANA (2006) stellen fest, dass die durch ökonomische Bedingungen getriebenen Löhne außerhalb der Landwirtschaft wichtiger für Investitionen sind als Charakteristika des Betriebs oder des Betriebsleiters selbst. Auch HENNESSY UND O BRIEN (2008) finden einen Einfluss des Nebenerwerbs, wobei es Unterschiede gibt für verschiedene Arten von Investitionen, und, ob das Nebeneinkommen vom Betriebsleiter oder Ehepartner verdient wird. Wenn der Betriebsleiter selbst noch außerhalb des Betriebs arbeitet, substituiert er demnach nicht zwingend Arbeit durch Kapital. Während HENNESSY UND O BRIEN (2008) FADN-Daten mit Angaben zur Einkommensspanne von Nebenerwerb benutzen, stützen FOLTZ UND ALDANA (2006) ihre Analysen auf Umfrageergebnisse von Milchviehhaltern. Die Schweizer FADN-Daten enthalten neben der Höhe von Nebenerwerbseinkommen auch den Umfang an Tätigkeit im Nebenerwerb. Neben dem Anteil Nebeneinkommen am Gesamteinkommen betrachten wir daher auch die Höhe des Nebeneinkommens bezogen auf eine volle Arbeitskraft. Dies dient gleichzeitig als Proxy für die ökonomischen Bedingungen außerhalb der Landwirtschaft und der Ausbildung. Das Median-Einkommen eines Schweizer Arbeitnehmers lag im Durchschnitt der Jahre 2003 bis 2014 bei CHF 65.442 (BUNDESAMT FÜR STATISTIK, 2016). Der Sog-Hypothese (BAUR, 2000; BOEHLJE, 1992) folgend, dürften Betriebe mit besseren außerlandwirtschaftlichen Verdienstmöglichkeiten eine geringere Investitionswahrscheinlichkeit haben. Die Wirkungsrichtung des Anteils von Nebenerwerb kann laut Literatur allerdings unterschiedlich sein.

Autoren, die Daten von Betrieben aus sehr verschiedenen Regionen analysieren, nutzen in der Regel Dummy-Variablen, um diese Regionen abzubilden (HINRICHS et al., 2008; LADUE et al., 1991; MANN, 2003; PUFAHL UND WEISS, 2009; SALVIONI UND SCIULLI, 2011). Die Schweizer Agrarstatistik trägt regionalen Unterschieden auf Grundlage der Landwirtschaftlichen Zonenverordnung (BUNDESRAT, 1998a) Rechnung. Die Schweizer Talregion hat aufgrund der klimatischen Bedingungen Vorteile bei der Milcherzeugung (GAZZARIN et al., 2008). Da wir uns in unserer Analyse auf die Tal- und Hügelregion beschränken, wird eine Dummy-Variable für die Hügelregion eingeführt.

Obwohl das Betriebseinkommen (CIAIAN et al., 2015; OLSEN UND LUND, 2009) oder das Familieneinkommen (FOLTZ UND ALDANA, 2006; HENNESSY UND O BRIEN, 2008) mitunter als erklärende Variable verwendet wird, erhält keine der in Tabelle 1 erwähnten Studien hier einen signifikanten Effekt. Die in unserem Sample untersuchten Investitionen wurden mit einem zinslosen Investitionskredit gefördert, für den die wirtschaftliche Tragbarkeit nachgewiesen werden muss (BUNDESRAT, 1998b). Ein höheres Betriebseinkommen sollte die Tragbarkeit verbessern, die Investition erleichtern und so die Investitionswahrscheinlichkeit erhöhen.

OLSEN UND LUND (2009) stellen fest, dass niedrige Zinsen Investitionen begünstigen, doch sind die Ergebnisse in der Literatur unterschiedlich. LADUE et al. (1991) finden keinen Effekt, MANN (2003) nur einen Effekt auf Maschineninvestitionen. Da Investitionskredite für Ökonomiegebäude in der Schweiz zinslos sind, wäre hier auch nur ein begrenzter Effekt zu erwarten. Von größerer Bedeutung dürfte der Anteil von verzinstem Fremdkapital am gesamten

Fremdkapital sein. Nach dem Bäuerlichen Bodenrecht können landwirtschaftliche Betriebe nur bis zu 135 % eines gesetzlich festgelegten Ertragswerts Kredite aufnehmen (BUNDESRAT, 1991), bei zinslosen Investitionskrediten dagegen auch mehr. Das Verhältnis stellt damit auch einen Proxy für die Kapitalverfügbarkeit dar.

Die landwirtschaftlich genutzte Fläche ist ein wichtiges Betriebscharakteristikum und wird daher auch in vier anderen Studien verwendet (s. Tabelle 1). HENNESSY UND O BRIEN (2008) stellen neben einem positiven Effekt der Fläche auf die Investitionsentscheidung fest, dass dieser Effekt mit zunehmender Größe kleiner wird. Für die Schweiz stellt MANN (2003) zwar einen signifikanten Effekt auf Investitionen und Maschinen fest, aber nicht für Gebäude. Da die Milcherzeugung stark von Grünland abhängig ist, verwenden wir den Grünlandanteil an der Nutzfläche. Auf diese Weise kann auch auf eine Dummy-Variable zur Unterscheidung des Betriebstyps verzichtet werden, da hier ein wesentlicher Unterschied zwischen den beiden Betriebstypen besteht. Die Verwendung der Fläche könnte verzerrte Ergebnisse hervorrufen, da die kombinierten Verkehrsmilch/Ackerbau-Betriebe im Durchschnitt größer sind.

Einige Autoren erwarten, dass eine bessere Ausbildung Investitionen fördert, können aber keinen signifikanten Zusammenhang feststellen (FOLTZ UND ALDANA, 2006; LADUE et al., 1991). WEISS (1999) kann einen positiven Effekt einer landwirtschaftlichen Ausbildung auf Wachstum und Weiterbestand feststellen. Um einen Investitionskredit zu erhalten, müssen Betriebsleiter die erfolgreiche Betriebsführung nachweisen, was mit einer abgeschlossenen Ausbildung zum Landwirt erfolgen kann oder alternativ über drei konsekutive Buchführungsabschlüsse (BUNDESRAT, 1998b). Daher wird eine Dummy-Variable eingeführt, wenn der Betriebsleiter mindestens eine Ausbildung zum Landwirt abgeschlossen hat.

FOLTZ UND ALDANA (2006) stellten fest, dass bei Betrieben, die die Anzahl ihrer Kühe erhöhen, die ursprüngliche Anzahl einen hoch signifikanten Einfluss auf den Umfang der Erweiterung, also die Erhöhung der Anzahl der Kuhplätze, hat. Für die Schweiz stellt MANN (2003) ebenfalls einen signifikanten Zusammenhang her. Da es sich in unserer Analyse um spezifische Investitionen in die Tierhaltung handelt, geht die Anzahl der insgesamt gehaltenen Großvieheinheiten (GV) ebenfalls als erklärende Variable in das Modell ein.

WEISS (1999) geht davon aus, dass eine größere Anzahl Familienmitglieder größere Arbeits-Ressourcen bedeutet, was sich in seiner Analyse in einer größeren Wahrscheinlichkeit für Betriebswachstum niederschlägt. In den FADN-Daten der Schweiz wird die Haushaltsgröße als Anzahl der Verbrauchereinheiten geführt. Auf Personen unter 16 Jahren wird dabei ein Korrekturwert angewandt (Hoop und Schmid, 2015). Daneben führen wir eine Dummy-Variable für den Fall ein, dass der Betriebsleiter eine Partnerin hat.

## 3.4 LOGISTISCHE REGRESSION

Probit- und Logit-Modelle sind sehr verbreitet in ihrer Anwendung, wenn binäre abhängige Variablen untersucht werden. In der Praxis liefern die beiden Ansätze sehr ähnliche Resultate (VERBEEK, 2012) und Empfehlungen, welches Modell wann angewandt werden sollte, sind rar (GREENE, 2012).

Das Logit-Modell bietet den Vorteil, dass die Koeffizienten auch als „odds" angegeben werden können. „Odds" sind das Verhältnis der Wahrscheinlichkeiten eines positiven und eines negativen Einflusses.

Logarithmiert man die Odds-Ratio, erhält man den Logit. Dieser liegt in linearer Form vor und entspricht dem geschätzten Modell (Gleichung 1):

(1) $$Y_i = \beta_0 + \beta_1 * L_i + \beta_2 * A_i + \beta_3 * A_i^2 + \beta_4 * EK_i + \beta_5 * NE_{Ant_i} + \beta_6 * NE_{L_i} + \beta_7 * H_i + \beta_8 * BE_i + \beta_9 * Z_{Ant_i} + \beta_{10} * W_{Ant_i} + \beta_{11} * AB_i + \beta_{12} * P_i + \beta_{13} * VBE_i + \beta_{14} * GV_i + \varepsilon_i$$

*Y* stellt die binäre abhängige Variable des Betriebs *i* dar, die nur den Wert 0 oder 1 annehmen kann. $\beta_0$ bezeichnet die Konstante, $\varepsilon_i$ den Fehlerterm. Wir verwenden robuste Standardfehler.

Zwar gibt es auch für binäre abhängige Variable Fixed-Effects und Random-Effects-Modelle, jedoch sind diese für die vorliegenden Daten nicht anwendbar. Ein Fixed-Effects-Modell benötigt Varianz innerhalb eines Individuums (z.B. Variation über die Zeit), die in unseren Daten nicht vorliegt, ein Random-Effects-Modell setzt voraus, dass die unbeobachtete Heterogenität nicht mit dem Fehlerterm korreliert. Diese Annahme ist in empirischen Datensätzen jedoch nicht plausibel (BELL UND JONES, 2015).

Ein für die logistische Regression geeignetes Bestimmtheitsmaß ($R^2$), das der Interpretation in linearen Regressionen am nächsten kommt WINDMEIJER (1995), ist das von MCKELVEY UND ZAVOINA (1975) vorgeschlagene Bestimmtheitsmaß ($R^2_{MZ}$). Es ist robuster gegenüber der Verteilung der abhängigen Variable als der Mc Fadden-Ansatz, der u.a. von Stata als Standard genutzt wird (BAUM, 2006). SALVIONI UND SCIULLI (2011) nutzen den Anteil durch das Modell korrekt klassifizierter Beobachtungen, im Folgenden mit $R^2_p$ abgekürzt. Meist wird als Schwellenwert 0,5 verwendet (WOOLDRIDGE, 2006). Dieses Maß ist aber stark von der Verteilung der abhängigen Variable abhängig (CRAMER, 1999; VERBEEK, 2012; WINDMEIJER, 1995; WOOLDRIDGE, 2006) und kann bei extremen Verteilungen eine hohe Anpassungsgüte suggerieren.

Die unabhängigen Variablen sind zur besseren Übersicht mit ihrer Abkürzung in Tabelle 2 dargestellt.

**Tabelle 2: Verwendete unabhängige Variablen mit Kürzel**

| Variable | Kürzel | Einheit |
|---|---|---|
| Rohleistung total | L | 1.000 CHF |
| Alter | A | Jahre |
| Alter² | $A^2$ | Jahre² |
| Betriebliches Eigenkapital | EK | 1.000 CHF |
| Anteil Nebeneinkommen an gesamtem Einkommen | $NE_{Ant}$ | % |
| Lohnhöhe Nebeneinkommen | $NE_L$ | 1.000 CHF |
| Dummy-Variable für Region (Region 1 = 0) | H (für Hügel) | |
| Betriebseinkommen | BE | 1.000 CHF |
| Anteil verzinstes Fremdkapital an Fremdkapital gesamt | $Z_{Ant}$ | % |
| Anteil Dauergrünland an landwirtschaftlicher Nutzfläche | $W_{Ant}$ | % |
| Dummy-Variable für Ausbildung Lehre oder höher | AB | |
| Dummy-Variable für Partnerin | P | |
| Größe Familie in Verbrauchereinheiten | VBE | VBE |
| Großvieheinheiten total | GV | GV |

Die Werte in CHF gehen als Tausendstel in das Modell ein, um die Interpretation zu erleichtern. Um die Güte des Schätzmodells zu beurteilen, wird das Bestimmtheitsmaß von McKelvey und Zavoina, $R^2_{MZ}$, als Bestimmtheitsmaß verwendet.

## 3.5 ERGEBNISSE

Die deskriptive Statistik der verwendeten Variablen ist in Tabelle 3 dargestellt.

**Tabelle 3: Deskriptive Statistik der verwendeten erklärenden Variablen**

| Variable | Anzahl Beobachtungen | Durchschnitt | Standard-abweichung |
|---|---|---|---|
| Y (Investition) | 11.004 | 0,021 | |
| L (1.000 CHF) | 11.004 | 249,29 | 114,99 |
| A | 11.004 | 46,67 | 9,34 |
| $A^2$ | 11.004 | 2265,10 | 871,88 |
| EK (1.000 CHF) | 11.004 | 453,03 | 326,45 |
| $NE_{Ant}$ (%) | 11.004 | 23,72 | 24,46 |
| NE_L (1.000 CHF) | 6.389[6] | 76,09 | 43,23 |
| H (für Hügel) | 11.004 | 0,52 | |
| BE (1.000 CHF) | 11.004 | 94,47 | 51,13 |
| $Z_{Ant}$ (%) | 11.004 | 68,24 | 30,22 |
| $W_{Ant}$ (%) | 11.004 | 62,25 | 32,13 |
| AB (1 = Landwirt oder höher) | 10.997 | 0,96 | |
| P (1 = mit Partner) | 11.004 | 0,85 | |
| VBE | 10.975 | 3,47 | 1,45 |
| GV | 11.004 | 30,18 | 14,39 |

Die Verteilung der abhängigen Variablen Y, die besagt, ob später eine Investition getätigt wurde, zeigt deutlich, dass nur ein sehr kleiner Teil der Beobachtungen sich auf Betriebe mit späterer Investition bezieht, nämlich rund 2.1% oder 227 Beobachtungspunkte (verteilt auf

[6] Viele Betriebe verfügen über kein Nebeneinkommen. Diese gingen mit dem Wert Null in die Regression ein. Für eine bessere Aussagekraft wurden diese Werte beim Durschnitt außen vor gelassen.

2.365 Betriebe). Dieser geringe Prozentsatz erklärt sich auch dadurch, dass Beobachtungen von Investitionsbetrieben nach der Investition von der Analyse ausgeschlossen wurden.

Die Ergebnisse der Logit-Regression und der logistischen Regression sind als Koeffizienten und Odds Ratios in Tabelle 4 zusammengefasst dargestellt. Der p-Wert gilt sowohl für den Logit als auch die Odds Ratio.

**Tabelle 4: Ergebnisse der Logit-Regression und der Odds-Ratios**

| | Logit | | Odds Ratio | | |
|---|---|---|---|---|---|
| | Koeffizient | Standardfehler | Koeffizient | Standardfehler | p-Wert |
| Konstante | -6.1446 | 1.8127 | 0.0021 | 0.0039 | 0.00 |
| L (1.000 CHF) | -0.0016 | 0.0017 | 0.9984 | 0.0017 | 0.34 |
| A | 0.1940 | 0.0823 | 1.2141 | 0.1000 | 0.02 |
| $A^2$ | -0.0033 | 0.0001 | 0.9967 | 0.0001 | 0.00 |
| EK (1.000 CHF) | 0.0005 | 0.0001 | 1.0005 | 0.0002 | 0.00 |
| $NE_{Ant}$ (%) | -0.0154 | 0.0048 | 0.9847 | 0.0047 | 0.00 |
| $NE_L$ (1.000 CHF) | -0.0057 | 0.0018 | 0.9943 | 0.0018 | 0.00 |
| H | 0.0549 | 0.1367 | 1.0564 | 0.1444 | 0.69 |
| BE (1.000 CHF) | 0.0041 | 0.0020 | 1.0041 | 0.0020 | 0.04 |
| $Z_{Ant}$ | 0.0067 | 0.0024 | 1.0067 | 0.0024 | 0.01 |
| $W_{Ant}$ | 0.0055 | 0.0026 | 1.0055 | 0.0026 | 0.03 |
| AB | -1.0970 | 0.2403 | 0.3339 | 0.0802 | 0.00 |
| P | 0.6865 | 0.2564 | 1.9867 | 0.5093 | 0.00 |
| VBE | 0.1357 | 0.0538 | 1.1454 | 0.0616 | 0.01 |
| GV | -0.0117 | 0.0086 | 0.9883 | 0.0085 | 0.17 |

Das Modell insgesamt ist hoch signifikant. Aufgrund des geringen Anteils an Beobachtungen mit späterer Investition führen wir hier, wie zuvor beschrieben, den $R^2_{MZ}$ als Bestimmtheitsmaß an. Dieser liegt bei 0,299. Der Anteil der korrekten Klassifizierung liegt bei 97.9 %, was damit genau der Verteilung der abhängigen Variable entspricht. Obwohl der Wert hoch erscheint, liefert das Modell nach diesem Maß keine bessere Erklärung als der Zufall. Das Ergebnis hängt aber sehr stark vom angelegten Schwellenwert ab[7].

Die Rohleistung, die Dummy-Variable für Hügel- oder Talregion und die insgesamt gehaltenen Großvieheinheiten (GV) haben keinen signifikanten Einfluss. Die restlichen Variablen zeigen sich signifikant. Die Odds Ratios für Eigenkapital, Betriebseinkommen, Anteil des verzinsten Kapitals am Fremdkapital und der Grünlandanteil sind zwar alle positiv, jedoch sehr nahe bei 1, d.h. ein höherer Wert führt zu einer höheren Wahrscheinlichkeit, dass in ein Ökonomiegebäude investiert wird. Die Wirkung ist demnach zwar signifikant, allerdings nicht besonders stark. Beim Nebeneinkommen wirken sowohl der Anteil als auch die Lohnhöhe pro Arbeitskraft im Nebenerwerb der Investitionswahrscheinlichkeit entgegen. Je mehr Einkommen außerhalb des Betriebs generiert wird, desto geringer ist die Wahrscheinlichkeit einer Investition. Auch hier liegen die Odds Ratios nahe bei 1. Eine signifikante und deutlichere Wirkung haben die Dummy-Variablen für landwirtschaftliche Ausbildung und für Partnerin, sowie die Haushaltsgröße. Die Präsenz einer Partnerin verdoppelt die Investitionswahrscheinlichkeit. Die Dummy-Variable für die landwirtschaftliche Ausbildung wirkt negativ und damit nicht in der erwarteten Richtung. Eine entsprechend hohe Ausbildung reduziert die Investitionswahrscheinlichkeit um mehr als die Hälfte. Das Alter hat den erwarteten positiven Effekt und einen Wendepunkt, wie dies auch in anderen Studien festgestellt wird (HENNESSY UND O BRIEN, 2008; WEISS, 1999).

[7] Für keine der Beobachtungen wird eine Wahrscheinlichkeit >0,5 geschätzt. Mit einer Absenkung des Schwellenwerts könnte daher die Klassifikationsmatrix beeinflusst werden.

## 3.6 DISKUSSION

### 3.6.1 Geschätztes Modell

Die Kritik an $R^2_p$ in Samples mit sehr starkem Ungleichgewicht der abhängigen binären Variable kann mit den vorliegenden Daten bestätigt werden. Zwar ist die Verteilung in diesem Beispiel recht extrem. Allerdings sind laut CRAMER (1999) deutlich ungleichmäßige Verteilungen eher die Regel als die Ausnahme. Da auch in der Praxis bei extremen Verteilungen Logit-Regressionen angewandt werden (CRAMER, 1999), ist es wichtig, Kriterien zu verwenden, die weniger anfällig für Verzerrungen aufgrund der Verteilung sind. Daher haben wir uns für das Bestimmtheitsmaß $R^2_{MZ}$ nach MCKELVEY UND ZAVOINA (1975) entschieden, das in unserem Fall auf eine recht gute Anpassungsgüte schließen lässt. SALVIONI UND SCIULLI (2011) erzielen für ihre Problemstellung, die recht nah bei unserer liegt, mit ihrem Logit-Modell ein $R^2_p$ leicht über der zufälligen Verteilung und damit einen Kuipers-score über 1. Hingegen liegt das verwendete $R^2$ in ihrer Analyse mit 0,057 recht niedrig. Allerdings wird nicht erwähnt, nach welchem Ansatz das $R^2$ berechnet wurde. Mit 15,4 % lag der Anteil der Beobachtungen mit späterer Investition aber auch sehr viel höher als in unserem Sample.

Im Vergleich zur Literatur, die Logit-Modelle als Basis für Propensity Score Matching verwenden, fällt auf, dass weder PUFAHL UND WEISS (2009) noch CIAIAN et al. (2015) Zahlen für die Anpassungsgüte präsentieren. In diesen Ansätzen haben die Modelle die Funktion, Ungleichgewichte bei den Kovariaten zwischen den Investitions- und Nicht-Investitionsbetrieben auszugleichen (PUFAHL UND WEISS, 2009).

Eine bessere Anpassungsgüte könnte in unserem Fall möglicherweise erreicht werden, wenn die Betriebe wie von HÜTTEL UND MARGARIAN (2009) in schrumpfend, stabil oder wachsend unterteilt werden. Dazu müsste das Sample allerdings mit weiteren Datenquellen kombiniert werden, die jedoch nicht verfügbar sind. Aufgrund der breiten Abstützung der abhängigen Variablen in der Literatur und des zufriedenstellenden Wertes des Pseudo-$R^2$ nach MCKELVEY UND ZAVOINA (1975) gehen wir davon aus, dass unser Modell geeignet ist, fundierte Rückschlüsse zu ziehen. Es muss allerdings beachtet werden, dass es sich hierbei um einen gepoolten Ansatz handelt und daher das Risiko einer Verzerrung nicht ausgeschlossen werden kann. Fixed-Effects- oder Random-Effects-Ansätze stellen in diesem Fall aber keine Alternative dar.

### 3.6.2 Ökonomische Größen

Bei allen ökonomischen Größen fällt auf, dass die Odds Ratios sehr nahe bei 1 liegen und auch als Tausendstel keinen deutlichen Effekt haben. Die Wirkungsrichtung bestätigt die Ergebnisse von MANN (2003). Allerdings stellte er nur einen signifikanten Zusammenhang von Eigenkapital in Boden und Maschinen, nicht aber in Gebäude fest. Der Anteil des verzinsten Fremdkapitals am gesamten Fremdkapital deutet darauf hin, dass Betriebe mit höherer Investitionswahrscheinlichkeit mehr finanziellen Spielraum haben. Vermutlich haben sie die vom Bäuerlichen Bodenrecht (BUNDESRAT, 1991) vorgesehene Verschuldungsgrenze noch nicht erreicht und können das Fremdkapital stärker ohne Investitionskredit finanzieren.

Je größer der Anteil des Gesamteinkommens, der aus dem Nebeneinkommen generiert wird, desto geringer ist die Investitionswahrscheinlichkeit, wie der Odds Ratio-Wert von unter 1 zeigt. Das entspricht den Ergebnissen in der Literatur, wo die Wirkung als überwiegend negativ gesehen wird (FOLTZ UND ALDANA, 2006; WEISS, 1999).

Die negative Wirkung der außerhalb der Landwirtschaft erzielbaren Löhne von FOLTZ UND ALDANA (2006) kann zwar bestätigt werden, nicht aber die höhere Bedeutung gegenüber Charakteristika von Betrieb und Betriebsleiter. Der Medianlohn, bezogen auf eine volle Arbeitskraft, im Nebenerwerb liegt in unserem Sample bei CHF 68.642 und damit über dem allgemeinen Medianlohn von Arbeitnehmern in der Schweiz von CHF 65.442 CHF. Ausbildung und ökonomisches Umfeld der untersuchten Betriebe scheinen daher sehr gut zu sein.

Die positive Wirkung des Grünlandanteils auf die Investitionswahrscheinlichkeit ist nachvollziehbar, da es bei Grünland nur wenige Produktionsalternativen zur Milchviehhaltung gibt (GAZZARIN et al., 2008).

### 3.6.3 Soziale Charakteristika

Die sozialen Charakteristika haben angesichts der größeren Odds Ratios einen deutlich stärkeren Einfluss als ökonomische Merkmale. Das Alter hat den aus der Literatur zu erwartenden Effekt einer zunehmenden Wahrscheinlichkeit mit einem Wendepunkt (HENNESSY UND O BRIEN, 2008; WEISS, 1999) und entspricht damit der Farm Life Cycle Theory (LADUE et al., 1991). Am deutlichsten wirkt sich aus, ob der Betriebsleiter eine Partnerin hat, wobei es sich hier um eine Dummy-Variable handelt. Es ist zu vermuten, dass bei extremen Verteilungen und deutlich ungleich verteilten Dummy-Variablen schon eine geringe Anzahl an Beobachtungen einen großen Effekt haben können. Daher muss auch der deutliche Effekt der Ausbildung mit Vorsicht interpretiert werden. Der Anteil der Betriebsleiter ohne eine Lehre liegt bei den Betrieben mit späterer Investition bei 9 %, bei Betrieben, die nicht investieren, aber nur bei4 %. Diese 9 % bei den Investitionsbetrieben bestehen nur aus 21 Beobachtungen. Dennoch erscheint der Effekt plausibel, da für den Erhalt von Direktzahlungen ebenfalls eine landwirtschaftliche Ausbildung vorliegen, oder eine längere praktische Tätigkeit in der Landwirtschaft nachgewiesen werden muss (BUNDESRAT, 2013).

Der positive Effekt der Verbrauchereinheiten deckt sich mit den Ergebnissen von WEISS (1999), wonach eine größere Familie mehr Arbeitsressourcen bedeuten und damit Wachstum und Überleben eines Betriebs verbessern. Außerdem stellt WEISS (1999) einen positiven Effekt eines Hofnachfolgers fest. Auch bei den Schweizer Betrieben dürfte die Wahrscheinlichkeit, dass ein Hofnachfolger vorhanden ist, höher sein bei größeren Haushalten. Insgesamt scheint der Einfluss der sozialen Charakteristika die Wirkung der wirtschaftlichen Eigenschaften der Betriebe deutlich zu übertreffen, wenn es um Investitionen in Milchviehställe geht.

## 3.7 SCHLUSSFOLGERUNG

Das hier verwendete Modell umfasst Variablen, die auch in der Literatur verwendet werden, und erlaubt dadurch eine gute Vergleichbarkeit. Die Wirkungsrichtung der Einflussgrößen entspricht dabei überwiegend der aus der Literatur erwarteten. Da der Anteil der positiven Beobachtungen mit rund 2 % sehr gering ist, wird die Beurteilung der Anpassungsgüte des Modells schwieriger. Die Verteilung muss auch bei der Interpretation beachtet werden.

Sozioökonomische Charakteristika wie das Alter des Betriebsleiters, die Anwesenheit einer Partnerin und die Familiengröße scheinen einen stärkeren Einfluss auf die Investitionswahrscheinlichkeit zu haben als wirtschaftliche Kenngrößen. Investitionen in Milchviehställe werden daher wohl eher durch große Familien ermöglicht denn durch wirtschaftlichen Erfolg.

Für die Förderpolitik ergibt sich daraus, dass die Beschränkung, nur tragfähige Konzepte zu fördern, einen untergeordneten Einfluss hat.

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# 4 SURVIVAL ANALYSIS FOR THE ADJUSTMENT PHASE FOLLOWING INVESTMENT IN SWISS DAIRY SHEDS

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**Abstract**

We analysed the adjustment phase following a dairy shed investment. On the basis of farm observations from both the Swiss Farm Accountancy Data Network (FADN) and a database of government-supported investments from 2003 through 2014, we focused on the imputed profit, the farm income minus opportunity costs for family labour and family capital. After investment, the analysed farms needed three years to return to the same profit level as that before the investment (median value). A Cox proportional-hazards model (survival analysis) showed that the probability of reattaining the imputed profit increased with equity capital. A reduction of the probability was related to a high imputed profit, a high off-farm income, high expenses for purchased animals and, in particular, a greater use of family labour before the investment. We conclude that the use of family labour after investment should be addressed more thoroughly during the planning process prior to an investment.

**Keywords**
Investment; dairy cattle; imputed profit; Switzerland

## 4.1 INTRODUCTION

Building a new dairy shed or investing substantially in an existing one is a decisive step in the development of a dairy farm. An investment is likely to go along with some technical progress. Given the small size of Swiss dairy farms, the labour input per cow can thus be roughly halved if the form of husbandry is converted from tethered to loose housing [1]. That many farms in Switzerland have taken this step is demonstrated by the increase in the number of cows kept in loose housing [2].

At the farm level, an investment may result in sunk costs [3] potentially forcing the farm to stay in the dairy business. According to Balmann et al. (2006) [3], this effect is also relevant for the dairy sector as a whole, because a suboptimal sectoral structure may persist for decades. As a consequence of specific investments, farmers may even accept a negative capital productivity before starting to disinvest [4]. Generally speaking, the locked-in situation may put into question whether the investment is leading to an economic improvement at all.

In fact, there is evidence that investments in dairy sheds are not, at least immediately, an economic success. Several studies have shown that the cattle population only grows with some delay following investment in dairy sheds [5–7]. Sauer and Latacz-Lohmann (2015) [8] point to the fact that an investment is followed by a phase of efficiency improvement that lasts for two years. In Switzerland too, there is evidence of unused capacity following investment in a dairy shed [9]. Investments with a longer-lasting learning effect and a subsequent increase in efficiency are also known from the downstream agricultural sector [10].

Kramer et al. (2019) [7] analysed the impact of a dairy shed investment on profitability focusing on imputed profit as an evaluation criterion. This paper goes one step further, analysing whether the imputed profit before an investment is reattained afterwards. In detail, two questions were answered. Firstly, how many years are necessary to recover the imputed profit before investment? Secondly, which factors favour or hamper the recovery of the imputed profit? The analysis of factors was carried out by means of a survival analysis, i.e., a Cox proportional-hazards model. As to our knowledge, a survival analysis has never been applied to investigate the course of an agricultural investment.

The paper is organised as follows. The subsequent methodological section deals with the variables used and the description of the Cox proportional-hazards model. Section three presents the results, followed by the discussion in section four. The final section puts forward the conclusions.

## 4.2 MATERIALS AND METHODS

### 4.2.1 Dataset

Similar to Kramer et al. (2019) [7], the analysis was based on two data sets. Firstly, we selected farms limited to the farm types “dairying” and “combined dairy/arable crops” from the Swiss Farm Accountancy Data Network (FADN) from 2003 to 2014 [11]. We focused on farms from the valley and hill regions, allowing for the analysis of specialised dairy farms with comparable natural conditions. The FADN data contain information only on the presence and amount of investment loans, not on their intended use. Hence, there is no indication about the type of investment (e.g., dairy shed, machine shed or another farm enterprise than dairy). Neither is the year or the years the investment has taken place available. Such information is provided by the second data base, MAPIS (Meliorations-und Agrarkredit-ProjektInformations-System [12]) including all subsidised investments in dairy sheds.

We matched both data sources by means of municipal code, loan amount and—if necessary—potential year(s) of investment. The resulting data set contained 103 farms with 544 observations. Due to the panel mortality in the FADN, the number of farm observations decreased with each subsequent year after the investment.

### 4.2.2 Imputed Profit

Because most dairy farms are family-run, they show a high share of family-owned factors, labour and capital. The latter also includes own land. Accordingly, the farm profit is highly dependent on the (assumed) remuneration of own factors. The imputed profit corresponds to the agricultural or farm income minus opportunity costs for family labour and family capital and is well suited as a criterion for economic success. The imputed profit is derived from FADN observation for farm j and year t according to Formula 1:

$$\textit{Imputed profit}_{j,t} = \textit{Agicultural income}_{j,t} - \textit{Opportunity costs labour}_{j,t} - \textit{Opportunity costs capital}_{j,t} \quad (1)$$

The agricultural income corresponds to the difference of all revenues including direct payments less all third-party costs. The latter include all direct costs and the costs for borrowed capital and non-family labour. Accordingly, agricultural income represents the remuneration of the family-owned factors.

Given the heterogeneity in size and the composition of the family-owned factors labour and capital, a standardisation is necessary. In order to enable a comparison of the farms, we deducted the opportunity costs for both factors, labour and capital [11]. The opportunity costs are defined by law [13], taking account of regional differences (valley vs. hill region). For family labour, the agricultural reference wage is applied. The latter corresponds to the income achieved in other sectors (industry and services), implicitly assuming a similar qualification ofworkforces. For equity capital, the interest rate on 10-year (Swiss) Federal bonds is applied asopportunity cost.

It is important to note that Swiss FADN was applying constant depreciation at the period of the data used. Accordingly, the depreciation was independent of the course of business.

### 4.2.3 Model

In order to analyse the determinants of the adjustment phase following the investment, the methods of survival analysis are suited. Survival analysis examines the time up to the occurrence of an event [14] and the influencing factors. The Cox proportional-hazards model is one of the models frequently used for survival analyses. It allows the analysis of variables with and without time variance and has been used in agricultural economics before [15,16]. Theuse of survival models is attractive for the data structure under consideration, as it takes into account the right censoring of data [14&7]. Right censoring means that individuals withdraw from a study without the event of interest being observed. In the case of the observed events, we knew the time to the event, but in the case of withdrawals, we knew that farms had not recovered the imputed profit at least up to the observation point. The survival method takes this into account by considering these two cases separately [14&18]. A critical step in survival analysis is the definition of a starting point at which a specific event may occur [14]. The specific event occurred when a farm returned to at least the imputed profit from the year prior to the investment. In the available data, the starting point could be precisely defined as the time of the investment. The Cox proportional-hazards model calculates the hazard for a farm j with properties xj as follows:

$$h(t|x_j) = h_0(t)\exp\,(x_j\beta_x) \quad (2)$$

Here, $\beta_x$ stands for the regression coefficients established from the data, and $h_0(t)$ for the baseline hazard [14]. The hazard represents the probability that an event will occur at time t, assuming that it has not occurred until (infinitesimally) shortly before time t [15]. The survival function in the model is an exponential function. The hazard for this exponential distribution is appropriate in this case, since no dependence of the hazard on the elapsed time is expected [15]. “Proportional hazards” means that the proportional change in hazards due to a change in an explanatory variable does not depend on time [15]. This assumption was checked using the test for proportional hazards according to Grambsch and Therneau (1994) [19] and could not be rejected.

#### 4.2.4 Independent Variables

Table 1 provides an overview of the independent variables used, including their mean value and standard deviation.

**Table 1.** Overview of the independent variables used, with abbreviations and units.

| Variable | Unit | Mean Value | Standard Deviation |
|---|---|---|---|
| Investment | 10 kCHF | 7.05 | 21.7 |
| Imputed profit before investment | 10 kCHF | −1.86 | 3.40 |
| Equity capital | 10 kCHF | 62.0 | 37.0 |
| Annual family work units | FWU | 1.31 | 0.34 |
| Off-farm income | 10 kCHF | 1.47 | 1.81 |
| Grassland | Ha | 20.0 | 8.56 |
| Stocking rate | LU/ha | 1.48 | 0.42 |
| Ratio of offspring to dairy cows (in LU) | - | 0.25 | 0.16 |
| Animal purchases | 10 kCHF | 1.44 | 2.24 |
| Milk produced | t/a | 211 | 101 |
| Type of farm (dummy) | - | 0.72 | 0.45 |

The mean investment of the farms under investigation was 0.5 kCHF. (CHF denotes Swiss francs. The average exchange rate in 2017 of the currency towards USD and Euro was 1 CHF = 0.90 Euro = 1.02 USD, as retrieved from https://data.snb.ch on 29 January 2018). Because the actual number of dairy shed places created by the investment was not apparent from the data, the level of investment was used as a proxy in order to control for this. The observed slow increase in livestock numbers after the investments [5–7] is an indication that the increased dairy shed capacity initially remained unutilised [9]. Accordingly, it is expected that size (of an investment) has a negative impact on the adjustment phase.

The use of own production factors directly influences the imputed profit, as a central factor in the analysis, via the opportunity costs. Equity capital, including own land, in tens of thousands of CHF, and family labour, in annual labour units, were therefore included in the model as explanatory variables. Opportunity costs should also be included in the model because they are perceived as being less important than financial accounting costs [20]. If the owners and managers of a farm are generally satisfied with lower remuneration of production factors or have made extensive investments in the past, it can be expected that the profit—and thus also imputed profit—will be at a lower level. To take this into account, the imputed profit before the investment was introduced in the model as a variable. A low starting position should also be easier to reattain and should therefore increase the probability of reattainment.

Regarding equity capital, two effects seem plausible. A higher equity capital reduces the imputed profit, via the interest claim. At the same time, however, it is to be expected that the equity capital stock is closely linked to economic success and enables better farm results. If a farm is comfortably endowed with family labour, expressed as annual family work units (FWU), this could lead to inefficient use, as there is no direct economic pressure to remunerate family workers in full. Given that family labour dominates the labour input in Swiss dairy farms, this variable is also linked to farm size.

Combining agricultural and non-agricultural income sources is not economically optimal and, if farming is not used as the single source of income, it might partly be a lifestyle decision [21]. However, Mittenzwei and Mann (2017) [21] also mentioned that other authors see the decline in agricultural incomes as a justification for combining income sources. In connection with investment, Foltz and Aldana (2006) [22] stated that the level of non-agricultural wages influences the decision whether to generate an off-farm income or to expand the farm. However, whether investments are made if off-farm income is available also seems to depend on who is earning a non-agricultural income, i.e., the farm managers or their partners [23]. The studies referenced here do not distinguish who earns the off-farm income or how high the wage level is. The off-farm income from both independent and dependent employment (in tens of thousands of CHF) is therefore included in the model. Although an off-farm income appears to reduce the probability of investment [22,23], a positive effect could be expected during the adjustment phase. Improving the input/output ratio without expanding the production would free up labour that could be used for the secondary occupation. Hennessy and O’Brien (2008) [23] also postulated a substitution effect of labour by capital in the case of a secondary occupation but found no significant correlation between secondary occupation and level of investment.

In the Swiss dairy production system, grassland forms the basis of milk production because of relatively high costs of concentrates. Due to economies of scale, one would expect more hectares of grassland to have a positive effect. At the same time, the fertiliser regulations set an upper limit for the stocking rate expressed in livestock units (LUs) per hectare (ha) of agricultural land, which could limit the benefit of economies of scale in dairy shed building and thus have a negative effect. Agricultural land includes arable land and grassland. In practice, this can be mitigated by outsourcing the rearing of offspring to other farms. Such a strategy could be identified by a low ratio of offspring to dairy cows, both measured in livestock units. Since a low ratio would correspond to a specialisation, it could be expected to have a positive effect.

In spite of the above-mentioned slow increase in livestock numbers after investment, the additional capacity generated by the investment could be used more quickly by purchasing additional animals. The FADN data record expenditure on animal purchases using a specific reference rate per animal for monetary valuation of the herd, for balance sheet purposes [24]. That this rate may deviate from actual market prices [25,26] must be taken into account for the interpretation of the results.

In order to account for a possible increase in milk yield as a result of the investment, the milk produced on the farm was included in the model.

Since the data referred to two different types of farm (“dairying” and “combined dairy/arable crops”), these two types were differentiated for the analysis using a dummy (1 = “dairying”).

## 4.3 RESULTS

Out of the 103 farms with investments, 65 were able to reattain the imputed profit from before the investment during the period of observation. The median time to reattainment was three years. The median imputed profit before the investment was CHF −20,843. The production factors were thus not fully remunerated for the majority of farms. For five of the explanatory variables, the p-value was below 0.1, so these were regarded as significant. The results are shown in Table 2.

**Table 2.** Results of the Cox proportional-hazards model.

| Variable | Hazard-Ratio | Standard Error | *p*-Value |
|---|---|---|---|
| Investment | 1.00 | 0.003 | 0.178 |
| Imputed profit before investment | 0.86 | 0.024 | **0.000**[a] |
| Equity capital | 1.01 | 0.003 | **0.084**[a] |
| Annual family work units | 0.26 | 0.090 | **0.000**[a] |
| Off-farm income | 0.94 | 0.035 | **0.084**[a] |
| Grassland | 1.02 | 0.023 | 0.350 |
| Stocking rate | 1.59 | 0.715 | 0.302 |
| Ratio of offspring to dairy cows (in LU) | 1.22 | 1.01 | 0.811 |
| Animal purchases | 0.85 | 0.071 | **0.052**[a] |
| Milk produced | 1.00 | 0.000 | 0.362 |
| Type of farm | 0.67 | 0.226 | 0.240 |

[a] A **bold *p*-Value** denotes a significant explanatory variable (p-Value < 0.1).

A hazard ratio greater than 1 means that a higher value of the corresponding variable is associated with a higher probability of reattaining the imputed profit. This was desirable in the present case, because the effect on the adjustment phase was positive, i.e., the starting level was reattained. It should be noted that a coefficient larger or smaller than 1 is not tantamount to a shorter or longer adjustment phase, which would only hold true in the case of time-invariant variables [15].

Only an increase in equity capital had a significantly increasing effect on the probability of reattainment, even though the strength of the effect was rather small (hazard ratio close to 1). The hazard ratios of all other significant variables such as imputed profit before investment, annual family work units, purchase of additional animals and off-farm income were below 1, thus reducing the probability of reattainment. While four out of the five significant variables showed a hazard ratio relatively close to 1, the hazard ratio for annual family work units was far below 0.5. To illustrate the interpretation of the hazard ratio, we used the example of imputed profit before investment: For every CHF 10,000 of imputed profit, the probability of re-attainment was reduced by 14%.

## 4.4 DISCUSSION

The median of three years until the imputed profit was reattained confirmed the results of Sauer and Latacz-Lohmann (2015) [8]. Since, as for opportunity costs, the remuneration of family labour surpassed clearly the remuneration of capital [27], it is not surprising that the use of family labour had a more significant influence than equity capital. The influence of equity capital was significantly positive, but rather small. The influence of family work units was significant and strongly negative. In addition to a less clear perception of opportunity costs [20], another reason for this could be the limited mobility of labour [28]. There may not be an immediate alternative. Due to the learning effects that can accompany investments [10], the final labour requirements may not yet be precisely determined before the investment, meaning that more family labour is held in reserve as it does not entail any direct costs.

As stated in the introduction, more off-farm income can be argued to hamper or increase the probability of re-attaining pre-investment profits. A high off-farm income might facilitate farm investment and, as result, free up labour for more off-farm income, if off-farm work opportunities exist. It might also allow a family to accept a lower labour productivity for the farm, as living expenses are covered by off-farm income. Off-farm income had a negative impact on the probability of attaining pre-investment profits. Its direct effect on liquidity and immediate contribution to covering the cost of living of the family might lessen the need to generate income from farm business. In addition, adopting the argument of combining incomes as a lifestyle choice [21], agriculture would be seen as a hobby, which in turn calls into question the actual applicability of the opportunity costs concept.

There are several potential reasons for the negative effect of a higher imputed profit before investment. Investment in a dairy shed requires long-term planning. Expenditure that reduced the profit and was related to the investment may have been incurred in advance. However, in our analysis, it was not possible to use an average imputed profit over several years before the investment as a benchmark, as this would additionally reduce the number of farms available for analysis. In the case of farms working with depreciated equipment, the lack of depreciation leads to a higher imputed profit before the investment, which is no longer the case after the investment. In addition, such accumulated needs could lead to subsequent investments that reduce the profit.

The acquisition of additional animals had a negative effect on the probability of reattaining pre-investment profits and is therefore contrary to the formulated hypothesis. However, in our analysis, only the monetary value was taken into account, which might bring accounting effects into play. The benchmark value of a cow for balance sheet purposes was, most recently, CHF 2200 [26], while the average price achieved for dairy cows at livestock auctions in the observation period was between CHF 2600 and CHF 3500 [25]. This indicates that market prices were above the reference rates used but does not permit a final conclusion to be drawn. However, if the amount for which animals are purchased is higher than the reference rate, the monetary expenditure is higher than the increase in value of the animals in the balance sheet. This difference has a direct negative effect on the imputed profit as compared to the case in which animals could be purchased at the reference rate.

In addition, dairy cows are generally used over several years, but are not written off in the accounts [24]. As a result, the costs of purchasing additional animals accrue completely in the year of acquisition, although they are also related to other periods, and thus lower the imputed profit in the period of acquisition only. Hence, if animals were purchased closely after the investment, this would artificially reduce imputed profits in that period and thus decrease the probability of reattaining pre-investment profits.

It would also be conceivable that animal purchases are made by farms whose herds show poor physical performance, that purchased animals affect the productivity of the herd negatively due to initial stress or that animals are bought at a young age, not directly being able to positively affect profit. However, all of this cannot be adequately represented by the data.

Since FADN data do not contain enough information on the reproductive characteristics of the dairy herd, we could not fully take into account its natural growth. This left us with the usage of the ratio of offspring to dairy cows as a proxy. The coefficient of this variable showed a positive impact on reattaining pre-investment profits, but not significantly so.

## 4.5 CONCLUSIONS

By means of a Cox proportional-hazards model, this paper analysed whether Swiss farms, which invested in their dairy shed, reattained their imputed profit prior to investment and which factors affected this process. Although the data set used was relatively small, the analysis provided relevant information for both farm management and agricultural policy. Four out of five significant influencing factors hampered the reattainment of the pre-investment imputed profit, which confirms the finding in the literature that the phase directly after an investment is not rewarded by dominant efficiency improvements [8&10]. Rather, the farms in this study appeared to take only limited advantage of both improved efficiency and increasing imputed profit after the investment. The clearly negative and highly significant influence of family labour points to the fact that family labour is not allocated in an optimal way. We conclude that the use of family labour after investment should be addressed more thoroughly during the planning process prior to an investment of a dairy shed. The shown negative influence of off-farm labour additionally emphasises the importance of planning how the farm manager’s family should deploy its work forces in the medium and long run.

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# 5 THE ROLE OF NEIGHBORHOOD EFFECTS ON INVESTING DAIRY FARMS

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**Abstract:** For the traditionally small-scaled Swiss agriculture, large economies of scale exist in dairy farming. Farm expansion is typically linked to a barn investment, but the opportunities for expanding the necessary acreage are limited. To enable an investing farm to expand its acreage, neighboring farms must shrink or phase out. Hence, the question arises how neighboring farms affect investing farms.

To address this question, we used a set of Farm Accountancy Data Network data and government data on subsidized projects. We combined this dataset with agricultural census data to assess the concentration of agricultural land as well as the number of subsidized investments within the municipality of an investing farm. By means of random-effects models for agricultural income per family working unit on the one side and herd size change on the other, we found two effects of neighborhood. A high number of subsidized projects and a high concentration of land (Gini coefficient) limited the growth in herd size due to scarcity of available land. At the same time, neighborhood positively influenced the management, leading to a higher agricultural income per family working unit. The results illustrate that an extension of the Farm Accountancy Data Network data, which in itself is extensive, can further help to address specific research questions.

**Keywords:** FADN, neighborhood effects, farm economics, dairy farming, investment

## 5.1 BACKGROUND

With 27 dairy cows, Swiss dairy farms hold less than half of the average number of dairy cows per farm, as compared with dairy farms in Germany, France and Italy (Hemme, 2017). Gazzarin and Hilty (2002) compared the necessary amount of investment between different herd sizes for Swiss dairy farms. Compared with an investment for 30 dairy cows, investment costs per cow declined by almost 30% for a capacity of 70 cows. In addition, economies of scale apply also to labor (Schick & Hartmann, 2005). Even more prominent is the labor-saving effect in changing from a stanchion to a free-stall barn (Schick & Hartmann, 2005). Usually, the switch between these two systems occurs with farm investments and can therefore be seen as substitution of labor through capital. In Switzerland, this change occurred relatively late. Whereas in 2003 about two thirds of all dairy cows in Switzerland were still held in stanchion barns, this applied to only one third in 2013 (Meyre, 2016). Investments in new dairy barns contributed substantially to this change.

Kramer et al. (2019a) showed that Swiss dairy farms investing in new barns need several years to reattain their pre-investment profitability. Consequently, investments in larger dairy barns do not lead to economies of scale in the short and medium term, even though this development would be expected from an increased labor productivity (Schick & Hartmann, 2005) and usually applies also to small farms (Chavas, 2001).

Animal husbandry is closely linked to acreage because of feed production and manure utilization. Dairy farming is linked even more strongly to the corresponding agricultural land because roughage is low in energy density and not as suitable for transportation as are concentrates. In addition, farmers must keep the number of livestock units below a certain level per acreage to obtain direct payments from the Swiss government (Bundesrat, 1998). Feinerman and Peerlings (2005) found that farm buildings and acreage act as complementary inputs.

The existence and consequences of neighborhood effects in agriculture have been studied in the literature. Schmidtner et al. (2012) analyzed the positive effects of neighboring farms on conversion to organic farming in Germany. Mack (2012) examined spatial influences on the conversion to suckler cow production and concluded that peer effects exist as long as a production process is new and therefore associated with uncertainty; as uncertainty declines, peer effects decline. Sauer and Zilberman (2012) found in Northern Europe that farms that adopted a milking robot early on positively influenced farms in their neighborhood to follow their example. The authors attributed those spill-over effects to knowledge transfer and imitation by other farmers. It has also been shown in the literature that the spatial limitation of land markets leads to interference of decisions of neighboring farms. Because of this spatial limitation, strategies of neighboring farms are mutually dependent (Margarian, 2010). For example, Feinerman and Peerlings (2005) derived a model to analyze the influence of the uncertain availability of agricultural land on the investment decision of Dutch dairy farmers, but their results were inconclusive. Hence, although the link between investments in a new technology and spill-over effects to neighbors has been made in the literature, to our knowledge there is no empirical study that links an agricultural investment and neighboring effects related to the availability of agricultural land.

The current study builds on the dataset of Kramer et al. (2019b). This dataset consists of Farm Accountancy Data Network (FADN) data matched to government data on projects with interest-free investment credits. In this way, investments related to dairy barns can be identified. We extended the dataset by adding data from the Swiss agricultural census “Agrarpolitisches Informationssystem” (AGIS) (BLW, 2020). Although direct matching was not possible due to data privacy, spatial indicators could be derived from the AGIS data and combined with the existing dataset. The newly constructed dataset then helped us gain new insights into the mechanisms that link successful investments in dairy barns to the availability of land.

## 5.2 MATERIALS AND METHODS

### 5.2.1 Dataset

In Switzerland, dairy farms willing to invest in a new dairy barn are eligible for interest-free investment credits supplied by cantonal institutions (at province level). Besides being interest free, these investment credits allow the farms to exceed the borrowing limit set by law (Bundesrat, 1991). According to government officials from cantonal lending institutions,almost all major projects on dairy barns are supported by interest-free investment credits

(Personal Communication, 2017). All projects subsidized by those credits are registered in a central database, the "Meliorations- und Agrarkredit-Projekt-Informationssystem" (MAPIS). Hence, by relying on this dataset, we captured all major dairy barn investments in Switzerland.

The Swiss FADN database comprises an unbalanced panel of farm data over time, with detailed data of the single farms. Details include information on key financial figures, farm structure, input of resources, inventories, yields and off-farm income. For the current study, we restricted the dataset to farms classified as specialized dairy farms (Type 21) or combined dairy–arable crop farms (Type 51) according to the Swiss FADN system (Hoop & Schmid, 2015). We also restricted the analysis to farms in the valley and hill regions, because farms in the mountain regions face largely different natural conditions. The years 2003 through 2014 were chosen as the period of investigation. Within this period, the methodology of data collection in the Swiss FADN system did not change.

By matching the described set of data with the MAPIS data, we derived a dataset with binding information of whether a farm had invested in a dairy barn. The resulting dataset was then restricted to farms that had definitely invested in dairy barns. This dataset was used previously by Kramer et al. (2019b).

The complete agricultural structure in Switzerland is assessed by AGIS. The corresponding dataset contains structural data such as acreage, livestock, municipality and other details for all Swiss farms, but it does not contain financial data. A direct matching between the datasets of Kramer et al. (2019b) and AGIS was not possible for data protection reasons. However, it was possible to derive spatial indicators on the level of municipalities from the AGIS dataset and match them to the farms whose municipality was known from the first dataset. For example, the AGIS dataset allowed calculating the Gini coefficient within a municipality as a measure of concentration of all available acreage (calculation of the Gini coefficient is described in more detail in the subsection Independent Variables). In addition, the number of all subsidized dairy barn projects within a specific municipality over the chosen period could be determined. Other studies on spatial distribution used a much coarser resolution on the level of canton or higher (Huettel & Margarian, 2009; Mack, 2012; Sauer & Zilberman, 2012).

### 5.2.2 Model and Dependent Variables

Kramer et al. (2019b) used two fixed-effects panel data models to analyze the effect of the investment on profitability and herd size, the latter measured by the annual difference in the number of dairy cow livestock units. There, the focus was on the adjustment of single farms after the investment. Therefore, intertemporal differences were of main interest leading to the choice of a fixed-effects model.

For the current study, building on the method of Kramer et al. (2019b), the focus was different—more on the relation between the farm's location and its investment than on the farm's evolution over time. Another difference was that we used agricultural income per family working unit (AI/FWU) as a measure of profitability. This measure can be viewed as the financial efficiency of the utilized family working units. In the following, we first discuss the decision of the model and then explain the dependent variables.

Except off-farm income, for all our explanatory variables and the AI/FWU, the cross-sectional variance component was greater than the temporal component (Table A.1), which indicates that a random-effects model is preferred. The cross-sectional variance component of the annual difference in herd size and off-farm income was about the same order of magnitude as the temporal component. This higher contribution of the temporal component was partly due to the abandonment of the milk quota system8.

The random-effects model is a frequently used approach in the literature. If a random-effects model is applicable, it has the advantage of allowing the straightforward inclusion of time-invariant explanatory variables. Moreover, the resulting model will be more efficient than its fixed-effects counterpart: If both a random-effects and a fixed-effects model are applicable, the random-effects model is more efficient, resulting in a narrower confidence interval for its computed coefficients. We tested the applicability of a random-effects model in three ways:

[8] With the abandonment of the milk quota system, dairy farms enlarged their dairy herd, which led partly to higher temporal variation for a short period.

using a straightforward Hausman test (Baltagi et al., 2003), a Mundlak-type correlated random-effects model (Mundlak, 1978) and a fixed-effects vector decomposition model (Greene, 2011).

The models employed were also chosen to address endogeneity: The Mundlak model tested for evidence of a correlation between a time-invariant unobservable variable and our regressors. Because the notion of an endogenous variable can be considered an explanatory variable correlated with the error term of a regression, we determined and indicated correlations between the error term of the random-effects model and explanatory variables in the Appendix.

Table A.1 gives an overview of the descriptive statistics of the sample. The variables and their definitions are discussed in detail later in this section.

**Table A.1** Overall, cross-sectional and temporal components of variance of the variables employed

| Variable | Unit | Number of observations | Average | Minimum | Maximum | Standard Deviation | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | overall | between (cross-sectional) | within (temporal) |
| AI/FWU | CHF/FWU | 418 | 55,428 | −31,387 | 231,634 | 35,529 | 28,339 | 21,787 |
| ΔLU dairy cows | LU | 418 | 1.40 | −11.12 | 18.92 | 3.41 | 2.34 | 2.99 |
| UAA | ha | 418 | 27.32 | 8.57 | 59.47 | 8.72 | 8.98 | 1.76 |
| Number subsidized projects in municipality | - | 418 | 47.95 | 6.00 | 159.0 | 31.46 | 34.56 | 0.00 |
| Gini coefficient | - | 418 | 0.38 | 0.19 | 0.65 | 0.11 | 0.11 | 0.00 |
| Dummy: region | 1 = valley, 0 = hill | 418 | 0.50 | 0.00 | 1.00 | 0.50 | 0.50 | 0.00 |
| Dummy: milk quota | 1 for year > 2009, 0 otherwise | 418 | 0.39 | 0.00 | 1.00 | 0.49 | 0.35 | 0.38 |
| Dummy: farm type | 1 = Type 21, 0 = Type 51 | 418 | 0.75 | 0.00 | 1.00 | 0.44 | 0.45 | 0.04 |
| Equity | Mio CHF | 418 | 0.72 | −0.11 | 2.97 | 0.48 | 0.48 | 0.11 |
| Off-farm income | k CHF | 418 | 45.68 | 0.00 | 1,250 | 92.56 | 58.22 | 69.92 |

CHF denotes Swiss francs. In 2017, the average exchange rate of the currency towards Euro was 1 CHF = 0.90 Euro, as retrieved from https://data.snb.ch on 12 March 2021. AI = agricultural income; FWU = family working unit; LU = livestock unit; UAA = utilized agricultural area.

In addition to the components given in Table A.1, we want to highlight a few peculiarities in the data. 53 % of the observations in the dataset had an off-farm income. Missing values were set to zero for analysis. It should be mentioned that the amount of full-time equivalent, that was put towards off-farm income was rather low for most observations (only one third of the observations with off-farm income dedicated more than 0.2 working units towards the off-farm income).

As mentioned before, we used AI/FWU besides herd size change as a dependent variable. Agricultural income is the farm income after interest on borrowed capital, taxes and paid labor. The AI/FWU is routinely calculated in the FADN data according to the following formula:

$$(1) \quad AI/FWU = \frac{Agricultural\ Income - Calculated\ Interest\ on\ Owner\acute{}s\ Equity}{Number\ of\ Family\ Working\ Units}$$

To calculate AI/FWU, calculated interest on owner's equity is subtracted from agricultural income. Interest on owner's equity is based on Swiss government bonds (Hoop & Schmid, 2015). Then, this residual number is divided by the number of family working units that are not already paid on a regular basis (Meier, 2000). Therefore, AI/FWU is a precursor of calculated profit, which in addition accounts for the opportunity cost for labor.

Besides AI/FWU, we analyzed herd size change. Following Kramer et al. (2019b), we used the change from one year to another to avoid distortions of the results from autocorrelation. Herd size was measured in terms of livestock units (LU). The change was calculated according to the following formula:

(2) $$\Delta LU\ dairy\ cows_{i,t} = N_{i,t} - N_{i,t-1}$$

For each dependent variable, a separate random-effects model relying on the same set of explanatory variables was used. The respective variables are described in the next subsection. The model is given by the following formula:

(3) $$X_{i,t} = \alpha + ha\ UAA_{(i,t)}\beta_{ha} + No\ Pro_{(i)}\beta_{NoPro} + Gini_{(i)}\beta_{Gini} + Reg_{(i)}\beta_{Reg} + Quota_{(i,t)}\beta_{Quota} + Type_{(i)}\beta_{Type} + Equ_{(i,t)}\beta_{Equ} + NonAI_{(i,t)}\beta_{NonAI} + \varepsilon_{(i,t)} + \mu_i$$

$X$ denotes the dependent variable, i.e., AI/FWU or change in herd size. α is the constant, ε denotes the individual specific error term and μ the remaining disturbance. The descriptive statistics of all used variables are stated in Table A.1, and their choice for the model is discussed in more detail in the next subsection.

### 5.2.3 Independent Variables

As pointed out in the previous sections, animal husbandry is closely linked to acreage. Due to this linkage, utilized agricultural area (UAA) was used as an independent variable with the abbreviation $ha\ UAA_{(i,t)}$.

The number of subsidized projects per municipality ($NoPro_{(i)}$) was used as a spatial variable. Although spill-over and neighborhood effects have previously been discussed in the literature (Mack, 2012; Sauer & Zilberman, 2012), we could not derive an expected effect. According to Sauer and Zilberman (2012) and Mack (2012), investing farms could trigger investment of neighboring farms through knowledge spill-over or visual example. However, strategic decisions of a farm are also influenced by the decision of other farms (Huettel & Margarian, 2009): A farm planning to invest could be discouraged by a high level of investments of neighboring farms because increased competition for resources could be expected. In addition, comparisons with findings in the literature would not be straightforward because usually larger regions were analyzed, not municipalities.

Another variable linked to spatial distribution was the Gini coefficient ($Gini_{(i)}$). The Gini coefficient is a measure to describe the degree of concentration (or inequality) of a distribution. In the literature, it has mainly been used to analyze the concentration of income or wealth. A Gini coefficient of 0 denotes total equality of the distribution, e.g., everyone of a large population being equally wealthy if analyzing the concentration of distribution of wealth. A Gini coefficient of 1 corresponds to total inequality, e.g., one person of the population holding the entire wealth of the population of which the wealth distribution is studied. Central to the calculation of the Gini coefficient is the distribution of a good of finite quantity, e.g., wealth or agricultural land, within a population of n individuals. For the calculation of the Gini coefficient, the following formula was used, where the individuals possessing the good or land are ordered by increasing amount of the good or land:

(4) $$G = \frac{n}{n-1} * \left(\frac{2\sum_{i=1}^{n} i x_{(i)}}{n\sum_{i=1}^{n} x_{(i)}} - \frac{n+1}{n}\right)$$

For two reasons, the Gini coefficient was used as a time-invariant variable. Firstly, this measure changes only slightly over time. For example, Huettel and Margarian (2009) observed an increase in the Gini coefficient in the fast-changing West-German agriculture from 0.44 in 1979 to 0.54 in 1999. Secondly and more importantly in our study, some municipalities have undergone administrative reforms, e.g., merged, and only the municipality structure at the end of the observation period was obtainable.

The Gini coefficient has been used frequently in the agricultural economics literature. Deininger and Squire (1998) and, following their work, Vollrath (2007) used the Gini coefficient to analyze the distribution of agricultural land among farms. Vollrath (2007) analyzed the relation of productivity and land distribution over different countries and found a negative influence of concentration on productivity. This negative influence was attributed to a lack of land market efficiency, which prevents the distribution from attaining an optimum point. Whereas Vollrath (2007) conducted a macroeconomic study, the Gini coefficient has also been used on a microeconomic level (Huettel & Margarian, 2009; Zimmermann & Heckelei, 2012). A more even distribution (i.e., a lower Gini coefficient) might represent a market where medium-sized farms have the potential to take over agricultural land from other farms in order to grow. On the other hand, large farms in concentrated markets (displaying a higher Gini coefficient) might already have enough acreage to utilize additional capacity from investment more quickly.

The independent variables $Reg_{(i)}$, $Quota_{(i,t)}$ and $Type_{(i)}$ were, in line with Kramer et al. (2019b), also part of our model. They controlled for region, (milk) quota abolishment and farm type, respectively. The sample was restricted to the valley and hill regions according to the Swiss FADN system and distinguished by the region dummy. Because quota abolishment occurred within the observed time span, a quota dummy was used to indicate years when the quota system was in place and years after abolishment from 2009 onwards. Another difference between the farms, arising from the Swiss FADN system, was farm type. We used specialized dairy farms and combined dairy–arable crop farms distinguished by means of a farm-type dummy variable.

Equity ($Equ_{(i,t)}$) plays a crucial role for investments. It allows the access to borrowed capital, restricting the size of credits. Particularly agricultural land serves as security for borrowed capital, thus facilitating credit access (Vollrath, 2007). There is also a direct link between equity and credit rationing for Swiss farms, because the total amount of mortgaging on agricultural land is restricted by law (Bundesrat, 1991). In addition, equity was shown to be a statistically significant variable for this dataset in other applications (Kramer et al., 2019a).

Non-agricultural income or off-farm income ($Non\ AI_{(i,t)}$) is of frequent interest in agricultural economics literature—particularly concerning cause and effect of part-time farming. Mittenzwei and Mann (2017) showed that specialization in either an agricultural or a non-agricultural profession is financially more viable than a combination of both. Therefore, in their point of view, a combination is rather seen as a lifestyle choice. It remains ambiguous if or when non-agricultural income becomes necessary in case of low financial power of the farm. Hennessy and O' Brien (2008) analyzed Irish farms for a substitution effect of labor due to non-agricultural income and found a decrease in probability of investment if the farmer earned an off-farm income. Based on economic theory, one would expect investments in labor-saving technologies if labor is better utilized financially in off-farm employment (Hennessy and O´Brien, 2008). The Swiss FADN dataset contains the information if off-farm income is obtained from employment or self-employment. In addition, the dataset contains information how much fulltime equivalent has been dedicated to obtain that off-farm income. We used the sum from employment and self-employment, divided by fulltime equivalent. Therefore, this variable reflects the wage level in the off-farm labor market.

## 5.3 RESULTS

Table A.2 presents the results of two random-effects models, one for the annual AI/FWU, the other for the annual difference in herd size based on livestock units (ΔLU dairy cows). By means of a Wald test, the overall significance of both random-effects models was assessed as being very high ($P < 0.001$).

By means of the Hausman test, the appropriateness of the random-effects models was demonstrated with a P-value of 0.31 (AI/FWU) and 0.65 (ΔLU dairy cows). The appropriateness of the Mundlak-type correlated random-effects model was demonstrated by none of the time-averaged regressors being significantly different from zero (see Appendix: Table A.3). The Mundlak models indicated that endogeneity was not of strong importance for our chosen set of variables for the random-effects model. We further addressed this issue by indicating correlations between the error term of the random-effects model and the explanatory variables in the Appendix (Table A.4). The fixed-effects vector decomposition model was consistent with the random-effects model, with the random-effects being more efficient (P-values of corresponding Hausman tests: 0.85 for AI/FWU and 0.96 for ΔLU dairy cows).

***Table A.2*** *Results of the random-effects model for agricultural income per family working unit (AI/FWU) and herd size change*

| Model result | AI/FWU | | | ΔLU dairy cows | | |
|---|---|---|---|---|---|---|
| $R^2$ within | 0.0847 | | | 0.0324 | | |
| $R^2$ between | 0.2957 | | | 0.3349 | | |
| $R^2$ overall | 0.2056 | | | 0.0875 | | |
| Variable | coefficient | standard error | *P*-value | coefficient | standard error | *P*-value |
| UAA | 1,498.2 | 326.8 | 0.00 | 0.07 | 0.03 | 0.01 |
| Subsidized projects per municipality | 160.0 | 88.7 | 0.07 | −0.01 | 0.01 | 0.09 |
| Gini coefficient | −19,235.4 | 27,734.5 | 0.49 | −3.81 | 2.00 | 0.06 |
| Dummy: region | 1,488.2 | 6,693.8 | 0.09 | 0.09 | 0.48 | 0.86 |
| Dummy: milk quota | −6,688.6 | 2,934.7 | 0.02 | 1.15 | 0.36 | 0.00 |
| Dummy: farm type | 1,171.2 | 7,401.5 | 0.87 | −0.64 | 0.55 | 0.24 |
| Equity | 12,785.8 | 5,800.0 | 0.03 | 0.63 | 0.46 | 0.17 |
| Off-farm income | 17.5 | 15.5 | 0.26 | 0.00 | 0.00 | 0.96 |
| Constant | 1,074.9 | 15,691.6 | 0.96 | 0.97 | 1.13 | 0.39 |

ΔLU = difference in livestock units; UAA = utilized agricultural area. Cells shaded in green indicate statistically significant effects below the 10% level of the *P*-value.

Both models showed a higher coefficient of determination between individuals than within. For the model of AI/FWU, all independent variables, except the Gini coefficient and farm type, were significant below the 10% level of the P-value. The more agricultural area a farm utilized, the higher was the AI/FWU. Also, the number of subsidized projects within a municipality resulted as significant, albeit with a smaller effect as apparent from the coefficient and the standard deviation.

Farms in the valley regions showed a significantly higher AI/FWU than farms in the hill regions. Milk quota abolishment had a negative effect on AI/FWU, as shown by the negative coefficient for the respective dummy. In investment literature, equity is commonly used as a key variable. In the present study, the effect was significant and in the middle range by size: Anincrease in equity by one standard deviation (approximately 0.5 million CHF) corresponded toa change in AI/FWU of 6,100 CHF.

With acreage, subsidized projects per municipality, Gini coefficient and milk quota dummy, mainly the structural variables are statistically significant for herd size change.

Acreage had a positive and significant effect on herd size change. The number of subsidized projects within a municipality was also statistically significant for change in herd size, having a negative effect on this variable: The more projects within a municipality were subsidized, the less a dairy herd grew. Also, a higher Gini coefficient was concomitant with a smaller herd size change: The more concentrated the agricultural land was distributed within a municipality, the less growth in herd size could be expected. While quota abolishment led to lower levels of AI/FWU in investing farms, it allowed them to expand their herds, as indicated by the higher coefficient for herd size change after the year 2009.

## 5.4 DISCUSSION

The selection of the appropriate model has been discussed and shown in the previous sections. For the interpretation of herd size change, it should be noted, that this variable was computed from herd size in the dataset. Thus, exhibits a larger variation than herd size in absolute values.

For growth in herd size, we found the number of subsidized projects in a farm's municipality to be an important indicator of neighborhood effects: More subsidized projects resulted in less growth. According to government officials (Personal Communication, 2017), almost no investment in a dairy farm building is made without subsidies. Hence, the number of subsidized projects within a municipality might be highly correlated to the total number of dairy farm buildings in the municipality. This assumed relationship supports the hypothesis that with increased density of investments in one area, the competition for land increases as well, leading to smaller increases in herd size.

In contrast to growth in herd size, the AI/FWU was positively influenced by the number of subsidized projects. Although the neighborhood (competition) can have a negative effect on the availability of land and consequently on additional livestock units, neighborhood seems to have a positive impact on management, leading to higher income. Although the effect in our study was significant but not highly significant, it was similar to the neighborhood effects found for the conversation to organic farming (Schmidtner et al., 2012) and suckler cow husbandry (Mack, 2012) or the introduction of milking robots (Sauer & Zilberman, 2012).

The negative impact of the Gini coefficient on herd size change is in line with previous findings in the relevant literature. A smaller mobility of resources has been documented when larger inequalities existed between farms (Huettel & Margarian, 2009; Zimmermann & Heckelei, 2012). The larger the Gini coefficient was in our analysis, the smaller was the herd size change and vice versa. This inverse relationship can be interpreted as follows: Investing farms in areas where acreage is distributed more evenly manage to acquire (relatively) more land allowing for a larger increase in herd size.

A positive influence of larger acreage on herd size expansion has previously been shown (Kramer et al., 2019b). To increase herd size or profitability, the presence of sufficient acreage in a farm is crucial. This key characteristic was clearly supported by our regression results, with the effect of acreage being highly significant (and having the highest impact for an increase by one standard deviation for both models). The effect was larger for AI/FWU than for herd size change. However, the magnitude of direct payments is strongly linked to acreage. At first glance, the coefficient of acreage for herd size change can be considered small. Bewley et al. (2001) analyzed experiences of US dairy farmers who had recently expanded their dairy herd in the aftermath of investments. They observed that herd size grew faster than acreage. However, the high level of direct payments in Switzerland, which requires the farmers to keep their livestock density below a certain level (Bundesrat, 1998), might contribute to this coefficient being not as large as in other countries. Although the coefficient was highly significant and large, compared to the other variables in the result.

The herein found effect of milk quota abolishment is in line with basic economic theory. With quota abolishment, Swiss farms increased their milk production considerably and maintained this level (Finger et al., 2013). For the investing farms in this sample, our analysis showed that this increase in productivity was achieved by an increase in herd size on an individual basis for each farm. Supply restrictions such as milk quota are considered to lead to higher production costs and inefficient structures (Richards & Jeffrey, 1997). This might not necessarily translate into higher margins for the producers—for example, Huettel und Jongeneel (2011) could not find unambiguous effects for rents of quota owners. Alongside an increase in herd size, AI/FWU dropped in our study when quota were abolished. Finger et al. (2013) pointed out that given the price drop after quota abolishment, sector production remained on the newly achieved high level.

A positive influence of equity was expected due to equity restricting the amount of borrowed capital by law (Bundesrat, 1991). As can be seen from the results, the effect for Swiss dairy farms was in the middle range, when magnitude of coefficient and standard deviation are taken into account. The effect might be limited for different reasons. First and foremost, the governmental institutions responsible for distributing subsidies and official investment credits among farms are allowed to expand the total amount of credit in this special case of investment (Bundesrat, 1991). Hence, this linkage and the contribution of equity might be more prominent in other investments where farmers have to rely on capital from private investors. In addition to the special case of dairy barns, the small effect of equity might stem from the low level of interest rates. For example, interest rates for 10-year Swiss government bonds kept decreasing from 2.4% in 2003 to negative values in 2015 (SNB, 2021). This development means that opportunity cost for equity diminished over time.

No evidence can be drawn from the data on the different hypotheses about off-farm income. It could be possible that the high share in observations of small amounts of work put to off-farm income added a considerable amount of variation, thus preventing the coefficient from achieving a statistically significant level. On the other hand, only considering higher levels of working units put to off-farm work would be arbitrary.

## 5.5 CONCLUSIONS

By combining three different sources of data, namely, FADN, MAPIS and AGIS data, we constructed a unique dataset apt to analyze influencing factors especially from a farm's neighborhood on two key variables of investing farms: herd size change and AI/FWU, with the latter allowing for comparison of financial productivity of unpaid family labor input. By means of two spatial indicators, namely, the Gini coefficient and the number of subsidized projects at municipality level, we analyzed the influence of neighboring farms on investing farms. We found that neighborhood had an impact on investing farms and that the impact was twofold. Firstly, growth in herd size was limited by a high number of subsidized projects and a high concentration of land (Gini coefficient). The competition for land, which was due to governmental regulation directly linked to herd size, was intense and an obstacle for growth. Secondly, neighborhood positively influenced the farms' management, leading to a higher AI/FWU. Given the intense competition for land, a high performance would be necessary, for example to offer a high rate for rental land. We conclude that an intense dairy farm neighborhood is a challenging precondition for an investment. In such cases, a cooperation with another dairy farm is an option to realize a substantial economies-of-scale effect. Furthermore, another production than dairy with a more favorable neighborhood influence could be an option.

Looking at the other results of the regressions, we can point out that mainly structural variables were of importance for herd size change. Concentration of land and more subsidized projects within a municipality contradicted herd size growth. Milk quota abolishment was an event affecting both key variables considerably. The analysis takes advantage of the detailed data sources. By matching and adding indicators, the FADN dataset which aims to reflect a representative sample of all farms could be used to analyze rather specific research questions from only a small subsample that could not have been identified otherwise. This illustrates that more detailed information about investments would further help to address specific research questions.

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## 5.7 APPENDIX

**Table A.3.** *P*-values of the coefficients for time-averaged regressors of the Mundlak-models

| **Time-averaged regressor** | **In the model for AI/FWU, *P*-value** | **In the model for ΔLU dairy cows, *P*-value** |
|---|---|---|
| UAA | 0.11 | 0.25 |
| Subsidized projects in municipality | NA | NA |
| Gini coefficient | NA | NA |
| Dummy: region (valley = 1, hill = 0) | NA | NA |
| Dummy: milk quota (abolished = 1, in effect = 0) | 0.60 | 0.30 |
| Dummy: farm type (Type 21 = 1, Type 51 = 0) | 0.98 | 0.82 |
| Equity | 0.79 | 0.42 |
| Off-farm income | 0.98 | 0.91 |

The number of subsidized projects and the Gini-coefficient did not vary over time; hence, time-averaged regressors could not be constructed (NA = not applicable). AI/FWU = agricultural income per farm working unit; LU = livestock unit; UAA = utilized agricultural area.

**Table A.4**. Correlations of independent variables and residues of the random-effects models

| **Variable** | **Correlation (*P*-values) with residues of random-effects model** | |
|---|---|---|
| | **for AI/FWU** | **for ΔLU dairy cows** |
| UAA | −0.05 *(0.29)* | −0.02 *(0.74)* |
| Subsidized projects in municipality | −0.00 *(0.95)* | 0.01 *(0.85)* |
| Gini coefficient | 0.04 *(0.38)* | −0.01 *(0.86)* |
| Dummy: region (valley = 1, hill = 0) | -0.02 *(0.62)* | 0.00 *(0.93)* |
| Dummy: milk quota (abolished = 1, in effect = 0) | 0.00 *(0.95)* | −0.01 *(0.80)* |
| Dummy: farm type (Type 21 = 1, Type 51 = 0) | -0.03 *(0.58)* | −0.00 *(0.95)* |
| Equity | 0.01 *(0.86)* | −0.01 *(0.83)* |
| Off-farm income | −0.03 *(0.60)* | 0.00 *(1.00)* |

AI/FWU = agricultural income per farm working unit; LU = livestock unit; UAA = utilized agricultural area.

# 6 GENERAL CONCLUSIONS AND OUTLOOK

In this chapter, the results of chapters 2 through 5, as well as their implications, are discussed and compared to the existing literature in the field. Moreover, the contribution to literature is highlighted and areas of interest for future research are identified. The following discussion is grouped together by topics in favour of grouping together by research questions.

## 6.1 METHODOLOGICAL APPROACH

This section seeks to explain the choice of central variables and approaches that were taken in order to answer the research question. Herd expansion and calculated profit were the main variables used. Only for chapter 5, with agricultural income per family working unit, a slightly different variable was used to measure financial success. The nature of these variables and how they can be used with the data at hand in order to answer the two research questions is outlined.

### 6.1.1 Profitability

#### *6.1.1.1 Advantage of analysing profitability*

In this section it is pointed out how profitability is implemented in agricultural policy and how opportunity costs for labour are derived. Agricultural policy is obliged to compare the income earned in Swiss agriculture to the comparable income of other sectors (Bundesrat, 1999a). The comparison of earned income to the comparable income translates directly into calculated profit, which is used as a central variable in chapter 2 and chapter 5. Calculated profit equals earned income less comparable income, which can result in a negative number. The benchmark for earned income in the sense of agricultural policy is that the highest performing quarter of farms in the FADN sample achieves an earned income higher than or equal to the comparable income (Bundesrat, 2005). This benchmark was set by a political process. Hence, it is not as such a meaningful benchmark for investing farms. All absolute comparisons between earned and comparable income are futile to a degree, since the decision to farm involves many factors that do not allow for the assignment of a monetary value. But, given that off-farm job opportunities exist, a farmer is free to choose an agricultural or other occupation. In addition, the concept is attractive as it allows for the implementation of regionally differing opportunity costs for labour, which are derived from a sound statistical basis. While the direct monetary comparison of farm income to other sectors probably suffers from a systematic bias because of non-monetary motives, the comparison to the farm situation before investment is more substantiated because the proven non-monetary motives (Lips et al., 2016) are more readily overcome. This is discussed further in the following sections.

While for chapter 2 and chapter 4 profitability is the central variable of success, the approach in chapter 5 differs slightly. Instead of profitability, agricultural income per family working unit (AI/FWU) is used. Chapter 4 points to the importance of family labor utilization in order to reattain pre-investment profitability. With Ai/FWU, a precursor of profitability is used and considered as a measure of financial efficiency of the input of family labor. Since profitability and AI/FWU are directly linked together with the only difference of profitability accounting for opportunity cost of labor, results still allow for conclusions of financial success.

#### *6.1.1.2 Sunken cost and opportunity cost of labour*

Since labour is a major opportunity cost to Swiss farms, the characteristics of these farms are discussed in this section. Furthermore, justification is given to use profitability before investment as an anchor to evaluate the development of profitability afterwards.

Specific investments produce sunken costs and a locked-in effect in consequence (Balmann et al., 2006). With a locked-in situation, opportunity costs become irrelevant since off-farm work is not a serious opportunity anymore in this case. This is why profitability before investment is used as an anchor to relate profitability after investment to. The relevance of opportunity costs in a specific situation is assumed to be the inverse of locked-in boundaries. These boundaries over a farmer’s life cycle are illustrated in Figure 8.

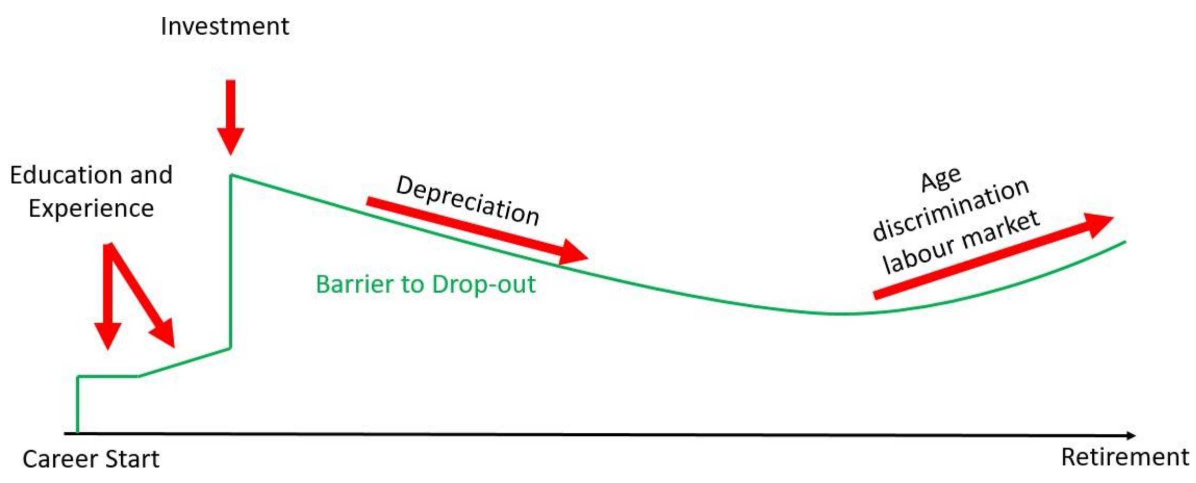


Figure 8: Illustration of boundary height for locked-in effect. Source: own illustration.

The first mild boundary to take on a job in another industry early in the career is the aforementioned sunken cost produced by education and experience (Mann and Mante, 2004). However, this argument from Mann and Mante (2004) is a quite narrow view. The value of an agricultural education might not entirely be restricted to a farm job. Upstream and downstream industries could value this education and provide alternative jobs besides a farm. For industries further away from agriculture, the assumption of sunken costs for education is probably more reasonable. In the case of agricultural education, sunken costs arise from forgone profits because other better paying jobs still require specific education and training to attain a higher income.

Not only sunken costs influence the availability of opportunities for labour but also age. It is assumed that it is relatively easier for a farmer to find a better paying off-farm job at a young age. Results in chapter 4 show an increasing investment probability with age but a decreasing effect for squared age. This means that there is a turning point in the influence of age. The location of this turning point can be derived mathematically through the first derivative of the coefficients for this variable. As a result, investment probability is considered to increase up to about 30 years and then starts decreasing, with all other variables held constant. Although interaction effects of a successor or other factors are neglected at this point, the results indicate that farmers invest at a young age. This implies that sunken cost effects through education and experience are limited and the possibility of off-farm work could be considered. The age effect for investing farmers is in line with literature from Switzerland since farmer's average age is

32 when taking over the farm (Meier et al., 2009) and the youngest age cohort below 35 years consistently invested the most of all cohorts in their farm from 2002 through 2010 (Schmid and Roesch, 2012). Hence, the arguments indicate that the assumption is reliable that opportunity costs matter in younger years the most – in particular before any investment.

The second more pronounced boundary shown in Figure 8 can be attained by an investment, in our case a dairy barn, which – as we argued before – is likely to be realized in the early years of a farmer's professional lifetime. For capital assets like a dairy barn, sunken costs arise from the difference between book value and the best-paying alternative (Balmann et al., 2006). Farm buildings usually have a small market because of immobility and specificity. Though, some variation exists due to individual alternatives. As book values for a dairy barn decrease, the gap between this book value and a possible alternative use of the building declines. Dairy equipment depreciates at a higher rate than the building (Agroscope, 2014). While the dairy equipment probably only has a salvage value that is below book value, the building might be put to alternative use with minor adjustments. Therefore, a locked-in effect is probably strongest in the years dairy equipment depreciates.

The illustration in Figure 8, is a simplification from what is suggested by the results in the literature. It can be assumed that the fundamental theory behind the locked-in boundary is also understood by practical farmers. They are aware that a dairy barn investment locks them into dairy farming for several years, even if some evidence for bounded rationality of farmers has been provided (Musshoff and Hirschauer, 2011). Chavas (1999) found for the U.S pork market that more than 90 % of the pork producers derive their expectations from a prolonged time span in the past. Only the remaining 10% build their expectation on very recent observations. This supports the concept of using the situation before investment as the evaluation anchor for the development afterwards. If a farmer is satisfied with the profitability to the extent that he decides to invest, it can be assumed that he aims to restore a similar level of profitability after investment.

From an economic point of view, all production factors have to be taken into account and a competitive entrepreneur yields a surplus on top of the cost of these factors, leading to positive profitability. This justifies calculated profit as a useful measure for the economic development of a farm, even if profitability sometimes seems to be a rather abstract construct for farmers, which is not perceived properly by practitioners. For example, Forstner et al. (2009) state that a majority of farmers perceived the development of their income after investment positively. This was only partly true if comparing the economic results before investments to the results afterwards, while an increase in cash flow per worker and per area was indeed detected (Forstner et al., 2009). This is in line with the argument that opportunity costs and out-of-pocketcosts are perceived differently (Kahneman et al., 1991). Liquidity can be observed directly, while income requires the inclusion of depreciation only stated in the balance sheet. On top of that, profitability requires assigning a monetary value to the owned production factors and comparing it to income.

While liquidity remains essential for the short-term survival of a business, full factor remuneration does not. Hence, the market does not punish farmers immediately for neglecting profitability in evaluating the success of their business. The hypothesised small attention that farmers pay to profitability does not contradict the high importance attributed to it in this work. The large work load Swiss farmers face (FSO, 2017) indicates that attention should be paid to labour management which includes remuneration for labour. Moreover, while liquidity secures the farm survival in the short-term, farm survival in the long-term can only be secured by a minimum level of profitability. Otherwise, obsolescence of capital stock and a lack of willingness by a successor to take over the farm can arise and lead to a knock-off factor.

#### *6.1.1.3 Time before investment as benchmark*

The advantage of comparable income is that it takes the economy of a region into account, being based on the Swiss Earnings Structure Survey. If comparable income, respectively a positive calculated profit, is not reached by a farmer prior to investment, the investment decisionmight be attributable to non-monetary motives. However, profitability before investment musthave been high enough for the decision to stay in agriculture and take on the risk of a locked- in situation. Of course, this does not mean that a farmer is not willing to improve his income via investment. One could argue based on studies pointing to a high importance of income improvement goals via investments (Bailey, 1997; Smith et al., 1997; Stahl et al., 1999; Hadleyet al., 2002), that profitability before investment could still be considered by the farmer to be too low. But the fact that they still invested and did not opt out of dairy farming, indicates thatthe situation must have been at least financially acceptable. For Swiss farmers, other factors like an improved work environment seem to be considered equally important to income goals (Eidgenössische Finanzkontrolle, 2015b). This was also found for Bavarian farm managers, which are similarly small-structured (Forstner et al., 2009). Such non-monetary investment goals are also in line with the conclusion that the financial situation prior to investment must have been acceptable and differences to comparable income reflect non-monetary motivations at least to some point. Otherwise, financial goals must have been of much higher importance. With a general non-monetary bias between farm income and comparable income, results based on an overall comparison between farm income and comparable income is not very reliable. Therefore, in this approach a comparison is made to the pre-investment situation and comparable income is only used to account for opportunity cost.

#### *6.1.1.4 Non-monetary motives and long-term strategies*

Based on Cochrane's treadmill theory of innovations, applied to dairy farm investments, it might be necessary for dairy farms to keep up with competitors as the innovation becomes widely used. This is also stated by El-Osta and Morehart (1999). While the adoption of an innovation in dairy farming increases the competitiveness via efficiency gains and consequential unit cost reduction, the accompanied herd extension has an inverse effect because of higher production in a market with inelastic demand. In turn, this forces non-adopters out of business in the long-term (El-Osta and Morehart, 1999). Based on El-Osta and Morehart (1999) and Levins and Cochrane (1996), investments can either be seen as a way to stay in business or a vehicle to increase income or profitability. Which one applies is likely linked to the time of adoption since early adopters might be able to squeeze a profit from an innovation (Levins and Cochrane, 1996). The presence of a depressed profitability over the first few years, i.e. the absence of an improved profitability compared to the pre-investment situation (chapter 2), is in line with the theory of investing in order to stay in business. Moreover, the analysis of investment probability (chapter 3) revealed the importance of non-economic factors. Hence, investment decisions might be also driven by non-monetary or non-pecuniary motives. A long-lasting decision of an investment in a dairy barn might involve the strategy to stay in dairy farming. Profitability, at least in the short-term, might then only play a minor role as a vehicle to get there. Of course, it is an oversimplification to picture a farmer as a person blind to economics, with the only long-term plan of milking dairy cows. However, liquidity is usually much more important to stay in business than profitability. The fact that farming is mainly carried out as family farming in Switzerland, allows a single farm to sacrifice profitability to a large extent and still preserve liquidity. The presence of strong non-monetary motives for dairy farming (Lips et al., 2016), gives rise to the argument that profitability is at least partly neglected or even neglectable. The income per worker of an average farm, falling short of the comparable income per worker in other sectors (Schmid and Hoop, 2015), points into the same direction.

#### *6.1.1.5 Time frame of analysis*

In the following, the time span of analysis is discussed with its shortcomings and advantages and its consequences for the analysis.

When evaluating such long-term investments like dairy barns, the time frame becomes important regarding the possible analysis and conclusion. For Swiss FADN data the comparable years are restricted from 2003 through 2014 due to methodological changes in the data collection system (Renner et al., 2018). Since farms can only be matched to a definiteinvestment in a dairy barn during this period, the later an investment occurs, the fewer observations after investment are possible[9]. Hence, with each period an after-investmentobservation is away from the starting point of the investment, the probability increases that thestarting point occurred early in the observation period. A high number of years after investment not only reduces the informative value of any measurement, as there are fewer observations forsuch high number of years, but also due to the selection that only observations that belong to very early investments. If conclusions are based on earlier observations in the time of analysis,the risk increases that the results are biased because of only relying on investments taking placebefore the abolishment of milk quota. This emphasizes the better reliance on conclusions that can be drawn from early years after investments.

A desirable time span of data for an encompassing analysis of dairy barn investment would be congruent with the operational lifetime of an investment. However, operational lifetimes of individual components of the dairy barn investment as a whole deviate from each other and can range from shorter time periods for technical installations up to several decades for the building

[9] E.g., if an investment occurred in 2012, only two observations in the first and second year are possible. If, however, the investment took place in 2004, observations are possible from year 1 through 10 after investment.

envelope (Schmid and Jan, 2015). Another trade-off comes with the level of detail. According to Baltagi (2013), micro data is barely available over more than ten years and longer timespans are often only provided via macro-data. Therefore, the timespan of twelve years with micro-data can be seen as a very valuable dataset and suitable for the employed analyses.

In turn, the restriction to observations early after investments brings an advantage. Because conclusions are based on observations more recent in time, results might be more readily transferable to future investments. For example, the economic conditions of one ten-year-period are probably more comparable to the next ten-year-period than a thirty-year period to the next thirty-year period. With giving up a long-term period of analysis, it is also reasonable to neglect interest rates. They are strongly influenced by economic conditions, can cause massive distortions in the overall profitability of a project and are likely not fully taken into account by practitioners (Musshoff and Hirschauer, 2011). Altogether, the available time span is still short but can still provide valuable results and insights.

#### *6.1.1.6 Modelling dairy herd size*

Investments in dairy barns are usually accompanied by an expansion of a dairy herd. The phase of herd expansion is important due to production increase and its effect on herd characteristics. The peculiarities of modelling herd expansion are discussed in the following.

In contrast to Samson et al. (2016), none of the used datasets contained information on capacity utilization. Therefore, the only way to deduce full capacity utilization is from herd size growth after investment. As described in chapter 2, if herd size as a dependent variable was used, the results would be affected from autocorrelation. Herd size in a given year is largely affected by herd size in the previous year. Even given stable herd sizes, the prediction of the economically optimal replacement rate for dairy herds differs considerably from replacement rates in practical farms, being higher in the latter case (Miranda and Schnitkey, 1995; Hadley et al., 2006). St-Pierre and Jones (2001) use herd production data to model dynamics of a herd over time. Given the less detailed FADN data and changing replacement decision during an expansion period (Faust et al., 2001), it becomes clear that the dynamics cannot be measured directly. Detailed and individual reproductive data would be needed. Because very specific information on herd dynamics is missing in FADN data, the amount of variation left to be explained with the present dependent variables in the sample is rather small. While there are econometric methods to correct biased standard errors for autocorrelation, one way to work around autocorrelation is to use first differences (Baltagi, 2013; Verbeek, 2012), which was employed in the previous chapters. The farms in the sample increased their average of LU dairy cows from 26.6 LU dairy cows in the year before investment to 34.8 LU dairy cows in the fifth year after investment, for example (data not shown in the results). These averages are not completely comparable because of the rolling panel but represent a strong indication, that farms after investment increased their dairy herd size. This considerable increase in herd size can be captured by means of year-to-year herd size change. Magnitude and significance level of the quota abolishment dummy in chapter 2 and chapter 5 indicate, that it captured the effect quota abolishment had on the utilization of idle capacity that was due to quota abolishment.

An increase of herd size can also be observed in the Swiss FADN data on general. The average number of total LU in dairy farms in the valley region increased from 29.7 LU in 2001 to 30.3 LU in 2006 (Jan, 2021), which represents an increase of 2 %. The same farm type in the valley region increased their overall livestock units to 34.3 LU in 2009 (Dux and Schmid, 2010) and 39.7 LU in 2014 (Hoop and Schmid, 2015), corresponding to a relative increase of 16 % over the latter period. Since herd size increase is often accompanied by investment (Hüttel and Jongeneel, 2011), the farms in the sample have contributed to this increase in average LU per farm, in addition to small farms going out of business.

### 6.1.2 Definition of success

The trade-offs between data availability and the desirable timespan have been pointed out in the previous chapter 6.1.1.5. The question remains how a successful investment can be defined the given data at hand with a limited time span. Forstner et al. (2009) consider 10 years as a necessary time span to evaluate the impact of investment aids. Although a long time span is desired to get to a reliable conclusion of the long-term effects of an investment, the insights gained from such a long-term view can be questioned. Of course, a time span congruent to operational life time of an investment allows for the conclusion if the investment paid off. But the more time passes by, the more incidents can occur with the investment that lies beyond a farmer’s control. Hence, the overall pay-off of a long-term investment is at least partly influenced by chance. It is very likely that within the 30 years of an operational life of a dairy barn, events occur that could not have been seen at the very beginning. Based on these considerations the thorough analysis of a shorter time span more recently after the investment is more valuable to practitioners since this involves less chance of unforeseen events and is in turn more readily influenced by the farmer. Therefore, it is reasonable to define success of an investment in a short- and medium-term time frame in order to deliver useful results to practitioners and decision makers.

The existence of an adjustment phase after investments has been shown in chapter 2. Such a phase after investment has also been found in the downstream industry, and was mainly attributed to learning effects (Geylani and Stefanou, 2013). Adjustment costs arise from changes in the level of quasi-fixed factors (Silva et al., 2015). Bokusheva et al. (2009) have shown the adjustment cost model to be adequate in analysing short-term investment behaviour in agriculture. That adjustment costs arise with dairy barn investments in Swiss dairy barns is indicated by the impaired profitability in chapter 2, while the result does not allow for the conclusion of a direct causal relationship of profitability and herd size change. However, a relationship seems reasonable, similarly to a finding by Richards (1996) that after investments in milk quota capital is adjusted immediately while herd size approaches its optimum over several periods. This underlines the differences in the speed of adjustment of the different production factors. Impaired profitability in this sense can be interpreted as adjustment cost. Since unit production costs play a crucial role in the competitiveness of a dairy farm, the competitive position is weakened during the adaption phase. Therefore, the success of an investment in the short- and medium-term can be defined as the adaption to the new combination of input factors. With that definition it becomes possible to analyse the parameters that help investments to be more successful than others.

An important implication of profitability that arises from herd growth dynamics is the average lifetime of a cow in the herd. Balaine et al. (1981b) state, that profitability increases up to a herd average of 4.3 lactations. Additionally, acquired cows are likely to lower the average number of lactations per cow in the herd. In addition, cows or heifers that add up to a fast increase of herd size might not all have the genetic merit to achieve the average number of lactations or beyond. In particular if a herd showed a high number of average lactations per cow, it probably takes years after an expansion to achieve that average again.

One could argue that measuring success of a dairy barn investment only with data comprising the whole farm dilutes the effects of the investment since related parts of the farm might adjust as well. While it could be assumed that with an isolated view, statistical evidence could be found more easily for some effects, the farm as a whole has the most importance to farmers and policy makers. The average balance sheet total for the years 2012 through 2014 for dairy farms in Switzerland (all regions) was about 900’000 CHF (Hoop and Schmid, 2015). Hence, if a farm invests in a dairy barn with a capacity for 20 cows with an average cost of 20’000 CHF per cow, this amounts to almost half of the balance sheet total. Therefore, effects from a dairy barn investment are likely to be large enough to be statistically detected on a sufficiently high, i.e. the total farm, level.

## 6.2 GENERAL DISCUSSION AND CONCLUSION

While the former section mainly aimed to justify the approaches that were taken to answer the research questions, the following sub sections deal with the results obtained and how they contribute to the literature.

### 6.2.1 Pre-investment period

#### *6.2.1.1 Profitability*

Profitability is of central interest here, because of its importance for agricultural policy and the incorporation of opportunity cost. The large and significant influence of pre-investment profitability on the adjustment period (chapter 4) warrants a careful examination on whether adaptions to the imminent event are already present. A plausible explanation for a low profitability would be depreciation. Since farm buildings represent a large amount of assets, they serve as a source of a considerable amount of depreciation despite their long operational life. For example, dairy farms in the valley region had an average book value of more than 500’000 CHF for farm buildings from year 2012 through 2015 (Hoop and Schmid, 2015), accounting for more than 45 % of the balance sheet total. With farm buildings written off, farms may achieve larger profitability in their sheets because of a possible investment backlog. A new barn creates a large amount of depreciation, depressing profitability and making it harder to achieve pre-investment levels. If the written-off farm building before investment is accompanied by an investment backlog, there also might be more follow-up investments necessary afterwards. However, descriptive data show that only five farms out of the 103 farms analysed had a depreciation of zero. Because pre-investment level is incorporated as a static variable in the analysis, the effect is controlled for. While the results in chapter 2 illustrate that basically all farms go through a period of impaired profitability after investment, chapter 4 shows that the ability to cope with this impairment differs. The results of chapter 4 reveal influencing factors that have a negative effect on the adjustment phase, with family labour having the largest effect. This is discussed in detail in section 6.2.5.

#### *6.2.1.2 Herd size*

Large parts of the theoretical framework in this work are based on the assumption that the time before investment serves as a good anchor for the development after investment. However, the pre-investment situation might already be influenced by the known imminent investment. Thus, it needs to be discussed how the pre-investment situation might be affected and what this means for the interpretation of the results. As indicated by herd size change in chapter 2, changes already occur before investment. Jan et al. (2005) found for the mountain region in Switzerland that one fifth of the farms had capacity to increase the dairy herd without investing in additional facilities. The utilization of such previously unused capacity might happen shortly before investing into a new barn, giving rise to a rather large herd in the year of investment and thus to a seemingly slow growth of the herd shortly after investment. Similar results were obtained by Samson et al. (2016) who found a capacity utilization by Dutch dairy farms in 2010 only at about 70 %. This was attributed to milk yield increases per cow under the quota regime and to the creation of unused excess capacity in anticipation of the upcoming quota abolishment. In a quota-free market, small possibilities might exist to overstock a barn for a short period of time. In addition, it needs to be considered that a dairy herd is not of definite and stable shape. Because of old cows exiting and new cows entering the herd, there will always be some fluctuation since the events do not necessarily match in timing. Some measures might exists to maximize utilization of the old barn. For example, a temporary barn could be created in a machine shop. Though, this would come at the cost of more difficult work and management conditions. It might be worthwhile to keep in mind that full capacity utilization of the old barn goes along with less underutilization of the new capacity.

### 6.2.2 Hesitant growth and specialization

U.S. dairy farms seem to make use of additional capacity immediately while European, hence also Swiss, dairy herds expand more slowly. This might happen due to several reasons, including the following: European farms might be limited by UAA in several respects, and farm size and hence the degree of specialization differs between the two regions.

The rather slow expansion found by Sauer and Zilberman (2012) and Kirchweger and Kantelhardt (2015) is also confirmed for Swiss dairy farms in the previous chapters – in relative and absolute terms. Hadley et al. (2002) state that the analysed farms expanded their dairy herd with only minor increases in UAA. The number of cows per ha increased from 0.75 before investment to 1.4 cows two years after investment. For analysed Swiss dairy farms, the number of cows per ha was 1.1 the year before investment and 1.2 two years after investment. Hence, Swiss farms are operating at a much higher livestock density rate prior to investment. However, these two numbers from American and Swiss farms are comparable to a limited extent only, since degrees of specialization might differ considerable. Moreover, no conclusions can be drawn if boundaries are set by UAA. Dairy farming is closely linked to roughage production in Switzerland, while roughage production per unit of land is given by natural conditions. Another potential UAA boundary is the restriction of livestock by fertilizer produced per livestock unit (FLU) (Steinmann, 2008). In addition, the eligibility for direct payments limits the maximum number of milk cows per ha. This number differs between regions and is restricted to two roughage animal units (equivalent to two dairy cows) per ha grassland in the valley region (El Benni and Finger, 2013b). These regulations were relevant for the analysed period. The restriction imposed by FLU is probably less strict than the restriction of two roughage animal units, since exceeding this boundary only obliges to balance nutrient imports and nutrient exports of the farm. Baur (1999) points out that land mobility in Switzerland is very low and only a few farms grew through substantial increases of leased land. A hypothesized effect of UAA on dairy herd expansion was found to be true in chapter 2 and chapter 5.

The key differentiator between the American (Hadley et al., 2002) and European (Sauer and Zilberman, 2012; Kirchweger and Kantelhardt, 2015) studies on dairy farm expansion is farm size. While Kirchweger and Kantelhardt (2015) used data on Austrian cattle farms, which are more readily comparable to Switzerland, Sauer and Zilberman (2012) analysed the adoption of automatic milking systems in Danish dairy farms with a larger average herd size of 107 cows in 2007. However, farms analysed by Hadley et al. (2002) owned 120 cows in the smallest and 1’350 cows in the largest case, with an average of 569 cows per farm. Given the average size of Swiss dairy farms, stated in chapter 1, of about 31 cows per farm, the American numbers are higher by a factor 18. Substantial differences in herd size growth behaviour between these size classes seem reasonable. With an average increase of 7 dairy cows, based on a pre-investment farm size of 26.6 dairy cows, Swiss farms increase their herd size on average by about 26 %. While this is an average, including larger relative investments, some US farms increase their size in the studies by 50 % and even 100 %. But still, the factors behind these differences remain vague. Additional to regulatory boundaries and availability of additional UAA, specialisation and financing may play a role. Farms in Switzerland are already rather diversified in comparison to European farms. However, some specialization occurred over the 20-year period from 1990 through 2010, with a decreasing number of branches of production. In animal production the average number declined from 1.3 to 1.1 (Lips and Schmid, 2012b). Even if this decline seems fairly moderate, it should be noted that it does not follow a traditional normal distribution but a fat tail distribution. Since the minimum number of branches of production cannot be smaller than one, many farms had to give up additional branches to cause this average to decline. But Swiss farms are still more diversified than large American farms, focusing only on one branch of production. The fact that farm managers of U.S. farm consider capacity utilization as a key requirement to meet capital service demands (Faust et al., 2001) indicates that they use relatively more borrowed capital and rely more heavily on cash flow from dairy for repayment.

#### *6.2.2.1 Low mobility of land*

Animal husbandry, and especially dairy farming, is strongly linked to acreage. Because of that, the importance of UAA is predominant in agricultural economics literature. The importance in Switzerland has been indirectly mentioned in the previous section with the restrictions that are imposed on the maximum number of animals that can be kept on a hectare. UAA is also a key variable for profitability and herd size change (chapter 2 and 5). The legal restrictions of animals per hectare were pointed out in the previous section. But since dairy farming is based on roughage production, also the natural conditions can restrict the maximum number of cowsheld per ha. Therefore, the hypothesis of hesitant growth because of low availability of agricultural land is still valid. Based on the link between these two variables, livestock densityis used in chapter 4 as an independent variable to detect if farms are restricted by their UAA. These results are consistent with the results of chapter 5. Stocking rate has no statistically significant effect on reattaining pre-investment profitability. In chapter 5 a higher Gini- coefficient is accompanied by a statistically significant smaller herd size increase, while not being significant for AI/FWU. According to the Literature, a high concentration in land lowersland mobility (Hüttel and Margarian, 2009). Though, the larger growth in herd size translates not directly in profitability or AI/FWU, respectively. Impaired profitability as a possible versionof adjustment cost has been discussed in chapter 6.1.2. As mentioned before, the number of observations declines with time after investment due to panel attrition. With a growing time-lag after investment, the probability increases, that the investment was made in an early stage of the observation period. Hence, before quota abolishment, when structures were more rigid in general as suggested by the increase in average LU per farm in FADN data over that time (i.e., 6.2.1.2). Therefore, the absence of a statistically significant effect of land availability on profitability might stem from an absence of observations from a large herd size growth and longer time span after investment. Since investment aids help to overcome capital restrictions and labor utilization appears not fully exploited, land availability might be the most restrictive factor on the implementation of economies of scale.

Special legal regulations on acreage apply for investing farms. These regulations require investing farms to base their investment on UAA that is under cultivation by the farm in the long-term (Bundesrat, 1998c). Yet, the impact of legal regulations depends upon their execution. Since cantonal institutions are in charge of the administrative tasks of lending, some regional variations likely exist due to differences in the interpretation of the regulations. In addition, it is known by practitioners that some leeway exist to work around legal regulations by farmers[10]. For example, deep litter housing instead of a stable with resting pens requires more space per cow, hence a larger building. With little further investment, deep litter housing can be converted to resting pens later on. Though, it is not known to which extent such practices are implemented by investing dairy farms.

Combined dairy/arable crops farms might be in a better position than pure dairy farms since they could reduce crop farming in favour of arable feed crop production for own animals. It should be noted that this still hampers profitability if the margin suffers by this reallocation. While dairy farming depends upon roughage production, there is no sharp boundary on the extent of this reliance since a market for roughage exists.

Balmann et al. (2006) state that over-investment in farming increases shadow prices for land. If over-investment was present in investing dairy farms in Switzerland, their marginal value for additional land should result in a competitive edge on the market for land because of their high

[10] Oral statement of an executive manager at the cantonal level.

willingness to pay. On the other hand, higher prices for land might decrease margin, hence profitability. In Switzerland, legal restrictions exist on the maximum amount of lease per ha. Though, it is known that these regulations suffer from poor execution.

Since farms can only expand their UAA by the amount obtained from other shrinking or exiting farms, farms compete with each other on the market for land. Hence, in their strategic decisions, farmers have to anticipate the strategies of other farmers. Pulfer and Lips (2009) mention that the mind-set of farmers favours investments in capital goods that can readily be seen. From an economic point of view, such investments might not be reasonable. It has not yet been investigated whether a signalling effect is inherent to such investments. In the case of dairy barn investments, excess capacity could be a signal to other farmers that the farm’s strategy is to continue dairy farming for the next decades and to increase UAA via agricultural land given up by other farmers. Such a signaling effect could be one aspect of neighborhood effects and are in line with the results of chapter 5.

#### *6.2.2.2 Biosecurity preventing purchased cows*

The previous sections pictured a hesitant growth mainly to be linked to low economic performance. However, reasons exist which justify a slower growth, based on own progeny only, as economically reasonable.

Results of chapter 2 clearly indicate that farms investing in dairy barns expand their business over several years. Yet, limited availability of land might not be the only reason for this process to take so long. In chapter 2, it was hypothesized that the purchase of additional cows could help to improve profitability at a faster rate, but the contradictory result was found in the analysis of chapter 4 showing a detrimental effect of expenses for animal purchases. While evidence is missing for the hypothesis of purchasing additional cows in order to overcome impaired profitability after investment, it does not prove the absence of a causal relationship between herd size change and profitability. Herd size increase by own progeny is limited, but a possible relationship still reasonable. Reasons inherent to the nature of the data, causing the coefficient for expenses for additional animals to be negative, have been discussed in chapter 4. However, the role of biosecurity has only played a minor role in the discussion up to now. Faust et al. (2001) highlight the importance of biosecurity measures when animals are purchased from other farms, in particular if the number of different farms is high or the origin not known. Hence it is advisable to buy additional animals only from one farm if the origin can be trusted in order to minimize the risk of diseases. This increases the challenge of finding suitable animals on the market. Based on these considerations, the trade-off between larger risk of diseases and lower capacity utilization might be economically worthwhile. In addition to that, with all capacity filled up immediately, an underperforming cow would block a space for a heifer with higher genetic merit. If a farmer can expect a high number of heifers with a high genetic merit from his own progeny in the future it might be worthwhile to wait because a bought cow would block a space for several years. Alternatively, the farm manager would have to cull older cows that still add up to profitability in their late lactations.

### 6.2.3 Missing significant improvement of profitability

#### *6.2.3.1 Follow-up investments*

A challenge in the evaluation of the development of a farm is that profitability or income includes depreciation which was touched before in section 6.1.1.2. Investments, producing depreciation, can partly be driven by tax policy (LeBlanc and Hrubovcak, 1986). Therefore, if an investment in dairy barn led to a higher income, some of the additional profit might get reinvested as net investment in order to increase depreciation for the future, hence reducing taxes. Although, an influence of tax policy on investment behaviour is likely, the effect might be modest in the short run since depreciation spreads over the useful life of the object of investment. On the other hand, if a farm was not able to yield a turnover that allows for net investments, it should be detected relatively easily, since no depreciation of further investments is relevant for income. This means that while additional income may partly be hidden by additional investments, with a lower income the effect of such surplus cash flow is harder to conceal. Besides the reasons already described, this might be an additional factor why the results in chapter 2 confirm a drop in profitability, but fail to confirm a rise compared to the pre-investment situation later on.

#### *6.2.3.2 Growing inequality with time after investment*

While investment theory assumes the goal of improving profitability via investment the results for calculated profit in chapter 2 seem contradictory. It seems that farms rather perform a loss minimization after investment than a profit maximization.

The spread between high-performing and low-performing farms in Switzerland is quite high. Measured as AI/FWU, the spread between the lowest and the highest quartile was a factor of 2.7 in 2014 and substantially above in the preceding years back until 2005 (Schmid and Hoop, 2015). Therefore, it seems reasonable to expect a spread to be present in investing farms, too. In relation to this spread, investments could be seen as a bottleneck. If significant coefficients for calculated profitability in the early years after investment are not only caused by a higher number of observations, but also by a lower variation between observations, some explanatory power could be attributed to the investment. The investment might cause profitability to be impaired unanimously for all farms directly afterwards. As time passes by, the effect of the investment might fade away, causing the differences to grow and consequently increasing variation. Hence, not only the decreasing number of observations with time causes the regression model to fail in obtaining significant coefficients later on but also the less unanimous development of the dairy farms.

### 6.2.4 Effects related to the milk market

Significant coefficients for the milk quota abolishment period on herd size change have been obtained in chapters 2 and 5. Several possible explanations exist in this context. Bozic et al. (2012) found a decreasing culling rate of cows with higher milk prices. Because prices for milk reached a peak during the quota-abolishment period (Finger et al., 2013), effects of quota abolishment may partly be due to milk price effects. In the following, it is argued that this might not be so.

The price-effect might be limited, since not only milk prices but profits are a trigger for a farmer’s desire to increase herd size (Bozic et al., 2012). On the other hand, Bozic et al. (2012) conclude that the culling decision in a dairy farm is rather a biological constraint than an economical decision. However, Weigel et al. (2003) report that in farms with better facilities and where more than 80 % of labour input is provided by family labour, culling decisions are more voluntary. But also, in these farms, involuntary culling occurs, hence reactions to milk price changes are still limited when herd size increase is mainly based on own offspring. The peak in milk price in 2008 occurred over a short period in time. Therefore, an additional increase in herd size as response to high milk prices could only have resulted from a different culling strategy, since a reaction with more offspring raised for dairy cows would require a larger timespan. The limited ability to react to milk price changes on the one hand in conjunction with the limited incentive of high milk prices to do so are a strong indication that the significant effect of quota abolishment on herd size change stems mainly from farms with larger expansion plans holding back investment till quota drop out was possible.

The economic incentive of utilizing the whole barn capacity stems from the fact that a considerable part of milk production costs are fixed costs (Miranda and Schnitkey, 1995). Lips et al. (2008) hypothesize that because of the time lag between the political decision of quota phasing out and its practical implementation, an incentive existed for not utilizing an investment's full capacity until buying milk quota became redundant. However, McDonald et al. (2013) demonstrate with simulation models for farms in the pre-quota abolition period in Ireland that it is economically favourable to wait for abolishment before investing in additional capacity at all. In the light of these contradictory findings and the evenly distributed investments over the analysed period, with lagged use of full capacity being present throughout the whole period, the hypothesized behaviour by Lips et al. (2008) is not expected to influence the results presented in the chapters before.

### 6.2.5 Farm labour

#### *6.2.5.1 Tailoring work force towards future farm*

The substitution of labour through capital by means of switching from tied-stall housing to free-stall housing (Pietola and Heikkilä, 2005; Schick and Hartmann, 2005) allows farms to either increase the number of animals or decrease labour input. The results from chapter 4 underpin the low mobility of agricultural labour (Tocco et al., 2012), as farm managers seemed to refuse allocating freed labour to non-farm activities. Hoop et al. (2014) found, that family labour input in Swiss farms increases in line with farm size. Since investment in dairy barns causes the farm to grow in terms of herd size, farms might anticipate the future farm size with their work force. The utilization of the family work force is likely to increase with herd size. The limited mobility of agricultural labour might cause the farms to accept a low labour efficiency after investment, causing impaired profitability.

#### *6.2.5.2 Non-monetary returns from investment*

When drawing conclusions on the possible reallocation of family labour, it is important to consider the nature of the variable in the data. Family working units can only be measured at the farm level. This means that labour that is saved in dairying through investment could be allocated to other branches of production. However, this does not necessarily entail that labour efficiency is increased after investment. Even if reallocated to another branch of production, the reallocation should result in a better financial labour efficiency to justify the investment. In addition to that, work pressure is a factor not covered by the available data. If the investment improved working conditions, this might alleviate mental and physical stress. According to the Eidgenössische Finanzkontrolle (2015b), the majority of investing farmers in Switzerland was satisfied with their new farm building, which could point to a non-monetary component of the investment. This could be seen as in line with Forstner et al. (2009) who state that financial results are not necessarily satisfying for all farms. The argument of non-monetary benefits of an investment is supported by Olsen and Lund (2009) who found that the main goal for Danish farms to invest in farm buildings was to attract skilled workers. Following this argument, an investment creating better working conditions, could contribute to the accepted gap between farm income and a forgone wage in other industries. Hence, not the entire locked-in effect, as discussed in chapter 6.1.1.2, might be seen as due to sunken costs.

Although improved working conditions were an important investment motivation (Eidgenössische Finanzkontrolle, 2015b), it remains questionable whether this goal is achieved at a satisfactory level. Kolstrup and Jakob (2016) consider a proportion of 85 % of dairy workers reporting musculoskeletal symptoms (MSS) as not acceptable. Even though, it is the most common complaint in the general population. Their study is based on a sample of dairy workers in larger Swedish and German farms with all farms being free-stall housing. Also, Pinzke (2016) finds a high share of MSS occurring in his survey among Swedish dairy farms. Quite interesting in this study is the development over time, since it was undertaken in 1988, 2002 and 2013 and the share of tied-stall housing has fallen from 96 % to 54 %. Though, only the affected body regions have changed but the overall occurrence had not decreased significantly.While free-stall housing contained more automation in general, only farmers working with milking robots showed a significantly lower occurrence of MSS. However, as Pinzke (2016) notes, only the occurrence of MSS could be assessed, not the severity. The latter study indicatesthat a switch from tied-stall housing to free-stall housing already brings a considerable improvement of working conditions into dairy farming. According to Cockburn et al. (2015), the workload in manual milking systems still differs for different farms depending on height ofcow and worker and parlour type. The bare switch itself from tied-stall housing to free-stall housing might not improve the working conditions to a desirable level.

### 6.2.6 Off-farm income

#### *6.2.6.1 Off-farm income as first signal to exit*

As pointed out in chapter 3, several authors studying farm investment have included off-farm income in their analysis with somewhat mixed results (Weiss, 1999; Hennessy and O'Brien, 2008; Olsen and Lund, 2009; Pufahl and Weiss, 2009; Salvioni and Sciulli, 2011). Off-farm income is often considered as a beginning of the end of the farm in business (Weiss, 1999) or as a lifestyle choice (Mittenzwei and Mann, 2017). This is based on the lower profitability of an income combination (Mittenzwei and Mann, 2017) or a higher probability of achieving only a low hourly wage in agriculture, when farming is not carried out as a full-time job (Roesch, 2012). From this point of view, farming pictured as a hobby, in the case of off-farm income, is justified. However, the question arises why farms with an off-farm income should not aim at farm income maximization. The hypothesis that they do not aim at such maximization creates the impression that farms with off-farm income would be less efficient on purpose or at least that the farmer would tolerate such inefficiency. It hast been questioned whether off-farm income is a way to compensate for falling farm incomes (Hennessy and O'Brien, 2008) or part-time farmers cannot choose profitable production options (Mittenzwei and Mann, 2017). If the efficiency of a farm is restricted by other factors such as environmental conditions, off-farm income could be seen rather as the effect of this lower efficiency than the cause.

### *6.2.6.2 Farm household model and farm investment*

In order to take into account off-farm income, the agricultural household model is widely employed. This model even can be extended in order to try to explain the relationship between farm investment and off-farm income. Off-farm income is a complex topic that shows dependencies on the person earning the off-farm income (Hennessy and O'Brien, 2008) or on the farm manager's family characteristics (Mishra, 1997; Goodwin and Mishra, 2004). Hennessy and O'Brien (2008) employ a household model to derive different theories of farm investment and off-farm income. One of them is an investment in the farm with off-farm income in order to substitute capital for labour, keeping farm output constant, hence free up labour for an increase in off-farm income, as illustrated in Figure 9.

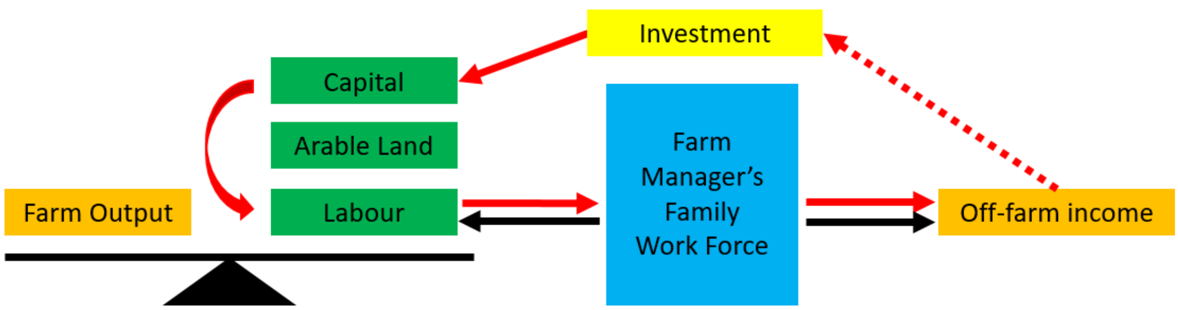


Figure 9: Illustration of a rational investment in the farm with off-farm income considering the farm household model. Source: own illustration based on Hennessy and O'Brien (2008).

If the off-farm job pays a better wage per hour it is economically reasonable to invest in labour-saving technology in order to substitute work through capital, even if farm investment is funded by off-farm income. This is illustrated by the red arrows. Because these investments could also be funded by borrowed capital, the arrow from off-farm income to investment is illustrated with a dotted red line. The black arrows represent the allocation of the family work force to farm and off-farm work. A second model from Hennessy and O'Brien (2008) is illustrated in Figure 10.

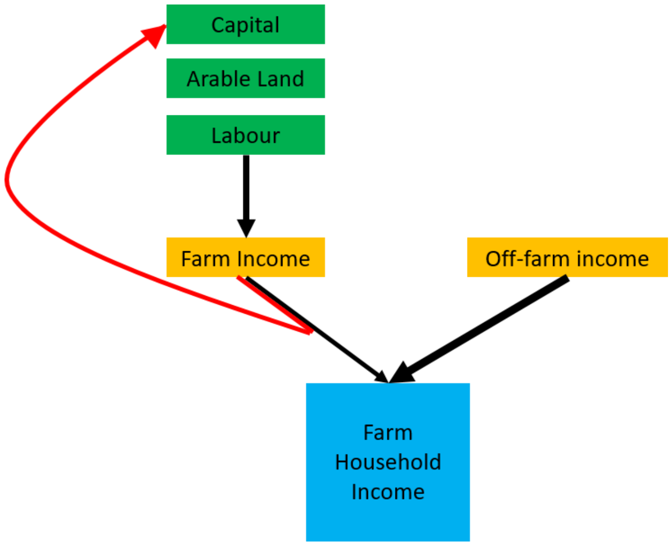


Figure 10: Illustration of farm investment funded by not used-up farm income. Source: own illustration based Hennessy and O'Brien (2008).

In this second model, illustrated in Figure 10, off-farm income is considered to relax the budget constraint of the household determined by the necessary household expenses. If a farm household is able to cover at least part of these expenses by off-farm income, the dependence on farm income declines. In theory, this enables the household to use farm income for investment that without off-farm income would have been needed to cover household expenses. This is illustrated in Figure 10 with a broader arrow for off-farm income and a thin arrow from farm income which is partly used to invest in the farm. This second model agrees more with the literature and the results provided in the chapters before. In chapter 3, the share of off-farm income as well as the wage obtained in off-farm income lowered the probability of a later occurrence of a dairy farm investment. However, the effect size is small. Additionally, the results in chapter 4 support this string of the theory. Off-farm income hampered the achievement of pre-investment profitability levels after an investment. Drawing on this, it can be concluded that the household was not economically forced to reallocate more labour to off-farm income. In this sense, off-farm income might give the farm household the leeway not to be maximally efficient.

In the literature, the second model (Figure 10) is backed up by Carriker et al. (1993) who found the propensity to shift labour towards off-farm income in order to consume larger off-farm income because of a lower volatility. According to Mishra (1997), the probability of off-farm income decreases with farm experience and is lower with larger farms and households having young children. Moreover, Mishra (1997) confirmed the often hypothesized effect that off-farm work is correlated with a lower risk aversion in the farm. Hence, farmers with a more volatile farm income were more likely to work off-farm. Also, El Benni et al. (2012a) concluded for Swiss farms that farmers, obtaining an off-farm income, are willing to take more risk in their farm operation. This is not contradictory to the negative impact of off-farm income in chapter 3 and 4, where the amount of off-farm income is taken into account rather than the pure presence of off-farm income. Based on the literature and drawing on the results of chapter 3, it could be concluded that more off-farm income allows taking on more risk with the investment, even if this would require further confirmation since a longer adaption phase does not directly translate into more risk taking.

#### *6.2.6.3 Limited divisibility of labour*

Another fact that contributes to the difference between the idealistic view of work which can be homogeneously allocated to different uses in the model and the more complex nature in the real world is the possibility to split up working units, which is not necessarily given. Off-farm working hours are likely to be not at a farmer's convenience to be increased at any time. Together with an asymmetry in the speed of switching to on-farm or off-farm work (Weiss, 1997) this might contribute to the fact that labor in agriculture is rather immobile (Tocco et al., 2012) and changes therefore cumbersome. Hence, the effects of family labor and off-farm income seen in chapter 4 might not only stem from a farmer's unwillingness to reallocate labor resources to the off-farm job market, but also from the difference in the nature of labor between the ideal view of models and the real world. The difficulties of the off-farm job market apply to farms that cannot increase their production to the same extent they saved labor through technical progress by an investment. Farms with sufficient production factors might more easily adapt to the situation after investment. According to Baur (2000), structural change in Switzerland is a combination of pressure to adapt and pull of labour from other sectors. She concludes that the availability of land was low and that technical progress would have allowed for structural change at a faster rate. If the labor-saving technical possibilities cannot be exploited right away because of limited availability of other production factors, farms would be forced to wait till a job market opportunity opens up that allows for the reallocation of the desired amount of off-farm labour. When a farm cannot reallocate a full annual working unit (AWU) to off-farm work, this creates an additional requirement besides qualification and location that adds to the prolongation of the time span to find an adequate off-farm job. Furthermore, off-farm work might hamper the availability of family labour during workload peaks which might create an additional restriction on suitable off-farm jobs. Because of reduced flexibility and divisibility, it might be worthwhile for farms to accept lower family labour efficiency.

#### *6.2.6.4 Future off-farm income possibilities*

Even if 10 member states in the European Union collect data on off-farm income in their FADN data, the data set suffers from incomplete data or differing methods (European Court of Auditors, 2016) to some extent. E.g. and in in particular for the present study, it is a great advantage that the Swiss FADN comprises information on the amount of off-farm income and the amount of AWU that is put towards off-farm income. In addition, it allows distinguishing between off-farm income from third-party employment and self-employment. In Switzerland, the number of part-time farms is lower than in other German-speaking countries, while definitions of part time farms differ (Lips et al., 2013). When looking at the number of farms with off-farm income, only 40 % of Swiss farms obtain no off-farm income at all and 16 % allocate only a small share up to 0.2 AWU to off-farm income (Lips et al., 2013). In the sample at hand of Swiss farms pursuing a dairy-barn investment, from a total of 792 observations, 509 observations show an off-farm income. While chapter 3 and chapter 4 do not take into account how much AWU are put towards the off-farm occupation, this is utilized in chapter 5. Though, no statistically significant effect for off-farm income is obtained from the regression results in chapter 5. In chapter 5, off-farm income for a full AWU is taken used in order to reflect off-farm wage levels. It should be noted, that a considerable number of observations only allocates a smaller share of AWU towards the off-farm occupation. The importance of the off-farm income for the farm household might differ conditional on the amount of off-farm income, hence a definition of a threshold necessary to analyze the effect of off-farm income in more detail.

The role of off-farm income might become even more important in the future. As the farming population in Switzerland decreases, also the pool of spouses with an agricultural background decreases. Besides, the level of education in the Swiss population rises. According to data from FSO (2018), the number of men earning a degree in tertiary education increased from about 20’000 in 2000 above 41’000 in 2015 – a twofold growth. The number of women over the same timespan increased almost four times from about 10’000 up to 39’000. This means that the pool of spouses over time is not only likely to become less educated in agriculture (due to fewer farms and fewer people with contact to farming) but also better educated on average which is described by Lips and Schmid (2012a) in a comparison of the situation in Swiss FADN data 2003/04 and 2009/10. With the vast majority of farms in Switzerland being managed by men, the strong increase in women’s education is even more important for this argument. With better education, off-farm job opportunities become more attractive. Lips et al. (2013) found that off-farm income per AWU is 80 % higher than on-farm income, in line with a good non-agricultural education level. Given that future spouses are likely to be better educated, reservation wages will increase for them. Hence, off-farm income might become more prominent over time.

### 6.2.7 Successor effects

Potter and Lobley (1996) found that, for a sample of around 500 British farms within a 30-year period, 9 % of all capital investments occurred within one year after the farm successor returned to the farm for full-time work. However, the information whether a successor is present or not, requires a rather specific data set. On a more general basis, Weiss (1999) found that the presence of more family members increases the likelihood of a farm to survive and even to grow. He also stated that his results were in line with life cycle theory. This theory was confirmed by Gale (1994) based on U.S. farm data and comprises three stages. The three stages are (1) entry/establishment, (2) growth and survival, and (3) exit. Although, Gale (1994) had no data to analyse investments, he points out that especially in livestock, investments are an important possible way of growth. LaDue et al. (1991) found, that the influence of age on investment behaviour is consistent with life cycle theory, where younger farmers aim to increase their income through investment. According to Weiss (1999), life cycle effects are only present in full-time farms. He also found that the presence of a successor influences farm performance. Hadrich et al. (2015) could not find life cycle effects in farm income, but in farm assets. The results in the previous chapters clearly show, that investments in dairy barns increase the farm size. Furthermore, it is indicated that younger farmers are more likely to invest. Whenhousehold size is seen as an indicator that a farm successor is present, this also is in line with life cycle theory. Based on the successor effect in the literature and the large effect of sociological factors like age, presence of a spouse and household size, the long-term survival of a farm seems to be more affected by family formation than financial performance.

An implication of the educational level (cf. 6.2.6.4) arises on the composition of households and hence possible farm successors. Sander (1986) found that increasing earning power of female farm managers or partners on farms goes along with a decrease in children. He also concluded that farm children are less costly to raise in rural areas, where job opportunities, hence the earning power, for female managers and partners are less, which causes farm households to have more children on average than the remaining cohort. Sander (1986) analysed farms in the U.S. where population density is much lower than in Switzerland. Therefore, the effects of education on Swiss farms might be more notable. Hence, with fewer children, the likelihood of a farm successor within the own family decreases for families whose female earning power is high.

An interesting explanation for an absence of a successor is provided by Berlinschi et al. (2014). They develop and test the theory that with increasing farm income, farm households are able to invest more in the education of their children. With better education, children have a higher probability to find jobs that pay better than farming, thus leaving the farm sector. Although, this theory is consistent and at least partly based on empirical evidence, a better paying job is not just obtained by a better education. The economy has to be favourable, too. Glauben et al. (2006) find a link between higher per capita Gross Domestic Product (GDP) and higher farm exit rates in different regions. They conclude that favourable economic conditions provide opportunities for good off-farm jobs for farmers and their heirs. Not in contrast to Berlinschi etal. (2014), Glauben et al. (2006) point to a strong influence of farm and family characteristics on farm exit rates. The probability that a farm is taken over increases with farm size (Glauben et al., 2009) and decreases with lower farm assets (Calus et al., 2008). Therefore, an investment works towards both arguments. It increases farm assets as well as the size of a farm. Hence, there might exist a strong link between investment and intergenerational farm transfer in the future.

The presence of a farm successor means for farms that they are more likely to had significant capital investments and expansions in the past (Lobley, 2010). In Switzerland, the legal conditions to take over a farm within the family are quite favourable. The statutory conditions allow the successor to take over a farm from his or her parents at the so-called earnings value, which currently is about only one fourth of a farm's actual market value (Rossier et al., 2012). On average, however, the earnings value of a farm, according to these statutory conditions, was found to be considerably lower than if actual income streams were taken into account (Dieterle, 2019). The argument that taking over a farm from the parents is made economically favourable by legal regulations, leads to the conclusion that farming is to a large part an inherited occupation (Poppe and Vrolijk, 2005; Lobley, 2010). Poppe and Vrolijk (2005) hypothesize that farmers with inferior results still could stay in business to accumulate capital gains. Transferred to the discounted farm take-over within family farms in Switzerland, this means that even taking over a rather low-performing farm could result in capital gains transformed to cash in the long run. Though, Hill and Bandford (2007) state that empiric evidence on the effects of tax concessions is scarce due to difficulties in defining an internationally comparable benchmark. Hence, they can only hypothesize that tax concessions on the inter-generational transfer of land show an inhibiting effect on structural change.

In general, the results comply with life cycle theory. Furthermore, the proxies for the presence of a successor in the data at hand indicate confirmation with successor effects, found in the literature. This highlights the complex structure of motivations behind investments. While creating better working conditions probably applied immediately and increased income in the medium-term, life cycle and successor effects should to be taken into account for long-term effects and motivations.

### 6.2.8 The role of investment support

The European Union has increased their efforts in evaluating agricultural investment support. Thanks to this, a considerable body of literature has evolved (Dirksmeyer et al., 2006; Forstner et al., 2009; Pufahl and Weiss, 2009; Doluschitz et al., 2010; Ciaian et al., 2015). In particular, propensity score matching was attractive to those evaluations (Pufahl and Weiss, 2009; Salvioni and Sciulli, 2011) because it offers a quantification of the effect of support by allowing the construction of a counterfactual group. However, different researchers came up with different conclusions from the same dataset, calling into question whether this technique is reliable in estimating a treatment effect (Dehejia and Wahba, 2002). It further requires the assumption that the selection into a program on observable covariates is valid (Dehejia and Wahba, 2002). Based on the results of the presented analyses in the previous chapters, this is alreadyquestionable. King and Nielsen (2016) argue that propensity score matching increases variancecompared to direct covariate matching, hence requires a larger dataset to obtain significant results. Kirchweger and Kantelhardt (2015) employed covariate matching as first step in their difference-in-difference approach, but the condition of selection on observables still needs to be fulfilled.

Hence, literature offers a rather ambivalent picture of the effectiveness and power of propensity score matching. It might be more helpful to draw generalized conclusions, based on literature and results, than splitting hairs about the quantification of an effect. Results of Dantler et al. (2010) in Austria show that the number of farms not having received investment support decreases more quickly with time than the number of farms which previously received investment support. The general concepts of Cochrane’s treadmill or path dependence suggest a systematic difference in farms dropping out of business and investing to prepare for the future. From a market perspective, structural change is limited to the possibilities of technical change while agricultural land seems to be the most restrictive production factor. Therefore, every policy measure with a side effect of restraining land by farms that would otherwise phase out of agriculture makes technical change for the remaining farms more expensive. Because with limited availability of production factors the adaption phase becomes more difficult.

## 6.3 OUTLOOK

This section addresses the future research that would contribute to the understanding of agricultural investments, and more specifically in the dairy barns. Future research is identified based on the findings and limitations of this dissertation.

- The definition of success in this framework was based on the adjustment phase. Though, with different goals in dairy barn investment by individual farmers the relevant definition of success might differ. When better working conditions are the main goal, financial measures might only represent a lower threshold of affordability.
- From a methodological point of view, farmers' incentives and envisaged goals for investments should best be investigated in the pre-investment situation. When the investment is already carried out, survey results are likely to be biased. Therefore, a comprehensive survey before and several years after investment would help to identify further investment goals and answer the question if and to what extent they were achieved.
- The legal background of investment aids commands them to improve competitiveness. Tough, competitiveness already is up to definition. In literature, competitiveness for dairy farms is mainly seen as having the lowest production cost. However, for a single farm this question becomes more strategic. With depreciated equipment and unfavourable job market conditions, opportunity costs for labour might be obsolete for farmer's decision making, production costs might be quite low while competitiveness is also low. Hence, competitiveness cannot be defined by financial measures only. Future research should address a broader definition or several definitions of competitiveness to allow a comprehensive evaluation of agricultural policy.
- Due to data availability, the time frame of analysis in this work was rather short. While the advantages of a shorter time frame have been pointed out, the question of long-term effects remains. Yet, it is indicated that it might be worthwhile to view an investment in a dairy barn more as a step in the long-term strategy of a farmer and his family. An answer after decades if a dairy barn investment was a good or a bad choice does not provide useful insight for the future since the next decades are likely to be very different than the previous decades. Future research would need to identify long-term strategies

of farmers. This could contribute to a better understanding of the goals and decision making of long-term investments.

- The system of mortgages in Switzerland is unique compared to other countries, since borrowers are not forced to pay them back. In contrast to that, farmers are obliged to pay back interest-free loans. In 2014, the average time to pay back an interest-free investment loan was 13.1 years (BLW, 2015). The need to repay a mortgage might force a farm to discipline on reducing borrowed capital and help to improve financial stability of a farm.
- Farm growth has been important in the past for implementation of technical progress. Hence, availability of land is a key factor. The obtained results indicate, that this applies also to dairy farm investments. Future research should take different strategies of neighbouring farms into account.

There is consensus in the literature that non-monetary motives contribute significantly to the motivations of farmers in general. Given the results of previous surveys that revealed a considerable share of farmers, aiming for improved working conditions, this seems also true for investments. Although, successors usually can take over considerable assets which might present some financial buffer, farmers cannot ignore finances completely. Future research, considering long-term effects of investment, should take farm social characteristics and strategies into account. While farmers are usually willing to accept lower income than workers in other sectors, the locked-in situation should not lead into a situation of continuous financial dispensability of the farm family.

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# 8 LIST OF PUBLICATIONS

**Peer-reviewed scientific journals**

*Short and medium-term impact of dairy barn investment on profitability and herd size in Switzerland*

| | |
|---|---|
| Status: | published |
| Journal: | Agric. Econ. – Czech 2019, 65: 270-277<br>https://doi.org/10.17221/170/2018-AGRICECON |
| Authors: | Benedikt Kramer, Anke Schorr, Reiner Doluschitz and Markus Lips |

*Survival Analysis for the Adjustment Phase Following Investment in Swiss Dairy Sheds*

| | |
|---|---|
| Status: | published |
| Journal: | Agriculture 2019, 9(11): 238<br>https://doi.org/10.3390/agriculture9110238 |
| Authors: | Benedikt Kramer, Anke Schorr, Reiner Doluschitz and Markus Lips |

*The Role of Neighborhood Effects on Investing Dairy Farms*

| | |
|---|---|
| Status: | submitted |
| Journal: | Economia Agro-Alimentare/Food Economy |
| Authors: | Benedikt Kramer, Anke Schorr, Reiner Doluschitz and Markus Lips |

## Conference proceedings

*Wahrscheinlichkeit von Investitionen in Milchviehställen Schweizer Verkehrsmilchbetriebe*

| | |
|---|---|
| Status: | published |
| Journal: | Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaues e.V. Band 54, 58. Jahrestagung der GEWISOLA e.V., 12-14. September 2018, Kiel |
| Authors: | Benedikt Kramer, Anke Schorr, Reiner Doluschitz and Markus Lips |

*Anpassungsphase nach Investitionen in Milchviehställe*

| | |
|---|---|
| Status: | published |
| Journal: | Tagungsband 28. Jahrestagung der Österreichischen Gesellschaft für Agrarökonomie |
| Authors: | Benedikt Kramer, Anke Schorr, Reiner Doluschitz and Markus Lips |

*Entwicklung des Viehbestands nach Investitionen in Milchviehställe*

| | |
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| Status: | published |
| Journal: | Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaues e.V. Band 53, 57. Jahrestagung der GEWISOLA e.V., 13-15. September 2017, Weihenstephan, page 303 |
| Authors: | Benedikt Kramer, Anke Schorr, Reiner Doluschitz and Markus Lips |

**Further topic relevant publications**

*Erfolgsfaktoren von einzelbetrieblichen Investitionsvorhaben; Untersuchung zuhanden des Bundesamtes für Landwirtschaft (BLW)*

Status: submitted
Journal: Final report for the Ministry of Agriculture
Author: Benedikt Kramer, Markus Lips and Nadja El Benni

*Rechnen Sie mit einer Durststrecke*

Status: published
Journal: Landfreund 10/2017
Author: Benedikt Kramer

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# 11 AUTHOR'S DECLARATION

**Declaration in lieu of an oath on independent work**

**According to Sec.18(3) sentence 5 of the University ofHohenheim's Doctoral Regulations for the Faculties of Agricultural Sciences, Natural Sciences, and Business, Economics and Social Sciences**

1. The dissertation submitted on the topic
   **Success Factors of Farm Investments: The Example of Swiss Dairy Farms**
   is work done independently by me.
2. I only used the sources and aids listed and did not make use of any impermissible assistance from third parties. In particular, I marked all content taken word-for-word of paraphrased from other works.
3. I did not use the assistance of commercial doctoral placement of advising agency.
4. I am aware of the importance of the declaration in lieu of oath and the criminal consequences of false or incomplete declarations in lieu of oath.

I confirm the declaration above is correct. I declare in lieu of oath that I have declared only the truth to the best ofmy knowledge and have not omitted anything.

Stuttgart, 19.05.2021

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