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Economic growth of farms:
An empirical analysis on organic farming

Brenes Muñoz, T., Lakner, S. and Brümmer, B[1].

Georg-August University of Göttingen,
Department of Agricultural Economics and Rural Development,
Platz der Göttinger Sieben 5, 37073 Göttingen, Germany

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Economic growth of farms an empirical analysis on organic farming

Abstract

This article investigates which factors influence the economic growth of organic farms. Organic farming has experienced a substantial growth in Germany since the beginning of the 1990s until today. Most organic farms are concentrated in the southern region of the country, Bavaria and Baden-Wuerttemberg. While some of these farms have expanded their business size, others have contracted, reconverted to conventional or ceased to operate. Using a panel data of 318 farms and a System GMM method, the economic growth of organic farms is analyzed. Regression results suggest that organic farms with high revenue from agriculture are less likely to grow than smaller farms. Growth is influenced by livestock intensity, multiple job holding, share of grasslands areas, soil quality and agri-environmental payments for organic farming.

Keywords: farm-growth, organic farming, Gibrat's law, part-time farming

1 Introduction

Organic farming has become one of the fastest growing branches of agriculture during the past two decades. The increasing consumer demand for sustainably produced goods, the higher price premiums and subsidies paid by governments are some of the driving forces for conversion to organic agriculture.

The organic sector in Germany has also been part of this development. Germany is the second biggest market of organic products worldwide and the leader country in production of organic potatoes and many cereals, such as soft wheat and rye (Willer and Kilcher, 2009). Furthermore, the number of organic farms in Germany rose from 7,353 in 1996 to 23,003 in 2011 and the number of hectares has almost tripled reaching the 951,557 hectares in 2011 (BOELW, 2012).

Nevertheless, the organic sector in Germany has some structural differences. Most of organic farms are located in Bavaria and Baden-Wuerttemberg. These two Federal States historically comprised more than half of organic farms (Federal Statistics Office, 2010). Moreover, the average farm size has increased over time, as in conventional agriculture. In Baden-Wuerttemberg, the share of farms with more than 50 hectares increased from 15% in 1999 to 21% in 2007 (Land Statistical Office of Baden-Wuerttemberg, 2011). In Bavaria the share of farms between 60 and 150 hectares grew from 9% in 1995 to 26% in 2010 (see Figure 1).

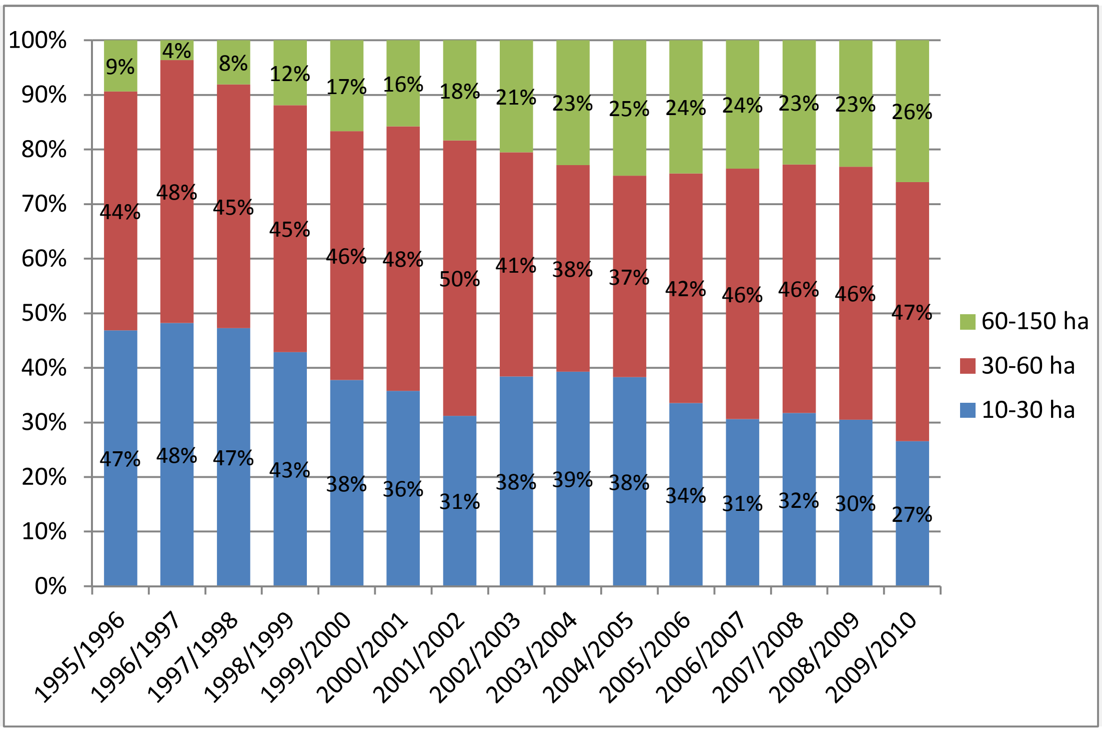

Figure 1 Percentage share of organic farms in Bavaria by farm size, 1995-2010
Source: own calculation, data from the Ministry of Agriculture in Bavaria

Organic farming, as agriculture in general, has become a highly competitive and thin-margined business; farm operators face the challenge of surviving economically or expanding their operations, sometimes with limited resources, e.g. land or labor. Organic farming has also become an instrument of state agricultural policy. All members of the European Union support conversion and maintenance of organic farming through payments per hectare under the framework of agri-environment and rural development policy, with the aim to increase the area managed organically (Stolze and Lampkin, 2009).

Addressing the determinants of farm growth at the firm level has practical implications for both private and public concern. It is relevant when making the decision of expand the farm business, for stability of product supply, as well as for the socioeconomic welfare of farmers. For policy makers, it is important to know what factors lead to increasing organically cultivated areas and farms revenues. Nevertheless, all previous studies of farm growth have addressed only conventional agriculture without any specific consideration of organic farming.

Given the importance of organic agriculture ant the fact existing studies have mostly concentrated on conventional agriculture, this research seeks to fill this gap in the empirical research by analyzing the economic and physical growth of 318 organic farms from Bavaria and Baden-Wuerttemberg. Specifically, the following two research questions will be addressed:

- *What causes the variation of growth rates?*
- *To what extent land and revenue changes depend on its previous size and other farm specific factors?*

The article proceeds as follows. We first review the theory of firm growth before providing background information on potential determinants of growth. Subsequently we present a brief description of the data and a detailed description of the estimation procedure. We then discuss the results and present our conclusions.

2 Theory of firm growth

There are different theories of firm growth. The impact of initial size of a firm on growth is a crucial point with respect to theoretical assumptions. One approach to treating this question in the agricultural sector is the *path-dependency approach,* which explains the persistence of technologies that become quasi-standard at a certain point of time, even though other technologies, are supposed to be more efficient (for a literature review see Theuvsen 2004; an application is provided by Balmann et al. 1996). In that sense the initial farm size might be the starting point for its further development, i.e. growth of a farm.

Many empirical studies which attempt to determine the relationship between growth rates and firm-specific factors use the Law of Proportionate Effect or ‘Gibrat’s Law’ as a foundation. According to Sutton (1997) and Coad (2009), Gibrat originally studied the distribution of income and plant (establishments) size in manufacturing, and wanted to determine which process could be responsible for generating this distribution. He found that plant size followed a skew distribution that resembled the lognormal; based on the assumption that the increment to a firm’s size in each period is product of a large number of small, independent and normally distributed shocks.

Although, Gibrat's Law was conceived to explain the distribution of plant size, several renditions have been derived to apply it in a wide range of social and economic studies. One of the main implications in economics was developed by Mansfield (1962: 1030), who argued that "the probability of a given proportionate change in size (growth) during a specified period is the same for all firms in a given industry – regardless of their size at the beginning of the period". This connotes that small and large farms have the same probability to grow in any period and that growth is independent of firm size.

Empirical studies which test this relationship rely on the following equation:

$$\Delta \ln S_{i,t} = \alpha + \beta \ln S_{i,t-1} + u_{i,t}, where\ \beta = (\beta - 1) \qquad (1)$$

where $S_{i,t}$ is size of the firm i at time t, β determines the effect of initial size on growth and $u_{i,t}$ is the random effect. The Law requires that $\beta = 0$, which implies that growth is independent of size. If $\beta > 1$, then large firms grow faster than small ones. This also implies an increasing concentration of the sector over time, with a few larger firms (Shapiro et al., 1987).

Simon and Bonini (1958) pointed out that Gibrat's Law holds only for very large firms above the Minimum Efficient Scales (MES), in which economies of scales have been fully exhausted. In addition, small firms face the challenge to become more efficient or exit the sector.

The vast majority of studies of Gibrat's Law have been conducted on the manufacturing and services sectors, with very few empirical researches on agriculture and without any specific consideration of organic farming. In agriculture, the first investigations were limited to test Gibrat's Law and the size distribution of farms. Over time, studies have paid more attention to others characteristics of the farm and farmer's attributes as determinants of growth. Sumner and Leiby (1987) and Upton and Haworth (1987) were the first in emphasizing the relevance of human capital, such as schooling, experience and age on farm growth. These two studies were the base for Weiss (1999), who besides including new factors on the growth model also proposed to estimate the probability of farm survival.

2.1 Farm Size

The importance on the proper measurement of firm size lies on the definition of growth, where growth is change of firm size. In agriculture, there is no a widely accepted definition for farm size. According to Hallam (1993) and Weiss (1998), measurements of size are either output- or input-based.

The most accepted measures are input-based, hectares of land for crop farms and livestock units for dairy farms. Particularly, the factor *land* in agriculture is relevant for two main reasons. First, changes in hectares of land reflect adjustments in the structure of the agricultural sector, in terms of farm distribution and sizes. Second, land is one of the main production factors in agriculture.

Figure 1 shows part of the structural change in organic farming. The share of large farms in Bavaria and Baden-Wuerttemberg has increased while the proportion of small farms has decreased. This fact denotes the changes on farm sizes and the need of organic farms to enlarge operations based on agricultural land. Nevertheless, land is also resource for other economic sectors such as urban and industrial expansion (Lee and Barry, 1977); its availability (for buying or renting) can be restricted by conditions of the regional land market. Particularly, farms in Bavaria and Baden Württemberg face high opportunity cost, in 2003 the land price in Bavaria was €22,848/ha and €19,668/ha in Baden Württemberg, which correspond to the second and third highest values among all federal states in Germany (Siegmund, 2004).

Despite market restrictions, land is almost an indispensable production factor for growth in agriculture. Especially in organic farming, with restrictions on stocking levels and the need to produce more on-farm inputs, such as fodder or manure, land may play a more central role than in conventional agriculture. Besides the issue of quantity of land, the quality of the soil plays also relevant role for organic farming. Laker (2009) found that organic farms in Germany located in zones with higher soil quality had higher scores of technical efficiency. This may also influence positively the probabilities of farm to expand.

Certainly, changes in size are not limited to expansion in area; it also involves adjustments in other factor proportions, as well as output quantity (Weiss, 1998). It is difficult to find a single variable that captures all adjustments occurred in a farm when size has changed. For this, the usual alternative to measure growth is an output-based indicator. As reported by Hallam (1993), valued added and inflation corrected sales are the most accepted output-based measures. For this study we used two measures of size, hectares of land and revenue from agriculture.

In most agricultural applications of Gibrat's Law, farm size had a significant effect on growth (see Shapiro et al., 1987; Gale, 1994; Weiss, 1998; Kostov et al., 2005 and Gardebroek et al., 2009). However, the direction of the effect probably depends on the production system. Owing to characteristics of organic farming, it is expected that farm size has a positive effect on growth.

As mentioned above, the rate and direction of growth are also considerably determined by managerial decisions in production, growth strategies, investment and financing. These choices are made with a given stock of resources, such as land, labor, and capital. The availability and intensity in which these factors are utilized in the production process affect the efficiency and consequently the likelihood of expansion. Many of these resources have an important impact on growth. However, they are also subject to external forces that can stimulate or impede growth (Lee and Barry, 1977). Some of these variables have been included in our model and we discuss them in the next section.

2.2 Others factor affecting farm growth

Almost all expansion alternatives in agriculture require additional *labor*; unless farms adopt a labor saving technology (Lee and Barry, 1977). Nonetheless, according to Table 1, organic farms in Germany are labor intensive; they require in average 16.8% more labor than conventional. This higher demand of labor indicates that labor may influence positively the expansion of farms in terms of area. However, from the economic perspective, the higher costs of hired labor may have a negative effect. The net effect will depend on the source and cost of this factor.

Table 1 Factor endowment of organic and comparable conventional farms in Germany, 1999/2000.

Factor	Unit	Organic Farms	Comparable conventional farms	Percentage difference
Land	ha	60,25	60,12	0.2%
Labor	WU/farm	1,91	1,64	16.8%
Farm owned capital	€/ha	7.315,74	9.480,19	-22.8%
Labor costs	€/ha	100,07	41,68	140.1%

Source: Own calculation, data from the Federal Ministry for Consumer-Protection, Food and Agriculture 1999.

Besides land and labor, farms need of *capital* for expansion, particularly for the acquisition of durable assets such as buildings, storage facilities and feed systems. The investments in farm businesses are addressed to improve productivity and efficiency. Actually, most of the growth in farms is due to expansion with such productive and durable assets (Lee and Barry, 1977). Empirical findings on the effect of capital on farm growth are rather ambiguous. Heshmati (2001) found that growth is positively related to capital intensity, contrary to the findings of Gardebroek et al. (2009). Although, organic agriculture is less capital intensive than conventional; this factor is still crucial for expansion. A positive effect of capital on growth is expected.

Specialization and *intensification* of farm production also influence farm growth. According to Bremmer et al. (2002), specialized farms are able to concentrate management and capital to fewer commodities at a larger scale, thus increasing technical efficiency as well as the probability of expand their operations. Villatoro and Langemeier (2006) found statistical evidence that intensive farms grew more than *less intensive farms*. Lakner (2009) could show intensive organic farms to be more technically efficient.

Farmer's age and off-farm work are factors, which commonly represents *human capital*. Farmer age or firm age are common indicators used also to measure the evolutionary learning process proposed by Jovanovic (1982), in which firm's managers do not know how productive they are until they entry the market. Once in the market, firms learn about their relative productivity. Those that understand and learn about the positive effects of their efficiency survive and growth, while less efficient firms decrease in size until disappearing with the course of time (for a discussion about Jovanovic's theory see Weiss, 1999; Oliviera and Fortunato, 2006; Coad, 2009). Sipilainen and Lansink (2005), found that organic farming practices are usually unknown for farmers before converting from conventional farming, and that they require time to gain experience and become more efficient. Additionally, Weiss (1999) found that the effect of age on farm growth follows an inverted U-shaped.

Another factor related to human capital is *off-farm employment*. According to Kimhi (2000) and Weiss (1999), off-farm work can be considered as a first step outside of agriculture, but it can also prevent the cessation of farms by stabilizing household income. Langemeier and Weeden (2006) found that non-farm income had a positive correlation with growth; contrary to Weiss (1999) and Juvancic (2006).

Offermann and Nieberg (2000) found that farms which sold their products directly to the consumer had higher profitability, because prices for organic products in direct marketing reached sometimes twice prices obtained from wholesales. For this reason, it is expected that direct marketing has a positive effect on farm growth via profitability.

External factors such as *public policies* also influence farm growth. Organic farms in Germany are characterized by a high dependency on policy support, particularly in the case of dairy and arable farms in the Southern region (Offermann et al., 2009). Glauben et al. (2006) demonstrated that subsidies keep farms in business that would otherwise cease. Nevertheless, the type of subsidies plays an important role, whereas environmental contracts may restrict farmers in the short-run to adapt to changes, subsides per unit of output may allow them to react to new market requirements.

3 Empirical model and estimation

The starting point to test the relationship between growth and farm size is the Law of Proportionate Effects. However, the econometric estimation of growth in equation (1) faces many econometrics problems. Results from previous empirical research on Gibrat's Law found that firms growth suffers from *autocorrelation* (Cheser, 1979). Moreover, Evans (1987) observed the *heteroskedasticity* problem, associated with a greater variation of growth rates among small firms, and *sample selection* bias, related to higher probability of attrition among small firms. According to Audretsch et al. (1999), the sample selection problem is inherent to growth, but it has a bigger repercussion when researchers only analyze surviving firms, i.e. firms that survived throughout all examined periods.

Another important aspect for the firm growth estimation is the potential endogeneity bias. The endogeneity arises because the lag of farm size on the right-hand side of equation (1) is not exogenously determined. The lag of farm size is in part explained by previous shocks of growth and the error term. Moreover, endogeneity could also come from unobserved heterogeneity of farms affecting growth rates.

So far, most of the empirical studies on firm growth ignore this problem and only very few deal with it. Among them, Weiss (1999) and Dolev and Kimhi (2008) proposed the use of the lag of firm size as an instrument to control for endogeneity.

Based on the literature review and equation (1), the growth model is derived from a fim size equation:

$$\mathrm{lnS_{it}} = \alpha_1 \mathrm{lnS_{it-1}} + \mathrm{X_{it-1}}\beta + \gamma_t + (\mathrm{a_i} + \mathrm{u_{it}}) \tag{2}$$

$$\varepsilon_{it} = \mathrm{a_i} + \mathrm{u_{it}} \tag{3}$$

The growth model is obtained by subtracting $\mathrm{lnS_{it-1}}$ on both sides of the equation (2):

$$\mathrm{G_{it}} = (\alpha_1 - 1)\,\mathrm{lnS_{it-1}} + \mathrm{X_{it-1}}\beta + \gamma_t + (\mathrm{a_i} + \mathrm{u_{it}}) \tag{4}$$

where the term α_1 describes the relationship of firm size in two consecutive periods between size and annual growth, $\mathrm{lnS_{it-1}}$ is the logarithm of farm size measured as revenue from agricultural products and hectares of land. Therefore, farm growth will be measure as the changes in land and in revenue. $\mathrm{X_{it-1}}$ represents other covariates that are not strictly exogenous, see Table 2; while a_i captures the unobserved and time constant farm specific effects, such as location (proximity to market), farmers' skills for management or differences in the initial levels of efficiency. The term γ_t captures the time effects common to all farms.

The analysis of the effect of farm size on growth consists of testing the null hypothesis H_0: $(\alpha_1 - 1) = 0$, which implies that growth is independent of farm size. If $\alpha_1 < 1$, then small farms will be growing faster than the large ones. The set of all variables used in the econometric model are presented in Table 2.

The application of a lagged dependent variable of farm size on the right hand side of equation (4) rules out the strict exogeneity assumption because the $\mathrm{lnS_{it-1}}$ term is correlated with the error term $(\mathrm{a_i} + \mathrm{u_{it}})$ and earlier shocks (Bond, 2002). Estimating equation (4) by OLS will then produce biased and inconsistent estimates. The Within Group estimator will eliminate this source of bias by eliminating the farm fixed effects $\mathrm{a_i}$. Nevertheless, it fails to remove the endogeneity bias, since the demeaned lagged dependent variable and the demeaned error term will remain correlated (Bond et al., 2001).

Table 2: Definition of variables for the model estimation

Variable	Units	Definition	Mean (Sd.)
Revenue	log	Logarithm of total revenue from agricultural sales	11.14 (0.73)
Capital	€	Annual depreciation	18,099.35 (12,626.63)
Labor	AWU	Sum of Agricultural Working Units (AWU) on the farm per year	1.64 (0.68)
Land	Hectares	Utilized agricultural area in hectares (owned and rented)	49.59 (31.74)
Share of Grassland	%	Share of grasslands in the total farm land	47.83 (32.95)
Soil quality	EMZ†/ha	Soil quality index from Germany which range from 25 to 10,000	3542.46 (1222.29)
Livestock intensity	GVE*/ha	'Grossvieheinheiten' is a measure of animal units, which are defined by the German building legislation ('Baugsetzbuch').	1.10 (0.72)
Age	years	Farm operator age in years.	43.42 (8.46)
Part-time farming	0/1	Dummy for off-farm employment; PT = 1 if the farmer has a part-time job; PT = 0 if operator is full time farmer.	0.11 (0.32)
Payed Subsidies	€	Agri-environmental payments for organic farming.	11,312.65 (6,677.84)
Farm shop	0/1	Dummy for farm shop, FSHOP = 1 if the farms has its own farm shop; FSHOP = 0; otherwise.	0.09 (0.30)
Vector for years	Years	Vector of years dummies.	-

†: Ertragsmesszahl (EMZ), soil quality index based on various plot characteristics that influence yield potential, such as soil texture, local temperature and soil water holding capacity.
*: Grossvieheinheiten, i.e. Livestock Units

Source: own elaboration

According to Bond (2002), in the presence of individual (farm) effects, the OLS estimator is biased upwards and the Within Group estimator has a downward bias. Arellano and Bond (1991) proposed a Difference *GMM* (DIFF GMM) estimation method which takes first differences from equation (4), eliminating that way the time invariant farm effects, and using the lagged levels of the dependent variable and explanatory variables as instruments for the first differenced equation (Bond et al., 2001). Thus, considering equation (4) in first differences

$$\Delta G_{it} = (\alpha_1 - 1)\Delta \ln S_{it-1} + \beta \Delta X_{it-1} + \Delta u_{it} \tag{5}$$

where $\ln S_{it-2}$ and X_{t-2} are considered valid instruments for $\Delta \ln S_{it-1}$, since they are expected to be uncorrelated to Δu_{it}.

The estimation of equation (6) is based on the following assumptions:

1) $E[a_i] = E[u_{it}] = E[a_i u_{it}] = 0$ for $i = 1, \ldots, N$ and $t = 2, .., T$.
2) The errors are serially uncorrelated $E[u_{it}u_{is}] = 0$ for $i = 1, \ldots, N$ and $s \neq t$
3) $E[\ln S_{i1} u_{it}] = 0$ for $i = 1$ and $t = 2, \ldots, T$

All these assumptions imply the following $E[S_{it-s} \Delta u_{it}] = 0$ for $t = 3, \ldots, T$ and $s \geq 2$

However, the DIFF GMM estimation has a poor performance when the lagged levels of the dependent variable are weakly correlated with the first differences. This occurs when the autoregressive parameter α_1 in equation (5) approaches to unity or the variance of the individual effects is not constant[1]. Simulation results show that the DIFF GMM estimator may be subject to downward bias in these cases, especially when the number of time periods is short. A first difference GMM estimator close to or below the Within Group estimate may denote serious finite sample bias associated with weak instruments (Bond et al., 2001).

To increase efficiency in the context of persistent series, Blundell and Bond (1998) developed the *System GMM* (SYS GMM) that was proposed by Arellano and Bover (1995). In addition to the first differenced equation (5), the System GMM uses a level equation, in which the first differences of the dependent and explanatory variable are used as instruments (Bond, 2002); this produces a system of level and first difference equations:

$$\begin{bmatrix} \Delta G_{it} \\ G_{it} \end{bmatrix} = \alpha \begin{bmatrix} \Delta \ln S_{it-1} \\ \ln S_{it-1} \end{bmatrix} + \beta \begin{bmatrix} \Delta X_{it-1} \\ X_{it-1} \end{bmatrix} + \varepsilon_{it} \qquad (6)$$

The System GMM considers an additional moment condition that the first differences are uncorrelated with the unobserved farm effect $\mathrm{E}(\Delta \ln S_{it} a_i) = 0 \; for \; i = 1, \ldots, N.$

This assumption yields $\mathrm{E}[(\Delta \ln S_{it-1}(a_i + u_{it}))] = 0 \; for \; \mathrm{i} = 1, \ldots, \mathrm{N} \text{ and } \mathrm{t} = 3, \ldots, \mathrm{T}.$

The last condition allows us to use the lagged differences of $\ln S_{it}$ as instruments in the equation in levels. In this context, the System GMM makes use of more instruments.

The validity of these additional instruments can be tested using the Difference in Hansen Test between the DIFF GMM and SYS GMM (Bond et. al, 2001). The null hypothesis of the Difference in Hansen Test is that the additional moment conditions used in the level equations are valid.

Through the conventional Hansen Test, we can verify if the null hypothesis of correct model specification and validity of the over-identifying restrictions holds. This test is robust to heteroskedasticity, but can be weakened by many instruments. There are no clear rules about how many instruments to use, but the number of instruments should not exceed the number of observations (Roodman, 2006).

Additionally, Arellano and Bond developed a test to determine for serial correlation. The test is applied to the residuals in first differences. Here, a negative serial correlation in first differences is expected, since Δu_{it} is related to Δu_{it-1} through the common term u_{it-1}. Thus, the AR(2) test will detect first order serial correlation in levels, between the u_{it-1} in Δu_{it} and the u_{it-2} in Δu_{it-2} (Roodman, 2006).

For the estimation of the growth model with SYS GMM, it was assumed that revenue from agriculture, capital, labor and land are potentially correlated with the farm specific effects, and previous shocks the error term and growth. For parsimonious estimation, we limited the number of instruments to two lags (t-2 and t-3). The

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[1] This means that the individual farm effect whilst differing across farms is constant through time for each individual.

variables share of grasslands, organic payments, part-time job, livestock intensity and farm shop were specified as exogenous.

4 Data and descriptive statistics

The analyzed data set is an unbalanced panel of 318 farms from Bavaria and Baden-Wuerttemberg, with observations over a 12 year period (1993/1994 to 2004/2005). The data is accounting information provided by Land Data GmbH. Small farms (< than 10 ha.) are underrepresented, probably because they are family businesses with no need for contracting external bookkeeping services. The number of very large farms is also small, perhaps as a result of having their own staff to carry out the farm's accountancy. Despite these limitations, the dataset is representative of medium-sized single farms, which have a strong relevance for the organic market in Germany.

The dataset is highly unbalanced; therefore it was not possible to track entry and exit of all farms. For the econometric analysis, we considered three types of farms: farms with observations over the 12 years; those with continuous observations but that at some point exited the dataset and new entrants. However, we eliminated those farms with discontinuous observations, for example those which exited the dataset for one or two years and then reappeared. All monetary variables are expressed in real terms, using 2000 as base year. We used standard agricultural price indices from the Federal Statistical Office (e.g. Destatis 2006).

Figure 2 plots the relationship of growth rates of revenue and farm size. Here is difficult to find a clear trend between these two variables; however, the dispersion of growth rates seems to be higher among smaller farms.

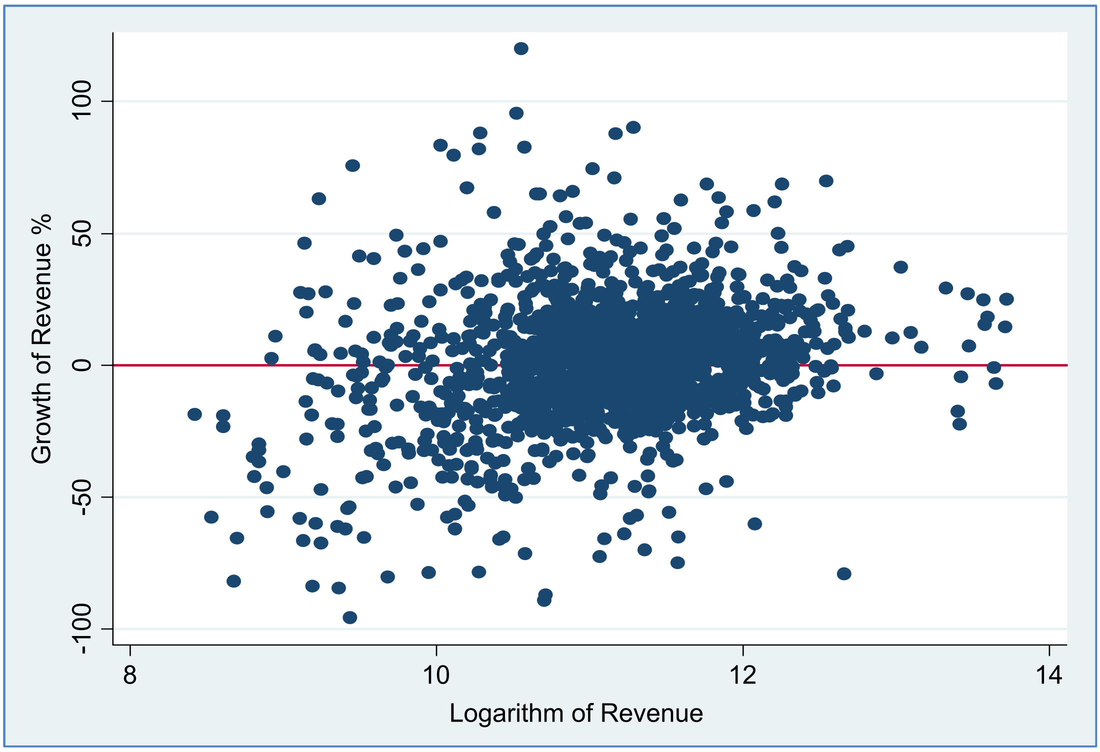

Figure 2: Farm size plot based on revenue from agriculture, 1993-2005

Source: own calculation

5 Results

Table 3 presents the regression for both econometric models, growth of revenue and number of hectares. The outcome of the AR(1) tests in columns (a) and (b) show that the residuals in first differences are negatively autocorrelated, in consonance with the process of first differencing equation (4). The AR(2) tests did not reject the null hypotheses of autocorrelation in second differences, a necessary assumption for the SYS GMM estimation.

Table 3: Results of the GMM estimation for farm growth

	Revenue (a)	**Number of hectares (b)**
Revenue$_{t-1}$	**-0.3195**** (0.1267)	-0.0734 (0.0658)
Capital $_{t-1}$	5.40E-06 (4.71E-06)	-4.2E-06 (3.1E-06)
Labor $_{t-1}$	0.0068 (0.0519)	0.0266 (0.0286)
Land $_{t-1}$	0.0012 (0.0020)	-0.0227 (0.0614)
Share of grasslands $_{t-1}$	**-0.0012*** (0.0007)	**-0.0009***** (0.0003)
Livestock intensity $_{t-1}$	**0.0931**** (0.0450)	**0.0631**** (0.0249)
Soil quality $_{t-1}$	**6.41-05***** (1.89-05)	5.25-06 (6.27-06)
Farmer's Age$_{t-1}$	-0.0012 (0.0014)	-0.0011 (0.0007)
Dummy Part-time $_{t-1}$	**-0.2069**** (0.0918)	-0.0560 (0.0432)
Payed subsidies $_{t-1}$	4.17E-06 (5.01E-06)	**7.4E-06**** (3.5E-06)
Dummy Farm shop $_{t-1}$	0.0116 (0.0283)	-0.0100 (0.0135)
Constant	3.3894 (1.3474)	0.9117 (0.6583)
Arellano-Bond test AR(1)	-4.64 [0.00]	-5.24 [0.00]
Arellano-Bond test AR(2)	0.59 [0.56]	-1.00 [0.32]
Hansen test of over-identification	[0.685]	[0.597]
Diff-in-Hansen tests of exogeneity of standard "IV" instrument subsets	[0.887]	[0.838]

Note: Robust standard errors in parentheses; p-values in brackets; *** coefficient significant at 1% level; ** at 5% level; * at 10% level respectively

Results were generated using the `xtabond2` command in STATA, developed by Roodman (2012)

The Hansen Tests for over-identification of the instruments show a p-value of 0.69 for the revenue growth model and 0.60 for number of hectares. This implies that we cannot reject the null hypotheses that the instruments of each regression are valid. Also, the Difference in Hansen Tests did not reject the null hypotheses that the additional subsets of instruments (for the SYS GMM) are exogenous.

Additionally, the coefficients of the SYS GMM regressions lie between the OLS and the Within Group regressions; see Appendix 1 and 2. This confirms the presence of unobserved individual effects, which make OLS and Within Group estimations bias and inconsistent for the growth models.

It is important to notice that the results obtained from both growth models are congruent with each other. For both regressions, share of grasslands and livestock intensity were statistically significant; moreover, the direction and magnitude of the effect are very similar. Some differences on the outcomes were expected, since growth models are sensitive to the type of dependent variable used (Heshmati, 2001). However, these differences are consistent with the economic theory.

Contrary to Gibrat's Law, *farm size* has a statically significant effect on the growth rates of *revenue*. The negative sign of the coefficient in Table 3 indicates that the growth rates of revenue decreases with farm size. This is in line with previous findings from Shapiro et al. (1987), Weiss (1999), Bremmer et al. (2002), and Gardebroek et al. (2009), who also found that small farms grow at higher rates.

According to our results, an increase of 1% in revenue, decreases growth rates of revenue in 0.32 percentage points. Figure 3 shows the decreasing relationship of the predicted values of growth with the revenue from the sample. The negative effect of farm size on growth indicates that larger farms are not economically expanding as expected. This result can be explained by the effect of a *Minimum Efficient Scale* (MES) of production and economies of scales, where small farms either leave the sector or show above average growth rates to adjust and to achieve a size that enables them to exist in the market (Teruel, 2007). However, after reaching the MES point, *economies of scale* are exhausted and the average cost of production starts to increase. Thus, an increase in revenue, once the MES has been achieved is difficult to obtain. In terms of sector concentration, it implies that a high concentration of few large farms in the organic sector is less likely to occur.

With respect to the growth model for the number of hectares, neither the revenue nor the number of hectares had an impact on the increase of land. Here, we fail to reject Gibrat's Law. However, the coefficient for land has a negative sign, which is coincides with our findings on column (a), that larger farms are less likely to expand their operations.

Capital and *labor* did not have statistical significance on both growth models. *Share of grasslands* area was statically significant, implying that those farms with a higher share of grasslands (specialized in livestock grazing) are less likely to increase revenue and land than their counterparts. Nevertheless, the magnitude of the effect on the growth rates of sales and land is rather small.

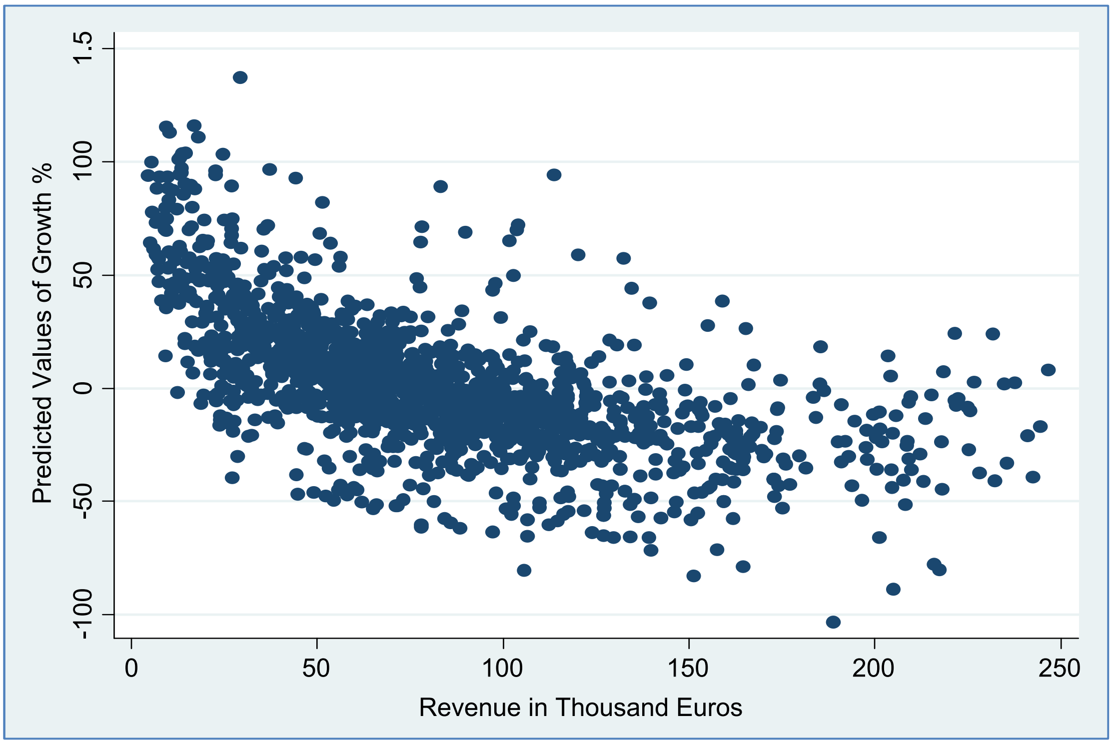

Figure 3: Predicted values for growth rate of revenue
Source: own calculation

A greater impact is caused by the intensity of production, where one additional livestock unit per hectare increases agricultural revenue, ceteris paribus, by almost 10 percentage points. For the land growth model, the variable was also statistically significant, every LU/ha additional, increases growth rates by 6.5 percentage points. The average of *livestock intensity* in the sample is 1.1 LU/ha and the stocking density for organic farming is restricted at 2.0 LU/ha. That means farmers have the opportunity to exploit almost half of the livestock density limit without defying the standards for organic farming. Moreover, the quality of the soil (EMZ/ha) had a positive effect on the change of revenue and no impact on the change of land. Nevertheless, the coefficient is rather small to have a significant economic effect on the growth rates of revenue.

The variable age was included to capture the effect of the learning process and experience of organic farming. Nevertheless, farmer's age did not show a statistical impact on growth, but its negative sign is in agreement with results from Gale, 1994 and Gardebroek et al., 2009, that found a negative relationship between age and growth.

Part-time work has statistically significant effect on growth rates of revenue; based on the regression results, in farms where the operator pursued an off farm job, the growth rates were 20 percentage points lower than full time farms. This negative relationship coincide with the results from Weiss (1999) and Juvancic (2006), where an off farm job reduces the need to increase farm revenue, since farmers have a stable household income. The large magnitude of the coefficient might be the outcome of the high wages in the non-agricultural sectors in Bavaria and Baden-Wuerttemberg. For instance, the average wage per hour in Baden-Wuerttemberg was the second highest in Germany in 1999 (Statistical Yearbook, 2000), which indicates that farmers prioritize the off farm job over farm expansion.

The subsidies received for organic farming did not have a statistical influence on growth of revenue. However, they did have significant influence on the increase of organically cultivated area. This effect gives a positive sign that policy measures to foster organic farming are well targeted but the magnitude is rather small for our group of farms.

6 Conclusions

The purpose of this study was to investigate if Gibrat's Law holds for organic farms and to what extent growth of organic agriculture depends on other farm factors. We analyzed growth from two perspectives: the economic aspect, using revenue as indicator, and physical growth through the number of hectares per farm.

In general terms, the results from both models were consistent with each other. However, there were some differences as a result of the different growth measurements. This indicates that the definition of farm size is crucial for empirical research on growth model. Moreover, results cannot be compared in any straightforward way among the different studies,

Farm size had only a significant impact on economic growth and no effect on the physical expansion of farms. The econometric model using the System GMM estimation method found a negative relationship between farm size and economic growth, rejecting Gibrat’s Law. This outcome is related to the effect of a Minimum Efficient Scale (MES) of production, where large farms above this threshold have exhausted the economies of scale and have less probability to make a substantial increase in revenue.

In addition to farm size, other factors as such livestock intensity, share of grasslands area, multiple job holding and subsidies had significant impact on farm growth. Particularly, intensity of livestock production had also a positive and high effect on the two econometric models. Thus, organic farmers that want to expand their operations, face the challenge to enhance productivity without contravening the organic regulations.

The variable part time job had effect only on economic growth of farms, supporting the argument that part-time farming promotes the restructuration of the agricultural sector. Other factors as agri-envirinmental subsidies and share of grasslands areas had a limited practical relevance.

Unfortunately, the present study could not take into account the effect of these factors in farm survival. However, the results represent the dynamic of farms in the context of organic agriculture.

Finally, extending this research by estimating the Minimum Efficient Scale may allow us to observe the point where the economies of scales (for the sample) are exploited. Moreover, analyzing the persistence of growth may contribute to better understand this process over time. Growth persistence is important to complement information and to determine whether firms that grew in the past are more likely to grow in the future and how negative growth is related to subsequent growth.

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Appendix 1 Estimation of the growth model using revenue as dependent variable

Dependent variable: $\Delta \ln S_{it}$ (revenue)				
	Pooled OLS	**Within Group**	**DIF- GMM**	**SYS-GMM**
Farm Size (Revenue)	**-0.0927**	**-0.7247**	**-0.9931**	**-0.3195**
	(0.0162)	(0.0631)	(0.2351)	(0.1267)
Capital	**2.02E-06**	**6.32E-06**	1.30E-05	5.40E-06
	(4.52E-07)	(2.04E-06)	(1.03E-05)	(4.71E-06)
Labor	**0.0392**	**0.0639**	-0.1278	0.0068
	(0.0095)	(0.0174)	(0.1532)	(0.0519)
Land	0.0004	**0.0039**	0.0090	0.0012
	(0.0003)	(0.0017)	(0.0062)	(0.0020)
Share of grasslands areas	**-0.0005**	0.0028	0.0006	**-0.0012**
	(0.0002)	(0.0020)	(0.0021)	(0.0007)
Livestock intensity	**0.0392**	**0.1433**	0.1570	**0.0931**
	(0.0167)	(0.0469)	(0.1057)	(0.0450)
Soil quality	**6.71-06*** **	6.89-06	0.1282	**6.41-05*** **
	3.84-06	(8.61-06)	(0.1040)	(1.89-05)
Farmer's Age	**-0.0012**	0.0001	-0.0011	-0.0012
	(0.0006)	(0.0017)	(0.0044)	(0.0014)
Dummy Part-time	**-0.0466**	-0.1471	-0.0359	**-0.2069**
	(0.0221)	(0.1050)	(0.1226)	(0.0918)
Payed subsidies	-3.39E-07	-2.59E-06	-4.71E-07	4.17E-06
	(1.35E-06)	(2.11E-06)	(1.98E-06)	(5.01E-06)
Dummy Farm shop	-0.0119	**0.1339**	**0.0809**	0.0116
	(0.0166)	(0.0415)	(0.0430)	(0.0283)
AR(1) test	-	-	-1.38	-4.64
			[0.169]	(0.000)
AR(2) test	-	-	-0.30	0.59
			[0.767]	[0.556]
Hansen test of over-identification	-	-	29.67	60.00
			[0.585]	[0.685]
Diff-in-Hansen tests of exogeneity	-	-	16.60	38.69
			[0.412]	[0.887]
Instruments	-		52	87

Note: Robust standard errors in parentheses; p-values in brackets; *** coefficient significant at 1% level; ** coefficient significant at 5% level

DIF-GMM refers to a two step estimation, instrumenting Firm size and capital with all available lags from t-2 and earlier.

Results were generated using the `xtabond2` command in STATA, developed by Roodman (2012)

Source: own calculations

Appendix 2 Estimation of the growth model using land as dependent variable

Dependent variable: $\Delta \ln S_{it}$ (number of hectares)				
	Pooled OLS	**Within Group**	**DIF- GMM**	**SYS-GMM**
Farm Size (Hectares)	__-0.0227__** (0.0102)	__-0.4704__*** (0.0613)	__-0.6492__*** (0.1748)	-0.0227 (0.0614)
Capital	3.74E-06 (3.09E-06)	-3.57E-06 (7.46E-06)	__-6.96E-05__** (4.24E-05)	4.20E-05 (3.12E-05)
Labor	0.0025 (0.0042)	0.0087 (0.0094)	-0.0755 (0.0632)	0.0266 (0.0286)
Revenue	0.0028 (0.0085)	__0.0429__*** (0.0150)	-0.0726 (0.0774)	-0.0734 (0.0658)
Share of grasslands areas	__-0.0003__*** (0.0001)	__0.0025__** (0.0012)	0.0005 (0.0012)	__-0.0009__*** (0.0003)
Livestock intensity	__0.0243__*** (0.0094)	__0.0506__*** (0.0176)	0.0728 (0.0525)	__0.0631__** (0.0249)
Soil quality	-3.32-06 (2.04-06)	6.79-06 (4.30-06)	__0.5462__* (0.0313)	5.25-06 (6.27-06)
Farmer's Age	-0.0002 (0.0003)	0.0009 (0.0007)	-0.0005 (0.0011)	-0.0011 (0.0007)
Dummy Part-time	0.0051 (0.0083)	0.0097 (0.0190)	-0.0104 (0.0239)	-0.0560 (0.0432)
Payed subsidies	__2.15E-05__*** (7.14E-06)	__2.94E-05__*** (8.43E-06)	1.29E-05 (1.17E-05)	__7.35E-05__** (3.51E-05)
Dummy Farm shop	0.0024 (0.0078)	0.0005 (0.0132)	-0.0066 (0.0120)	-0.0100 (0.0135)
AR(1) test	-	-	-1.22 [0.222]	-5.24 [0.000]
AR(2) test	-	-	-0.84 [0.401]	-1.00 [0.318]
Hansen test of over-identification	-	-	48.49 [0.494]	62.57 [0.59]
Diff-in-Hansen tests of exogeneity	-	-	29.72 [0.631]	40.20 [0.838]
Instruments	-	-	69	87

Note: Robust standard errors in parentheses; p-values in brackets; *** coefficient significant at 1% level; ** coefficient significant at 5% level

DIF-GMM refers to a two step estimation, instrumenting Firm size and capital with all available lags from t-2 and earlier.

Results were generated using the `xtabond2` command in STATA, developed by Roodman (2012)

Source: own calculations