GROWTH OF GERMAN DAIRY FARMS UNDER THE EU MILK QUOTA

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Abstract

We estimate determinants of growth among German dairy farms between 1997 und 2005 under the EU milk quota system. Higher milk yield per cow, more family labour, and higher milk prices increase the growth rate of growing farms, ceteris paribus. Older growing farmers tend to grow at lower rates. In line with WEISS' findings (1999) for Austrian farms, Gibrat's Law of relative firm growth being independent of initial firm size does not hold for our subsample of farms growing in milk production, either: the growth rate is quite high for small farms and has a minimum for farms around 400 000 kg of initial quota. For the nine % of growing farms that have more initial quota the growth rate increases up to some out-of sample maximum. We corrected for selection bias by means of a multinomial logit model which explains the choice among different growth regimes in more detail than the well known Heckman procedure. In our case, e.g. age impacts the choice between growth and stagnation but not between growth and exiting from milk production; crop subsidies only influence the decision between growth and exiting from milk production but not the decision between growth and decline or stagnation.

Keywords: farm growth, Gibrat's Law, milk quota, selection bias

1. Introduction

Growth of farms is one key aspect of change in farm structure. Unfortunately, empirical findings of farm growth are rather limited. This is particularly true and unfortunate for EU dairy farming. On one hand, rapid structural change in the farm dairy sector is expected to occur when the supply control – the 'milk quota' – will be abolished in 2014. On the other hand, we are not aware of any empirical study about growth of milk farms in the EU, in particular, nor under a quota system, in general.

We study determinants of growth among German dairy farms between 1997 und 2005 to give some first empirical findings on growth determinants for dairy farms under milk quota. We distinguish between four different growth regimes – growth, stagnation, decline, and exit from milk production – to account for selection bias in the estimation of growth rate determinants.

The paper is structured as follows: we first review the literature about empirical farm growth analyses before giving some background of the EU milk quota system and German particularities in quota transfer rules among farms. Data presentation and some detailed description of the estimation procedure follow. Results and conclusion finish the paper.

2. Literature

The most extreme choice about farm size can be seen between the alternatives of exiting from farming or staying in farm business. A bulk of empirical and theoretical literature is dedicated to this choice between two discrete alternatives: farm exit or continuation (e.g. BARKLEY, 1990; KIMHI, 2000; WEISS, 1999). In addition to exit FOLTZ' theoretical model (2004) distinguishes among three regimes of continuation: net investment (growth), disinvestment (decline), and hysteresis. Within the growth and the decline regime the farmer can choose his farm size from a continuous size measure (number of cows) while exit equals a size of zero and hysteresis implies an unchanged farm size. FOLTZ (2004) assumes a farmer choosing farm size, i.e. choosing among the four regimes and the level of growth, according to expected utility. FOLTZ' farmer is faced with uncertain product prices, he takes into account the (partial) irreversibility of investments and he can choose about farm size several times within his planning horizon. While FOLTZ' empirical analysis is about milk farms in Connecticut HINRICHS et al. (2008) study investment, disinvestment and inactivity in hog fattening of German farms. In general, HINRICHS et al. (2008) assume an environment for the farmer similar to FOLTZ. However, they are only interested in the discrete choice among the regimes. In contrast to FOLTZ, they measure size change in number of livestock and capital stock.

Following the analyses of FOLTZ (2004), ODENING et al. (2005), HINRICHS et al. (2008), and WEISS (1999) hysteresis, growth and exit are the most relevant regimes of farms. Partial decline is rather unusual in livestock because costs for stable are mainly sunk costs and because marginal costs of production – in general – do not increase substantially up to the stable's full capacity and average production costs may even decrease.

Unfortunately the following section about the milk quota system in Germany will show that - in a milk quota environment - size changes might not be modelled appropriately based on investment models such as FOLTZ (2004) or HINRICHS et al. (2008).

3. Background and Economic framework

The policy instrument of milk quota had been introduced in the EU in 1984 to restrict milk production under price support. In general, farmers were allowed to produce only the amount of milk they had quota for. In Germany, farmers received milk quota in 1984 based on their historical production figures. Farmers, then, were allowed to sell or lease their quota to other farmers. Quota transfer was restricted through several measures, such as the connection of quota to land needed for milk production. Although this restriction was abolished after some years quota transfers are still restricted to happen only between farmers within the same region that – in general – covers a federal state. In 2000 a remarkable change occurred: quota was only allowed to be sold on an exchange platform three times a year. New lease contracts were not allowed anymore. Besides renewal of old contracts, purchasing quota is the main possibility to expand a dairy farmer's milk quota endowment now. Until 2007 the trades were still allowed to happen only within specified regions such that the spatial distribution of German milk production did not change considerably.

The characteristics of the German quota systems imply two important conceptual issues for an analysis of size changes of the dairy branch of German farms between 1997 and 2005. These interrelated questions are: how should we measure size of the dairy branch? And, how can we conceptualize the size changes of a farm's dairy branch under a milk quota system?

In the literature FOLTZ (2004) measures the size of specialized dairy farms in number of cows while WEISS (1999) used livestock units. Unfortunately, number of cows is not necessarily an appropriate size change indicator in a milk quota environment. The quota restriction implies (short-run) cost-minimizing behaviour of farmers. In this framework the number of cows may change between two years because e.g. the relative price between forage and concentrated feed changes. This change, however, is not related to any change in milk production quantity. We, thus, prefer a farm's quota endowment instead, including both owned and leased quota.

Obviously, leased quota does not fit into an investment model accounting for sunk cost such as FOLTZ (2004) or HINRICHS et al. (2008). Both allow for different regimes of farm size change: e.g. net investment, disinvestment, exiting, and hysteresis. On one hand, our farm size model must incorporate sunk costs (and uncertain profits) because investment in dairy production may require investment in special buildings and specific milking equipment. So our model must allow for investment decisions in line with FOLTZ (2004). On the other hand, our model must allow for size changes that follow from changes of leased quota amount. But these size changes are neither disinvestment nor investment with sunk costs. Consequently, the terms "investment", "hysteresis", and "disinvestment" seem too narrow within a milk quota environment. We, thus, refer to "growth", "stagnation", "decline", and "exit" instead.

We interpret farm size change as a discrete choice among these regime alternatives. This is in line with FOLTZ (2004) and HINRICHS et al. (2008). However, the alternatives' valuation should be more general than comparing costs of (dis)investment and return on (dis)investment. This comes at a cost: our conceptual framework gives only a broad overview over the decisions we want to measure empirically. We cannot gain deep analytical insights from this framework about farmers' growth decisions.

We simply assume that farmer i chooses regime k at time t_0 if the expected utility of regime k V_k* is maximum among M alternative regimes. The expected utility in each regime $j \in \{1, 2, \ldots M\}$ is a latent variable V_j* determined by some exogenous variables z_i with regime-specific marginal impact γ_j and an unobservable error η_j:

$$(1) \qquad V_{ij}^* = z_i \gamma_j + \eta_{ij} \qquad \text{with } V_{ik}^* = \max\left\{V_{i1}^*,\ V_{i2}^*, \ldots\ V_{iM}^*\right\}$$

The regimes include "growth", "stagnation", "decline", and "exit from milk production". The regimes are determined by the relative size change $(S_{t0} - S_T) / S_{t0}$ between t_0 and T in a farm's milk branch. Size S is measured in milk quota endowment. For the decision at t_0 we assume that S_T is planned by the farmer and, thus, he plans to belong to one of the regimes which we can observe through S_T. If $S_T = 0$ the farmer has chosen "exit from milk production", if $S_{t0} = S_T$ he has chosen "stagnation". In these regimes, there is no variation of the sample farms' relative size changes. So we can analyse size changes only in the "growth" and "decline" regime. In addition to the determinants of the regime choice we want to estimate the determinants for the relative size change in the latter two regimes.

4. Data

The descriptive statistics of our farm data separated for the four regimes are given in Table 1. All farms had milk quota milk in 1995 until 1997. The regime for each farm was decided based on the change of milk quota endowment (own and leased quota) between 1997 and 2005 (first row). Farms that increased their milk quota are among the "growth" subsample, farms that did not change their milk quota endowment are among the "stagnation" subsample, farms that faced a decline of quota endowment are in the "decline" subsample while farms that had not any milk quota in 2005 are among the "exit from milk production" subsample. Note that the farms in the latter group are still actively farming, but not dairy farming.

Coming from "LandData GmbH", an agricultural accountancy company the data covers a wide range of farming reality in Germany. There are farms from all over western Germany, though Bavaria with 1 549, Baden- Wuerttemberg (755), Lower-Saxony (739) and North Rhine-Westphalia with 681 farms make up for the majority of the 3939 farms in the sample.

Table 1: Descriptive Statistics of Variables (Values from1997 if not stated otherwise)

	Regime	Growth		Stagnation		Decline		Exit	
Variable name	Description	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Change	Ln (Quota in 2005) - Ln (Quota in 1997)	0.38	0.31	0	0	-0.60	0.90	not defined	
Business	Dummy for major farm branch (1 = non-dairy; 0 = dairy)	0.01	0.08	0.03	0.17	0.02	0.13	0.02	0.13
Organic	Dummy for organic farms (1 = organic; 0 = non-organic)	0.01	0.11	0.02	0.12	0.02	0.13	0.02	0.14
Part time	Dummy for part time farms (1 = part time; 0 = full time)	0.01	0.10	0.03	0.17	0.04	0.20	0.04	0.19
Corporate	Dummy for legal status (1 = corporate farm; 0 = else)	0.14	0.35	0.07	0.25	0.10	0.30	0.10	0.30
Dep. buildings	Depreciation on buildings to total depreciation in %	23.4	11.8	20.7	12.5	23.3	13.4	20.7	12.3
Profit	Total farm profits in 1,000 €	30.9	24.5	26.2	23.2	23.0	22.3	26.0	27.5
Revenues	Total revenues in 1,000 €	166.1	80.2	144.9	81.4	146.2	85.0	166.5	101.5
Debt	Debt to total assets in %	16.9	16.4	16.6	18.5	18.2	20.4	17.6	18.9
Crop subsidies	Subsidy payments for crops in 1,000 €	7.94	7.17	8.64	7.70	8.12	7.83	9.00	6.33
Ass. buildings	Assets in buildings to fixed assets in %	17.1	12.7	14.4	11.9	13.6	10.9	13.5	11.8
Animal subsidies	Subsidy payments for animals in 1,000 €	1.43	2.28	1.44	3.36	0.98	1.66	2.05	5.23
Dep. share	Accumulated depreciation of buildings relative to purchase cost in %	44.0	16.9	46.8	18.3	49.0	17.4	49.2	19.3
Interest	Interest paid for debt in 1,000 €	5.65	6.22	4.76	5.98	5.98	7.77	5.90	7.48
Interest subsidies	subsidy payments on interest in 1,000 €	1.18	2.46	0.52	1.54	0.57	1.51	0.36	1.10
Other subsidies	Other subsidy payments in 1,000 €	7.44	10.0	6.35	10.8	5.71	6.72	4.45	5.68
Soil quality	German soil quality index (0 = worst; 100 = best)	32.2	10.7	34.7	11.7	35.0	12.4	34.6	11.5
Land	Land used in hectare	58.8	32.0	57.0	32.6	52.3	32.1	54.9	30.5
Grassland	Share of grassland	47.6	25.0	39.8	24.5	40.5	26.9	29.6	19.1
Rented land	Share of rented land	51.4	27.1	53.5	28.3	47.9	28.2	49.6	28.9
Education	Agricultural education (1 = “farm master” and higher; 0 = lower)	0.30	0.46	0.23	0.42	0.29	0.45	0.28	0.45
Family labour	Family workers in full time equivalents	1.70	0.49	1.59	0.46	1.53	0.44	1.59	0.48
Other labour	Other workers in full time equivalents	0.09	0.29	0.07	0.29	0.06	0.23	0.09	0.24
Age	Age of the farm operator	44.1	10.1	46.5	10.1	45.6	9.33	45.2	11.0
Calves	Calves per 100 cows and year	110	23.4	104	28.9	105	25.9	101	31.4
Cows	Number of cows	42.4	18.0	31.2	17.5	31.9	14.7	24.1	14.9
Yield	Milk yield in 1000 kg / cow	5.90	1.14	5.39	1.32	5.50	1.13	5.48	1.38
Quota	Quota 1997 in 1000 kg	225	126	157	93.1	191	243	137	90.2
Density	Quota per hectare in kg / hectare	4243	2115	3150	1749	4163	3638	2828	1673
Unemployment	County unemployment rate in %	9.03	2.54	9.65	2.96	8.80	2.18	9.51	2.57
Restrictions	Share of land under use restrictions in %	1.87	11.8	1.63	11.2	2.17	12.6	1.22	9.55
Less favoured	Dummy for farms in less favoured areas (1 = less favoured; 0 = not)	0.53	0.50	0.46	0.50	0.47	0.50	0.41	0.49
Milk price	Milk price in Euro cents / kg	34.0	1.84	34.1	3.67	34.0	2.79	33.8	2.03
	Number of observations	2243		1060		343		293	

Source: Own Calculation based on data from LandData GmbH

There are some organic farms and part time farms in the sample. Most farms produce on 50 to 60 hectares, while they have between 30 to 40 cows in 1997. Farms that quit milk production until 2005 are smaller in terms of livestock with only 24 cows on average. In terms of milk quota the average size in the regimes varies between 137 000 kg and 225 000 kg. As one may expect, on average growing farms have the highest initial milk quota endowment. Also, the distribution of the growing farms' quota in 1997 exhibits a positive skewness, as shown in Figure 1. Overall there are only two farms with more than one million kilograms of quota, a number rising to 24 in 2005.

The average farmer is of an age of 45. The milk price obtained is around 0.34 € per kilogram of milk. Other variables include values of buildings, debt and interest payments as well as family labour. These variables may capture some determinants for investment such as sunk costs and financial soundness of a farm. Management performance is proxied by milk yield per cow and numbers of calves per cow.

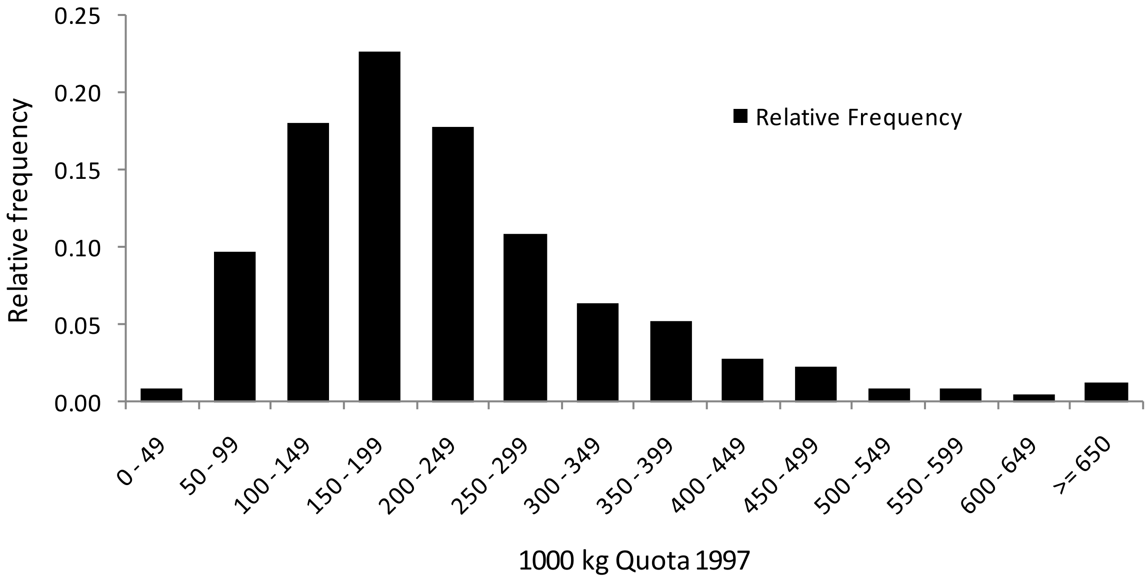

Figure 1: Distribution of Quota on growing farms in 1997 (Source: Own Calculations)

5. Estimation

We borrow the description of the estimation model from BOURGUIGNON et al. (2007) and apply it to the farmer's choice problem on changes of farm size *S* introduced above. The choice is between different regimes, e.g. growth, stagnation, shrinking, exit from milk production. In the regimes growth and shrinking the farmer can also choose among different relative size changes. The changes in these regimes are different from zero and different from minus 100 %, of course. The change rate *G* in regime *k* for farmer *i* is given by:

(2) $$G_{ik} = \ln(S_{i0}) - \ln(S_{iT}) = x_{ik}\beta + u_{ik}$$

Determinants of the change rate are represented by a vector of variables x_i, β is to be estimated and u_i is the error term. However, the change rate in regime k can be only observed if k is chosen accordingly to (**1**).

Of course, for identification purposes variables x and z must not be completely identical. If we now set

(3) $$\varepsilon_k = \max_{j \neq k} \left\{ V_{ij}^* - V_{ik}^* \right\} = \max_{j \neq k} \left\{ z_i \gamma_j + \eta_{ij} - z_i \gamma_k - \eta_{ik} \right\}$$

The condition in (1) becomes

(4) $$\varepsilon_k < 0$$

BOURGUIGNON et al. (2007) proceed (p. 176): under the assumption that the $(\eta_j)s$ are independent and identically Gumbel distributed (i.e. under the assumption that the so called IIA assumption holds) the $(\gamma_j)s$ can be estimated in a multinomial logit model (MCFADDEN, 1973), whereas P_j is the probability that regime j is chosen, i.e. that the expected utility of j is maximum among the M regimes:

(5) $$P_k\left(\varepsilon_k < 0 \middle| z\right) = P_k\left(V_{ik}^* = \max\left\{V_{i1}^*,\ V_{i2}^*, \ldots V_{iM}^*\right\} \middle| z\right) = \frac{e^{(z\gamma_k)}}{\sum_j e^{(z\gamma_j)}}$$

The problem lies in estimating β from (2) because the error u from (2) might not be independent from all $(\eta_j)s$ in (1). If there are only two regimes, i.e. $M = 2$, HECKMAN (1979) has proposed a solution for this selection bias: the expectation of the error u is some function of $z\gamma_1$ and $z\gamma_2$. In fact, the inverse Mill's Ratio times its estimation coefficient is such a function. Generalizing this idea to the multinomial logit gives some function λ of all $z\gamma_j$: $\lambda = \lambda\left(z\gamma_1, z\gamma_2, \ldots z\gamma_M\right)$ or an equivalent function μ of the probabilities that regime k is chosen

(6) $$\mu_i = \mu\left(P_{1i}, P_{2i}, \ldots P_{Mi}\right)$$

Then β can be consistently estimated by including μ (or λ) into (2).

(7) $$G_{ik} = x_{ik}\beta + \mu_i + u_{ik}$$

However, for both λ or μ an intractable large number of parameters has to be estimated for a multinomial logit. Thus, several authors suggest restrictions on λ or μ. We follow DAHL (2002) who suggests that $\mu(P_1, P_2, \ldots P_M)$ can be approximated by series expansion and interaction terms and the respective parameters to be estimated in (7). In other words, μ is a linear combination of the terms in the series expansion and the interaction terms whereas the weights are parameters to be estimated in (7). In our case, we have $M = 4$ and choose a series expansion of grade 3 and get P_1, P_2, P_3, and P_4 as linear, quadratic and cubic terms as well as interaction terms between two terms of the series expansion. Note that some of these terms might be dropped due to multicollinearity in the estimation procedure.

Based on Monte Carlo simulations BOURGUIGNON et al. (2007) found that DAHL'S approach is not dominated by other approaches known from the literature. The authors also found "that the selection bias correction based on the multinomial logit model can provide fairly good correction for the outcome equation, even when the IIA hypothesis is violated." (p. 174)

What are the differences of this estimation approach compared to literature analyses on farm size change? The difference to studies estimating determinants of growth rates without accounting for selection bias is obvious (e.g. FOLTZ, 2004). However, WEISS (1999) already showed that such studies may produce biased estimates. When estimating growth he accounted for self-selection between staying in business and exiting from farming. Compared to WEISS (1999) (7) accounts for more than two regimes. (6) allows for many variables to be included in the growth rate equation and parameters to be estimated while the Heckman procedure in WEISS (1999) includes the inverse Mill's ratio only. Thus, our approach may account for a more complex selection bias.

HINRICHS et al. (2008) estimate the determinants for a farmer investing, disinvesting or not changing hog fattening production capacity. This approach is quite similar to ours in that more than two regimes are accounted for. However, the authors do not estimate change rates but regime choice only. They account for the ordering of the latent variable among regimes in the estimation of regime choice. This is appropriate in their setting since the latent variable that determines the farmer's regime choice is expected (marginal) return of capital. If the farmer actually invests the expected return of capital is highest for the investment alternative (because capital costs are higher for investment than for inactivity or disinvestment). If the farmer does not invest his marginal return of capital is assumed to be smaller than his capital costs for investment. If he disinvests his returns to capital are assumed to be smaller than in case of unchanged production capacity. The reasons are sunk costs that cause low returns to capital in case of reducing production capacity because of small salvage values. In our setting, the size change is not only determined by return of capital because e.g. quota lease contracts may simply expire. Thus, we do not assume an ordering of our regime alternatives.

We are mainly interested in estimates of growth determinants and whether these estimates are sensitive to selection bias correction. Consequently, we have an OLS estimation with all farms in the sample that produced milk in 1997 and 2005, an OLS estimation including only farms that have higher milk quota endowment in 2005 than in 1997. Furthermore, we have a Heckman estimation with only the growth farms in the second step estimation and a selection equation with two regimes: either more milk quota endowment in 2005 than in 1997 or producing milk in 1997 and no increase in milk quota endowment till 2005. Finally, we followed the two step approach of Dahl with again growing farms in the second step estimation but accounting for four different regimes in a system selection equation.

6. Results

The results are structured into three sections. We, first, compare the estimation results for determinants of growth from the different procedures to account for the selection bias. We, then, present the selection equations for the growth regime against the three remaining regimes and discuss their results. We, finally, study the impact of farm size in more detail to test Gibrat's law for our dataset.

Table 2 shows the OLS estimates that explain growth rates while Table 3 shows the respective estimates accounting for selection bias. Although all estimations exhibit several significant variables there are noticeable differences. In the first estimation in Table 2 all farms that have milk quota in 1997 and 2005 are included. Restricting the sample to growing farms only, i.e. quota endowment in 2005 is higher than in 1997, changes estimates, of course. For example, part-time farming (third row) seems to reduce growth in the non-exiting farms sample while part-time farms do not grow significantly differently than other growing farms.

Table 2: Growth rate determinants (OLS without accounting of selection bias)

Estimation method	OLS for non-exiting farms			OLS for growing farms		
Observations	3646			2243		
Variable	Parameter		Probability	Parameter		Probability
Business	-0.112	*	0.08	0.089		0.17
Organic	-0.088		0.16	-0.067		0.13
Part time	-0.271	***	0.00	-0.017		0.75
Corporate	-0.002		0.94	-0.012		0.43
Dep. buildings	-0.002	**	0.01	0.000		0.55
Profit	0.000		0.57	-0.001	*	0.06
Revenues	0.000		0.45	0.001	***	0.00
Debt	-0.001	*	0.08	0.000		0.97
Crop subsidies	0.000		0.99	-0.003	*	0.06
Ass. buildings	0.001		0.21	0.000		0.52
Animal subsidies	0.013	***	0.00	0.009	***	0.00
Dep. share	-0.001		0.11	0.000		0.24
Interest	-0.003		0.10	-0.003	**	0.04
Interest subsidies	0.009	**	0.02	0.004		0.10
Other subsidies	0.002	*	0.05	0.002	***	0.00
Soil quality	-0.002	***	0.00	-0.001	**	0.03
Land	-0.001	**	0.02	0.000		0.59
Grassland	0.001	**	0.02	0.000		0.13
Rented land	0.000		0.68	0.000		0.63
Education	-0.001		0.97	0.001		0.92
Family labour	0.064	***	0.00	0.028	**	0.01
Other labour	-0.008		0.79	-0.042	**	0.03
Age	-0.002	***	0.00	-0.002	***	0.00
Calves	0.000		0.90	0.000		0.80
Cows	-1.927	***	0.00	2.585	**	0.01
Cows squared	0.774	***	0.00	-0.456		0.12
Cows cubic	-0.072	***	0.00	0.040		0.15
Yield	0.115	***	0.00	0.138	***	0.00
Quota	0.225		0.70	-2.799	***	0.00
Quota squared	-0.161		0.18	0.400	**	0.01
Quota cubic	0.010		0.22	-0.027	**	0.01
Density	0.000		0.12	0.000		0.81
Unemployment	0.004		0.22	0.004		0.10
Restrictions	0.001		0.10	0.000		0.54
Less favoured	-0.032	*	0.07	-0.011		0.36
Milk price	0.006	*	0.06	0.009	***	0.00
Constant	1.560		0.10	1.577		0.20

Significance on the 1% (***), 5% (**) and 10% (*) level. Source: Own Calculations

The growth determinants in Table 3 are estimated accounting for sample selection bias. The estimates of a Heckman procedure in the growth farms sample – such as WEISS (1999) – differ substantially from the OLS estimates of the growth sample in some respects. The correlation between the error terms of the selection equation and the growth equation is highly significant. This is in line with some specifications in WEISS' (1999). However, the impact of many variables is similar in the Heckman estimation and in the OLS of the growth sample:

farms that receive higher milk prices and more subsidies for livestock production (which is only slightly correlated to our size measures) and that produce more milk per cow tend to grow at a higher rate (among the growing farmers). In addition, farms on worse land and with more family labour also tend to grow faster. In contrast, farms with older farm operators tend to grow less.

Table 3: Growth rate determinants (second step Heckman and Dahl estimations)

Estimation method	Heckman second step			Dahl second step		
Observations	2243			2243		
Variable	Parameter		Probability	Parameter		Probability
Business	-0.084		0.21	-0.083		0.63
Organic	-0.070		0.18	-0.084		0.37
Part time	-0.045		0.41	-0.096		0.33
Corporate	0.023		0.23	0.041		0.53
Dep. buildings	-0.002	**	0.02	-0.003	**	0.01
Profit	-0.001	*	0.05	0.000		0.67
Revenues	0.000	***	0.00	0.000		0.12
Debt	-0.001	*	0.05	-0.002	**	0.04
Crop subsidies	0.000		0.97	-0.001		0.79
Ass. buildings	0.001		0.11	0.003	*	0.07
Animal subsidies	0.009	***	0.00	0.017	***	0.00
Dep. share	-0.001		0.23	-0.001		0.21
Interest	-0.005	***	0.00	-0.005	*	0.07
Interest subsidies	0.012	***	0.00	0.020	**	0.02
Other subsidies	0.002	***	0.00	0.003	**	0.02
Soil quality	-0.002	***	0.00	-0.003	**	0.04
Land	-0.002	***	0.00	-0.002		0.10
Grassland	0.000		0.20	0.001		0.34
Rented land	-0.001	*	0.06	-0.001		0.46
Education	0.004		0.79	-0.008		0.73
Family labour	0.050	***	0.00	0.094	**	0.01
Other labour	-0.036		0.15	-0.032		0.45
Age	-0.004	***	0.00	-0.005	**	0.03
Calves	0.001	**	0.02	0.001		0.24
Cows	1.623		0.13	1.708		0.36
Cows squared	0.032		0.92	0.099		0.87
Cows cubic	-0.021		0.48	-0.027		0.67
Yield	0.159	***	0.00	0.210	***	0.00
Quota	-0.968		0.18	-1.015		0.47
Quota squared	-0.034		0.82	-0.103		0.77
Quota cubic	0.007		0.52	0.013		0.65
Density	0.000		0.15	0.000		0.24
Unemployment	-0.004		0.13	0.002		0.86
Restrictions	0.000		0.46	0.000		0.68
Less favoured	-0.013		0.37	-0.027		0.24
Milk price	0.012	***	0.00	0.012	**	0.04
Constant	-1.153		0.30	8.269		0.49

Parameter estimates of terms used for correcting the selection bias are not reported.
Significant at the 1% (***), 5% (**) and 10%(*) level. Source: Own Calculations

However, there are also considerable differences between both estimations: the Heckman estimation reveals that farms having a higher share of debt capital or that have more land tend to grow significantly slower. The sensitivity of the estimates for the initial size measures – quota endowment and cows – depending on the estimation approach can be explained by multicollinearity.

The more detailed incorporation of terms correcting for selection bias by the Dahl estimation reveals only small differences compared to the Heckman-based results. Some variables loose significance. The most noticeable difference might be that the marginal impact of milk yield per cow is higher by one third in the Dahl procedure. The latter reveals that a farmer with 1 000 kilogram more milk yield per cow in 1997 would have grown 21 %-points more than other growing farmers, ceteris paribus. Well in line with expectations is that higher interest payments and a higher debt share reduces growth while higher subsidies for interest increase growth[1].

Most results are in line with the literature: Farms with higher milk yields per cow grow at a higher rate. This is in line with FOLTZ (2004) and expresses that more productive farmers tend to grow faster – also under a milk quota system. FOLTZ' (2004) study reveals a positive impact of (the previous year's) milk price on the number of cows on a farm. However, the impact of FOLTZ' price may follow from price variation over time and not among farms. FOLTZ' result may show that farmers invest in years after high prices, but it does not necessarily show that farmers who receive higher prices invest more. In line with our negative coefficient for age WEISS (1999) reveals a negative marginal impact of farm operator's age on growth for fulltime farmers older than 38. The positive impact of family labour on growth we found also seems to be in line with WEISS (1999): he found a positive impact for large farm families and for farms already having found a successor within their family. A noticeably difference is that we have not any significant impact of part-time farming on the growth rate of growing farms. WEISS found a negative impact in a specification including part- and full-time farmers.

Table 4 shows, that there is not any significant impact of part-time farming on the selection of growth farms, either. Table 4 exhibits the determinants of choosing the growth regime versus either stagnation, or shrinking or exiting from milk production.

Several results could be also found in a Heckman selection equation since the parameters do not differ substantially among the three selection equation of growth versus stagnation, shrinking, or exit, respectively. For example, a higher milk yield per cow increases the probability for belonging to the growth sample against each of the three other regimes. However, the multinomial logit reveals some relationships that cannot be obtained by a binary choice model. E.g. older farmers tend to stagnate or to reduce milk production instead of growing. But age has no impact on the choice between growth in milk production and exiting from milk production. Also the level of subsidies received for crop production increases only the probability of belonging to the growth regime relative to exiting from milk production; it does not impact the choice between growth and stagnation or decline. The county unemployment rate impacts the regime in three different ways. The choice between growth and exiting is not significantly affected. On one hand, for higher unemployment the choice for growth becomes more probable than the choice for decline. On the other hand, higher unemployment increases the probability for stagnation versus growth.

[1] To account for endogneity we also used specifications including interest payments, subsidies on interest payments, debt share, and accumulated depreciation of buildings with its 1995 values. The above results are confirmed by this specification.

Table 4: Selection determinants for growth against the choice of other regimes (multinomial logit)

Odds[2] for	Stagnation			Decline			Exit		
Variable	Parameter		Prob.	Parameter		Prob.	Parameter		Prob.
Business	3.131	***	0.00	2.654	*	0.07	1.295		0.67
Organic	0.793		0.51	1.426		0.48	2.581	*	0.08
Part time	1.069		0.83	1.804		0.12	1.032		0.94
Corporate	0.556	***	0.00	0.901		0.62	1.089		0.72
Dep. buildings	1.005		0.27	1.023	***	0.00	1.012		0.10
Profit	1.002		0.46	0.995		0.15	1.005		0.21
Revenues	0.999		0.60	1.003	**	0.02	1.002	*	0.07
Debt	1.008	**	0.02	1.017	***	0.00	1.009		0.11
Crop subsidies	0.994		0.57	0.994		0.74	0.958	**	0.03
Ass. buildings	0.991		0.12	0.974	***	0.00	0.990		0.26
Animal subsidies	0.990		0.54	0.886	***	0.00	0.992		0.71
Dep. share	1.000		0.96	1.004		0.31	1.007		0.11
Interest	1.005		0.63	1.015		0.28	1.050	***	0.00
Interest subsidies	0.922	**	0.01	0.897	**	0.02	0.835	**	0.01
Other subsidies	0.997		0.61	0.995		0.60	0.950	***	0.00
Soil quality	1.013	**	0.01	1.015	**	0.03	0.996		0.64
Land	1.008	**	0.02	1.013	**	0.02	1.012	*	0.05
Grassland	0.997		0.23	0.994	*	0.09	0.981	***	0.00
Rented land	1.006	***	0.00	1.002		0.44	1.005		0.16
Education	0.896		0.27	1.165		0.29	1.086		0.62
Family labour	0.810	**	0.03	0.517	***	0.00	1.044		0.80
Other labour	1.248		0.23	0.677		0.20	0.927		0.80
Age	1.019	***	0.00	1.019	**	0.01	1.003		0.73
Calves	0.995	***	0.00	0.996		0.10	0.992	***	0.00
Cows	36.176		0.40	73.830		0.39	8.253		0.63
Cows squared	0.046	**	0.02	0.079		0.11	0.121		0.14
Cows cubic	1.538	***	0.00	1.263		0.18	1.241		0.17
Yield	0.677	***	0.00	0.527	***	0.00	0.663	***	0.00
Quota	0.004		0.29	0.001		0.21	1.402		0.95
Quota squared	8.712	*	0.05	9.904	*	0.07	1.333		0.81
Quota cubic	0.814	**	0.01	0.848	*	0.07	0.985		0.86
Density	1.000		0.91	1.000	**	0.02	1.000		0.60
Unemployment	1.091	***	0.00	0.948	*	0.09	1.003		0.92
Restrictions	0.998		0.64	1.002		0.73	0.998		0.80
Less favoured	0.939		0.54	1.234		0.17	1.099		0.59
Milk price	1.004		0.83	0.956		0.16	0.937	**	0.03

Significance on the 1% (***), 5% (**) and 10% (*) level. Source: Own Calculations

However, these detailed insights are not substantial for correcting the selection bias as we can see from the high similarity between the growth rate estimations following the Heckman and the Dahl procedure. This is also true for the size measures that are jointly highly significant in explaining growth rate. Not only the log of quota endowment but also the ln of number of cows influences the growth rate significantly.

[2] Parameters smaller than one indicate that a higher value of the respective variable increases the probability to belong to the growth regime.

But what can we say about Gibrat's law of proportionate effects? This law demands that relative firm size growth is independent of initial firm size. WEISS (1999) revealed a relationship between the farm size growth rate and the initial farm size that is similar to our impact of initial milk quota endowment on the growth of milk quota. In Figure 2 we graph the partial relationship between growth rate and initial milk quota for growing farms. In contrast to Weiss we have two size measures that are highly correlated to each other – milk quota endowment and number of cows. To account for the multicollinearity between quota and number of cows in the growth sample we have also included the correlation between quota and number of cows and the impact of number of cows on growth rate. The function in Figure 2 is based on

$$G_{97-05} = -1.015 \ln S_{97} - 0.103 (\ln S_{97})^2 + 0.013 (\ln S_{97})^3$$

$$+1.7079 \ln cows_{97} + 0.0992 (\ln cows_{97})^2 - 0.026 (\ln cows_{97})^3 \quad (8)$$

$$with\ \ cows_{97} = 15.0 + 0{,}122\, S_{97}$$

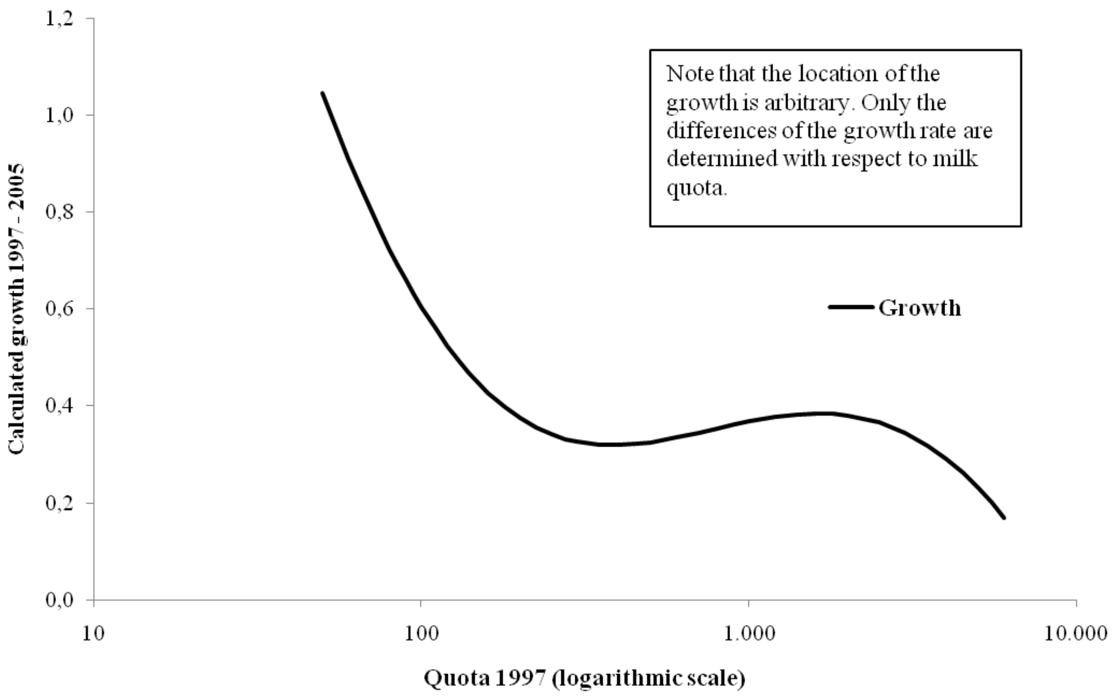

Figure 2: Impact of initial size on growth (growing farms sample)

For 400 000 kilogram of milk quota the growth rate function reveals a local minimum. A local maximum is around 1.6 million kilogram of quota. Unfortunately, this quota endowment is out-of-sample, only two farms have had between one and two million kilogram quota in 1997. The corresponding growth rate is around six percentage points higher than at the local minimum and equals the growth rate of small farms with roughly 190 000 kilogram of quota. In contrast to WEISS (1999) we restrict our graph to the growing farms only. The high growth rate of small farms makes sense in the German quota system of the 1990s: if a small farmer has chosen to grow he competes for lease contracts from quota owners. Most owners can be assumed to prefer leasing their quota to one farmer. Consequently, a given lease contract results in a higher relative growth for small than for large farmers. An analogous reasoning may follow from fixed costs elements in an investment decision. Some minimum absolute investment size results in higher relative growth for a farm with a low initial size.

7. Conclusions

For the technical aim of the analysis concerning the estimation of growth rate determinants we can draw the following conclusions: for our data set accounting for selection bias in the group of growing farms is necessary. However, the chosen procedure based on a multinomial logit estimation which is more complex and more detailed than the common Heckman correction does not reveal significantly different results. Nevertheless, the multinomial logit has its own right since it explains the regime choice among different growth regimes more differentiated than the Heckman procedure. In our case, e.g. age impacts the choice between growth and stagnation but not between growth and exiting from milk production. Another example are crop subsidies which only influence the decision between growth and exiting but not the decision between growth and decline or stagnation.

Most variables found to be significant determinants for growth rates are in line with the literature of growth of livestock production. Higher milk yield per cow, more family labour, and higher milk prices increase the growth rate of growing farms, ceteris paribus. Older growing farmers tend to grow at lower rates. Results on testing Gibrat's Law of firm growth confirm results of WEISS (1999) for Austrian farms: The growth rate is quite high for small farms and has a minimum for farms around 400 000 kg of initial quota. For the nine % of growing farms that have more initial quota the growth rate increases up to some out-of sample maximum. Consequently, Gibrat's Law does not hold for our subsample of farms with growing milk production between 1997 und 2005 under German milk quota.

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