THE EXPANSION OF DAIRY HERDS
IN RUSSIA AND KAZAKHSTAN
AFTER THE IMPORT BAN ON WESTERN FOOD PRODUCTS

Martin Petrick and Linde Götz

petrick@iamo.de

Leibniz Institute of Agricultural Development in Transition Economies
(IAMO), Halle (Saale), Germany

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Abstract

Self-sufficiency in dairy products is a central policy goal of the Russian government, as the ban on food imports from the West imposed by the Kremlin vividly demonstrated. Western export opportunities into the Eurasian Economic Union depend inversely on the growth of milk production within the Union. Against this background, we explore the evolution of herd sizes and the role of state support among commercial dairy producers in Russia and Kazakhstan between 2012 and 2015. We show that dairy farms did grow as long as they kept less than 70 cows. Less than 10% of our 180 randomly selected dairy farms received livestock-related subsidies. Regression analysis using an innovative simultaneous equation framework shows that subsidised farms were bigger and younger than their peers, although they usually did not belong to vertically integrated agroholdings. Our results suggest that broad-based herd growth will be stimulated if many farms receive small subsidies, not if very few receive individually large amounts. However, the effects of good management practice and access to milk marketing contracts were much bigger than the subsidy impact. Processors provided inputs or services to only 5% of farmers in our sample. 25 years after the end of central planning, structural change among dairy farms in Eurasia in many ways resembles the patterns observed in the West.

Keywords: Dairy farming; Eurasian Economic Union; import substitution; Gibrat's law; vertical coordination.

1 Introduction

In August 2014, as a reaction to sanctions imposed by Western countries in the course of the political conflict over Ukraine, the Russian government imposed an embargo on a range of agricultural and food products imported from the European Union (EU), the United States, Canada, Australia and Norway (FAO 2014). It was unlikely an accident that the Russian administration chose the agricultural sector as an arena for import restrictions: against the collapse of the domestic livestock herd after the dissolution of the Soviet Union, worldwide food price increases, and recurrent droughts in some of the main agricultural regions, self-sufficiency in food had become a strategic policy goal of the Russian government (Wegren et al. 2017). The import embargo is considered by some analysts to be one of the key factors responsible for the subsequent slump in global agricultural commodity prices, raising concerns about future export opportunities for farmers in the West and prompting policymakers such as the European Commission to issue multi-million aid packages to farmers (Agra Europe 2015). Potential exporters not affected by the ban were keen on replenishing the shelves of Russian retailers, in particular from Belarus and Kazakhstan, which are members of the customs union within the Russian-led Eurasian Economic Union (EAEC).

In the midst of these market turbulences and their geopolitical context, the dairy sector plays a crucial role: among all products covered by the Russian import ban, the deficit in domestic self-sufficiency has been among the biggest for dairy products. Moreover, other than in poultry or pork, self-sufficiency in dairy has not caught up recently (Gataulina et al. 2016; Wegren et al. 2017). At the same time, dairy prices worldwide experienced the longest recession in at least a decade (IFCN 2016). The possible revival of dairy production in Russia, or in the EAEC more generally, has become a decisive question not only for the Russian government but also for dairy farmers and policymakers worldwide.

Against this background, we investigate the evolution of herd sizes among commercial dairy producers in Russia and Kazakhstan between 2012 and 2015. Both countries had experienced the disintegration of their dairy sectors in the 1990s, raising fundamental questions of farm restructuring and value chain development (Serova and Karlova 2010; Van Engelen 2011). While Western observers called into question the global competitiveness of livestock production in the former Soviet Union (Liefert and Liefert 2012), governments in both countries earmarked considerable funds for the revitalisation of dairy and meat production (OECD 2013; 2016). In Russia, it was codified in the 2010 "Doctrine on Food Security" and became the major objective of the current multi-year State Programme for the Development of Agriculture (2013-2020). The Doctrine sets specific goals for self-sufficiency ranging from 80% to 95% for grains, sugar, vegetable oil, meat, dairy and fish products. In Kazakhstan, the prime motivation has been to reduce the country's dependency on oil revenues and to diversify the economy, leading to the Programme for the Development of the Agro-industrial Complex for the years 2013–2020 ("Agribusiness 2020") (Petrick et al. 2017). Both programmes are similarly structured in that they rely on a wide range of instruments including payments based on output, concessional credits and direct transfers targeted at input purchases or investment (Gataulina et al. 2016; OECD 2013; 2016).

Given the political significance of dairy revival in both Russia and Kazakhstan, and the amount of public funds spent, it is surprising how little analytical work on the economics of dairy farming and dairy policy is available. While governments in both countries may not encourage independent evaluation of policy measures for political reasons, it is also the sheer lack of sufficiently disaggregate data that hampers this effort. As a result, analysts used to have no other choice than to rely on data published by the national statistical offices.[1] We take a first step to overcome this constraint by using primary survey data collected from 180 randomly selected dairy producers in five Russian and one Kazakhstani province in fall 2015.

In the following, we analyse the determinants of dairy herd size and growth, focusing on three sets of factors: (a) producer characteristics such as farm type, size and management, (b) vertical coordination, in particular with regard to consumers and processors, and (c) governmental subsidies. Building on work by Weiss (1999) and Foltz (2004), we frame this analysis in the international literature on structural change in the dairy sector. In addition to providing unique insights into current patterns of dairy farming in Russia and Kazakhstan, the article makes systematic contributions to the study of farm growth in a post-socialist context. In the framework of an innovative simultaneous equation regression framework that allows for both censored and qualitative dependent variables (Roodman 2011), we isolate the factors that determine herd expansion, subsidy absorption and contract farming. The estimation results allow us to predict an equilibrium herd size and to quantify the major driving forces of herd growth. By empirically demonstrating how on-farm management practices and marketing arrangements stimulate or retard growth, we add to the emerging literature on value chain modernisation in transitional agriculture (Dries et al. 2009; Sauer et al. 2012). Finally, this paper is among the first to empirically evaluate the success of policy measures aiming at import substitution in Russia and Kazakhstan, using data that was collected about a year after the import ban was imposed. We scrutinise the effectiveness of these measures and discuss plausible alternatives.

2 Empirical approach and hypotheses

The current study uses unique, primary survey data to empirically examine dairy production structures and patterns of herd growth for a sample of 180 commercial dairy farmers in five Russian and one Kazakhstani province. Drawing on but going beyond the literature considering Gibrat's law as applied to farm growth by Sumner and Leiby (1987), Weiss (1999), and Rizov and Mathijs (2003), we estimate a recursive multi-equation model of herd growth that endogenises the initial stock of dairy cows, the level of livestock subsidies and the use of marketing contracts. Inspired by Roodman

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[1] Even though statistical offices in both countries liberalised their data access policies and revamped their official websites over the past years, the reliability of agricultural production data has occasionally been called into question. Recently, critics have cast doubt on the accuracy of beef and milk production data published by the Russian Federal State Statistics Service on small household producers (USDA 2016).

(2011) and Dong et al. (2016), this approach addresses endogeneity concerns in the cross-sectional analysis and increases the efficiency of estimation.

We hypothesise that dairy herd size at the farm level is determined by six sets of factors:

1. Output and input prices,
2. resource endowments,
3. human capital and technologies employed,
4. various dimensions of vertical coordination,
5. subsidies,
6. regional fixed effects.

Static production theory treating dairy cows as a production factor suggests that a profit maximising farmer will, ceteris paribus, keep more cows if the milk price goes up or the prices of complementary inputs (such as concentrate fodder) go down. As Foltz' (2004) dairy investment model shows, this result also holds for dynamic settings with sunk costs and uncertainty. Ceteris paribus, under such conditions, herd growth will also be more profitable and thus higher if the salvage value of the livestock herd is lower.

Resource endowments related to dairy production represent a second set of factors. These can be physical or immaterial. In the present context, we expect that farms with greater fodder production potential as measured by land allocated to fodder crops and more workers will have bigger herds. Whether they also grow faster depends on the capacity utilisation which can be controlled by including initial herd size in the analysis. In addition, more able and better trained managers are expected to produce at lower cost and thus manage larger herds (Sumner and Leiby 1987). For the same reason, managers who employ certain best practice technologies (such as pregnancy tests and artificial insemination) are also hypothesised to keep more cows. Following Jovanovic (1982), older firms are assumed to grow less. Older managers may possess more human capital, but they also may have a lower propensity to invest as they are approaching pension age.

We analyse producers' access to funding using a method that directly elicits individual borrowing status from the respondents. Following Boucher et al. (2009) and Petrick et al. (2017), we consider a farm to be credit rationed if the manager applied for a loan and was rejected or would have liked to borrow more at the going interest rate than he/she actually obtained. We also classified managers as rationed if they refrained from borrowing because they feared the risk of defaulting on the loan or regarded the application procedures as too complicated. It is assumed that credit rationed farms keep less animals and grow more slowly.

Beyond these standard factors, we are specifically interested in the roles of farm organisation, vertical coordination and government subsidies. We test whether farm type as well as membership in an agriholding have a direct effect on herd size and growth. In addition, we investigate how these dependent variables are affected by the share of hired workers in the total labour force. While large dairy herds may technically be impossible to manage without hired labour, the relation to herd growth is not so straightforward. But recent empirical research in a EU context suggests that farms with more hired workers are often more efficient (Latruffe et al. 2016) and may thus also grow faster. From the survey data, we also know whether a farm sells raw milk under a long-term contract. Our hypothesis is that marketing under contract allows farmers to keep bigger herds and instigate higher growth (Gorton et al. 2007).

The survey data contains information about livestock-related subsidies and subsidies on loans that the farms received. We hypothesise in line with expectations of policy makers that more subsidies lead to bigger herds and higher growth. Subsidies in our sample come in different forms, as direct transfers tied to livestock-related expenses or as interest subsidies, and farmers were asked to quantify the cash value of the subsidy.

Finally, we assume there exist fixed effects by province which are not captured by the variables described before. These may include effects of regional market structure as well as natural conditions for farming.

We test these hypotheses using a recursive multi-equation model of herd growth in the spirit of the simultaneous equation framework suggested by Roodman (2011). This framework allows the simultaneous estimation of several equations endogenising selected variables. We included separate equations for the initial number of dairy cows in 2012, the level of subsidies, and the participation in a milk marketing contract. Two additional complications are that only some farms received subsidies, so that this is a censored variable, and contract participation is a binary variable:

$$g_{i1215} = \alpha_a h_{i12} + \theta_{sa} s_i + \theta_{ma} M_i + x'_i \theta_{xa} + \epsilon_{ia}, \quad (1a)$$

$$h_{i12} = x'_i \theta_{xb} + \epsilon_{ib}, \quad (1b)$$

$$s_i = \begin{cases} \log(1) \ \text{if}\, S_i^* \le 0 \\ \alpha_c h_{i12} + x'_i \theta_{xc} + \epsilon_{ic} \ \text{if}\, S_i^* > 0 \end{cases} \quad (1c)$$

$$M_i = \begin{cases} 0 \ \text{if}\, M_i^* = \alpha_d h_{i12} + x'_i \theta_{xd} + \epsilon_{id} \le 0 \\ 1 \ \text{if}\, M_i^* > 0 \end{cases} \quad (1d)$$

with $\epsilon = (\epsilon_{ia}, \epsilon_{ib}, \epsilon_{ic}, \epsilon_{id})' \sim N(0, \Sigma)$

and $\Sigma = \begin{bmatrix} \rho_{aa} & \cdots & \rho_{ad} \\ \vdots & \ddots & \vdots \\ \rho_{ad} & \cdots & 1 \end{bmatrix}$,

where g_{i1215} is the growth of the herd size between 2012 and 2015, h_{i12} is the natural logarithm of herd size measured as number of dairy cows in 2012 per observed farm, i denotes the observations in the sample, s_i is log subsidies received, S_i^* is a partly latent subsidy index in levels, M_i is participation in milk contract (1/0), M_i^* is a latent contract participation index, x'_i includes determinants which can differ by equation, α and θ indicate different parameter vectors, and the ϵ_i's are error terms. The estimator maximises the joint likelihood function of the system of equations (1a) to (1d), using a probit formulation for model (1d) and assuming that the error terms follow a joint normal distribution. Estimation was carried out using the conditional mixed-process (`cmp`) routine by Roodman (2011) in Stata 14. Estimation in simultaneous equations is more efficient than, for example, a single equation instrumental variables approach, because it takes into account the full covariance structure of the system of equations. Moreover, in the presence of missing observations for some variables, data utilisation is more efficient as well, as the estimating sample is defined per equation, not for the system as a whole (Roodman 2011).

3 Data, focus regions and variable definitions

The data for this analysis comes from the multi-purpose IAMO Russia Kazakhstan Farm Survey 2015, a cross-sectional survey of 800 agricultural enterprises and individual farms conducted in Belgorod, Riazan, Stavropol, Altai Krai and Novosibirsk provinces in Russia and in Akmola province in Kazakhstan. These six provinces were selected purposefully to represent some of the main agricultural regions in Russia, including black earth and non-black earth as well as European and Siberian provinces, and one of the major grain producing provinces in Kazakhstan. Among the 79 regions for which Rosstat reported milk production by agricultural enterprises and individual farms in

2015, the provinces covered here held the following ranks: Altai Krai 6, Novosibirsk 11, Belgorod 14, Riazan 19, Stavropol 33.[2] Akmola has rank 7 among 16 provinces in Kazakhstan.

Within the provinces, a stratified two-stage random sampling procedure was employed to identify farmers to be interviewed: in the first stage, counties (raions) were selected purposefully from different parts of the provinces, in the second stage, farmers were selected randomly from farm registries provided by the local public administration of these counties. Professional enumerators held face-to-face interviews with farm managers between July and October 2015.

While cross-sectional in nature, the questionnaire used in the interviews contained several recall questions, so that data for three different time periods can be extracted:

a) Information referring to the time the survey was conducted, i.e. the end of the growing season 2014/2015. This is referred to as "2015" in this paper and covers mostly stocks and resource, such as worker and livestock numbers or characteristics of the manager.
b) Information referring to the 12 months before the interviews took place, i.e. the period of the growing season 2014/2015. This includes transactions and practices, such as sales, prices, technology use.
c) Information referring to a point in time three years before the survey was conducted, i.e. the end of the growing season 2011/2012. This is referred to as "2012" in the paper and also covers stocks and resources.

In addition, certain land ownership and land use data is also available for earlier points in time. It will be used to define instrumental variables in the regression analysis below.

We calculate dairy herd growth based on the difference between livestock numbers in 2012 and 2015. We then move on to econometrically explain this growth by predetermined variables observed in 2012 and by practices and transactions that occurred in 2014 and 2015. This paper focuses on data from a total of 180 dairy farms among the 800 that were surveyed in total. The definition of a dairy farm is that the number of dairy cows kept by this farm is positive in either 2012 or 2015 or both. Table 1 shows that the herd size of the average farm in the sample grew indeed, from 201 to 255 cows.

Table 1: Descriptive statistics of variables

Variable	Mean	Median	Min	Max	N
Dairy herd indicators					
Number of cows in 2015	255.3	60	0	3,000	180
Number of cows in 2012	201.4	43	0	2,000	176
Proportionate change of dairy herd 2012-2015	0.37	0.14	-1.00	6.71	152
Log herd 2015 - log herd 2012 incl. new entrants	0.53	0.21	-3.91	6.91	176
Annual milk yield (kg/cow)	4,798.5	4,500.0	800.0	10,000.0	165
Share of milk sales in total farm revenue	0.42	0.41	0.00	1.00	123
Entered dairying after 2012 (1/0)	0.13	0	0	1	180
Output and input prices					
Milk price (USD/kg)	0.33	0.28	0.15	0.83	180
Agricultural wage (USD/month)	218.1	166.0	0.1	3,964.0	180
Concentrate price (USD/ton)	136.3	123.3	0.0	2,166.7	180
Resource endowments					
Land cultivated 2009 (ha)	2,064.9	45.0	0.1	30,000.0	177
Land owned when farm was established (ha)	1,960.5	40.0	0.1	39,918.0	172

[2] The top three regions in milk production by enterprises and farms were Tatarstan, Krasnodar, and Bashkortostan.

Land with fodder crops (ha)	701.8	30.0	0.0	17,420.0	180
Permanent workers in 2012 (heads)	43.5	7.0	0.0	550.0	170
Salvage value of livestock (USD/LU)	485.9	390.6	0.0	9,500.0	177
Credit rationed farm (1/0)	0.41	0	0	1	180
Subsidies					
Farm received livestock subsidy (1/0)	0.09	0	0	1	180
Livestock subsidies received (USD)	636.0	0.0	0.0	20,000.0	180
Human capital and technology level					
Age of the manager (years)	47.4	47	28	78	180
Age of the farm (years)	17.3	12	0	86	180
Share of hired workers in total	0.71	1	0	1	180
Uses pregnancy tests (1/0)	0.18	0	0	1	175
Uses artificial insemination (1/0)	0.38	0	0	1	175
Manager has agricultural education (1/0)	0.40	0	0	1	180
Vertical coordination					
Individual farm (1/0)	0.54	1	0	1	180
Farm belongs to an agroholding (1/0)	0.10	0	0	1	180
Sells milk under contract (1/0)	0.62	1	0	1	169
Regional distribution					
Belgorod province (1/0)	0.13	0	0	1	180
Riazan province (1/0)	0.23	0	0	1	180
Stavropol province (1/0)	0.08	0	0	1	180
Altai Krai province (1/0)	0.22	0	0	1	180
Novosibirsk province (1/0)	0.21	0	0	1	180
Akmola (KZ) province (1/0)	0.13	0	0	1	180

Note: Data refers to 2014/5 growing season unless stated otherwise.
Source: IAMO Farm Survey 2015.

As a comparison of means and median values demonstrates, herd size distributions are highly skewed to the right. We therefore log transformed all scale-sensitive variables used in the subsequent regression models. Zero values were replaced by log(1) for subsidy levels and by log(0.1) for land, workers, and other monetary variables. These were measured in US dollars (USD), using an exchange rate of 60 Russian ruble (RUB) per USD and 185 Kazakhstani tenge (KZT) per USD. Missing prices per farm were replaced by provincial median prices from the survey.

We follow the literature on Gibrat's law (e.g. Sumner and Leiby 1987; Weiss 1999) and calculate growth as:

$$g_{i1215} = \log h_{i15} - \log h_{i12}. \quad (2)$$

In this formulation, the dispersion of herd sizes is narrowed via the log transformation. It is essentially imposing a functional form assumption on the growth process. However, (2) is not defined for $h_{i12} = 0$, i.e. for entering farms. Given the small overall sample size, it would be very costly in terms of data and potential insight to discard all the new entrants. We therefore assumed that each new entrant kept one hypothetical cow in 2012 and recalculated growth using (2).

Table 2: Regression results of herd growth 2012-2015, recursive multi-equation system

	Herd growth 2012-2015 (A)		Log dairy cows in 2012 (B)		Log livestock subsidies (C)		Milk contract (1/0) (D)	
	Coeff.	**p-val.**	**Coeff.**	**p-val.**	**Coeff.**	**p-val.**	**Coeff.**	**p-val.**
Log dairy cows 2012	-0.402 **	0.023	--		15.682	0.383	0.330	0.486
Log dairy cows 2012 squared	0.002	0.893	--		--		--	
Log milk price	-0.539 ***	0.002	--		--		--	
Log agricultural wage	0.073 *	0.069	--		--		--	
Log concentrate price	-0.006	0.804	--		--		--	
Log fodder land	0.032 *	0.095	--		--		--	
Log perm workers 2012	-0.002	0.967	--		--		--	
Log livestock value	-0.023 *	0.061	--		--		--	
Log livestock subsidies	0.117 ***	0.002	--		--		--	
Age of manager	-0.002	0.794	--		0.238	0.176	-0.002	0.847
Age of farm	0.008 **	0.031	--		-0.452 *	0.079	-0.004	0.663
Share of hired workers	0.482 **	0.013	--		--		--	
Pregnancy tests (1/0)	0.552 **	0.042	--		-10.518 ***	0.009	-0.239	0.574
Artificial insemination (1/0)	-0.061	0.773	--		7.968 *	0.055	0.711 *	0.096
Agric education (1/0)	-0.006	0.962	--		-3.693	0.412	0.269	0.455
Agroholding (1/0)	-0.040	0.800	--		5.156	0.237	0.074	0.872
Credit rationed (1/0)	-0.035	0.810	--		4.624	0.161	-0.270	0.266
Milk contract (1/0)	0.451	0.169	--		--		--	
Individual farm (1/0)	-0.336	0.160	--		13.419 ***	0.002	-0.280	0.439
New entrant (1/0)	1.546 ***	<0.001	--		13.669 **	0.029	0.087	0.854
Riazan (1/0)	0.420	0.180	1.795 ***	<0.001	-21.092	0.542	-0.060	0.953
Stavropol (1/0)	-0.215	0.445	-0.178	0.874	9.863	0.561	0.454	0.459
Altai Krai (1/0)	0.242	0.482	-0.093	0.873	0.561	0.946	-0.248	0.653
Novosibirsk (1/0)	-0.090	0.759	-0.758 **	0.032	0.003	1.000	0.282	0.553
Akmola (KZ) (1/0)	0.371	0.199	-0.715	0.249	0.062	0.996	0.342	0.520
Constant	-0.020	0.972	1.394 ***	<0.001	-71.972 **	0.011	-0.562	0.583
Additional instruments (see note to table)	No		Yes		Yes		Yes	
N					172			

Note: Equations A – D simultaneously estimated by Maximum Likelihood using the conditional mixed process estimator by Roodman (2011). * (**, ***): significantly different from zero at the 10 (5, 1) % level. Equations B – D also include the variables land owned when the farm was established, land cultivated in 2004 and land cultivated in 2009 and their interactions and square terms as instruments.

Source: Authors.

4 Determinants of herd growth

We present estimation results for the recursive multi-equation model specified by equations (1a) to (1d) in Table 2. By including separate equations in a simultaneous equation model, we endogenise the variables log dairy cows in 2012, log livestock subsidies and participation in milk contracting. We suspect all of them to potentially cause an endogeneity bias as the first is an argument in the calculation of herd growth and the second and third may be altered simultaneously with the herd growth decisions of the manager.

The results confirm the statistically significant influence of initial herd size, milk price, wage, subsidies, share of hired workers, pregnancy tests and new entrant status on herd growth. In addition, equation A shows that farms with more fodder land grow faster, whereas a higher salvage value of the herd retards growth. Contrary to the implications of the evolutionary learning literature (Jovanovic 1982), model A indicates that farms existing for a longer time grow faster.[3] It is also interesting to note that the age and education of the manager seem to not affect farm growth. The same holds for the credit rationing status and membership in an agroholding. Growth rates do not differ significantly between provinces, holding all other factors constant. Individual farms seem to grow slower on average, but the parameter estimate just misses the 15% level of significance in model A.

The initial herd size in 2012 can be explained fairly well by provincial dummy variables and a set of additional instruments not shown in Table 2. Among these, the log of land cultivated in 2009 and the log of land owned when the farm was established had significantly positive effects on herd size, the latter in quadratic form.

The results of model C reveal interesting insights into the determinants of the incidence and level of livestock subsidies received by dairy producers. It indicates that younger farms and farms that newly entered dairying were significantly more likely to obtain subsidies than older farms. Again, manager characteristics and agroholding membership did not affect subsidy uptake. Even so, individual farms receive significantly more subsidies than enterprises, about 13% more, according to the parameter estimate reported in Table 2.[4]

Both variables measuring management practices had a statistically significant influence on subsidies, but somewhat surprisingly, with different signs: the practice of pregnancy testing lowered subsidy absorption, whereas artificial insemination increased it. A possible explanation for the negative effect of pregnancy tests is that farmers receiving subsidies for enlarging their herd buy pregnant cows rather than raising them from their existing herd. In our sample, 38% of dairy farmers who received livestock subsidies said that they had bought animals in the past year. Such farmers may not (yet) practice pregnancy testing, so that this indicator in fact measures the source of the animals added to the herd. The negative sign may thus imply that farmers receiving subsidies buy cows more often than non-recipients. Indeed, only 16% of dairy farmers not receiving subsidies said that they bought livestock in the previous year.

Credit rationing has a positive sign in the subsidy equation, but it misses the 15% level of statistical significance. In addition, according to model C, neither incidence nor level are affected by the initial size of the dairy herd, as no statistically significant effect of the number of dairy cows in 2012 could be established. In order to assess how sensitive these results are to the endogenous initial dairy herd size in models A-D, we also estimated single equation probit and tobit regressions for equation (1c) (not shown). While these regressions confirm the previous results on the determinants of livestock subsidies, they cast serious doubt on the finding that initial herd size does not affect subsidy uptake. In fact, they strongly suggest that initially bigger herds are more likely to receive subsidies and they

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[3] 10% of dairy farms in the sample were established between 2012 and 2015, the rest was founded earlier.

[4] The findings on subsidy uptake are not sensitive to the inclusion of either the share of hired workers or the new entrant dummy in equation C.

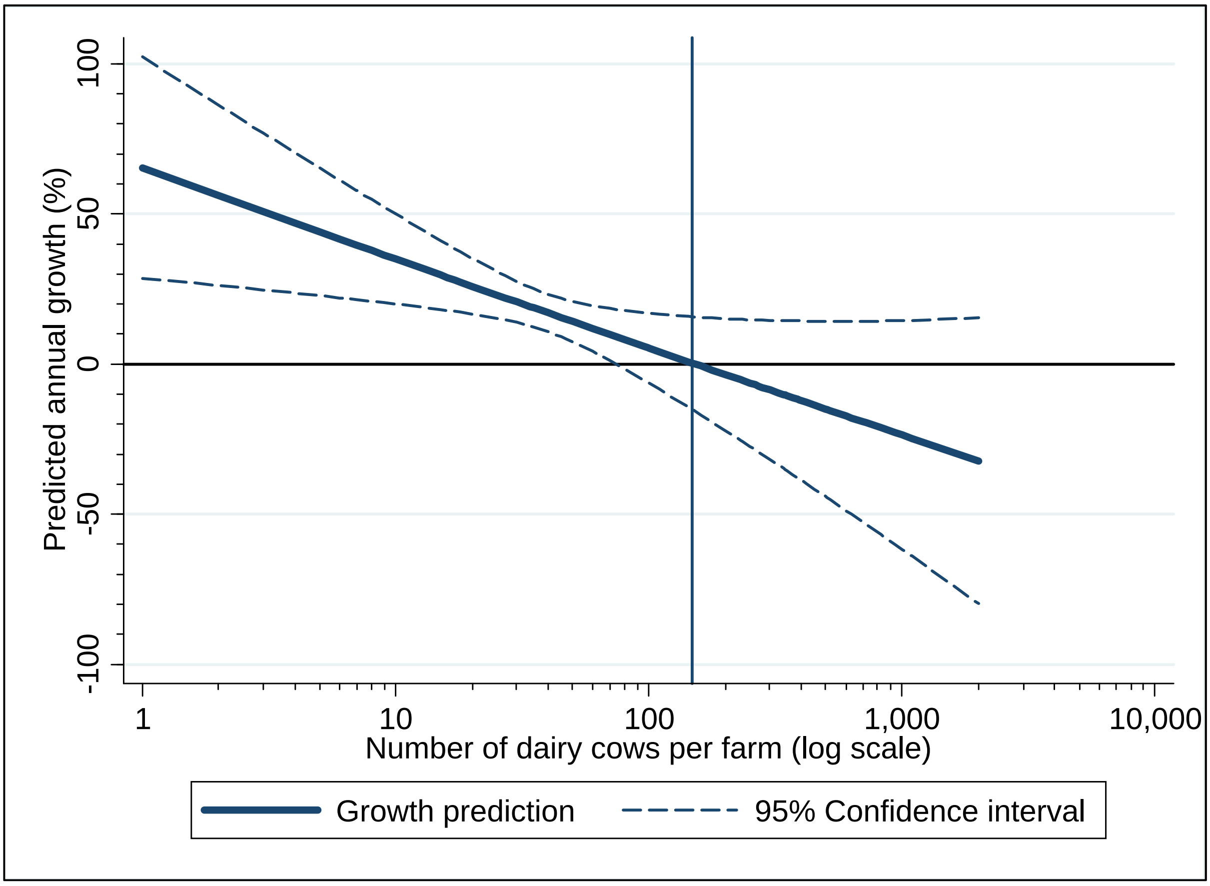
obtain larger amounts. The finding on initial herd size in model C may thus be an artefact of endogenising this variable in the system of equations.

Participation in milk marketing contracts is not well explained by model D in Table 2. The only parameter that is statistically significantly different from zero is the one indicating the use of artificial insemination. We thus conclude that farms which practice more advanced technologies of dairy farming are also more likely to market under a contract. Moreover, a single equation regression of model D provides a coefficient estimate for the initial herd size in 2012 of 0.212 that is statistically significant at the 5% level, similar to model C.

5 Discussion

Several of the key findings on growth patterns among Russian and Kazakhstani dairy farmers are illustrated by Figure 1, which plots the predicted growth path implied by the parameters of model A along with a 95% confidence interval at geometric sample means of all other variables, i.e. $\frac{\partial \widehat{g_{i1215}}}{\partial h_{i12}}$. It shows that dairy farms in Russia and Kazakhstan *do* grow, and this growth is significantly positive up to a herd size of about 70 cows – the intersection point of the lower confidence interval with the horizontal axis indicating zero growth. Consistent with most empirical literature on dairy herd growth, our finding rejects Gibrat's law of farm growth independence from initial size. The equilibrium farm size implied by the growth path in Figure 1 is around 150 cows (as indicated by the solid vertical line). However, the widening confidence interval suggests that growth is largely undetermined by current herd size for herd sizes above the equilibrium number of cows.

Figure 1: Predicted growth path based on parameters of multi-equation model



Notes: Prediction evaluated at geometric sample means, based on parameters of model A.
Source: Authors.

While cross-sectional variation in concentrate prices did not affect herd growth, milk prices had an unexpected negative sign and wage levels of agricultural workers a positive one. The lack of a concentrate price effect may be explained by the considerable heterogeneity of concentrate fodder qualities, so that statements by different farmers are hard to compare. The wage effect implies that managers of faster growing herds pay higher salaries. This finding is consistent with evidence provided by Petrick (2016) indicating that higher wages increase the productivity of workers in post-socialist agriculture, either because the managers pay efficiency wages or because they employ traditional piece rate pay systems. This interpretation implies that wages are not necessarily exogenously given, but rather that managers have some scope for an active compensation policy.

While inconsistent with standard microeconomic models of supply response, the literature has documented various cases of inelastic milk supply with regard to output prices (Huettel and Jongeneel 2011; Zimmermann and Heckelei 2012, 598). The common argument is that herd growth is tied to other resources which are fixed in the short run, so that growth is retarded. Our evidence suggests that producers face a downward sloping demand schedule by consumers or processors. Our data confirms the coexistence of multiple marketing channels. Beyond a residual category of "other" sales channels with generally low prices, farmers report four distinct marketing channels as their main milk outlets: direct sales to consumers, independent traders, dairy processors and state procurement. At least for the first three of these, longer-term contracting is possible and coexists with spot market sales. Direct sales to consumers tend to generate the highest prices, followed by traders and processors. Sales under marketing contracts tend to increase prices paid by both traders and processors.

Respondents were also asked about the specific contractual obligations implied by their marketing contract. With contracting limited to the specification of milk sales alone as the default, 7% of farmers marketing under contract stated that their buyer would also participate in production decisions and quality control, whereas only 5% said that their buyer provided credit, inputs or services to them. The second could be called a management contract, while the latter case is reflecting a resource providing contract as described by Dries et al. (2009). Almost all resource providing contracts were reported for Riazan province in Russia. A modified version of model A (not shown) suggests that management contracts are associated with higher growth rates of farms, but not resource providing contracts. There is also evidence that farms who did not sell any milk in 2015 grew less.

Taken these findings together, higher prices generated by a short cut to consumers put a break on herd growth. Under current conditions, direct marketing channels provide only limited options for farm expansion.

The parameter estimate for the subsidy effect reported for model A suggests a non-linear effect of subsidy payments on herd growth. The marginal effect of an additional subsidy worth 100 USD on average annual growth over the three-year period strongly decreases with the subsidy level up to about 5,000 USD per farm, after which it converges to zero. But even for small amounts, the economic (rather than the statistical) significance is limited, as it induces extra herd growth of less than 3 percentage points annually.

6 Conclusions

The Russian and Kazakhstani farms in our sample succeeded to increase their dairy herds if they employed good management practice and if they had access to milk marketing contracts. Small farms grow more than large farms, with a predicted equilibrium herd size of around 150 cows. However, for herds above this threshold, growth is no longer determined by size. Embodied manager characteristics such as age and education have no perceived influence and, distinct from herd size, agroholding membership does not matter for herd growth.

While smaller farms often manage to obtain higher milk prices by selling directly to consumers, these outlets can absorb only a limited volume of produce. This explains why farms realising higher milk prices grow less. We confirm the crucial importance of reliable vertical coordination for dairy expansion in a post-socialist context, but our results partly qualify the existing literature. Other than

Sauer et al. (2012), we establish a negative rather than a positive relation between herd size and milk price. The reason is fairly obvious: Sauer et al. consider only farms that sell exclusively to commercial processors, whereas we also study farms that sell to consumers directly. We find only very few cases of resource providing contracts in the spirit of Dries et al. (2009) (5% of respondents), and such arrangements did not appear to have an effect on growth.

Less than 10% of dairy farms in our sample received livestock subsidies and the few farms that were lucky to get them were bigger and younger than their peers, although they did not necessarily belong to vertically integrated agroholdings. However, while significantly different from zero in a statistical sense, the subsidy effect on growth was almost negligible economically. Our findings indicate that broad-based herd growth will be much more stimulated if many farms receive small subsidies, not if very few receive individually large amounts. These results suggest a strategy that accelerates growth of many smaller herds simultaneously. If this is the goal, support should be more impartial and have a much broader outreach.

Before further scaling up subsidy programmes, decision makers should understand that public investments in best practices of farm management and vertical coordination promise to be much more effective for invigorating growth than cash handouts. In this regard, knowledge about specific herd management techniques matters more than formal education levels. In addition, small farms often do not have access to value chains that generate milk prices comparable to those obtained from direct sales to consumers. Competitive dairy processing structures that connect small producers to a wide network of spatially dispersed consumers are still missing in the Russian and Kazakhstani regions included in our study.

This article provides evidence that 25 years after the end of central planning, structural change among dairy farms in Russia and Kazakhstan is in many ways similar to the patterns observed in the US, if not also in the EU (Zimmermann and Heckelei 2012; Sumner 2014): smaller farms catch up in terms of herd growth, at least up to a certain minimum viable herd size, classical family-run operations coexist with vertically integrated agribusinesses based on hired labour, and few farms exit dairy production in times of strong government support.

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