Rural Development Support and Farm Size: Evidence from Swedish Dairy Farms

Fredrik Samuelsson

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Landsbygdsstöd och gårdsstorlek: Evidens från svenska mjölkgårdar

Fredrik Samuelsson

Supervisor:	**Shaibu Mellon Bedi, Swedish University of Agricultural Science, Department of Economics**
Examiner:	Shon Ferguson, Swedish University of Agricultural Science, Department of Economics

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Swedish University of Agricultural Sciences
Faculty of Natural Resources and Agricultual Sciences
Department of Economics

Abstract

This study examines the relationship between rural development support and herd size among Swedish dairy farms. Using farm-level panel data from the Swedish Farm Accountancy Data Network (FADN) for the period 2011–2021, the analysis investigates whether CAP rural development support is associated with changes in dairy herd size and whether this relationship differs across farms of different sizes. Pooled OLS, fixed effects models, subsample regressions, and quantile regression are applied to estimate both average and heterogeneous relationships**,** under assumptions regarding selection and unobserved heterogeneity**.**

The results suggest a positive relationship between rural development support and herd size, although the estimated average effect is relatively small. In the fixed effects specification, a 100 percent increase in rural development support is associated with approximately a 1.1 percent increase in herd size. The dynamic GMM results, which account for persistence in herd size and potential endogeneity associated with rural development support, provide further support for this relationship. In this specification, a 100 percent increase in rural development support is associated with approximately a 2.5 percent increase in herd size. The quantile regression results indicate that the relationship is stronger among smaller and medium-sized farms, while no statistically significant relationship is found among larger farms. Overall, the findings suggest that rural development support may contribute to farm expansion, but that the magnitude of the effect is modest and differs across the herd size distribution.

Keywords: Common Agricultural Policy, Rural delopment support, Dairy farms, Herd size

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Abbreviations

Abbreviation	Description
CAP	Common Agricultural Policy
EU	European Union
FADN	Farm Accountancy Data Network
SLU	Swedish University of Agricultural Sciences

1. Introduction

The Common Agricultural Policy (CAP) represents one of the largest components of the European Union budget, accounting for around 30 percent of total EU spending (European Commission, 2021). As the European Union’s main framework for supporting agriculture and rural areas, CAP aims to ensure a stable food supply, support farm incomes and resilience, and promote environmental sustainability and rural development (European Commission, n.d.-a). The majority of CAP funding is allocated to direct payments under Pillar I, accounting for approximately 72 percent of the budget, while rural development measures under Pillar II account for around 25 percent of total CAP spending (European Commission, 2022).

Rural development measures under Pillar II aim to support long-term development in agriculture, including investments and farm restructuring (European Commission, n.d.-b)**.** One important component of rural development policy is investment support, which is intended to promote farm modernisation, improve production conditions, and support structural adjustment in agriculture. Such support may be particularly relevant for farm expansion, as investments in buildings, machinery, land, or livestock can influence production capacity and herd size**.** These types of support measures may influence farm-level decisions, including production choices, investment behaviour, and potentially farm size. Farm size is an important characteristic in agricultural production, as it is often linked to productivity and efficiency. Empirical evidence from Norway suggests the presence of economies of scale and scope in dairy production (Alem et al., 2017). Similarly, Rasmussen (2011), using Danish farm data, shows that many farms operate below their optimal production scale, indicating that increasing farm size may improve efficiency and productivity. Evidence from Czech dairy farms further suggests that increasing herd size may be associated with higher milk yields and greater production efficiency (Krpalkova et al., 2016).

Despite the substantial resources allocated to rural development support, it remains unclear whether these support measures are associated with herd size and whether the relationship differs across farms of different sizes. This study examines the relationship between rural development support and herd size among Swedish dairy farms. Specifically, the analysis examines whether rural development support is associated with changes in herd size and whether this relationship differs between smaller and larger farms as well as across the farm size distribution. An unbalanced panel dataset of Swedish dairy farms obtained from the Swedish Farm Accountancy Data Network (FADN), covering the period 2011–2021, is used. To examine both average and heterogeneous effects, a pooled OLS, fixed effects models, subsample regressions, and quantile regression are applied. In addition, a dynamic two-step difference GMM model is estimated to account for persistence in herd size and potential endogeneity.

To examine the relationship between rural development support and herd size, panel regressions with farm fixed effects are used as the main estimation approach. The fixed effects and quantile regression models are estimated under the assumption of selection on observables, meaning that the analysis controls for observed farm characteristics and, in the fixed effects model, time-invariant farm characteristics (Cameron and Trivedi, 2005). In addition, subsample regressions and quantile regression are applied to analyse whether the relationship differs across farms of different sizes. While the subsample regressions provide a simple comparison between small and large farms, they rely on predefined groups and may miss variation within these groups. Quantile regression provides a more flexible approach by estimating the relationship at different points of the herd size distribution. Finally, a dynamic GMM model is estimated as an additional specification to account for persistence in herd size and potential endogeneity associated with rural development support by using lagged variables as internal instruments (Arellano and Bond, 1991).

Overall, the results suggest that rural development support is positively associated with herd size, although the estimated magnitude is relatively modest. The dynamic GMM results provide further support for a positive relationship after accounting for persistence in herd size and potential endogeneity. The quantile regression results indicate that the relationship is stronger among smaller and medium-sized farms, while no statistically significant relationship is observed among larger farms. The findings also suggest that factors such as total farm area, veterinary costs, and the share of culled animals are important determinants of herd size.

This study contributes to the literature in three ways. First, while previous studies primarily focus on the effects of CAP support on productivity and technical efficiency, this study examines farm size as a structural outcome. Farm size may itself be related to productivity and efficiency through economies of scale, suggesting that support measures influencing farm expansion may have broader implications for agricultural development.

Second, the analysis focuses specifically on rural development support under Pillar II. While previous research has examined various forms of CAP support, this study provides a more specific focus on rural development measures and their relationship with herd size.

Third, the analysis examines whether the relationship differs across farms of different sizes. Previous research highlights the concentrated nature of CAP payments, suggesting that larger farms tend to receive a disproportionate share of support, which may have implications for both efficiency and structural development in the agricultural sector (Pierangeli et al., 2025). This raises questions regarding whether support contributes to farm expansion or instead reinforces existing differences between smaller and larger farms. By combining subsample analysis with quantile regression, the study examines differences across farms of different sizes and across the farm size distribution.

2. Litterature Review

2.1 Previous Literature

The Common Agricultural Policy (CAP) has been widely studied in the academic literature, including both Pillar I direct payments and Pillar II rural development measures, particularly with regard to the effectiveness of public support and its impact on agricultural outcomes. A particular focus has been on how different forms of support influence farm performance.

Several studies have examined the relationship between CAP support and productivity, although the findings remain mixed. Nilsson (2017) finds positive productivity effects of Pillar II investment support among smaller Swedish farms, while no significant effects are observed for larger farms. Similar mixed findings are reported in broader European studies. Rizov et al. (2013) suggest that the impact of subsidies depends on policy design, while Mary (2013) finds negative productivity effects for certain types of support. Overall, the evidence indicates that the effects of CAP support on productivity vary depending on factors such as policy design, farm characteristics, and the type of support provided.

A closely related strand of literature examines the relationship between CAP support and technical efficiency. Similar to the productivity literature, the findings remain inconclusive. Latruffe et al. (2017) report heterogeneous effects across countries, while Zhu et al. (2012) and Minviel and Latruffe (2016) suggest more negative relationships between subsidies and efficiency. These findings indicate that support measures may affect farms differently depending on their characteristics and institutional context.

Overall, previous research provides mixed evidence regarding the effects of CAP support on farm performance. While most studies focus on productivity and technical efficiency outcomes, considerably less attention has been given to structural outcomes such as farm size. Examining farm size may provide additional insights into how agricultural support is associated with structural change within agriculture.

2.2 Theoretical framework

Standard agricultural production theory assumes that farmers make production and investment decisions with the aim of maximizing profits, although these decisions are constrained by available resources, risk, uncertainty, and policy conditions (Debertin, 2012). Farmers must decide what to produce and how to allocate inputs such as land, labour, machinery, and capital across decisions (Debertin, 2012). In this framework, rural development support may affect farm-level decisions by changing incentives, reducing financial constraints, or altering the expected returns from investment and expansion. Similarly, investment theory within standard microeconomic theory suggests that firms invest when their existing stock of capital is insufficient for the desired level of production. Investment can therefore be understood as the purchase of additional capital, such as machinery, buildings, or other durable inputs, in order to expand production capacity (Nicholson and Snyder, 2007). Rural development support may influence this decision by lowering the effective cost of investment or making additional capital accumulation more feasible.

Agricultural production decisions are often made within a long-term planning horizon rather than within a single production season (Debertin, 2012). Farmers may invest in durable inputs such as land, machinery, or buildings in order to increase future profitability, even if these investments involve short-run costs (Debertin, 2012). Rural development support under Pillar II may therefore influence farm size by making investment and expansion more feasible. This provides a theoretical link between policy support, investment behaviour, and structural change at the farm level.

In production theory, farm size and scale are related but not identical concepts. Debertin (2012) defines scale as a proportional increase in all inputs, while farm size may change without all inputs increasing in the same proportion. This distinction is important because economies of scale are more closely related to the relationship between output and production costs than to proportional changes in all inputs. In standard microeconomic theory, economies of scale occur when output can be expanded at less than a proportional increase in cost, leading to lower average production costs as production increases (Pindyck and Rubinfeld, 2018). This may occur because larger firms can benefit from specialization, more flexible input combinations, lower input prices, or more efficient production technologies. In dairy production, larger farms may for example be better able to adopt capital-intensive technologies, such as milking machinery, which can reduce average production costs. However, true changes in scale are difficult to observe in agriculture because inputs such as land, labour, machinery, and management are rarely adjusted proportionally (Debertin, 2012). In this study, herd size is therefore used as an empirical measure of farm size and structural development, rather than as a strict measure of scale.

3. Method and Data

3.1 Data and Variables

The study is based on data from the Swedish Farm Accountancy Data Network (FADN), provided by the Swedish Board of Agriculture. FADN is a harmonised survey-based data system used across EU member states, where each country collects farm-level data according to a common framework. The original dataset covers the period from 2002 onwards; however, the sample used in this study is restricted to the period 2011–2021. The dataset consists of an unbalanced panel of Swedish farms, where the same farms may be observed repeatedly over time, although not all farms are observed in every year. The sample is limited to dairy farms. Observations where farms ceased dairy production (i.e. where the number of dairy cows equals zero) were excluded from the analysis. The final sample consists of 2,219 observations.

The dependent variable and selected independent variables are expressed in logarithmic form, allowing the coefficients to be interpreted as elasticities and reducing skewness in the data. For variables that may take zero values, a small constant (0.01) is added prior to log-transformation in order to retain these observations in the analysis.

The dependent variable is herd size, measured as the logarithm of the number of dairy cows. The main explanatory variable is rural development support, measured as the logarithm of CAP rural development support received by the farm. The analysis also includes socio-demographic and farm-level control variables that may be related to herd size. Farmer age and age squared are included to capture potential non-linear relationships between farmer age and herd size. Total farm area captures land availability, while veterinary costs may reflect differences in animal health management and production intensity. The share of culled animals is included because culling affects herd composition and may be related to changes in herd size over time.

Table 1. Variable desciption and descriptive statistics

Variable	Definition	Mean	Median	SD
ln_dairy	Logarithm of dairy cows in herd size	3.703	3.773	0.895
ln_cap	Logarithm of CAP rural development support in SEK	11.755	11.907	1.729
age	Age of farmer	54.747	56	9.614
age2	Age squared	3089.541	3136	1033.923
share_culling	Share of culled animals	0.230	0.172	0.327
ln_vet_cost	Logarithm of veterinary costs	7.729	9.800	5.336
t_area	Total farm area in hectares	124.658	93	103.567
Observations		2219		

3.2 Econometric Model

As a starting point, a pooled OLS regression including only rural development support is estimated as a benchmark specification.

$$\text{ln\_dairy}_{\text{it}} = \beta_0 + \beta_1 ln_{cap_{it}} + u_{it} \quad (1)$$

This specification serves as a benchmark before estimating the fixed effects models. To further examine the relationship, fixed effects models are estimated both without and with additional control variables:

$$ln\_dairy_{it} = \beta_0 + \beta_1 ln_{cap_{it}} + \alpha_i + \lambda_t + u_{it} \quad (2)$$

$$ln\_dairy_{it} = \beta_0 + \beta_1 ln\_cap_{it} + \beta_2 age_{it} + \beta_3 age_{it}^2 + \beta_4 share\_culling_{it} + \beta_5 ln\_vet\_cost_{it} + \beta_6\, t\_area_{it} + \alpha_i + \lambda_t + u_{it} \quad (3)$$

where $ln_{dairy_{it}}$represents the herd size of farm i in year t. Farm fixed effects (α_i) are included to control for unobserved characteristics that remain constant over time, such as management ability, location, or production conditions. Year fixed effects (λ_t) are included to account for factors affecting all farms over time, while u_{it} represents the error term.

OLS estimates may be biased due to unobserved differences across farms that are not captured by the observed variables. By using fixed effects, the estimation relies on within-farm variation over time, thereby reducing potential omitted variable bias. Standard errors are clustered at the farm level to account for potential serial correlation within farms over time.

To examine potential differences across farm sizes, the sample is divided into two groups based on the median of the average herd size over the sample period. First, the average herd size for each farm is calculated across all available years. Farms with an average herd size above the median are classified as large farms, while farms at or below the median are classified as small farms. Separate regressions are then estimated for each group in order to analyse whether the relationship between rural development support and herd size differs across farm sizes.

Furthermore, quantile regression is used to analyse heterogeneous effects across the distribution of farm size. Unlike standard regression models, which estimate average effects, quantile regression allows for examining how the impact of rural development support varies at different points of the distribution, for example between smaller and larger farms (Koenker and Bassett, 1978). In this study, quantile regression is estimated at q25, q50, and q75, representing the lower, median, and upper parts of the herd size distribution. Year fixed effects are included to control for common shocks over time, while farm fixed effects are not included due to the additional complexity of estimating quantile regression models with many farm-specific effects. This makes it possible to examine whether rural development support is more strongly associated with herd size among smaller, medium-sized, or larger dairy farms.

$$Q_\tau\left(\ln\_dairy_{it} \mid X_{it}\right) = \beta_0(\tau) + \beta_1(\tau)\ln\_cap_{it} + \beta_2(\tau)age_{it} + \beta_3(\tau)age_{it}^2 + \beta_4(\tau)share\_culling_{it} + \beta_5(\tau)\ln\_vet\_cost_{it} + \beta_6(\tau)t\_area_{it} + \lambda_t + u_{it}(\tau) \quad (4)$$

where
$Q_\tau\left(ln_{dairy_{it}} \mid X_{it}\right)$
represents the conditional quantile of herd size at quantile τ, and λ_t represents year fixed effects controlling for common shocks affecting all farms over time.

Quantile regression also provides a more flexible approach than the subsample regressions. The subsample analysis divides farms into two predefined groups, small and large farms, based on the median of average herd size. While this provides a simple comparison, it reduces the variation available within each regression and may miss differences within each group. Quantile regression instead uses the full sample and estimates the relationship at different points of the herd size distribution. This is useful because average effects and simple group comparisons may conceal heterogeneous relationships across the outcome distribution (Abrevaya and Dahl, 2008).

The fixed effects and quantile regression models are estimated under the assumption of selection on observables. This means that rural development support is assumed to be as good as randomly assigned after conditioning on observed control variables, including farmer age, age squared, the share of culled animals, veterinary costs, total farm area, and year fixed effects. In the fixed effects models, farm fixed effects are also included to control for time-invariant farm characteristics. However, this assumption may be violated if unobserved time-varying factors, such as investment plans or growth ambitions, affect both rural development support and herd size.
As an additional dynamic specification, a two-step difference GMM model is estimated to account for persistence in herd size and potential endogeneity. Herd size is likely to adjust gradually over time, meaning that current herd size may depend on herd size in previous periods. In addition, rural development support may be endogenous if farms that already plan to expand are more likely to apply for and receive support. A dynamic GMM approach is therefore useful because it includes lagged herd size and uses internal instruments based on lagged values of the variables (Arellano and Bond, 1991; Roodman, 2009).

$$\ln\_dairy_{\{it\}} = \rho_1 \ln\_dairy_{\{i,t-1\}} + \rho_2 \ln\_dairy_{\{i,t-2\}} + \beta_1 \ln\_cap_{\{it\}} + X_{\{it\}\gamma} + \lambda_t + u_{\{it\}} \tag{5}$$

where ln_dairy_{it} represents herd size for farm i in year t, $ln\_dairy_{i,t-1}$ and $ln_{dairy_{i,t-2}}$ represent lagged herd size, ln_cap_{it} is rural development support, and X_{it} is a vector of control variables including farmer age, age squared, the share of culled animals, veterinary costs, and total farm area. Year fixed effects λ_t are included to control for common shocks over time. The model is estimated using two-step difference GMM. The validity of the specification is assessed using the Arellano-Bond tests for first- and second-order serial correlation and the Hansen/Sargan tests of overidentifying restrictions.

4. Results

4.1 Average effects

Table 2 presents the results from the pooled OLS and fixed effects estimations. Overall, the results suggest a positive relationship between rural development support and herd size across all model specifications. However, the magnitude of the estimated effect decreases substantially when fixed effects and additional control variables are introduced.

Table 2. OLS and fixed effects

Variables	(1) OLS	(2) FE	(3) FE + Controls
ln_cap	0.205***	0.019***	0.011**
	(0.010)	(0.006)	(0.005)
age			0.013
			(0.013)
age2			-0.00016
			(0.00013)
share_culling			-0.369***
			(0.039)
ln_vet_cost			0.0075***
			(0.0027)
t_area			0.00178***
			(0.00036)
Constant	1.289***	3.552***	3.197***
	(0.119)	(0.076)	(0.327)
Farm FE	NO	YES	YES
Year FE	NO	YES	YES
Observations	2219	2219	2219

Note: Standard errors are reported in parentheses. Column (1) presents the pooled OLS specification, column (2) includes farm and year fixed effects, and column (3) includes farm and year fixed effects as well as additional control variables. Farm FE and Year FE indicate whether farm and year fixed effects are included.
* $p < 0.10$,
** $p < 0.05$,
*** $p < 0.01$.

The pooled OLS model suggests that a 100 percent increase in rural development support is associated with approximately a 20.5 percent increase in herd size. After accounting for farm and year fixed effects, the estimated effect decreases to approximately 1.9 percent. Including additional control variables further reduces the estimated effect to around 1.1 percent, although the relationship remains statistically significant at the 5 percent level.

Turning to the control variables, the results indicate that the share of culled animals is negatively associated with herd size, while veterinary costs and total farm area are positively associated with herd size. These findings are consistent with the theoretical framework, where farm production decisions depend on the allocation of inputs such as land, capital, and other farm resources (Debertin, 2012). The positive relationship between total farm area and herd size may reflect that land availability facilitates herd expansion, while veterinary costs may capture differences in animal health management and production intensity. The negative relationship between culling and herd size is also intuitive, as a higher share of culled animals means that more animals are removed from the herd.

4.2 Heterogeneous effects

Table 3 presents the results separately for small and large farms. Overall, the results suggest that the relationship between rural development support and herd size is similar across the two groups. Specifically, the coefficient for rural development support (ln_cap) is positive for both small and large farms, although the estimates are not statistically significant in either specification. This indicates that the positive relationship observed in the full sample is not statistically confirmed when the sample is divided into small and large farms.

Table 3. Regression Results by Farm Size

Variables	**Small farms**	**Large farms**
ln_cap	0.009	0.011
	(0.006)	(0.009)
age	0.003	0.002
	(0.018)	(0.024)
age2	-0.00009	-0.00022
	(0.00020)	(0.00023)
share_culling	-0.383***	-0.121**
	(0.033)	(0.057)
ln_vet_cost	0.0099***	0.0007
	(0.0036)	(0.0027)
t_area	0.00156*	0.00129***
	(0.00080)	(0.00044)
Constant	3.073***	3.501***
	(0.412)	(0.587)
Farm FE	YES	YES
Year FE	YES	YES
Observations	1111	1108
Number of farms	264	296

Note: Standard errors are reported in parentheses. The sample is divided into small and large farms based on the median of average herd size over the sample period. Both specifications include farm and year fixed effects. Farm FE and Year FE indicate whether farm and year fixed effects are included.

* $p < 0.10$,
** $p < 0.05$,
*** $p < 0.01$.

Some differences are observed across the control variables. The share of culled animals is negative and statistically significant for both groups, with a larger coefficient for small farms (-0.383) than for large farms (-0.121). Veterinary costs are positive and statistically significant at the 1 percent level for small farms but are not statistically significant for large farms.

Total farm area is positively associated with herd size in both groups. The relationship is statistically significant at the 10 percent level for small farms and at the 1 percent level for large farms. Age and age squared are not statistically significant in either specificatio

4.3 Distributional effects

Table 4 presents the quantile regression estimates across different points of the herd size distribution. Overall, the results suggest that the relationship between rural development support and herd size differs across quantiles.

Table 4. Quantile Regression Results

Variables	**q25**	**q50**	**q75**
ln_cap	0.050***	0.024***	0.002
	(0.019)	(0.006)	(0.011)
age	0.008	0.003	0.001
	(0.009)	(0.014)	(0.006)
age2	-0.00019***	-0.00012	-0.00007
	(0.00006)	(0.00014)	(0.00006)
share_culling	-0.405***	-0.457***	-0.514***
	(0.059)	(0.047)	(0.037)
ln_vet_cost	0.0227***	0.0249***	0.0165***
	(0.0046)	(0.0043)	(0.0028)
t_area	0.00510***	0.00587***	0.00630***
	(0.00018)	(0.00032)	(0.00030)
Constant	2.025***	2.258***	3.258***
	(0.446)	(0.262)	(0.262)
Farm FE	NO	NO	NO
Year FE	YES	YES	YES
Observations	2219	2219	2219

Note: Standard errors are reported in parentheses. Columns q25, q50, and q75 report quantile regression estimates at the 25th, 50th, and 75th percentiles of the herd size distribution. Year fixed effects are included, while farm fixed effects are not included.
* $p < 0.10$,
** $p < 0.05$,
*** $p < 0.01$.

Specifically, the coefficient for rural development support (ln_cap) is positive and statistically significant at the 1 percent level for the lower quantile (q25). The estimated coefficient suggests that a 100 percent increase in rural development support is associated with approximately a 5.0 percent increase in herd size. A similar relationship is observed at the median quantile (q50), where the coefficient remains positive and statistically significant at the 1 percent level, although smaller in magnitude. The estimated coefficient indicates that a 100 percent increase in support is associated with approximately a 2.4 percent increase in herd size.

By contrast, the coefficient for rural development support at the upper quantile (q75) is close to zero and not statistically significant.

Turning to the control variables, the results display relatively similar patterns across quantiles. The share of culled animals is negative and statistically significant at the 1 percent level throughout the distribution. Veterinary costs and total farm area are positive and statistically significant across all quantiles, while age is not statistically significant. Age squared is negative and statistically significant at the 10 percent level only for q25.

4.4 Dynamic GMM results

Table 5 presents the dynamic GMM results. The model includes lagged herd size in order to account for persistence in herd size over time and to address potential endogeneity. The first lag of herd size is positive and statistically significant, suggesting that current herd size is partly explained by herd size in the previous period. The second lag is negative but not statistically significant.

Table 5. Dynamic GMM results

Variables	**Dynamic GMM**
L.ln_dairy	0.460**
	(0.223)
L2.ln_dairy	-0.269
	(0.231)
ln_cap	0.0246***
	(0.0088)
Controls	YES
Year FE	YES
AR(1) p-value	0.318
AR(2) p-value	0.923
Sargan p-value	0.613
Hansen p-value	0.146
Difference-in-Hansen p-value	0.090

Note: Standard errors are reported in parentheses. The dynamic GMM model includes the same control variables as the main fixed effects specification: farmer age, age squared, share of culled animals, veterinary costs, and total farm area. Year fixed effects are included. AR(1) and AR(2) refer to Arellano-Bond tests for serial correlation in first differences. Sargan and Hansen p-values refer to tests of overidentifying restrictions.

* $p < 0.10$,

** $p < 0.05$,

*** $p < 0.01$.

The coefficient for rural development support remains positive and statistically significant. Specifically, the coefficient of 0.0246 suggests that a 100 percent increase in rural development support is associated with approximately a 2.5 percent increase in herd size. This indicates that the positive relationship between rural development support and herd size remains after accounting for dynamic adjustment.

The diagnostic tests support the validity of the specification. The AR(2) test is not statistically significant, suggesting no evidence of second-order serial correlation in the differenced errors. The Hansen and Sargan tests do not reject the validity of the instruments. Overall, the dynamic GMM results provide additional support for a positive relationship between rural development support and herd size, although the estimated effect remains relatively modest.

5. Disscusion and conclussion

This study examined the relationship between rural development support and herd size among Swedish dairy farms using farm-level data from the Swedish Farm Accountancy Data Network (FADN) covering the period 2011–2021. To analyse both the overall relationship and potential differences across farms of different sizes, pooled OLS, fixed effects models, subsample regressions, quantile regression and a dynamic GMM specification were applied.

Overall, the results suggest a positive relationship between rural development support and herd size. Although the relationship remains statistically significant after introducing farm and year fixed effects as well as additional control variables, the estimated magnitude is relatively small. Specifically, the specification with fixed effects and control variables suggests that a 100 percent increase in rural development support is associated with approximately a 1.1 percent increase in herd size.

The dynamic GMM results provide further support for a positive relationship between rural development support and herd size. This specification accounts for persistence in herd size by including lagged herd size and also addresses potential endogeneity using internal instruments. In the dynamic model, rural development support remains positive and statistically significant, with a 100 percent increase in support associated with approximately a 2.5 percent increase in herd size. The first lag of herd size is also positive and statistically significant, suggesting that herd size adjusts gradually over time. The diagnostic tests do not indicate second-order serial correlation, and the Hansen test does not reject the validity of the instruments. These results strengthen the evidence that rural development support is related to herd expansion, although the estimated effect remains modest.

This finding is broadly consistent with the theoretical framework of the study. Agricultural production theory suggests that farmers make production and investment decisions under constraints such as available resources, risk, uncertainty, and policy conditions. Rural development support may therefore influence herd size by reducing financial constraints or altering incentives for investment and expansion. However, the relatively small estimated effects suggests that rural development support alone is unlikely to be the main determinant of herd size decisions. This is important because the theoretical framework implies that farm expansion decisions are influenced by multiple factors beyond policy support, such as economic conditions, investment opportunities, and farm-specific characteristics.

The substantial reduction in the coefficient after introducing fixed effects suggests that part of the relationship observed in the pooled OLS model may be driven by differences between farms that remain relatively constant over time, rather than changes in support alone. This highlights the importance of controlling for unobserved farm-level heterogeneity when analysing the relationship between support and herd size.

The subsample results show that the coefficients for rural development support remain positive for both small and large farms, although the estimates are not statistically significant in either specification. One possible explanation is that dividing the sample into separate groups reduces the variation available within each regression, leading to lower estimation precision.

The results may also suggest that the relationship between rural development support and herd size is relatively weak within each farm size category and that the statistically significant relationship observed in the full sample reflects smaller effects distributed across farms rather than a strong effect within a specific group.

While the subsample analysis does not reveal statistically significant differences between small and large farms, the quantile regression results suggest that the relationship may vary across the herd size distribution. The coefficient remains positive and statistically significant at q25 and q50, while no statistically significant relationship is observed at q75**.** This may indicate that rural development support is more strongly associated with herd size among smaller and medium-sized farms than among larger farms. The magnitude of the estimated effects also differs across quantiles. A 100 percent increase in support is associated with approximately a 5.0 percent increase in herd size at q25 and a 2.4 percent increase at q50, compared to approximately 1.1 percent in the average fixed effects specification. This suggests that average estimates may mask important differences across farms.

Previous studies examining CAP support have reported mixed findings regarding farm outcomes such as productivity and efficiency, with some studies finding positive effects and others reporting negative or insignificant relationships.

The findings are also partly consistent with Nilsson (2017), who examined the effects of investment support under CAP Pillar II on productivity among Swedish farms. The study found positive effects for smaller farms but no significant effects for larger farms. Although the outcome variable differs, focusing on productivity rather than herd size, the stronger relationships observed among smaller and medium-sized farms in the quantile analysis may suggest that support measures affect farms differently depending on farm size.

The results also relate to studies showing that farm size may be connected to productivity and efficiency. Alem et al. (2017) find evidence of economies of scale and scope in dairy production, while Rasmussen (2011) shows that many farms operate below their optimal production scale. In addition, Krpalkova et al. (2016) find that increasing herd size in Czech dairy farms is associated with higher milk yields and overall efficiency. In this context, the positive relationship between rural development support and herd size may indicate that support is linked to structural development, although the relatively small estimated effect suggests that rural development support alone is unlikely to explain herd expansion.

Several limitations should be acknowledged. Although the dynamic GMM model addresses potential endogeneity by using internal instruments, the results should still be interpreted with some caution. The analysis is based on observational data, and the validity of the GMM approach depends on the assumptions underlying the use of lagged variables as instruments. Moreover, rural development support, especially investment support, may not be randomly distributed across farms. Farmers may already have planned to expand or invest in new buildings and may apply for support as part of this process. In this case, the estimated relationship may partly reflect pre-existing investment plans or growth strategies rather than the effect of support alone.

Furthermore, herd size represents only one dimension of structural change and may not fully capture broader aspects of farm development such as productivity, efficency, or long-term farm performance A larger herd does not necessarily imply that a farm is more profitable or more technically efficient.

From a policy perspective, the findings suggest that rural development support may affect farms differently depending on farm size. The stronger relationships observed among smaller and medium-sized farms may indicate that support plays a larger role among these farms compared to larger farms. This suggests that a uniform support structure may not affect all farms in the same way. The absence of a statistically significant relationship among larger farms may also indicate that factors beyond rural development support, such as land availability, investment capacity, market conditions, or farm-specific growth strategies, play a greater role in herd expansion decisions for these farms.

However, these policy implications should be interpreted with caution. Although the dynamic GMM model addresses potential endogeneity using internal instruments, the results are still based on observational data and rely on the validity of the instruments. Therefore, the findings should be seen as evidence of a positive relationship between rural development support and herd size, rather than definitive proof of a causal effect.

Future research could further investigate the causal relationship between rural development support and herd size in order to determine whether support directly contributes to farm expansion. Future studies could also examine why the relationship appears stronger among smaller and medium-sized farms than among larger farms, and whether differences in investment behaviour or farm characteristics explain these patterns. In addition, future research could include alternative indicators of farm development, such as productivity, profitability, or technical efficiency, to provide a broader understanding of how rural development support affects agricultural outcomes. Further research could also explore additional explanatory variables and farm characteristics that may influence herd size decisions and improve the understanding of factors underlying farm expansion.

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