How Fluctuations in Farm and Off-Farm Income Could Affect the Financial Performance of U.S. Farm Operator Dairy Farms: A Farm-level Analysis

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Introduction

Dairy farming in the U.S. is undergoing dramatic changes, driven both by supply and demand factors (MacDonald et al., 2016; Mosheim and Lovell, 2009; Wolf et al., 2017). Consumption is shifting from fluid milk toward manufactured products, such as cheese, and dairy-based ingredients produced for national and global markets. Innovations in breeding and feeding systems have resulted in large increases in the amount of milk that a cow produces. Also, milk production is shifting toward Western States such as California, Idaho, and New Mexico. Finally, production (by herd size) is shifting to much larger farms as farms enjoy scale economies (Appendix Figure 1).

One of the most important and difficult decisions a farm business must make is the choice of capital structure (how a firm finances its overall operations and growth by using different sources of funds). The theory of optimal leverage suggests that the cost of debt is less than the cost of equity due to differences in risk and the tax deductibility of debt. Thus, the use of leverage can increase the rate of return to equity. However, debt increases financial risk, making insolvency a more likely possibility.

Debt can be an effective tool to improve dairy farm profitability. Over time, farmers and lenders perceptions of acceptable debt loads have changed. Also, dairy milk prices are subject to considerable volatility (Wolf et al., 2017), affecting financial viability and performance. Off-farm income and employment can be a part of the dairy farm's efforts to manage both financial and price risks.

Objective

This study analyzes how off-farm income could and employment are affecting the capital structure of U.S. dairy farms, and the probability of loan default over time. We use the synthetic credit model proposed by Featherstone, Roessler and Barry (2006) based on the scores for variables that indicate payment ability (Featherstone et al., July 16-17, 2012). This model has been previously used to assess financial viability and performance of U.S. crop and livestock farms (Wilson, Morehart, Featherstone et al, 2010). The KMV model descends from the Merton model (Merton, 1974) and was developed by KMV ((Kealhofer, McQuown and Vasicek) and is now maintained by Moody's KMV) (McNeil, p. 336).

Data and Empirical Procedures

We use farm-level data, 1996 – 2015, from the USDA's Agricultural Resource Management Survey(ARMS) and Moody's KMV loan model to examine how fluctuations in both *farm and off-farm income* could affect the leverage conditions and financial performance of U.S. dairy farm households. We use the KMV model to compare probabilities of loan default for U.S. dairy farms with and without off-farm income. We do not however assume that dairy farmers with off-farm income would invest all their off-farm income in the farm business. Credit scores are found using financial data from each farm, where each is viewed as a potential borrower. This allows us to assess the risk that a loan will enter default status. After evaluating the risk of default and assigning an appropriate credit rating, we are able to determine the riskiness of the sector by aggregating the individual farms.

The farm record data used for this study are expected to provide an accurate representation of the financial data received by a lender from a borrower. These data are obtained from ARMS and are used to calculate the probability of default and the corresponding credit score for each farm. The probability of default for each loan in the sample is calculated from an equation derived from a binary logit regression using actual loan origination data.

We sub-set the data into dairy farms with off-farm income, and those without off-farm income and examine how this income source could affect dairy farm capital structure and probability of farm loan default, or *prob*. We also apply a financial performance measure, the *Critical ROA* (Turvey, 2011) as an alternative measure of financial performance.

Previous studies of farm capital structure and of farm loan default probabilities have considered two farm types: crop farms and livestock farms. These studies found that the probability of farm loan default varies across time, by farm size and type, and by production region (Brewer et al., 2012; Featherstone, 2016). This study focuses on U.S. dairy farms. We divide the U.S. into 6 dairy regions: 1. *Northeast*: Vermont and New York (646 obs.), 2. *Lake States*: Michigan, Minnesota, and Wisconsin (1884 obs.), 3. *Corn Belt*: Illinois, Indiana, Iowa, and Ohio (492 obs.); 4. *Southern Plains*: Texas (763 obs.); 5. *Mountain*: Idaho, Colorado, New Mexico, Utah (352 obs.); and 6. *Pacific*: California (1923 obs.). These states and dairy regions were chosen since these had sufficient (unweighted) observations for statistical significance.

The entire data set consists of 7,434 observations for dairy operations in these 6 major production regions. The list and area frame components are incorporated using a system of weights. Inferences for the states and regions must account for the survey design by using weighted observations. Changes in farm household capital structure affect farm operators' solvency. This is particularly important for capital-intensive dairy farms.

Credit scores are found using financial data for each farm. Each dairy farm in the ARMS data is viewed as a potential borrower. This allows us to assess the risk that a loan will enter default status. After assessing the risk of each dairy farm and assigning an appropriate credit rating, we are able to determine the risk status of the dairy sector by aggregating the individual farms.
A synthetic credit rating model is used to predict the probability of default and the corresponding score for each farm (gross cash income > $100K). The probability of default for each loan in the sample is calculated from an equation derived from a binary logic regression using actual loan origination data. We use this loan model to estimate the probability of farm loan default by (6) dairy regions – 1996 - 2015, conditioning on capital debt repayment capacity (CRDC), solvency (equity to assets percentage), liquidity (working capital percentage), and on the presence or absence of off-farm income and employment. Results of this analysis provides insights into which dairy farms may be under financial stress and whether those dairy farms have common characteristics.

Using these farm-level ARMS data, we calculated working capital percentage, equity to assets, and debt repayment for U.S. dairy farms and calculated the probability of loan default,
by year, region (6), farm size, and by the farm's dependency on off-farm income.

(1) $Ln(probability\ of\ default/[1\text{-}probability\ of\ default]) = \beta 0 + \beta 1(Repayment\ Capacity\ Percentage) + \beta 2(Owner\ Equity\ Percentage) + \beta 3(Working\ Capital\ Percentage)$

where probability of default prob = $(e^{XB})/(1 + e^{XB})$. These probabilities of default are then expressed in the model as both a numeric ranking and as a rating from alphabetic rating from AA+ to C (Appendix Table 1).

Empirical Results

Summary Statistics

We first present summary statistics (selected financial measures) for U.S. dairy farms, by region, 2010 and 2015 (Table 2, Appendix). These overall statistics suggest that dairy farm capital structure varies across these 6 regions, as well as the average cost of debt (interest expenses/farm business debt). Also the Critical ROA is a measure which reveals information on how both the debt-asset ratio and the cost of debt jointly affect dairy farm financial performance. Turvey (2011) notes that farms with a critical ROA is the minimal ROA required to meet interest expenses on debt (i.e., ROE=0). Therefore, a critical ROA of 1.00 is the “break even” point (Appendix Table 2).

Probabilities of farm loan default with and without off-farm income

We use the KMV model to estimate the distributions of *prob* for farms with and without off-farm income: means, medians, standard errors, and lower and upper quartiles. In 2010, 2012, and 2015, mean and medium values of *prob* for dairy farms without off-farm income exceeded those dairy farms with off-farm income (Appendix Table 3.)

For dairy farms with off-farm income, when we controlled for farm size (small farms vs. large farms), for 2010-2014, large dairy farms had higher mean values of prob than small dairy farms. However, in 2015, small dairy farms had a higher probability of loan default than large dairy farms (Appendix Table 4). For dairy farms without off-farm income, large dairy farms had higher probabilities of default for all years, 2010-2015 (Appendix Table 5).

Figures 1 – 6 show the frequency distribution of Moody's KMV ratings by dairy regions, 2010-2015. Generally speaking, dairy farms in the ***Northeast*** (VT_NY) and in the ***Lake States*** (MI_MN_WI) had the strongest ratings, while those in the ***Corn Belt*** (IL, IN, IA and OH), ***Southern Plains*** (TX), Mountain States (CO, ID, NM, and UT), and the ***Pacific*** (CA) had relatively more dairy farms in the lower ratings categories. The year 2012 was an exception with a relatively higher percentage of dairy farms in all regions grouped between B, B+ and BB+, BB-.

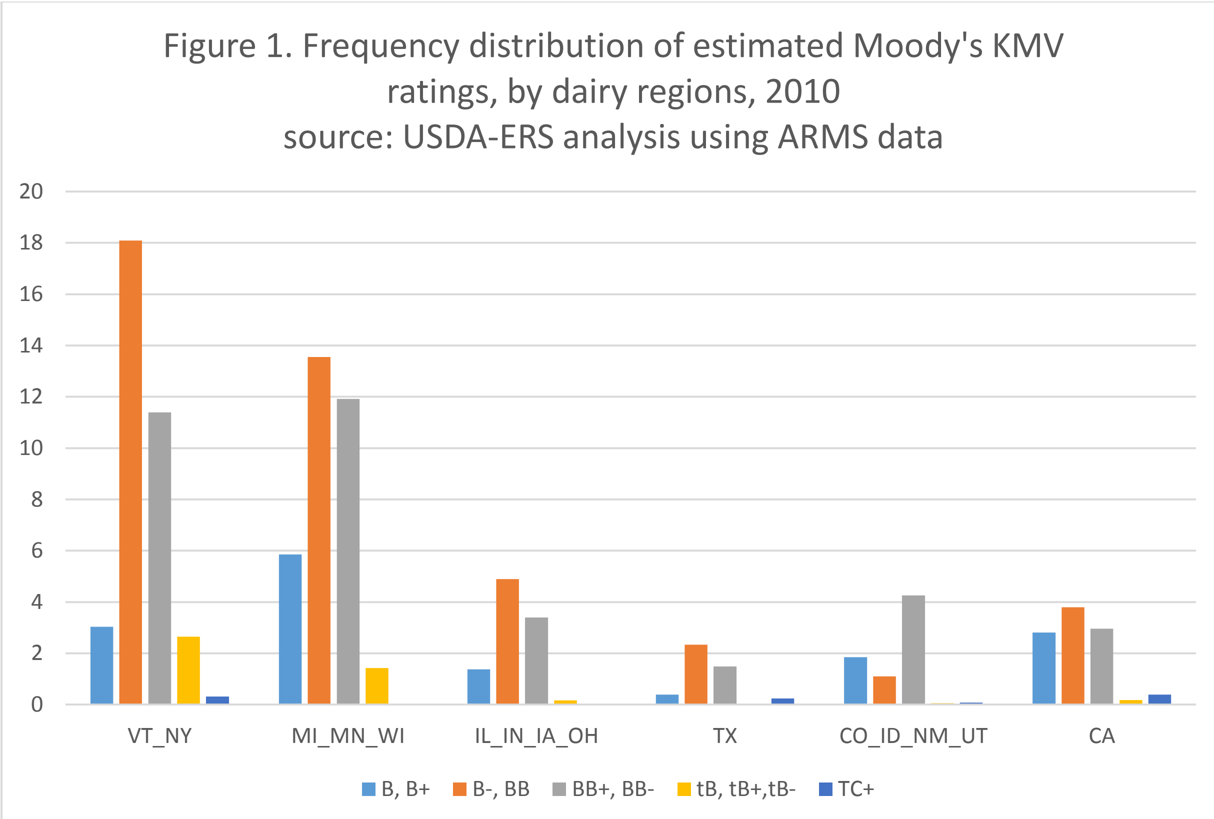


Figure 1. Frequency distribution of estimated Moody's KMV ratings, by dairy regions, 2010
source: USDA-ERS analysis using ARMS data
20
18
16
14
12
10
8
6
4
2
0
VT_NY
MI_MN_WI
IL_IN_IA_OH
TX
CO_ID_NM_UT
CA
B, B+
B-, BB
BB+, BB-
tB, tB+,tB-
TC+

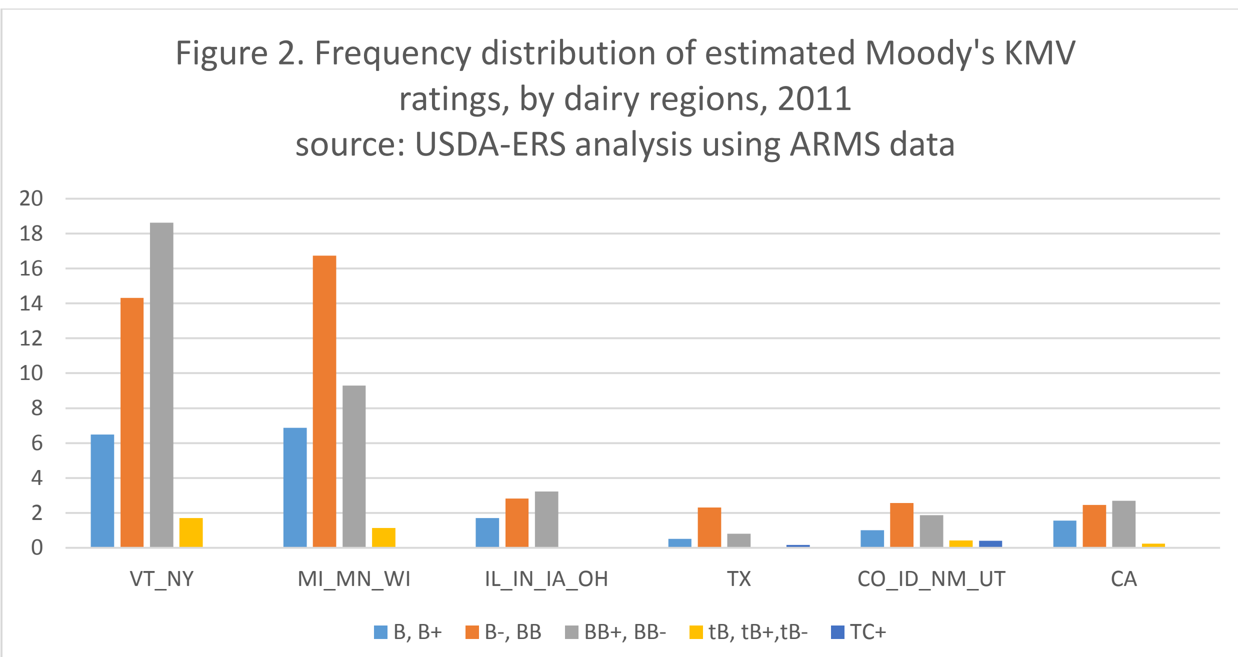


Figure 2. Frequency distribution of estimated Moody's KMV ratings, by dairy regions, 2011
source: USDA-ERS analysis using ARMS data
20
18
16
14
12
10
8
6
4
2
0
VT_NY
MI_MN_WI
IL_IN_IA_OH
TX
CO_ID_NM_UT
CA
B, B+
B-, BB
BB+, BB-
tB, tB+,tB-
TC+

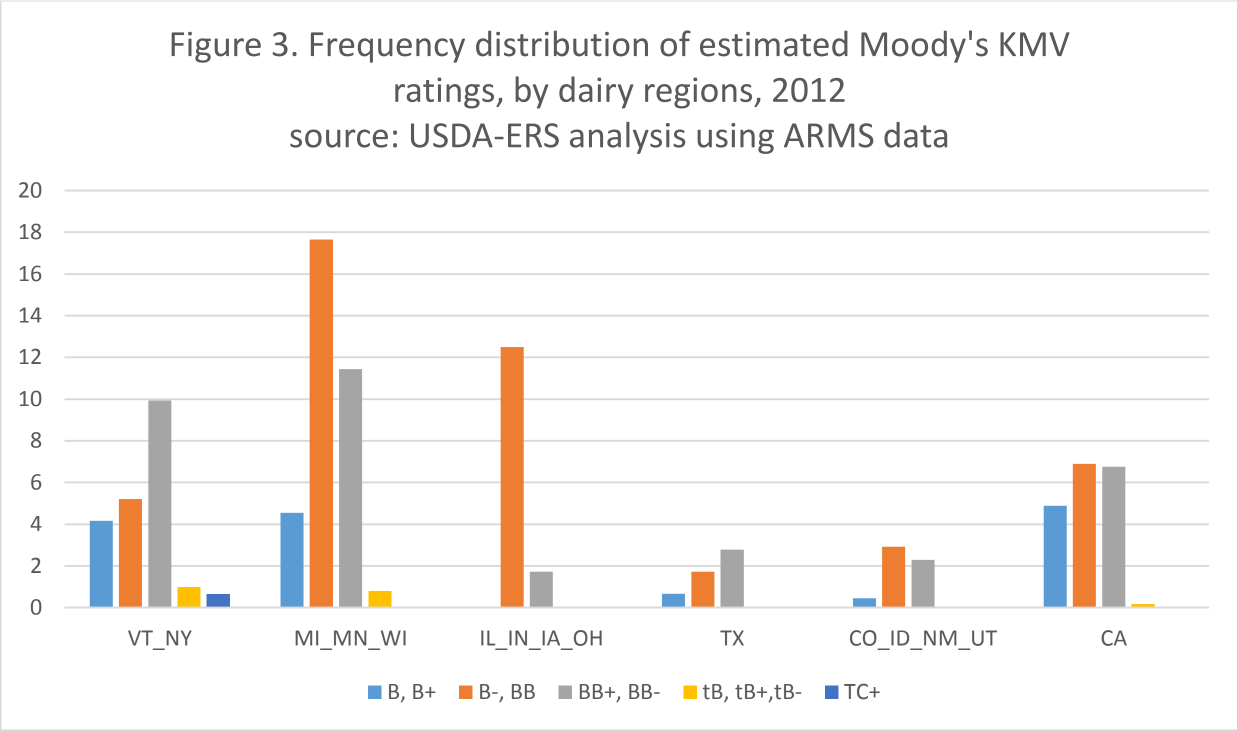


Figure 3. Frequency distribution of estimated Moody's KMV ratings, by dairy regions, 2012
source: USDA-ERS analysis using ARMS data
20
18
16
14
12
10
8
6
4
2
0
VT_NY
MI_MN_WI
IL_IN_IA_OH
TX
CO_ID_NM_UT
CA
B, B+
B-, BB
BB+, BB-
tB, tB+,tB-
TC+

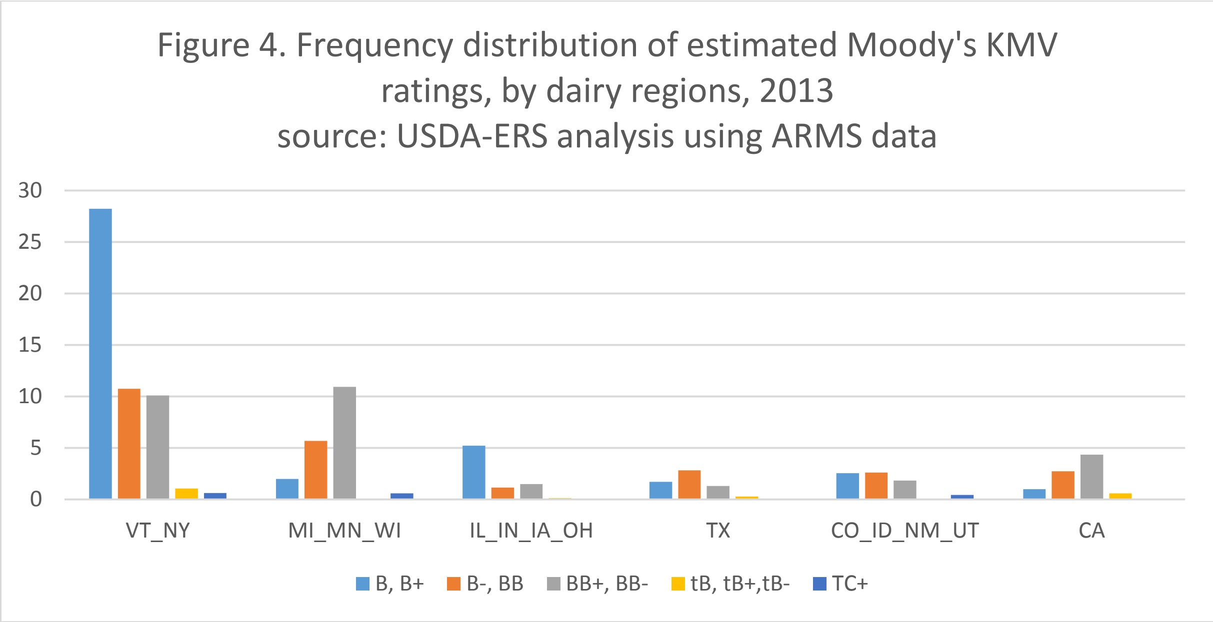
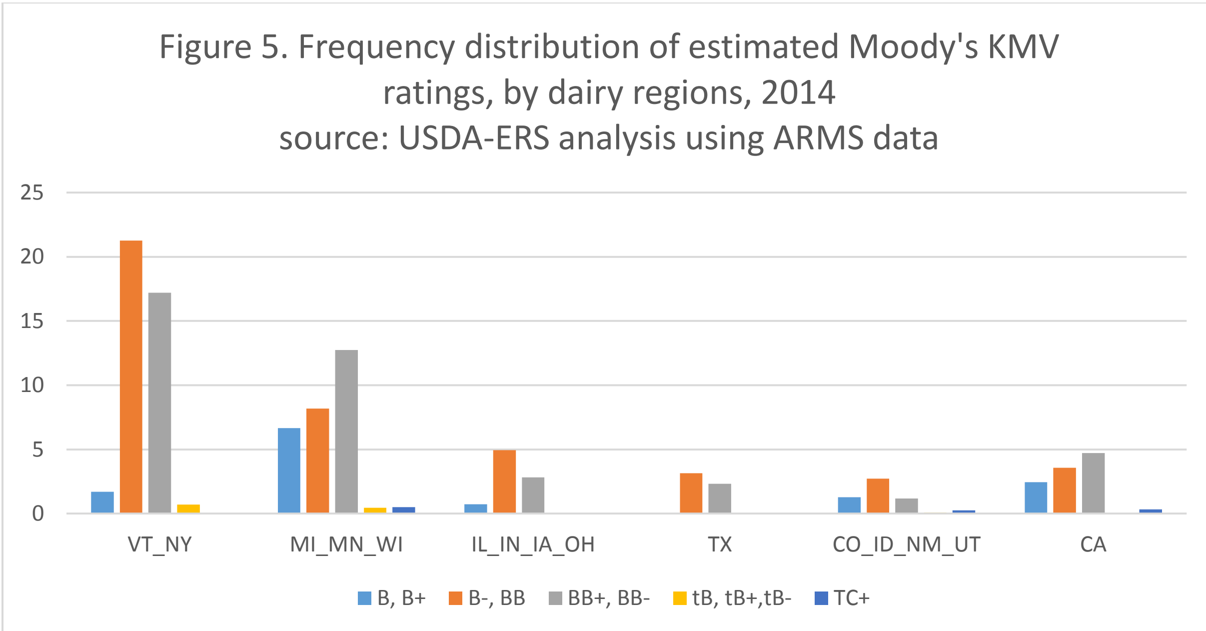
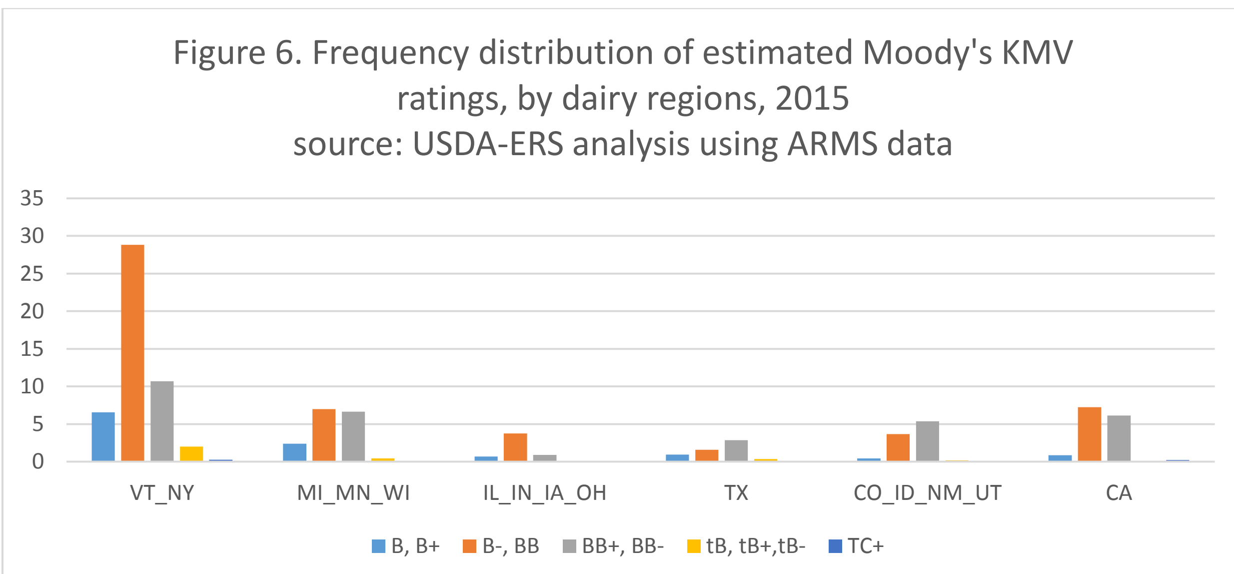


Figure 4. Frequency distribution of estimated Moody's KMV ratings, by dairy regions, 2013
source: USDA-ERS analysis using ARMS data
30
25
20
15
10
5
0
VT_NY
MI_MN_WI
IL_IN_IA_OH
TX
CO_ID_NM_UT
CA
B, B+
B-, BB
BB+, BB-
tB, tB+,tB-
TC+





Summary and Implications for Risk Management in U.S. Dairy Production

This study uses a synthetic credit model to examine how off-farm income could affect the capital structure and financial strength of U.S. dairy farms. The credit model produces estimated credit ratings similar to the well-known benchmark Standard and Poor's (S&P) credit ratings.

We have examined the probability how the probability of loan default has varied by off-farm income dependency: with mean, median, standard errors, and by quantiles, and by years.

Our main conclusions are: (1) ceteris paribus, dairy farms with off-farm income had lower estimated probabilities of farm loan default then those without off-farm income, (2) these probabilities of loan default vary across dairy regions and over time, (3) dairy farms with off-farm income tended to have higher debt-asset ratios than those without off-farm income as the off-farm income can serve as a hedge and thus diversify business risks, and (4), other metrics of financial performance such as the Critical ROA also help to understand how the cost of debt and the capital structure (debt-to-asset ratio) jointly interact to affect probabilities of loan default.

This study "benchmarks" dairy farm financial performance across 1996 - 2015. Therefore, our results help us understand the extent to which off-farm income is useful as a risk management strategy.

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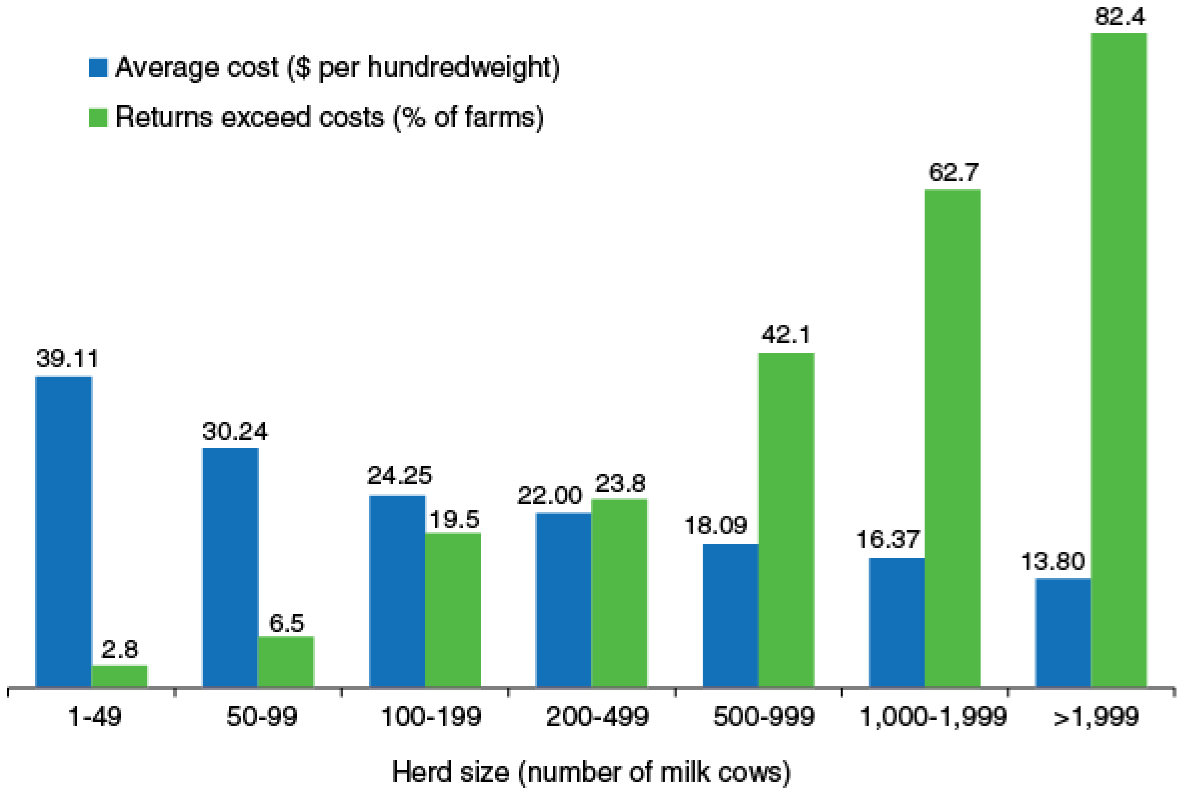
Appendix

Figure 1.
On average, larger dairy farms realize lower costs and higher profits



Source: USDA, Economic Research Service using USDA, National Agricultural Statistics Service, Agricultural Resource Management Survey (ARMS).

Table 1. Calculated probabilities of loan default (prob) and Moody's AAA ratings

Probability of loan default (prob)	Moody's AAA ratings
< 0.020 and <= 0.030	AA+
< 0.030 and <= 0.040	AA
< 0.040 and <= 0.050	AA-
< 0.050 and <= 0.070	A+
< 0.070 and <= 0.090	A
< 0.090 and <= 0.140	A-
< 0.140 and <= 0.210	tB+
< 0.210 and <= 0.310	tB
< 0.310 and <= 0.520	tB-
< 0.520 and <= 0.860	BB+
< 0.860 and <= 1.43	BB
< 01.43 and <= 2.03	BB-
< 02.03 and <= 2.88	B+
< 2.88 and <= 4.090	B
< 4.09 and <= 6.940	B-
< 6.94 and <= 11.780	tC+
< 11.78 and <= 14.000	tC
< 14.00 and <= 16.700	tC-
< 17.00 and <= 18.250	CC
< 18.25	C

Estimated using *Ln(probability of default/[1-probability of default]) = β0 + β1(Repayment Capacity Percentage)+ β2(Owner Equity Percentage)+ β3(Working Capital Percentage)* where probability of default prob = $(e^{XB})/(1 + e^{XB})$.

Table 2. Selected financial measures: U.S. dairy farms, by regions, 2010 and 2015

Dairy region	Year	Debt-asset ratio	Cost of Debt	Critical ROA
VT, NY	2010	0.17	4.78	0.89
	2015	0.17	5.06	1.09
MI, MN, WI	2010	0.20	5.38	1.25
	2015	0.22	4.85	1.14
IL, IN, IA, OH	2010	0.17	4.94	0.86
	2015	0.21	3.65	0.82
TX	2010	0.23	6.51	1.56
	2015	0.23	3.63	1.14
CO, ID, NM,UT	2010	0.24	5.01	1.39
	2015	0.15	5.29	1.91
CA	2010	0.34	4.82	1.93
	2015	0.14	3.15	0.81

Source: USDA, ARMS data, 2010 and 2015, Phase 3

[1]Critical ROA = average interest rate on farm debt x debt-asset ratio.

Table 3. Probability of default (prob) U.S. dairy farms with and without off-farm income					
U.S. dairy farms with off-farm income					
Year	Mean	Median	Std error	Lower Quartile	Upper Quartile
2010	1.44	1.17	0.04	0.88	1.67
2011	1.36	1.08	0.06	0.92	1.75
2012	1.57	1.27	0.08	0.95	1.81
2013	1.70	1.30	0.10	0.97	2.15
2014	1.64	1.27	0.09	1.01	1.93
2015	1.36	1.14	0.06	1.03	1.56
U.S. dairy farms without off-farm income					
2010	1.60	1.32	0.16	0.99	1.85
2011	1.21	1.00	0.17	0.62	1.16
2012	2.14	1.63	0.35	1.21	2.25
2013	1.34	1.17	0.23	0.56	2.11
2014	1.37	1.33	1.98	1.04	1.65
2015	1.61	1.86	0.14	1.42	1.86
Source: USDA Phase 3 ARMS Survey, 2010-2015					

Table 3. Probability of default: all dairy farms with off-farm income, by farm size					
U.S. dairy farms with off-farm income: small farms					
Year	Mean	Median	Std error	Lower Quartile	Upper Quartile
2010	1.32	1.09	0.04	0.85	1.52
2011	1.27	1.057	0.07	0.74	1.52
2012	1.45	1.17	0.12	0.73	1.65
2013	1.59	1.29	0.11	0.92	1.79
2014	1.41	1.12	0.11	0.94	1.68
2015	1.38	1.15	0.08	1.05	1.55
U.S. dairy farms with off-farm income: large farms					
2010	2.02	1.70	0.09	1.22	2.39
2011	1.79	1.55	0.11	1.04	2.20
2012	1.79	1.43	0.11	1.14	1.96
2013	1.91	1.44	0.17	0.99	2.17
2014	1.92	1.55	0.15	1.13	2.12
2015	1.27	1.03	0.10	0.75	1.56
Source: USDA Phase 3 ARMS Survey, 2010-2015					

Table 4. Probability of default: all dairy farms without off-farm income, by farm size					
U.S. dairy farms without off-farm income: small farms					
	Mean	Median	Std error	Lower Quartile	Upper Quartile
2010	1.32	1.31	0.11	1.00	1.51
2011	0.97	1.00	0.04	0.91	1.00
2012	n.a.	n.a.	n.a.	n.a.	n.a.
2013	0.81	0.61	0.14	0.58	1.19
2014	n.a.	n.a.	n.a.	n.a.	n.a.
2015	n.a.	n.a.	n.a.	n.a.	n.a.
U.S. dairy farms without off-farm income: large farms					
2010	1.73	1.43	0.21	0.94	1.88
2011	1.29	1.02	0.21	0.60	1.75
2012	2.15	1.63	0.34	1.21	2.25
2013	1.66	1.76	0.31	0.56	2.11
2014	1.53	1.61	0.11	1.20	2.12
2015	1.61	1.85	0.15	1.42	1.85
Source: USDA Phase 3 ARMS Survey, 2010-2015					