Confirmatory Factor Analysis of Farm Size and Performance

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Introduction

• 2007 Census of Agriculture reported that 8% of the principal farm operations surveyed were under the age of 35. It is estimated that by 2012, 51% of the principal farm operators will be over the age of 65.

• **What does this mean for production agriculture?**
  *New and beginning farmers will be managing one or more of the farms exiting the industry. This may lead to increased farm size, but may also play a role in farm performance.

•**How do we measure farm size and performance?**
  *Agricultural Economics literature uses farm size to define the farm life cycle as the following, but does not specify the measures to define "farm size":
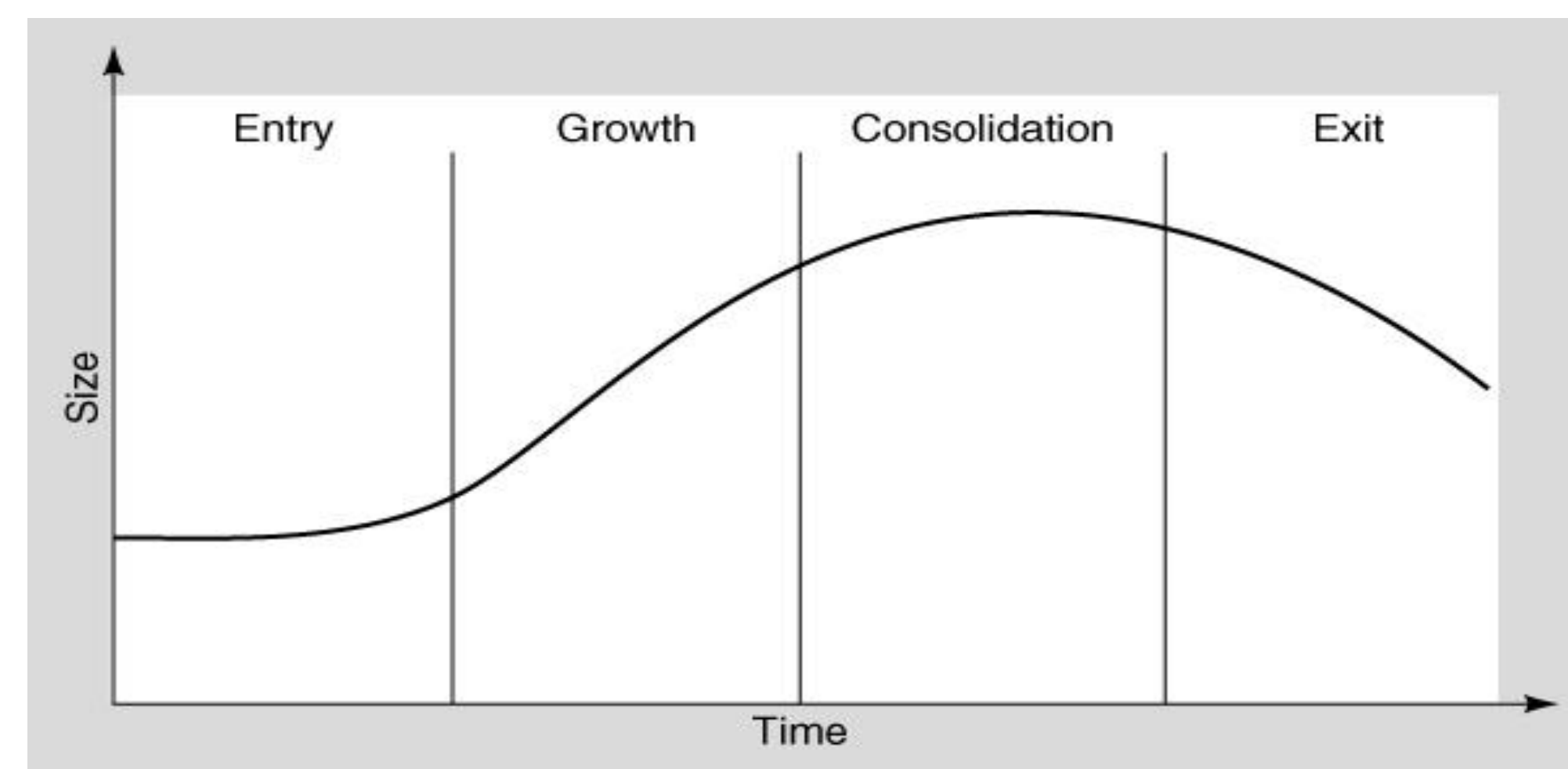
Kay, Edwards, and Duffy. Farm Management, 2008).

•Rather than using one indicator to define "farm size" a combination of size indicators may be more appropriate and provide a more accurate estimation of the farm business life cycle. Secondly, "farm performance" may also provide a source for defining the farm business life cycle.
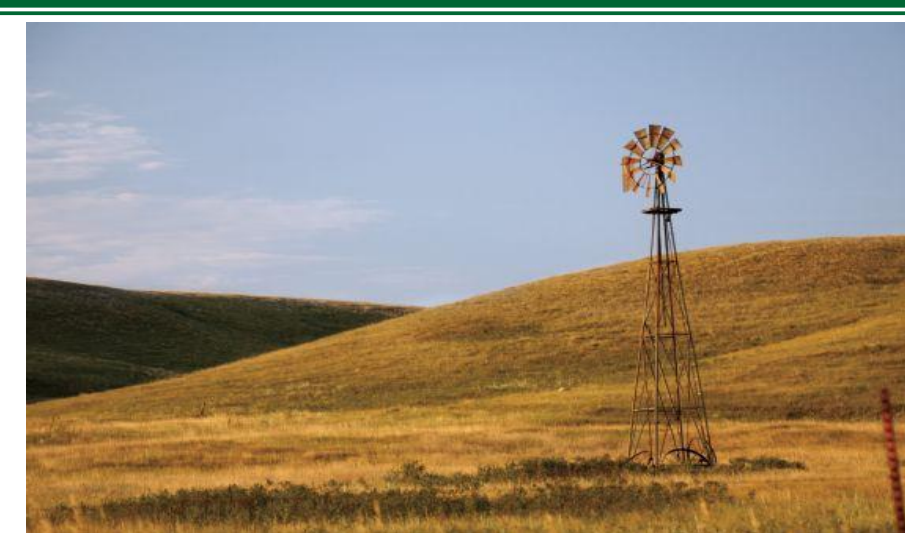
• Understanding the indicators defining "farm size" and "farm performance" and the relationship between them will lay the foundation for estimating and further analyzing the farm business life cycle.

Research Objective

• Determine the set of underlying indicators that define "farm size" and "farm performance"

Methods

• Confirmatory Factor Analysis (CFA)

•**What is CFA?**
  → **Type of SEM estimation**

  → **Researcher defines the relationship between indicator variables based upon theoretical justification and tests how well the relationships assumed in the model reproduces the observed relationships in the data.**

  → **Estimates factor loadings (statistical estimates of direct effects) to determine the explanatory power of individual indicator variables for the latent variable.**

Path Diagram for Farm Size and Performance Confirmatory Factor Analysis
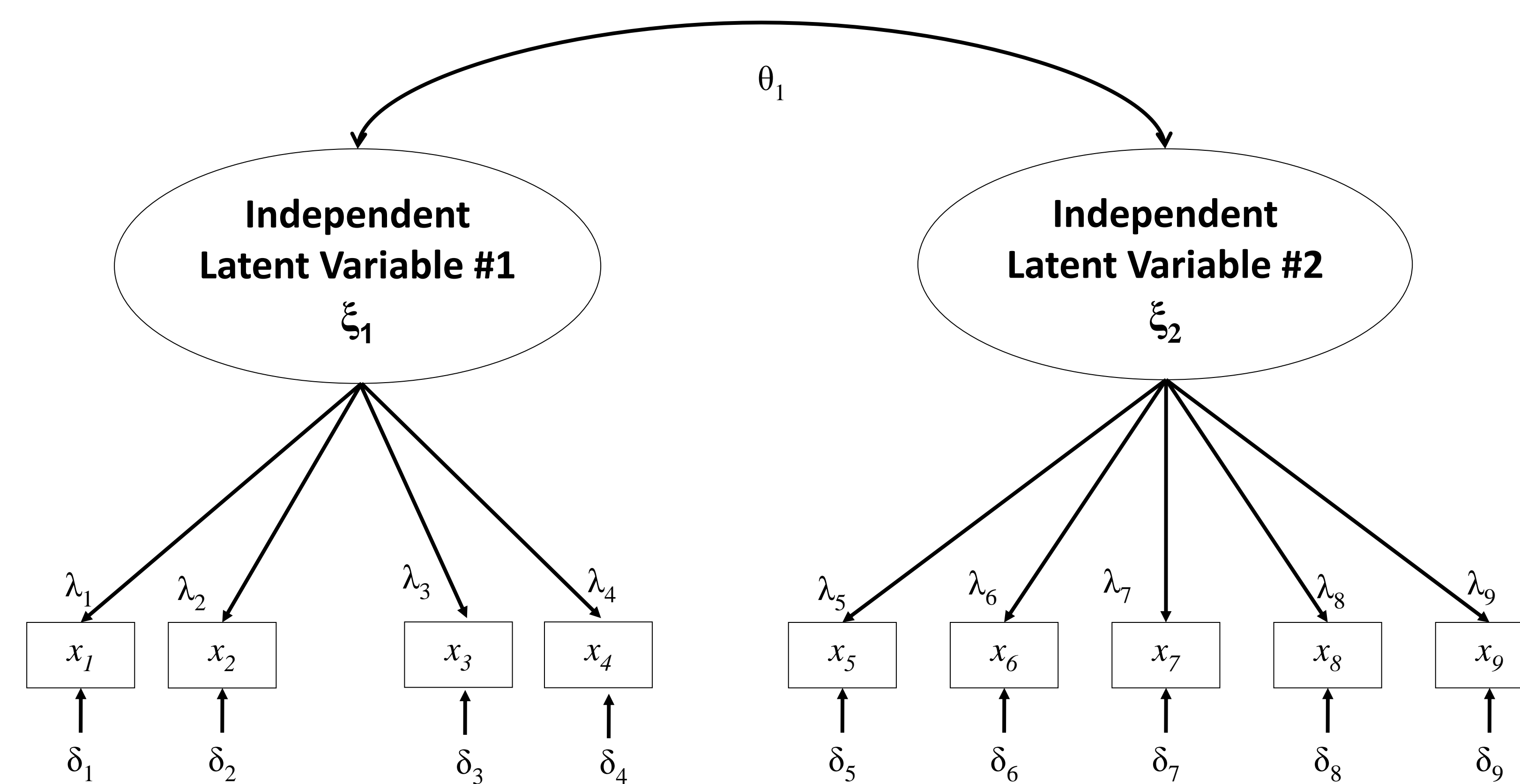
ξ_1 = Farm Size
X_1 = Acres
X_2 = Gross Sales
X_3 = Pounds of Output produced
X_4 = Total Farm Assets

X_1…. X_4 = Size Indicator Variable
λ_1…. λ_4 = Size Factor Loadings
δ_1…. δ_4 = Error Terms

ξ_2 = Farm Performance
X_5 = Operating Expense Ratio
X_6 = Current Ratio
X_7 = Rate of Return on Assets (ROA)
X_8 = Debt-to-Equity Ratio
X_9 = Gross Sales/Labor hours

X_6…. X_9 = Performance Indicator Variables
λ_6…. λ_9 = Performance Factor Loadings
δ_6…. δ_9 = Error Terms
θ_1 = Correlation term between farm size and performance

Data/Summary Statistics

Size Indicator	Symbol	2008 Average	2008 Std. Dev.	2009 Average	2009 Std. Dev.
Acres	X_1	2,589	2,167	2,522	2,143
Gross Sales	X_2	607.623	581,739	559,739	544,680
Pounds Output produced	X_3	4,647,770	5,873,148	4,808,542	5,532,919
Farm Assets	X_4	1,305,773	1,248,256	1,545,789	1,508,008
Performance Indicators					
Operating Expense Ratio	X_5	0.89	0.40	0.92	0.35
Current Ratio	X_6	3.75	7.58	4.12	15.02
ROA	X_7	13.22	15.81	6.32	11.09
Debt-equity ratio	X_8	1.26	1.89	1.39	2.15
Gross Sales/Labor Hours	X_9	206.48	132.18	107.29	68.33

• 2008 & 2009 Farm Financial and demographic data collected, 532 North Dakota Farms, 270 Crop Farms, 262 Crop & Livestock Farms

Graphical Summary
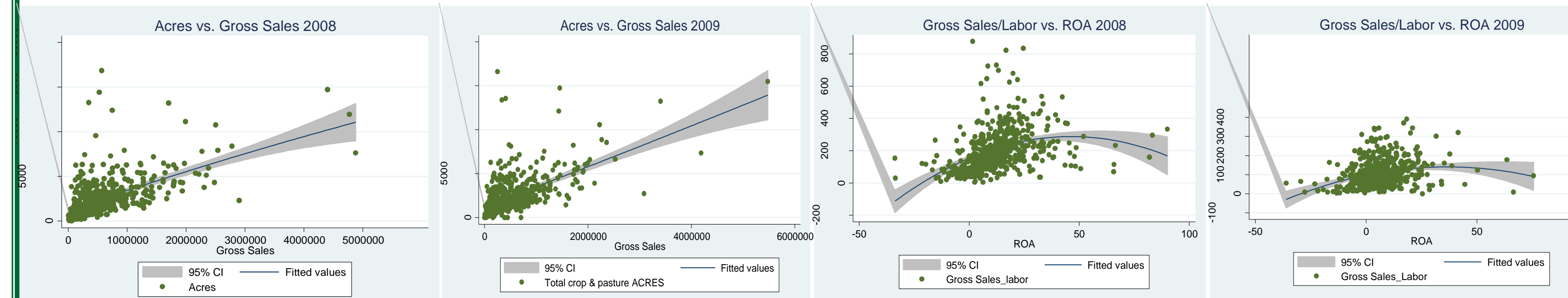
•The graphical summary depicts the relationship between selected indicators of farm size and farm performance for the 2008 and 2009 data sets. The relationships are similar but the magnitudes differ between 2008 and 2009. This suggests that these selected indicators are closely related, but not substitutes for each other.

Factor Loadings

Size Indicators	2008 Factor Loadings	2008 P-value	2009 Factor Loadings	2009 P-value
Acres	0.57	0.0000	0.59	0.0000
Gross Sales	0.99	0.0000	0.98	0.0000
Pounds of Output produced	0.79	0.0000	0.80	0.0000
Farm Assets	0.86	0.0000	0.86	0.0000
Performance Indicators				
Operating Expense Ratio	-0.35	0.0000	-0.38	0.0000
Current Ratio	0.16	0.0016	0.11	0.0173
ROA	0.41	0.0000	0.27	0.0000
Debt-equity ratio	-0.24	0.0000	-0.21	0.0000
Gross Sales/Labor Hours	0.82	0.0000	0.94	0.0000
θ_1 **(Correlation term)**	**0.64**	**0.0000**	**0.73**	**0.0000**

Goodness of Fit	Statistic	Fit	Statistic	Fit
RMSEA	0.1226	Moderate	0.1348	Moderate
NFI	0.8807	Good	0.8688	Good
CFI	0.8915	Good	0.8786	Good
TLI	0.8122	Moderate	0.7899	Moderate

Results

• A set of statistically significant indicators define farm size and performance, rather than just one indicator. The set of indicators provide a more complete measure of size and performance.

•Estimated factor loadings for farm size and performance are similar from 2008 to 2009 even though returns varied greatly between the two years. Therefore, indicators are measuring multiple dimensions of the latent variables consistently.

• *Gross Sales* and *Farm Assets* are the strongest indicators of farm size. *Acres* is statistically significant, but the weakest indicator for farm size. This is surprising since acres are typically the "standard" for measuring farm size.

•*Gross sales/labor hour* is the strongest indicator of farm performance emphasizing the importance of labor efficiency. Asset management as measured by the *ROA* is the second strongest indicator of farm performance.

•As hypothesized, there is a negative relationship between farm performance and the operating expense ratio and debt-to-equity ratio.

•Correlation between farm size and farm performance is positive and significant. This indicates that both factors must be considered jointly in order to appropriately estimate the farm business life cycle.

Further Considerations

• Results from CFA will be used to estimate the farm business life cycle over time.

•Up to 15 years of consecutive data is available for ND farms.
  → Provide estimation of farm business life cycle over time considering the correlation between farm size and performance.
  → Evaluate how farm business life cycle differs by livestock enterprises grown, farm tenure, and location.