

**Optimal Fertilizer Warehousing and Distribution for Farm Supply Cooperatives**

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**Background**

- Demand for nitrogenous fertilizers in the U.S. has been mainly satisfied by domestic producers of anhydrous ammonia ( $\text{NH}_3$ )
- Manufacturing is shifting overseas due to differential production costs: imports grew from 21% in 1999 to 42% in 2002
- U.S. mainly imports dry forms because infrastructure to off-load and transport  $\text{NH}_3$  is limited
- Increased farm size has also promoted the use dry and liquid forms that are applied using large-scale machinery
- Security and environmental concerns related to the use of  $\text{NH}_3$  have also contributed to the shift
- Most coops have coordinated businesses and are attempting to consolidate their systems of multiple warehouses
- Shift in product forms and the tradeoff between economies of size in storage and increased warehouse-to-field fleet time and cost make the assessment difficult

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**Objectives**

- Identify the major cost components of warehousing and distribution and product margins and fees needed to cover costs
- Determine the optimal level of warehouse centralization and equipment complement

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### The Data

- Fertilizer information: From 7 service regions of an Oklahoma farm supply cooperative
- Warehouse and equipment costs and capacity information: From equipment manufacturers and warehouse constructors
- Additional data: From historic and market records

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### Procedure

- Costs for liquid and dry applicators were estimated following the American Society of Agricultural Engineers (ASAE) machinery standards
- Costs for  $\text{NH}_3$  applicators were estimated using historic values
- Fertilizer Transportation costs were calculated using distances and commercial freight rates or tender truck costs
- Machinery capacities were adjusted to account for breakdown probabilities and travel times to-and-from fields
- Warehouse values were depreciated over 40 years using straight line-method, other warehouse costs were calculated as percentages of warehouse construction values
- Scenario evaluations and sensitivity analysis were used to assess the feasibility of the optimal warehousing and application system

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### Models

- Modeled four distinct application systems to select warehouse configuration and application fleet that minimize total cost
- Alternative fertilizer application systems
  - Base: Fall applications of  $\text{P}_2\text{O}_5$  and  $\text{NH}_3$ , and spring application of UAN
  - Model #2: Fall applications of  $\text{P}_2\text{O}_5$  and Urea, and Spring application of UAN
    - To assess effects of eliminating  $\text{NH}_3$  in the supply chain
  - Model #3: Fall applications of  $\text{P}_2\text{O}_5$  and Urea
    - To assess effects of eliminating  $\text{NH}_3$  and UAN in the supply chain
  - Model #4: Fall applications of  $\text{P}_2\text{O}_5$  and spring application of UAN
    - To assess effects of applying little N in fall and supplementing it through top dressed UAN

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**#2: Optimal level of warehouse centralization and equipment complement**

Model results indicated partial but not complete centralization of fertilizer warehousing and application

**Comparison of transportation, application and equipment ownership costs for partially centralized and non-centralized business operations**

Model Description	Costs (\$)	
	Partial-Centralization	Non-Centralized
Base-line model	1,670,064.31 (7.96)	1,849,129.65 (8.81)
Model 2	1,799,818.97 (8.57)	2,136,563.19 (10.18)
Model 3	1,100,448.80 (5.24)	1,345,424.42 (6.41)
Model 4	1,929,317.68 (9.19)	2,311,713.82 (11.01)

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**The impact of single coordinated warehouse on operating cost**

Model	Costs (\$)			
	Change in Fertilizer Transportation (From Sources to Warehouse)	Change in Fertilizer Transportation (From Warehouses to Fields)	Change in Applicator Ownership Cost	Net Impact on Transportation and Application Cost
Model 2	-11,159.6 (0.05)	+354,953.54 (1.69)	+78,986.42 (0.38)	+422,780.32 (2.01)
Model 3	-6,035.24 (0.03)	+321,600.83 (1.53)	+78,986.41 (0.38)	-394,552.00 (1.88)
Model 4	-60,898.40 (0.29)	+472,432.41 (2.25)	+157,972.83 (0.75)	+569,506.84 (2.71)

- Represents decrease in cost

+ Represents increase in cost

The baseline-model is excluded from this analysis because data on large-scale storage of anhydrous ammonia was not available

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**Comparison of optimal equipment complement with current structure of application equipment**

	Total Number of Applicators		
	Dry	Liquid	NH <sub>3</sub>
Optimal Number	7	10	53
Existing number	8	8	90

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- Partial centralization might reduce per acre costs by \$ 0.85, \$1.61, \$ 1.17, and \$ 1.82 for the baseline-model, model #2, model #3, and model # 4, respectively
- Total consolidation of warehousing was infeasible because increases in warehouse-to-field transportation costs outweigh gains from economies of size in warehousing
- The cooperatives use equipment complement near its engineered capacity. However, the coops have excessive capacity in NH<sub>3</sub> applicators

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**Conclusions**

- Cooperatives' costs did not vary substantially across models
- The major impacts of shift from NH<sub>3</sub> to dry or liquid formulations would be the producers' increased material cost
- The impacts need to be weighted against potential costs and advantages associated with timing of nitrogen application and opportunity costs associated with fertilizer applied to crops that might be damaged by pests or bad weather
- In supply and application of fertilizers, fertilizer transportation and applicator ownership and fleet costs have much impact than warehousing costs
- Cooperatives should carefully evaluate warehouse-to-field transportation costs before consolidating warehouse locations

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