7. Machinery Costs and Efficiency of Field Size and Shape

Kevin Dhuyvetter <kcd@ksu.edu>

Kevin Dhuyvetter assists farmers, landowners, and others throughout Kansas with risk and return assessment of alternative crop and livestock production and marketing systems. He works extensively with land-related issues such as buying and leasing land. Current research projects are looking at factors impacting land values, economics of no-tillage and other crop-related production technologies, the economics of grazing systems, and factors affecting feeder cattle prices and basis, and the economic returns of alternative dairy systems. One of Kevin's trademarks is his development of decision tools that can be used by clientele for helping them with the myriad of decisions they face in their operations.

Terry Kastens

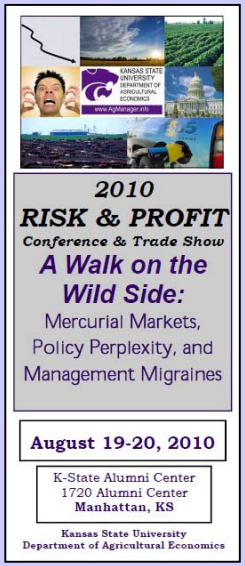
Terry Kastens, now Emeritus Professor, thrives on crunching numbers in innovative ways for the purpose of making more profitable farm management and investment decisions. He routinely works in areas of marketing, precision agriculture, machinery management, soil fertility management, no-till economics, and most importantly, land ownership and leasing. He is especially intrigued by thinking about the future and how farm managers, agribusinesses, and investors can gain from the wisdom of their forbearers yet think differently to position themselves for a profitable future in production agriculture.

Abstract/Summary

Research has consistently shown that the most profitable farms tend to have lower costs than average and one of the areas they differentiate themselves the most is machinery costs. While many factors impact machinery costs, this session will focus on how field size, shape, and distance from farm headquarters impact machinery costs. While these factors may not be able to be explicitly managed to lower costs, it is important to know their impact when thinking about renting or buying additional land.

Kansas State UNIVERSITY

Department of Agricultural Economics



Machinery Costs –

The impact of field size, shape, and distance

Kevin C. Dhuyvetter
kcd@ksu.edu – 785-532-3527

Terry L. Kastens, Emeritus

Department of Ag Economics
Kansas State University
www.agmanager.info

AG MANAGER.INFO
Kansas State Research & Extension
www.agmanager.info

Kansas State UNIVERSITY

Department of Agricultural Economics

Motivation

- **As operations continue to expand and consolidate, producers will routinely be looking at land farther away from their home base. While this is a complex issue, quantifying as many factors as possible will help ensure producers make good management decisions (e.g., how much they can bid for varying land acquisition opportunities).**

Machinery decision-tools available from KSU…

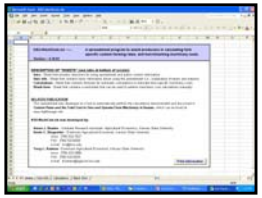
www.AgManager.info

OwnCombine.xls

KSU-GPSguidance.xls

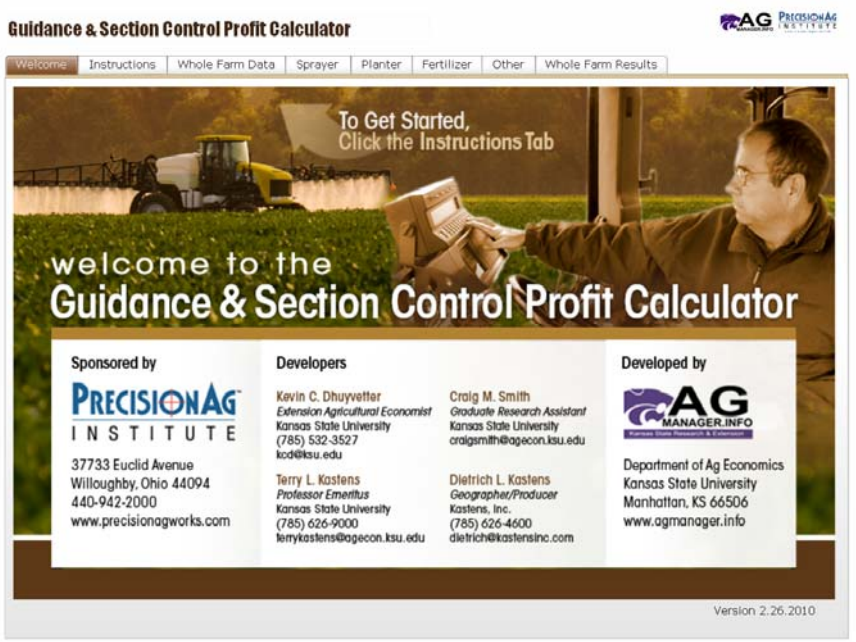
OwnBaler.xls

OwnSprayer.xls



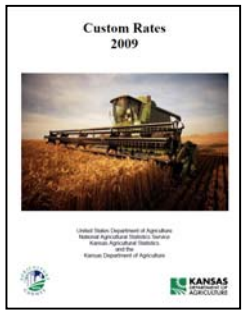
KSU-MachCost.xls

OwnTractor.xls



Machinery cost categories

- Repair and maintenance
- Labor
- Depreciation (market, not tax depreciation)
- Interest (opportunity interest)
- Fuel and lubrication
- Taxes, insurance, and shelter
- **Custom hire – a reasonable proxy for average machinery cost**

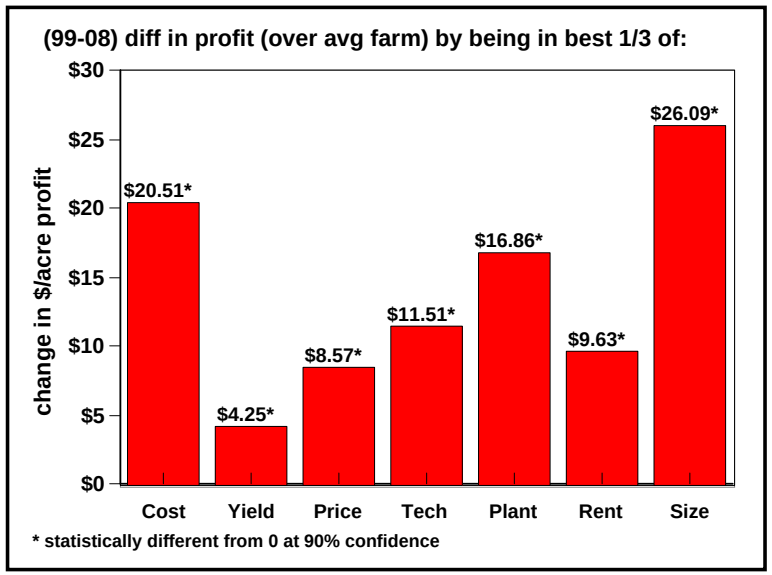


Kansas State UNIVERSITY
Department of Agricultural Economics

Key drivers of profitability differences among producers…

- Costs
- Technology adoption
- Farm size

Factors impacting profitability differences…



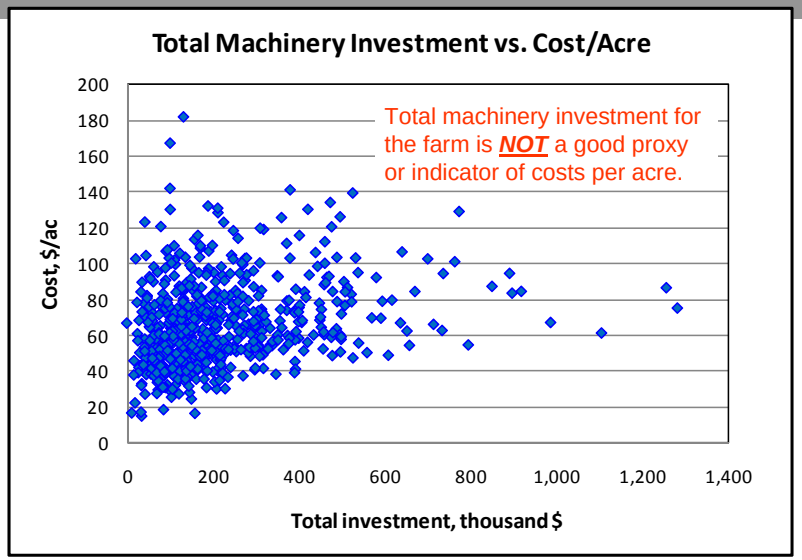
Kansas State UNIVERSITY
Department of Agricultural Economics

Key drivers of profitability differences among producers…

- Costs
- Technology adoption
- Farm size

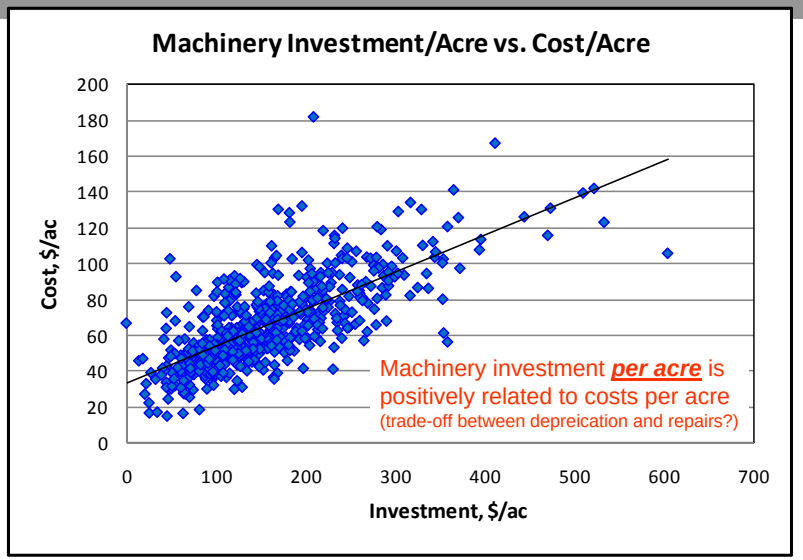
…machinery investment and costs are directly related to these three factors.

Machinery investment is not the same as machinery cost



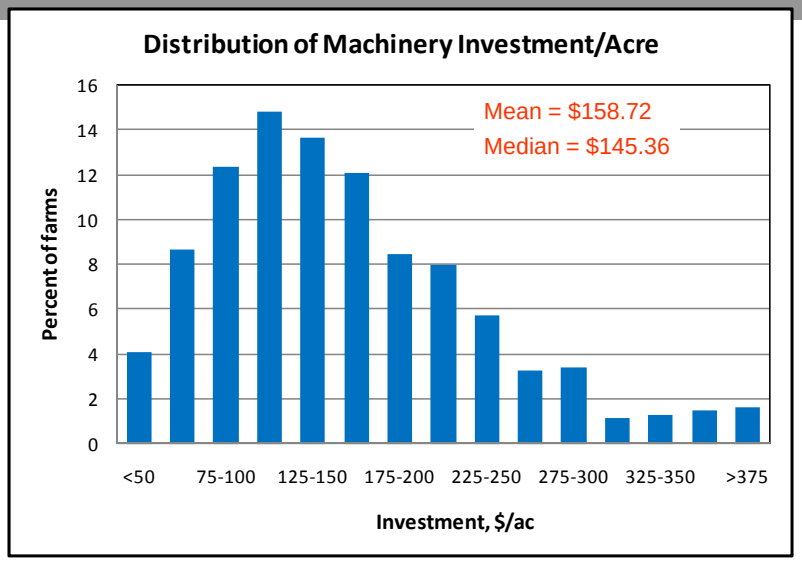
Source: KFMA non-irrigated crop farms having continuous data from 2005-2009
(minimum of 160 acres and machinery cost/acre > $10/ac; costs do not include labor – total of 614 farms)

It is important to use assets efficiently…



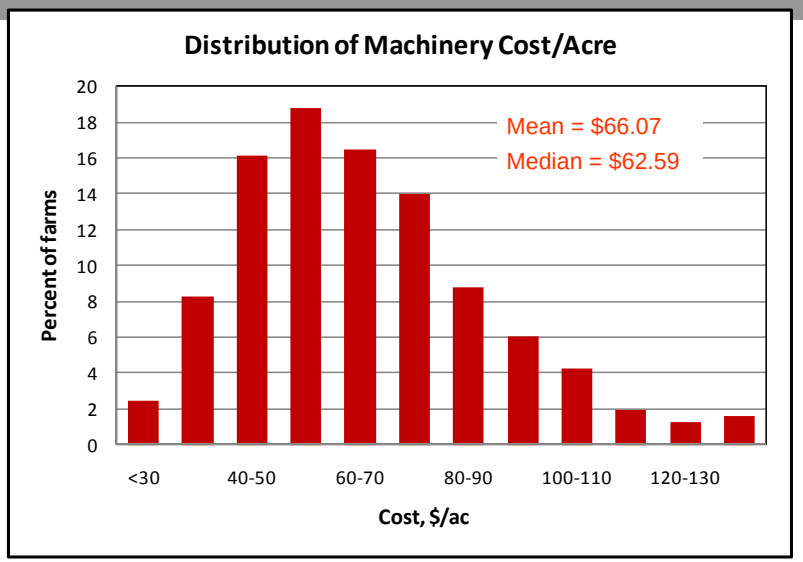
Source: KFMA non-irrigated crop farms having continuous data from 2005-2009
(minimum of 160 acres and machinery cost/acre > $10/ac; costs do not include labor – total of 614 farms)

Machinery investment/acre varies across producers…



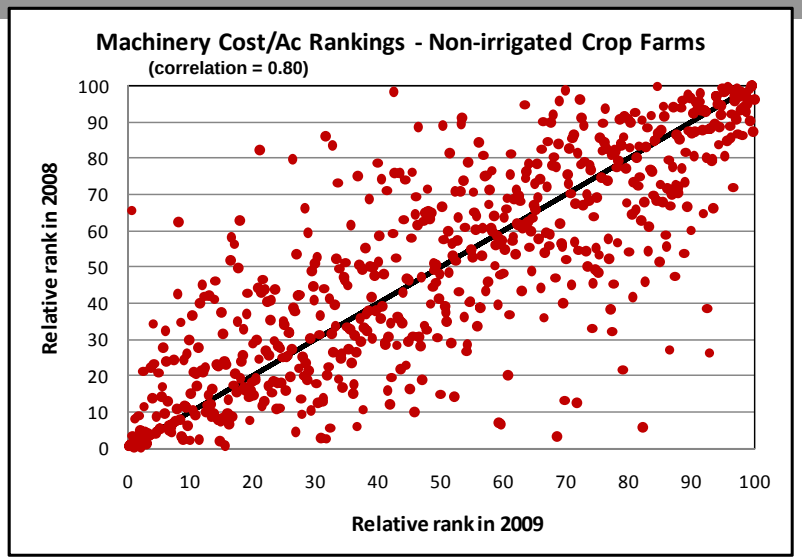
Source: KFMA non-irrigated crop farms having continuous data from 2005-2009
(minimum of 160 acres and machinery cost/acre > $10/ac; costs do not include labor – total of 614 farms)

Hence, machinery cost varies across producers…



Source: KFMA non-irrigated crop farms having continuous data from 2005-2009
(minimum of 160 acres and machinery cost/acre > $10/ac; costs do not include labor – total of 614 farms)

Machinery costs per acre are fairly persistent…

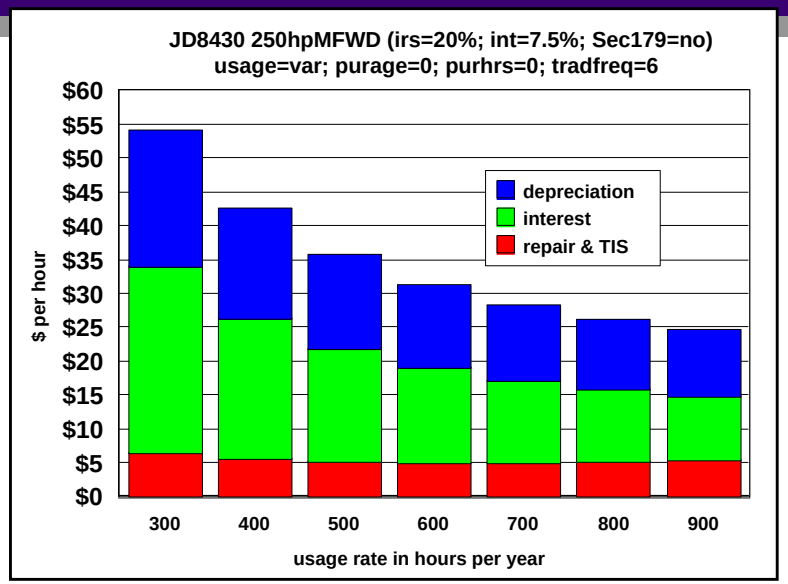


Source: KFMA non-irrigated crop farms having continuous data from 2005-2009
(minimum of 160 acres and machinery cost/acre > $10/ac – total of 614 farms)

Kansas State UNIVERSITY
Department of Agricultural Economics

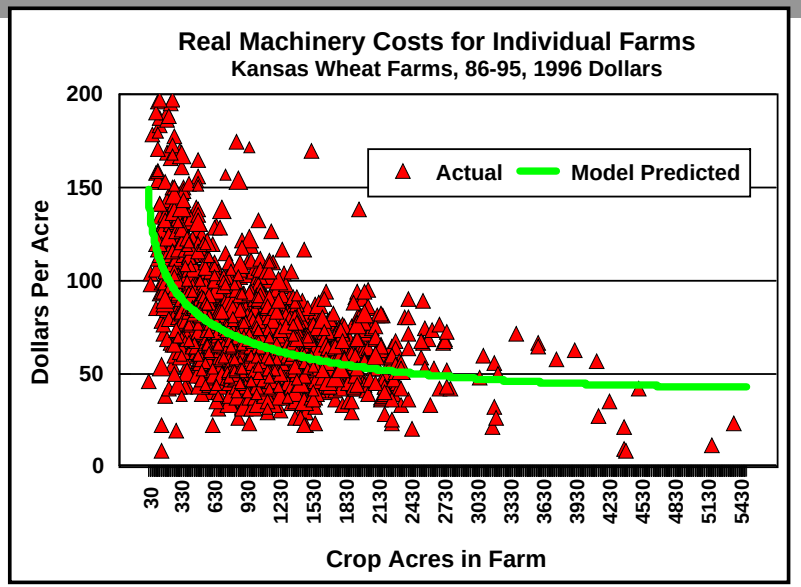
Hard to beat intensity of use as a cost reducer…

Results from *OwnTractor.xls*



Not a trading strategy, but putting more hours on per year really pays off

Machinery costs fall as more acres are farmed…



Kansas State UNIVERSITY

Department of Agricultural Economics

Hard to beat machinery size as a cost reducer… at least historically

Machinery size issues…

- Large equipment requires major investment
  - investment is not the same as cost
  - ability to use capacity is critical
- *Per acre*, larger machines require
  - similar or a bit lower investment
  - much lower labor costs (the big driver)
- But, since field size has not kept up with machine size, per acre, larger machines:
  - require more road time (reduces efficiency)
  - have more headland overlap (reduces efficiency)

Kansas State UNIVERSITY

Department of Agricultural Economics

Impact of field size on machinery and input costs

Analysis based on *KSU-GPSguidance.xls*

(similar values could be derived from *GuidanceSectionControlProfitCalculator.xls*)

Field size & shape are basically headland issues

- Headlands cause economic problems:
  - Increase cost of machine operations
    - Doubling up of machine operations
    - Machines need to slow down for turnaround
  - Increase crop input costs due to doubling up
  - Double-planting, -applying, -tilling, and extra compaction can reduce crop yield, thus revenue
- Portion of field covered by headlands:
  - Affects *costs* and *revenues*
  - Greatly affected by field size and shape
  - Especially affected by width of machine

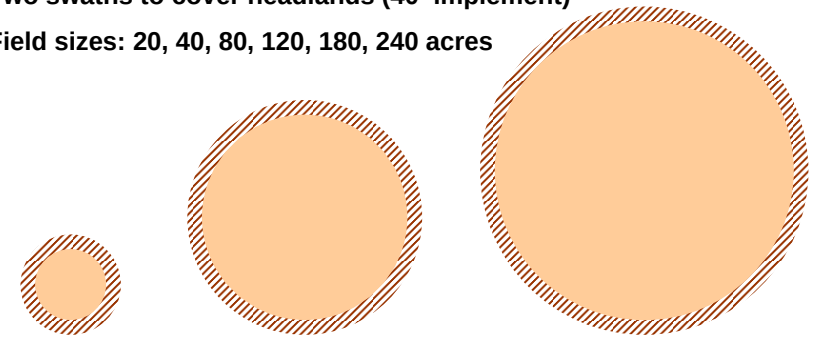
Larger fields have less area in headlands…

Assumptions for this example:

All fields have average angle of approach to headland of 39.5

Two swaths to cover headlands (40' implement)

Field sizes: 20, 40, 80, 120, 180, 240 acres



20 acres
(30% in HL)

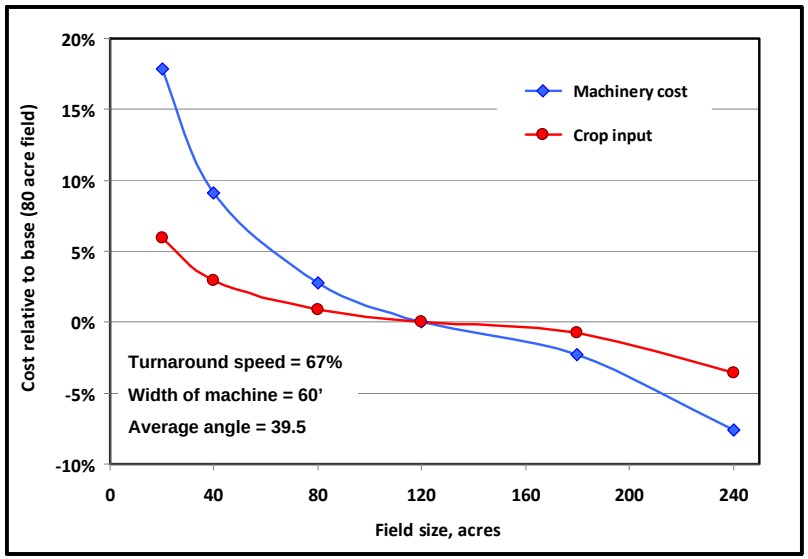
120 acres
(12% in HL)

240 acres
(8.6% in HL)

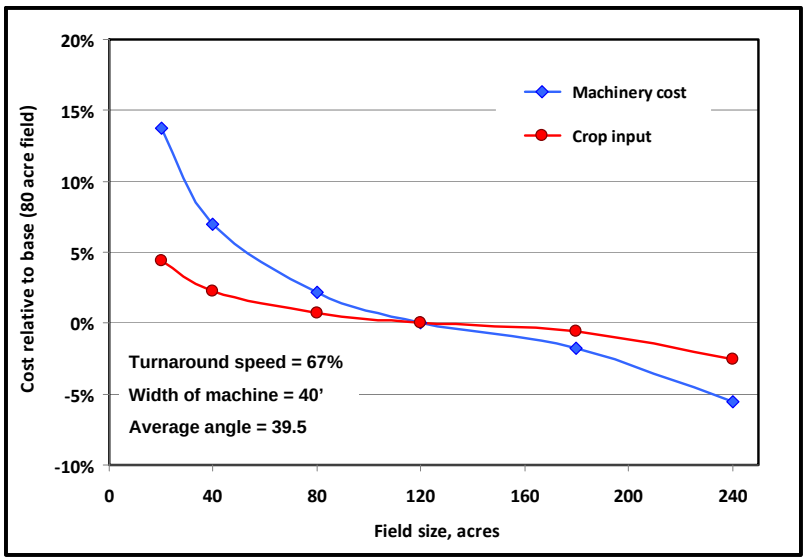
Impact of field size on costs…

- **Machinery costs**
  - **percent machinery costs vary relative to base field (120 acres)**
  - **vary due to "covering" acres more than once (i.e., overlap and area in headlands)**
  - **slowing down to turn increases costs**
- **Crop inputs**
  - **percent crop inputs (e.g., seed, fertilizer, chemicals) vary relative to base field**
  - **vary due to "doubling up" on overlap acres and areas in headlands**

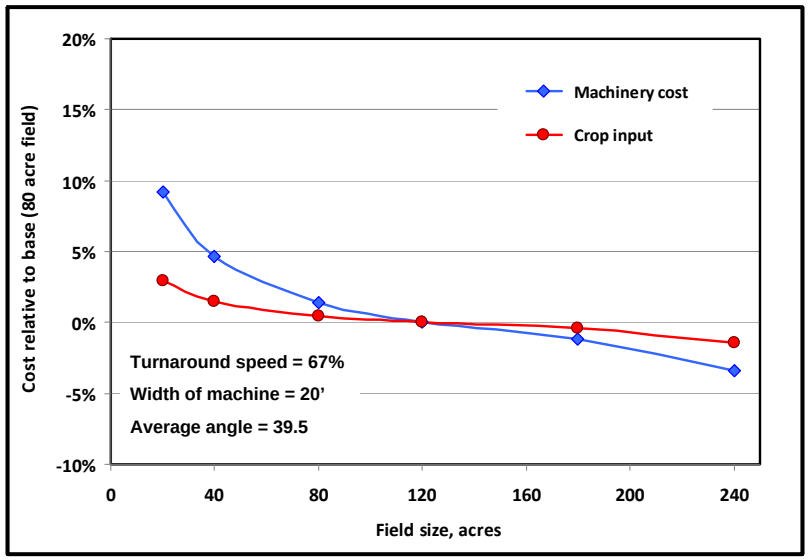
Machinery and input costs as field size varies



Machinery and input costs as field size varies



Machinery and input costs as field size varies



Kansas State UNIVERSITY

Department of Agricultural Economics

Impact of field shape on machinery and input costs

Analysis based on *KSU-GPSguidance.xls*

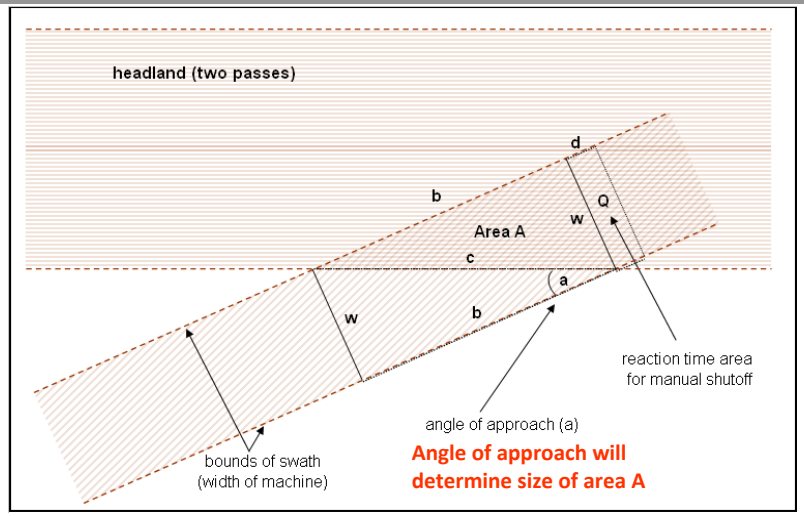
(similar values could be derived from *GuidanceSectionControlProfitCalculator.xls*)

Large (wide) machine issues

- **Need large turnaround area, increasing headland size (problem is compounded with small fields)**
- **By using section controllers we can make larger machines behave as though they were smaller, at least in terms of the portion of a headland affected by input doubling-up (but we still "cover the acres" with the machine)**

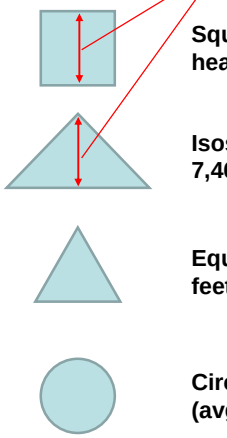
Technology reduces the "over applied input" problem…

Overlap and headlands geometry



Areas A and Q and turnaround counterparts will have a) doubling-up of inputs and b) possible yield losses due to this doubling-up. After the turnaround there will be overlap along b, also accounted for.

Stylized field shapes (farm left to right)



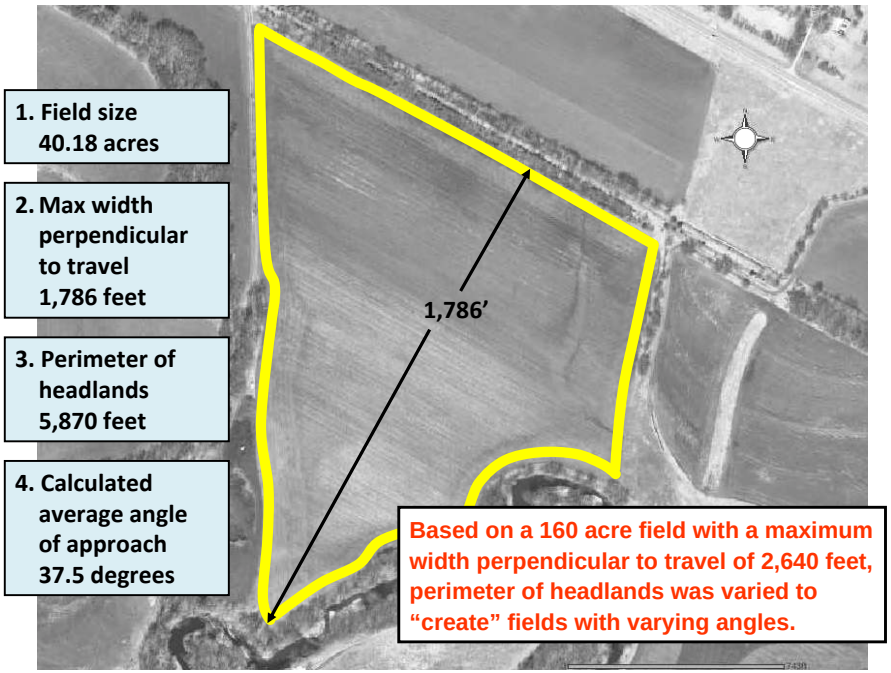
Maximum width of field, perpendicular to direction of swaths (passes) = 2,640 feet

Square; hit ends at 90 degree angles, 5,280 feet of headlands in 160 acre field

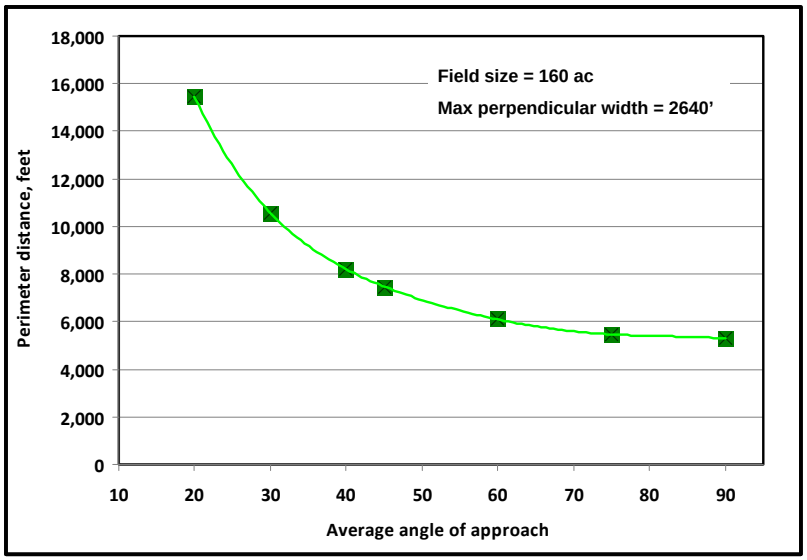
Isosceles right triangle; hit ends at 60 degree angles, 7,467 feet of headlands in 160 acre field

Equilateral triangle; hit ends at 45 degree angles, 8,024 feet of headlands in 160 acre field

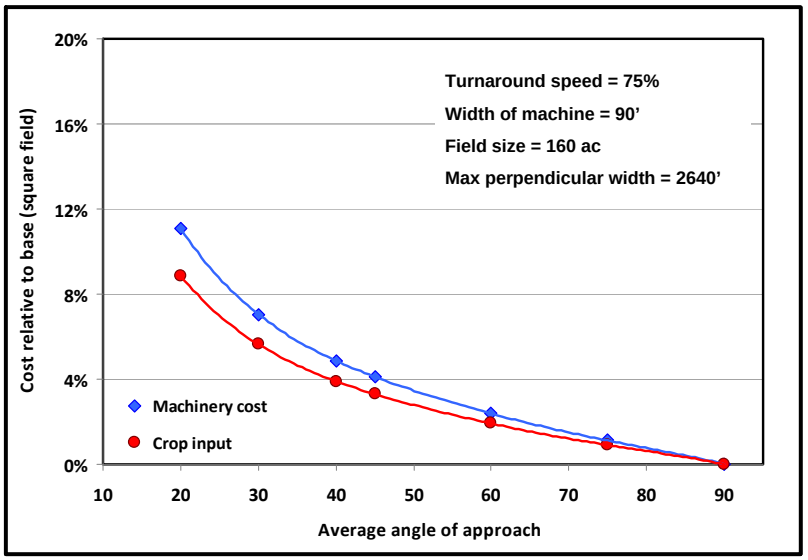
Circle; hit ends at angles varying from 0 to 90 degrees (avg. 40 degrees) 9,359 feet of headlands in 160 acre field



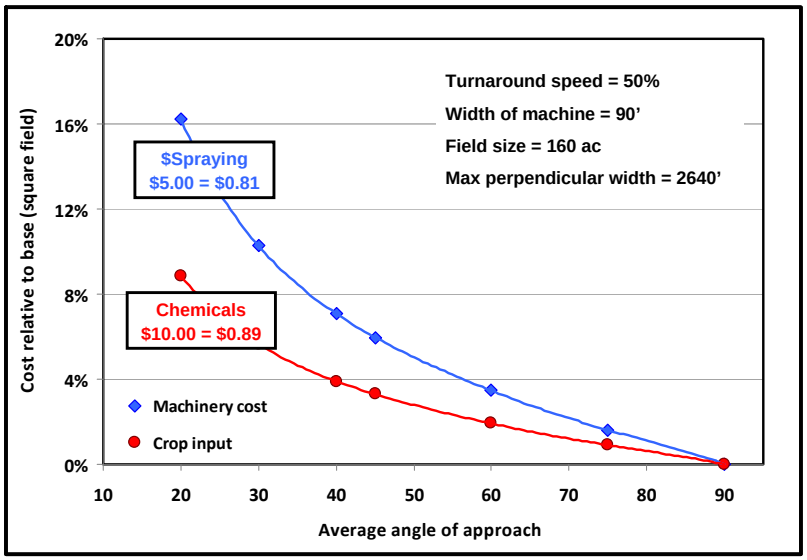
Headland distance as field shape varies



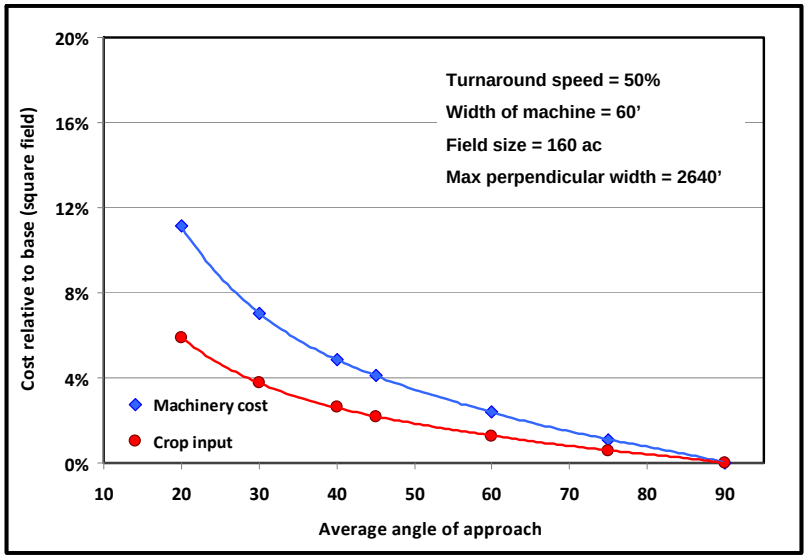
Machinery and input costs as field shape varies



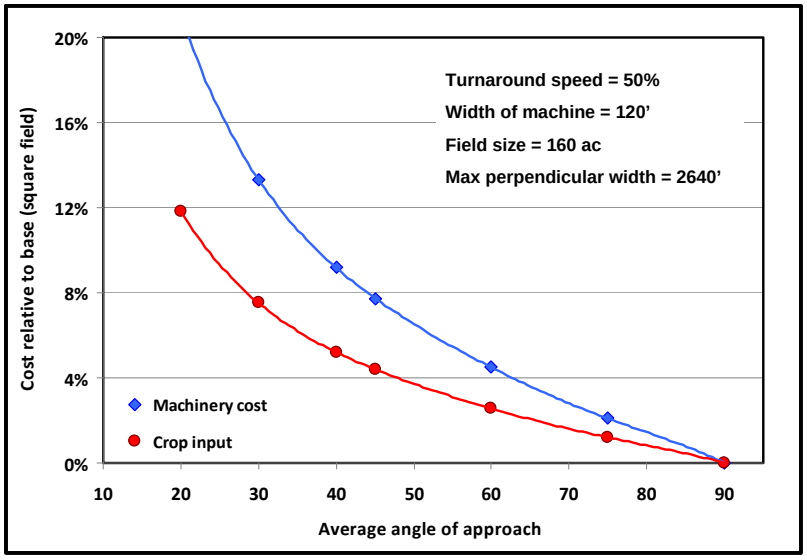
Machinery and input costs as field shape varies



Machinery and input costs as field shape varies



Machinery and input costs as field shape varies



Field shape significantly impacts costs…

- Section controller technology can help significantly with regard to crop input usage
- All else equal, reducing machine size will lower machinery cost associated with irregular shaped fields (for same reason as with small fields)
- While you may not be able to do a lot about the impact of field shape on machinery costs, it is still important to be aware of this issue for other management decisions

Kansas State UNIVERSITY

Department of Agricultural Economics

Impact of distance from headquarters on costs

Analysis based on *KSU-DistanceToFields.xls*

Kansas State UNIVERSITY

Department of Agricultural Economics

Field distance increases travel costs…

Travel costs are a function of:

- Crop acres and rotation
- Distance from headquarters
- Distance from elevator/input source
- Labor costs per hour
- Vehicle speed (pickup, semi, and machines)
- Vehicle cost per mile
- Field operations and machine capacity
- Use of pickup for travelling back and forth
- Input levels required and yield (trips with semi)

Base assumptions…

- **Acres** – 150, 300, 600, and 1200
- **Crop rotation** -- corn/soybean/wheat

  (plant each crop each year and rotate by year (300 acres or less))
- **Distance from HQ** – 5, 10, 20, 35, 50 (current fields 2.5)
- **Distance from elevator/input source** – 15 miles
- **Labor costs per hour** – $15
- **Vehicle speed** – pickup=55, semi=40, machines=17-26
- **Vehicle cost per mile** – pickup=$0.50, semi=$2.00
- **Field operations and machine capacity** – no-till
- **Use pickup for all operations except spraying**

Example of model developed (only one crop shown)…

Analysis of Farming Additional Acres a Given Distance from Farm Headquarters

Crops and acres considered (max of three crops)

	Corn	Wheat	Soybean	Other	Total
Crop name					
Average annual acres	200	200	200	0	600
Distance from headquarters in miles (dist1)	30				
Distance from elevator/fert source in miles (dist2)	15				
Labor cost per hour	$15.00				

Vehicle travel costs

	Speed, mph	Cost, $/mi	Total $/mi
Pickup	55	$0.50	$0.77
Semi	40	$2.00	$2.38

Breakpoint for where days are "rounded down" (percent of day): 10.0%

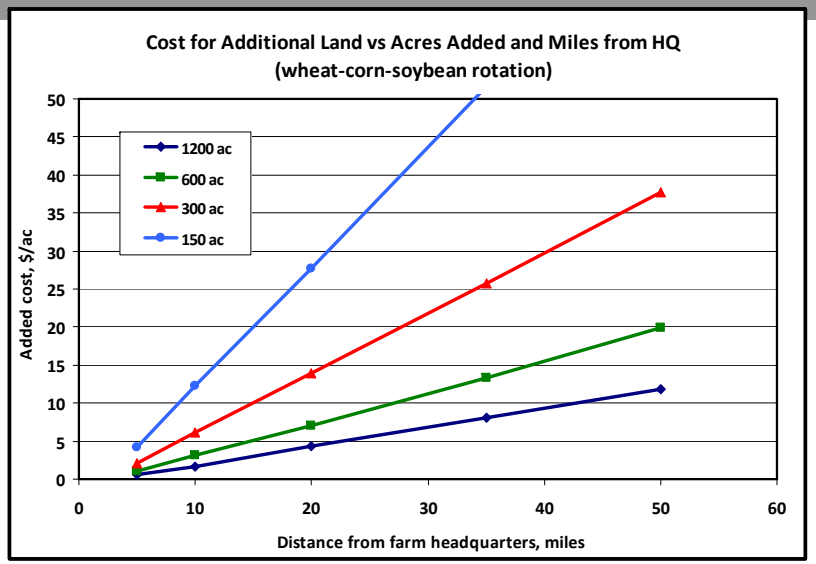
Blue values are inputs
Black values are calculated

Crop	number machines	number operations	haul to field	use a pickup	avg ac/day /machine	in these "field" hrs	required days	hours of travel first & last day	hours of travel other days	number semis	semi units per acre	semi units per semi	average machine road speed	non-labor machine cost $/hr	machine road cost $/mi
Corn															
Spraying	1	2	1	0	400	8	2	1.50	1.50	1	5	3,000	26	$0	$0.58
Disking	1	0	0	1	175	10	0	0.00	0.00	0	0	0	18	$62	$4.28
Field cultivate	1	0	0	1	350	10	0	0.00	0.00	0	0	0	18	$62	$4.28
Planting	1	1	0	1	240	10	1	2.12	1.09	1	25	4,200	19	$62	$4.05
Fertilizing	1	1	0	1	240	10	1	2.05	1.09	1	25	4,200	20	$62	$3.85
Harvest	2	1	0	1	100	10	2	2.31	1.09	3	100	1,050	17	$80	$5.59
Scouting	1	8	0	0	1200	10	8	1.09	1.09	0	0	0	55	$28	$0.77
Total		13					14								
Total for all crops		31					34								

Calculated Costs Associated with Travel

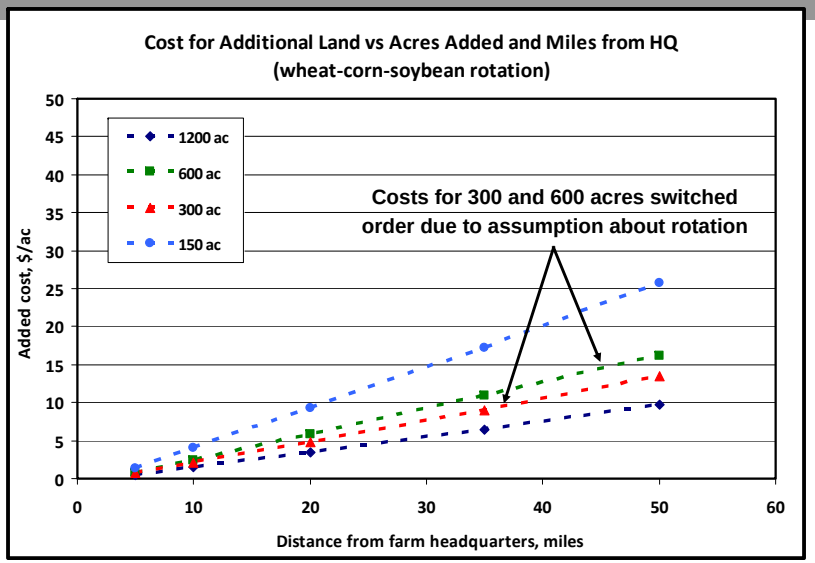
Crop	Number of trips (roundtrip) # pickup dist1	# semi dist1	# semi dist2	# machine dist1	Total number of miles # pickup dist1	# semi dist1	# semi dist2	# machine dist1	Travel-related costs pickup dist1	semi dist1	semi dist2	machine dist1	total cost
Corn													
Spraying	0	2	0	2	0	120	0	0	$0.00	$285.00	$0.00	$0.00	$285.00
Disking	0	0	0	0	0	0	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
Field cultivate	0	0	0	0	0	0	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
Planting	1	1	1	1	60	60	30	60	$46.36	$142.50	$71.25	$243.16	$503.27
Fertilizing	1	1	1	1	60	60	30	60	$46.36	$142.50	$71.25	$231.00	$491.11
Harvest	2	3	19	2	120	180	570	120	$92.73	$427.50	$1,353.75	$670.59	$2,544.57
Scouting	0	0	0	8	0	0	0	480	$0.00	$0.00	$0.00	$370.91	$370.91
Total	4	7	21	14	240	420	630	720	$185	$998	$1,496	$1,516	$4,195
Total for all crops	11	20	39	34	660	1200	1170	1620	$510	$2,850	$2,779	$3,945	$10,084
Total per acre	0.02	0.03	0.07	0.06	1.10	2.00	1.95	2.70	$0.85	$4.75	$4.63	$6.58	$16.81

Adding small acreage very far away is costly…



Assumes each crop is planted each year with no overlap of operations.

How rotation is managed has large impact on costs…



Assumes entire farm is planted to one crop per year for 300 acres or less, with larger acres, corn and soybean operations overlap (reducing the number of trips required).

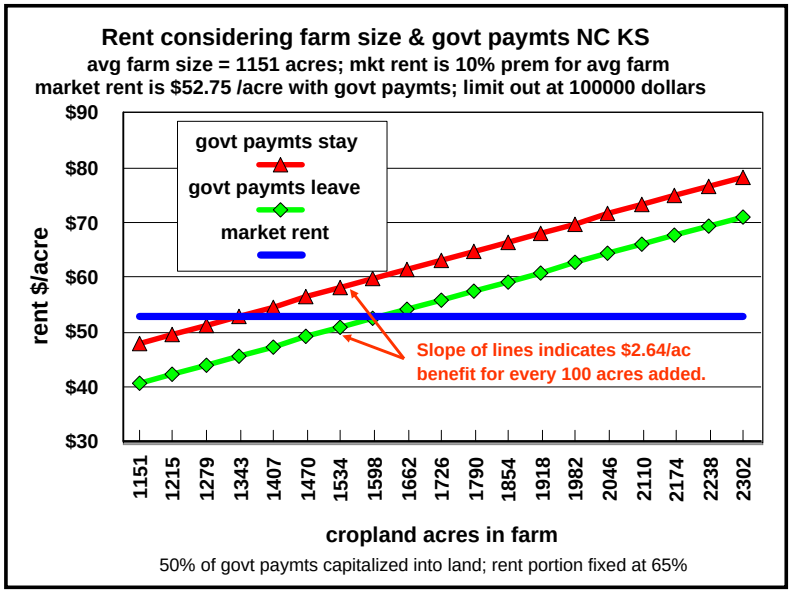
Kansas State UNIVERSITY

Department of Agricultural Economics

Factors not accounted for (there are many)…

- Impact on overall costs (i.e., EOS benefit)

Economies of size analysis for typical NC KS farm in 2008

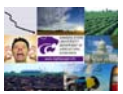


Kansas State UNIVERSITY

Department of Agricultural Economics

Factors not accounted for (there are many)…

- Impact on overall costs (i.e., EOS benefit)
- Geographical diversification
  - Spread weather risk over larger area
  - More visibility (double-edged sword)
- Manage less intensively at greater distance?
  - Weed escapes, replant acres, repairs, etc.
- Hire some operations, stay overnight, separate line of equipment (costs might not be linear)?
- Costs decrease as you "fill in the gap"
- Other?



Summary…

- Given economies of size that exist, a growth strategy makes sense for long-term sustainability
- Adding acres that are (1) in small fields, (2) irregular shaped fields, and (3) far away can increase costs potentially offsetting EOS benefits
- Machinery technologies available can help reduce some of the negative effects of small and odd-shaped fields (e.g., section controllers, auto-steer)
- The economics of expansion opportunities is complex, but producers should quantify the benefits and costs where they can

Kansas State UNIVERSITY

Department of Agricultural Economics

Questions ???

AG MANAGER.INFO
Kansas State Research & Extension

www.agmanager.info

MAST

If interested in receiving weekly *AgManager.info Update* or any of our other Ag Econ newsletters via email, please let me know (kcd@ksu.edu or 785-532-3527).