FINANCES AND RETURNS FOR ROBOTIC DAIRIES

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Introduction

Over 35,000 robotic milking systems (RMS) units are operational on dairy farms around the world. The main reasons dairy producers install milking robots are to improve their lifestyle and to expand without hiring additional labor.

What drives robot profitability?

Milk production per cow, milk produced per robot per day, labor savings, and length of useful life are the main factors affecting RMS profitability. The primary disadvantage is the capital investment of $150,000 to $200,000 per robot that will milk 50 to70 cows each. Most historical data shows milking robots are less profitable than conventional milking systems. Advances in robotic technology, improved management skills, and higher labor costs may change these results.

Labor efficiency

USDA (2016) reports that wages paid to livestock workers increased 3% in 2014 and 4% in 2015. Reported RMS labor savings vary. Researchers have reported from no savings up to 29% savings with RMS. Barn design and management may explain much of this variation. Farm Management Records (Finbin, 2016) showed that Upper Midwest RMS farms averaged 2.2 million lb of milk per full time worker compared to 1.5 million lb for similar sized herds milking in parlors (Table 1). Our survey of 53 Minnesota and Wisconsin robot farms showed that even when total labor is similar, time saved from milking is used for activities, such as improving animal health, analyzing records, improving reproduction, and more timely forage harvest.

Another factor affecting the decision to install robots is the future availability of labor for milking cows. A 2014 survey indicated that 51% of all farm labor was immigrant labor (Adcock et al., 2015). The future availability of immigrant workers may be reduced if less foreign workers choose to work on farms or if tighter immigration laws are passed in the US.

Milk production change when transitioning to robots

The primary driver for the change in milk production with RMS is a change in milking frequency. de Koning (2010) found that robotic herds had production increases of 5 to 10% compared to milking 2X, but production decreased 5 to 10% compared to milking 3X. In our survey, the average RMS milking frequency was 2.8 with a range of 2.4 to 3.2. To optimize efficiency, the goal is to have high milking frequency in early lactation and lower milking frequency in later

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lactation. The primary factors that affect individual cow and herd average milking frequency include:

1. Number of cows per robot
2. Milking permission settings
3. Palatability and quality of partial mixed ration and robot box feed
4. Robot free time (time robot is idle)
5. Cow fetching policy
6. Barn design and walking distance (a major factor for grazing herds)

Robotic milking systems compared to conventional parlor systems

Bijl et al. (2007) compared the economic performance of Dutch farms using RMS to closely matched conventional farms milking 2X. Because of higher costs for the RMS, conventional farms were more profitable. However, the labor requirement was 29% lower on the RMS farms resulting in more milk production and income per worker. They concluded that investing in RMS allows farms to milk more cows and produce more milk with less labor.

Farm management records collected by the University of Minnesota show a similar pattern (Table 1). Herds utilizing RMS had higher milk production and gross margin, but costs were higher, resulting in slightly lower net farm income.

Table 1. Robot and parlor farm profitability, 2011-2015, Upper Midwest[1]

Item	Robot	Parlor	Difference
Milk/cow/yr	23,532 lb	21,528 lb	+2004 lb
Gross margin/cow/yr	$4564	$4254	+$310
Feed cost/cow/yr	$2251	$2206	+$45
Direct cost/cow/yr[2]	$3261	$3190	+$71
Overhead cost/cow/yr[3]	$899	$581	+$318
Net farm income/cow/yr	$185	$230	-$45
Milk sold/Full time worker/yr	2,206,107 lb	1,542,874 lb	+663,233 lb
Depreciation + interest/cow/yr	$547	$249	+$298

[1]Finbin, University of Minnesota www.finbin.umn.edu

[2]Feed, vet, supplies, bedding, fuel repairs, marketing and hired labor

[3]Building and machinery depreciation, building leases, insurance, utilities, interest

We developed a web application to compare the profitability of robots and parlors: http://z.umn.edu/RobotParlor. This tool was used to compare the economics of RMS and parlor systems on farms with 120, 240 and 1,500 lactating cows over a 20-year pay-back time. Milking labor costs were set at $16/hr with a milk price of $17/cwt. We assumed milk production would increase 5 lb/day per cow with RMS compared to milking 2X and decrease 2 lb/day compared to 3X milking. The per cow barn investment is higher for the RMS, reflecting the additional cost to install labor savings features typical in RMS barns. We inflated labor costs at 1, 2, or 3%

annually. Net annual impact refers to the net present value of projected differences in RMS cash flows converted to an annuity.

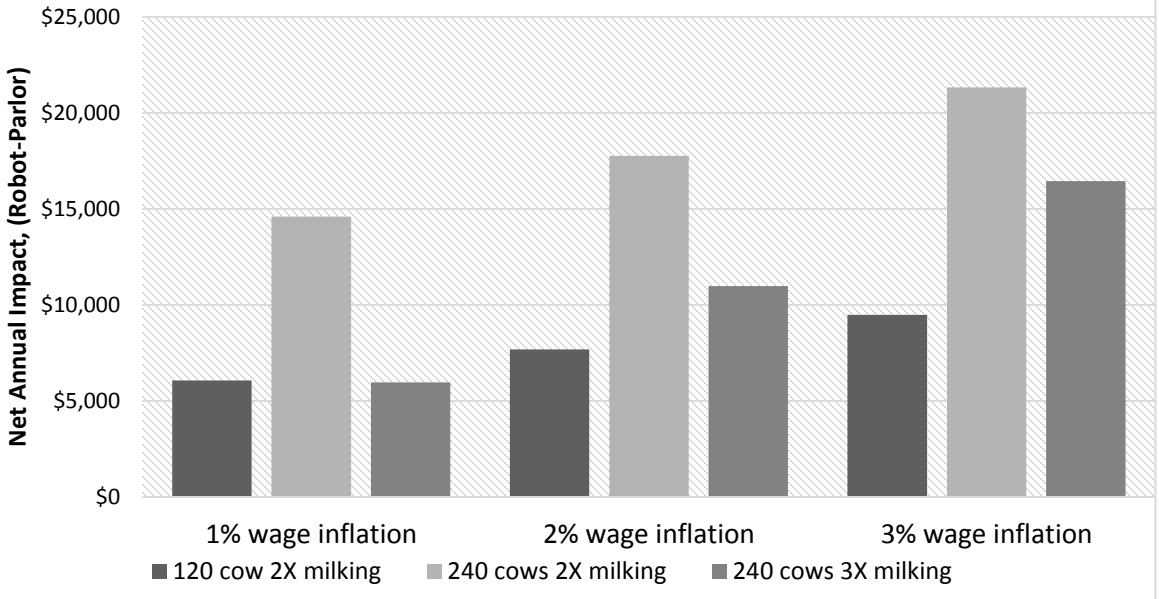
The 120 and 240 cow RMS systems had higher net annual impact compared to a double 8-parlor system (Figure 1). Labor cost inflation and milk production per cow had a large impact on profit. For each pound change in daily production per cow, the net annual impact changed by $931.

The 1,500-cow parlor system was more profitable than RMS. A 1% annual wage inflation resulted in a $162,672 (3X milking) and $51,177 (2X milking) more profit for the parlor. The difference was $130,570 (3X milking) and $32,395 (2X milking) at 3% wage inflation. Using similar milk production and 3% wage inflation the parlor had $80,672 higher annual impact.

The primary reason for the differences in profit is the more intensive use of the milking system. The RMS assumed full utilization at 60 cows per robot across all herd sizes. The parlor was only being used four hours per day with the 120-cow system. In the 240-cow simulations, the parlor was being used 8 and 12 hr/day in the 2X and 3X respectively. For the 1,500-cow herd, both the robot and parlor were at near maximum utilization.

Milk production and labor assumptions between the systems greatly affect the profitability projections. More research is needed to understand the economics of how these systems perform with different herd sizes and management practices.

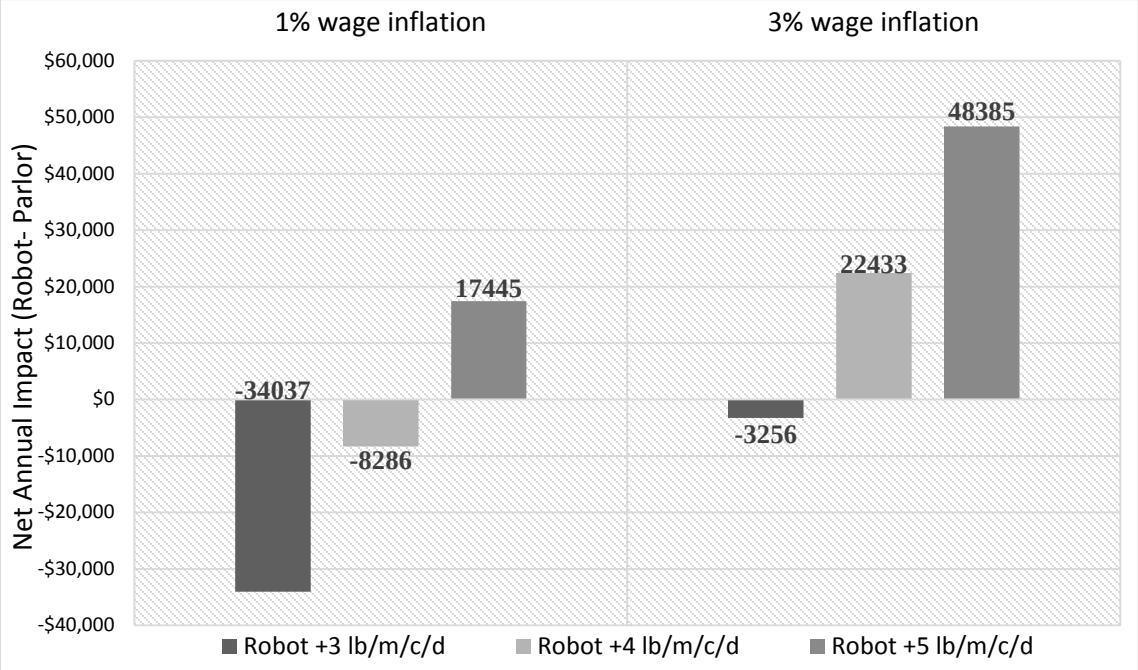
Figure 1. Net annual impact of robot system compared to a parlor system



Breakeven labor rate. Since the 1,500-cow robot system was less profitable than the parlor system at $16 labor, we determined the breakeven labor rate at which the two systems would have similar annual incomes. At the wage inflation rate of 1% and a 2 lb lower milk production with the robot system, the breakeven labor rate is $32.30 per hour. If the farm is able to achieve similar milk production between the two systems and wage inflation averages 3% over the 20-year time horizon, the breakeven wage rate drops to $22.91 per hour.

Breakeven milk production. We also examined how higher milk production in RMS would affect the profit comparison (Figure 2). If the robot system can get 3 lbs more milk/cow per day than a parlor with 3% annual wage inflation, the annual income is only $3256 higher for the parlor. At 5 lbs more milk, the RMS is more profitable under both 1% and 3% wage inflation rates. Current research indicates that RMS on average do not achieve as high of milk production as a parlor milking 3X, but as robot management and facility design improve, this may change. Another potential advantage is that cows in robot barns can be managed and milked in stable groups within the pens. Cows have access to resources (feed, water, beds, milking) at all times. More precise feeding management can potentially increase milk per cow.

Figure 2. Net annual impact of a 1,500-cow dairy with 25 robots compared to a double-24 parlor at different milk production levels and wage inflation rates



Milk per robot

Total daily milk per robot is an important characteristic to maximize profit. Using a four robot system with a 2% annual wage inflation rate and a 20-year time horizon, net annual income increases approximately $4,100 for every 500 lb increase in daily milk production per robot. Currently a small number of US farms are consistently achieving in excess of 6,000 lb of milk per robot per day. Many factors can influence milk per AMS unit. The most important factors include:

1. Milking permission settings and strategies that get the correct cows milked at the correct times
2. High daily milk production per cow
3. Reduced box time per cow
4. RMS in top working condition

Effect or RMS Dairy Enterprise Profitability

We also examined how the economic life, labor efficiency and milk yield change affects the profitability of RMS. For 180 cow dairy we considered two scenarios: RMS retrofitted in an existing facility and a RMS in combination with a new high technology free stall barn.

Robot retrofit

This is retrofitting 3 robots in an existing 180 cow barn. We included increased annual payments for the 3 new robots ($63,000) for 10 years and increases in insurance ($2,700) and maintenance ($9,000/robot per year). The annual impact is the return compared to a current milking system with no debt payments. Table 2 shows how annual impact varies with different milk production, milking labor and robot lifespan. Our survey of producers indicated that well designed (automatic manure removal, split entry pens), well managed free flow barns average about 45 minutes of daily milking type labor per robot. It is slightly lower with similar guided flow barns. Dairy producers need to reduce daily milking labor to about 45 minutes per robot and achieve a small increase in milk yield for the RMS to have a higher annual impact than the previous milking system. Robots must also last for 10 to 14 years to breakeven.

Table 2. Net annual impact of installing a robot in an existing facility[1]

Milking labor (min/d/robot)	Robot lifespan (years) 8	10	13	15	17	20
I. Milk yield increase of 2.0 lb/cow/d						
75	($7,469)	($144)	$7,169	$10,747	$13,723	$17,461
60	($4,581)	$2,821	$10,251	$13,910	$16,966	$20,828
45	($1,693)	$5,786	$13,334	$17,073	$20,210	$24,196
30	$1,195	$8,751	$16,417	$20,235	$23,454	$27,563
II. No change in milk yield						
75	($17,516)	($10,394)	($3,387)	($14)	$2,754	$6,181
60	($14,628)	($7,429)	($305)	$3,148	$5,998	$9,548
45	($11,740)	($4,464)	$2,778	$6,311	$9,242	$12,915
30	($8,852)	($1,499)	$5,861	$9,474	$12,485	$16,283
III. Milk yield decrease of 2.0 lb/cow/d						
75	($27,615)	($20,696)	($13,998)	($10,832)	($8,271)	($5,158)
60	($24,727)	($17,731)	($10,915)	($7,669)	($5,027)	($1,791)
45	($21,839)	($14,766)	($7,832)	($4,506)	($1,783)	$1,577
30	($18,951)	($11,801)	($4,749)	($1,344)	$1,460	$4,944

[1]Net Annual Impact compared to the status quo with 13.5 h/d milking labor.

Robot with a New Barn

To achieve the maximum benefit of robots it is preferable to design them into a new, high technology, low labor requirement facility. This facility would include various upgrades such as wider and more frequent crossovers to facilitate cow movement, automated manure removal, automated feed pushers, and a more temperature-controlled environment. This totally new facility resulted in annual payments of about $101,000 over 20 years for the 180-cow farm. A 10 lb per day increase in daily production is required before robots are consistently more profitable than the previous system.

Table 3 shows the results by projected milk yield increase and milking labor. Much higher milk production and labor savings must be achieved to recuperate the large investment. We assumed a 15-year economic life for the robots and 30 years for the barn. This could be different depending on farmer's desire to upgrade the robots and potential barn time horizon.

Table 3. Net annual impact with robots as part of a new facility.[1]

Milking labor	Milk yield increase (lb/cow/d)					
(min/robot/d)	4.0	8.0	10.0	12.0	14.0	16.0
30 year time horizon; 15 year AMS economic life[2]						
75	($17,581)	($5,375)	$6,768	$18,847	$30,862	$42,814
60	($13,784)	($1,577)	$10,565	$22,644	$34,659	$46,611
45	($9,986)	$2,220	$14,362	$26,441	$38,457	$50,408
30	($6,189)	$6,017	$18,160	$30,239	$42,254	$54,205

[1] Annual Impact compared to the status quo with 13.5 h/d milking labor.
[2] Robot is replaced twice over the 30-yr time horizon

CONCLUSIONS

Most previous simulations and observational studies have shown that RMS are not as profitable as parlors. Our understanding of robotic facility design, feeding, and management will continue to improve, resulting in decreased labor requirements and higher milk production of cows milked with robots. The main management factors affecting whether robots are more profitable than parlors are increased milk production per cow, labor wages and labor savings. Another major factor is years of economically useful life. For comparing the relative return of robots versus parlors, the producer needs to understand how their management ability and future wage inflation affect potential future net income.

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