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An examination of the effects of labor efficiency on the profitability of grass-based, seasonal-calving dairy farms

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ABSTRACT

The seasonality of grass-based, seasonal-calving dairy systems results in disproportionately higher labor demands during the spring, when cows are calving, than in the remaining seasons. This study aimed to (1) examine the relationship between labor efficiency and profitability; (2) investigate strategies to reduce the hours worked per day by the farmer, family, and farm staff in the spring by having certain tasks outsourced; and (3) quantify the economic implications of those strategies. Data from an existing labor efficiency study on Irish dairy farms were used in conjunction with economic performance data from the farms. Tasks that required the highest level of farm labor per day in the spring were identified and hypothetical strategies to reduce the farm hours worked per day were examined. A stochastic budgetary simulation model was then used to examine the economic implications of employing these strategies and the effects of their use in conjunction with a proportionate increase in cow numbers that would leave the hours worked per day unchanged. The strategies were to use contractors to perform calf rearing, machinery work, or milking. Contracting out milking resulted in the greatest reduction in hours worked per day (5.6 h/d) followed by calf rearing (2.7 h/d) and machinery work (2 h/d). Reducing the hours worked per day by removing those tasks had slight (i.e., <5%) negative effects on profitability; however, maintaining the farm hours worked per day while utilizing the same strategies and increasing herd sizes resulted in profitable options. The most profitable scenario was for farms to increase herd size while contracting out milking.
Key words: pasture-based, profitability, labor efficiency, seasonality

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INTRODUCTION

Dairy systems that follow a seasonal calving and grazing structure have unique patterns of labor demand compared with confinement systems, which practice year-round calving and have relatively even patterns of labor demand. These seasonal systems, most commonly found in Ireland, New Zealand, and parts of Australia, time their calving periods and thus lactation curves to match the feed supply from grass (McCarthy et al., 2007). If managed efficiently, this can allow farmers to maximize both lactation length and seasonal supply of pasture, resulting in a low-cost system (Dillon et al., 1995; Macdonald et al., 2008). Studies on labor input in pasture-based systems, like in Ireland, have demonstrated that the seasonality of labor demand with peaks occurring in the spring months and lowest labor demand in the winter months (O'Donovan et al., 2008; Deming et al., 2018). In a recent study, Deming et al. (2018) found that, on average, 32 and 25% of annual farm labor requirement occurred in the spring and summer seasons, respectively.

In the 2015 Irish National Census Survey, which compared the agriculture, forestry, and fishing sector with other sectors, dairy farmers were classified as having the longest working week (Central Statistics Office, 2015). Within that survey, it was documented that on average, dairy farmers worked 50.4 h/wk compared with the national average workweek of 35.7 h (Central Statistics Office, 2015). Based on the seasonal nature of the work, the spring would be longer for these farmers. Recognizing the stress that is put on the system and the demand for on-farm labor during the spring period, focusing on reducing labor demand through a range of efficiency factors, including the outsourcing and utilization of contractors, should be part of the overall strategy. Irish studies have highlighted which tasks are the most time consuming during the busiest months. These studies have also outlined the labor management strategies used by the most efficient farms (O'Donovan et al., 2008; Deming et al., 2018).

Because milking, calf rearing tasks, and winter feeding all peak during the spring in seasonal dairy herds, identifying ways in which to reduce labor or eliminate these tasks altogether is crucial. One option farmers are turning to is the use of contractors to rear their calves. Contract rearing is an arrangement in which a dairy farmer pays another farmer to rear replacements on their own farm. Contract rearing may be extended in the case of heifer calves to older heifers. Although contract rearing of heifers is relatively more expensive per heifer reared and there are some biosecurity concerns, it can be a viable option to free up facilities and the farm's own labor (Wolf and Harsh, 2001). The use of contractors is not limited to calf and heifer rearing but can also be an option for a variety of other tasks on-farm. In their study of pasture-based dairy farms, Deming et al. (2018) found that larger farms were generally more labor efficient, they had fewer hours of machinery work to be performed, and that a higher proportion of that work was carried out by contractors (compared with smaller, less efficient farms). The utilization of contractors for particular tasks could have a 2-fold effect: (1) reducing the amount of machinery on-farm and, thus, reducing investment and depreciation costs, and (2) outsourcing specific seasonal tasks to free up farmer and farm staff time, which could then be used on the tasks of milking and calf care. However, a fundamental point is that the farming business provides the livelihood of the farming family and must operate as profitably as possible.

The objectives of this study were first to establish the relationship between labor efficiency and financial performance on grass-based, seasonal-calving dairy farms, and second, to model the effect of substituting labor on the farm by purchasing other services in the spring when the farm is at peak workload, and using the freed-up time to either reduce the farm hours worked per day or to retain the farm hours worked per day and carry additional cows on the farm where farm facilities and infrastructure allowed.

MATERIALS AND METHODS

The data used in this study were from a larger dairy farm labor efficiency study, the results of which can be found in Deming et al. (2018). That study focused on the Irish dairy system and was developed before the abolition of the European Union (**EU**) milk quota in 2015. The study aimed to identify labor-saving facilities and management practices because herd sizes were expected to increase. As outlined in greater detail in Deming et al. (2018), 38 farmers, who were identified by dairy advisors as being labor efficient, were enrolled in the study and recorded their farm's labor data through the use of a smartphone application (app) and a monthly online survey. A phone survey was also conducted with the farmers regarding facilities and management practices. Herd sizes ranged from 79 to 533 cows and herds were spread throughout Ireland. The project spanned between May 2015 and August 2016. For the current study, not all 38 farms could be included; a description of why certain farms were used is outlined under "Farmer Selection" below.

The farmer labor input data from the spring period in the Deming et al. (2018) study were used. Additionally, data from the Teagasc Eprofit Monitor were also used. This profit monitor is a financial benchmarking tool into which farm-associated income and expenditure is entered and costs and profits may be calculated; it is completed by farm advisors in consultation with the farmer.

The average farm hours worked per day and for individual tasks per day in spring across all farms were determined. The tasks that consumed the greatest proportion of time were identified as milking, calf rearing, and machinery work. Different scenarios were then identified where a specific task was carried out by a hired-in service contractor. The work associated with this task was eliminated from the labor demand of the farm and modeled to examine how it affected the overall farm hours worked per day and thus spring efficiency (h/cow per spring).

Farmer Selection

Dairy farmers were selected based on the following criteria: spring-calving dairy farms with dairy as the primary enterprise (>70% livestock being dairy cows); herd size ranging between 60 and 600 cows; the farmer being an owner and user of a smartphone; and an active participant in farmer discussion groups working with Teagasc (The Irish Agriculture and Food Development Authority; Deming et al., 2018). For the current analysis, from the original 38 farms in the study by Deming et al. (2018), farms that had completed their Eprofit Monitor (n = 32 farms) and had a complete data set for spring labor (n = 26) were included.

The Smartphone Application

The required features of a smartphone app to record farm labor were identified and it was developed by an external company that specializes in digital data collection (Acorn Agricultural Research, Cork, Ireland). The design of the app allowed farmers to record labor data in real-time by starting and stopping the app's stopwatch as each designated task was begun and completed. Each farmer used the app on their smartphone to record their own personal labor data for 3 consecutive days (the last Tuesday, Wednesday, and Thursday of each month) for between 12 and 15 mo. Employees or family members who provided farm labor and had their own smartphone were also able to use the app to record their labor input. The goal was to capture 12 mo of high-quality data; some farms were asked to record beyond the 12 mo if their initial months of data recording were insufficient. Consistency for the farmers was considered important, thus the same 3 weekdays of each month were used to capture regular farm activity. This technique of a 3-d data collection period each month has been used in previous labor studies (O'Donovan et al., 2008; Shortall et al., 2016). Twenty-nine tasks were listed in alphabetical order on the app that the farmers could choose from at any given time. When the app user wished to start a task, they pressed the selected task "start" button, at which point the timer would start recording. When the task was complete, the app user pressed the "stop" button. Using the app allowed data to be collected on actual start and finish times of tasks throughout the day. Upon the first meeting with farmers, we stressed that real-time data collection was most desirable. As app users entered their task data throughout the collection periods, data were automatically sent to the online database. If the phone was outside of 3G, 4G, or Wi-Fi coverage, the app would continue to work and data would be sent to the online database when the phone returned to internet coverage.

Additional Information

Farmers were visited before the start of the study and detailed instructions were outlined as to how data should be entered and how it would be analyzed. To capture other labor contributions on the farm (i.e., farm staff who did not use the app or work performed by contractors), a short online survey was implemented, which farmers completed once per month. At the end of the 3 app-based data collection days, each farmer received an automated text message requesting them to complete the online survey; they received a reminder text message every day until the online survey was completed. In this survey, farmers were asked to complete labor data for any part-time or full-time (1,800 h/yr) labor (family or hired) that worked on the farm during the 3 data collection days and whose data were not already collected via the app. Farmers were also asked to input stock data and to indicate hours of machinery work conducted on-farm for the entire month using their own equipment. Farmers were then asked to record the number of contracted machinery hours per month that were delivered by a contractor for the same list of machinery work.

A one-time phone survey was conducted with each farmer regarding their farm facilities and practices. The researcher telephoned each farmer in December 2015 and asked them to complete a questionnaire that collected data on winter housing, grassland management, the milking process, breeding, and calves; responses were entered directly into an Excel spreadsheet (Excel 16, Microsoft Corp., Redmond, WA). Descriptions regarding the different categories can be found in Deming et al. (2018). Eprofit Monitor data for all 26 dairy farmers were collected for 2015 and 2016.

Calculations of Hours and Efficiency Data

The average monthly labor input by the farmers per task was obtained by adding the task duration for each day within the 3 d of data collection and dividing by the number of days the farmer used the app in that month (app users were asked to record all 3 d but that did not always occur). The total duration of the tasks was then summed (creating an average over the days of data input via the app) and multiplied by the total number of days for that calendar month less half the number of Sundays for that month (except for February, explained below; Shortall et al., 2016). This calculation was based on the premise that farmers work 6 full days throughout the week and one half day over the weekends throughout the spring time as opposed to 5 full days and 2 half days throughout the rest of the year. Total labor hours worked was calculated by summing the hours worked by each individual including family on the farm plus the hours of contractor work performed each month.

The farm hours worked per day was determined by taking the sum of all hours worked on farm for each month in the spring and dividing those hours by the number of days worked in that month. February is considered the busiest month of the year for Irish dairy farmers and, thus, our calculation estimated that farmers were working every day in February so their total hours that month were divided by 28 d. For March and April, we considered farms were working 6 full days and one half day on the weekends; thus, total farm hours were divided by 29 d for March and 26 d for April.

Similarly, spring efficiency was calculated by isolating the total hours worked on the farm solely in the spring and expressed per week. Overall farm labor efficiency was measured on an hour-per cow-per year basis (h/cow per year), whereas spring-efficiency was measured as hours per cow per week given 13 wk in the spring season (first week of February to the last week in April). Cow numbers (both dry and milking cows) were collected via the online monthly survey and an average was taken over the year. For comparison of financial performance with labor efficiency, farms were split into 1 of 2 categories: category A (annual farm

Table 1. Descriptive statistics of all farms based on annual farm efficiency

Item	Efficiency category	
	A	B
No. of farms	16	16
Efficiency category parameter (h/cow per year)	<21.0	≥21.0
Average efficiency (h/cow per year)	17.1	27.2
Range of efficiency (h/cow per year)	12.6–21.0	21.2–38.9
Average herd size (cows)	209	139
Range of herd size (cows)	108–329	79–264
Average land area (ha)	105	80
Range of land area (ha)	56–182	39–125

efficiency <21 h/cow per year) and category B (annual farm efficiency ≥21 h/cow per year; Table 1). This cutoff level of efficiency for the categories was established by using the labor efficiency data procured during the labor input and efficiency study before this analysis, and was chosen due to the median value of the farm labor efficiencies being 21 h/cow per year. To model different spring labor management strategies, data were examined for the spring months only. Farms were split into 1 of 2 categories regarding their spring efficiency. When the farms were ranked on their spring efficiency, the median value was 0.6 h/cow per week and farms were assigned to category A (spring efficiency <0.6 h/cow per week) or B (spring efficiency ≥0.6 h/cow per week; Table 2).

Teagasc Eprofit Monitor: Financial Benchmarking

The Teagasc Eprofit Monitor data were collected for 2015 and 2016 as the project spanned the 2 calendar years. The Eprofit Monitor is a financial benchmarking tool used by Teagasc clients in which whole-farm net profit was calculated as net profit excluding direct payments. Direct payments come from the EU Common Agricultural Policy, which aims to support active farmers based on objective criteria—agricultural production and provision of public goods (DAFM, 2015). Whole-farm total costs were calculated by adding total fixed costs and whole-farm total variable costs. Land base (hectares) was calculated by adding total owned land and total leased land. Kilograms of milk solids (**MS**), average herd size, and stocking rate were also collected from the Eprofit Monitor. A cost on own farm labor was not included in the monitor data.

Moorepark Dairy Systems Model: Bioeconomic Model

The Moorepark Dairy Systems Model (**MDSM**) was developed to examine key aspects of grass-based systems of production, with a focus on the Irish system, and allows the examination of the effects of varying biological, technical, and physical factors on farm profitability. The MDSM is a stochastic budgetary simulation model of a dairy farm combining animal inventory and valuation, milk supply, feed requirements, land and labor utilization, and financial and economic analysis of the production systems (Shalloo et al., 2004). Since its development, the model has been used to assess technology investments (Upton et al., 2015), varying pasture production systems (Patton et al., 2012), and farm expansion strategies (Hutchinson et al., 2013). The model was used in this study to quantify the economic implications of different strategies to reduce the labor require-

Table 2. Descriptive statistics on farms based on spring labor efficiency

Item	Spring efficiency category	
	A	B
No. of farms	13	13
Efficiency category parameter (h/cow per week)	<0.6	≥0.6
Average spring efficiency (h/cow per week)	0.5	0.7
Range of spring efficiency (h/cow per week)	0.3–0.5	0.6–0.9
Average annual efficiency (h/cow per year)	19.9	26.6
Range of annual efficiency (h/cow per year)	13.9–30.5	15.2–39.9
Average herd size (cows)	216	156
Range of herd size (cows)	101–534	79–329
Average land area (ha)	101	89
Range of land area (ha)	74–147	39–182

ment on grass-based, seasonal-calving dairy farms in the spring, such as utilizing contractors for the tasks of milking, calf rearing, and machinery work. This has the effect of reducing owned labor requirements and paying an external contractor. This service is modeled using a budgetary simulation model (Shalloo et al., 2004) to examine the effects on profitability. These options were evaluated using scenarios in which (1) cow numbers remained static and labor by the hired-in service was used to reduce own/family farm hours worked per day, and (2) where cow numbers increased and the labor by the hired-in service was used to contribute the additional labor associated with additional cows, and the total farm hours worked per day remained unchanged. All of the pay rate assumptions were based on current industry situations. The model assumptions were based on current national average performance figures (Hanrahan et al., 2018). A farm size of 185 cows, with a stocking density of 2.1 cows/ha was applied to each farm simulation (Deming et al., 2018). Annual milk production of 430 kg of MS/cow, concentrate supplementation input of 770 kg of DM/cow, grass growth of 10.5 t of DM/ha, and annual replacement rate of 23% were assumed in the analysis. These assumptions were included in the model to represent the group of farms included in this study. Farmer labor was valued at €15.00/h, whereas an opportunity cost of land was included at €500/ha. The contract rearing cost of heifer calves was included at €1.30/calf per day. When additional labor was purchased for the milking process, it was brought onto the farm at a cost (€18/h) that was 20% higher than the standard value of own labor in the MDSM model (€15/h). This increase was applied to reflect the increased rates usually paid to "daily rate contracting" individuals (Icon Accounting, 2016). Variable costs (concentrate feed, fertilizer, veterinarian fees, contractor charges, silage, and reseeding), fixed costs (farm maintenance and running costs, car, telephone, electricity, and insurance), and sales value (milk, cull cow, milking cow and calf) were based on current prices (Teagasc, 2017). Contractor costs for replacement machinery work, which included spring feeding of cattle, fertilizer and slurry spreading, was included at €45/h. A reduction in machinery time (180 h or 2 h/d) was observed on the farm when a machinery contractor was used. Own machinery expenses in the model were based on €15/h for the running of machinery on their own farm ± the associated labor costs.

Scenarios

We modeled 3 scenarios beyond the baseline category (which was representative of the sample of 26 farms used in the spring efficiency analysis) in which different strategies were applied to reduce the labor requirement per day (farm hours worked per day) in the spring by contracting out the tasks of milking, calf rearing, and machinery work. The economic outcome of contracting out these 3 tasks was examined in terms of the cost/benefit of replacing own labor with contracted labor, while (a) reducing the farm hours worked per day, and (b) increasing cow numbers and retaining the farm hours worked per day. The model assumed that there was a requirement to rent additional land (for the scenarios with added cows) with land rented at a cost of €500/ha per year. There was a requirement to build additional winter housing and milk facilities for the expansion, resulting in an investment cost of €2,500/cow, which was depreciated over a 15-yr period and financed with a 15-yr term loan with an interest rate of 4%, all of which was included in the analysis.

For each scenario modeled, there were 2 options: (1) shorten the farm hours worked per day or (2) maintain farm work hours and increase cow numbers (but at increased labor efficiency) to a level at which current farm hours were worked. Cow numbers were increased based on calculating the daily labor requirement per cow in the spring period using the shorter farm hours worked per day for each of the scenarios modeled. The farm hours worked per day (when contracting out was practiced) were divided by the original number of cows (n = 185) resulting in a new daily efficiency (h/cow per day). The original farm hours worked per day (16.6 h) were divided by the new daily efficiency (h/cow per day) to get the cow numbers.

Statistical Analysis

Statistical analyses were conducted using SAS software (SAS Institute Inc., Cary, NC). Least squares means among categories were calculated for variables using linear models in PROC MIXED and PROC CORR of SAS. Tukey's test for multiple comparisons was used and statistical differences were considered significant at a 0.05 significance level. Residual checks were made to ensure the assumptions of the analysis were met.

The effects of efficiency category on hours and hours/cow spent on the labor tasks of calf care, cleaning, winter feeding, grassland management, maintenance, management, milking, miscellaneous, and veterinary were examined. Additionally, the relationship between efficiency category and whole-farm net profit (€/ha and €/kg of MS), whole-farm costs (€/kg of MS), MS per hectare, MS per cow, and stocking rate were also examined.

RESULTS

The results of these analyses are presented first with respect to the relationship between annual farm labor efficiency and financial performance, and then in terms of labor demand in the spring and modeled strategies to reduce hours required each day.

Efficiency and Financial Performance

The relationship between level of annual farm efficiency and various financial performance indicators is illustrated in Table 3. The most labor efficient farms had a significantly higher ($P = 0.02$) farm net profit/hectare than the least efficient farms, and farm costs per kilogram of MS tended to be higher ($P = 0.10$) on the less labor efficient farms. This analysis suggests that the more labor efficient farms were also more financially efficient, but it must be noted that this analysis does not include own labor. There was no association between efficiency levels and MS/hectare or MS/cow. Additionally, we found no significant relationship between stocking rate and different labor efficiency levels.

Spring Efficiency and Farm Hours Worked per Day

The mean herd size for all farms (n = 26) in the spring efficiency analysis was 185 cows with an average overall farm labor efficiency of 23.3 h/cow per year and average spring labor efficiency of 0.6 h/cow per week. The average total land area was 102 ha. Descriptive statistics of the farms used in the analysis can be found in Table 2. Overall hours and time (h/cow per week) spent at different tasks in the spring can be found in Table 4. Farms were ranked on their level of labor efficiency during the spring. There was a correlation between spring labor efficiency and overall annual labor efficiency (r = 0.75). The most time-consuming tasks in the spring on an hour-per-cow basis across farms were milking (442 h; 0.2 h/cow per week), calf care (217 h; 0.1 h/cow per week), grassland management (147 h; 0.1 h/cow per week), and winter feeding (146 h; 0.1 h/cow per week). The task of milking was the only one in which absolute hours worked varied significantly in the spring between efficiency categories. However, when analyzed on an h/cow per week basis, significant differences were noted between efficiency categories for calf care, grassland management, and milking. The largest difference was observed for the task of milking, in which the most efficient farms used 0.9 h/cow per week less in the spring than the least efficient farms.

The effects of removing particular tasks on the total farm hours worked daily in the spring and annual farm labor efficiency are shown in Table 5. The average farm hours worked per day in the spring across the 26 farms was 16.6 h and average annual farm labor efficiency was 23.3 h/cow per year. We found no significant differences between farm hours worked per day before or after task eliminations between the separation of spring efficiency or annual efficiency groups; thus, results are presented for all 26 farms together. Eliminating the milking task had the greatest effect on changing the average farm hours worked per day in the spring with, on average, a 5.6-h reduction in farm labor per day. Removing the milking task also had the greatest effect on the annual farm labor efficiency and average hours-per-cow savings over the course of the year. The removal of calf care and machinery work each resulted in an average of 2.7 h of labor reductions to the average farm hours worked per day and annual farm labor efficiency.

Modeling

The effects of 3 different strategies to reduce labor demand in the spring are shown in Table 6. Based on the farm scenario modeled (185 cows), none of the

Table 3. The relationship between level of annual labor efficiency and various economic parameters

	Efficiency category[1]			
Item	A (n = 16 farms)	B (n = 16 farms)	SE	P-value
Whole-farm net profit (€/ha)	1,123	848	81.2	0.02
Whole-farm net profit (€/kg of MS[2])	1.34	0.17	0.13	NS
Whole-farm costs (€/kg of MS)	2.95	3.24	0.12	0.10
MS/ha (kg)	761	797	52	NS
MS/cow (kg)	447	448	0.9	NS
Stocking rate (LU[3]/ha)	2.2	2.4	0.13	NS

[1]Efficiency categories A (<21 h/cow per year) and B (≥21 h/cow per year).

[2]Milk solids.

[3]Livestock units.

Table 4. Differences in time spent at tasks in the spring across spring-efficiency categories

Task and time	Spring efficiency category A (n = 13)	Spring efficiency category B (n = 13)	SE	*P*-value
Calf care				
h	201	234	36	NS
h/cow per week	0.08	0.12	0.17	0.04
Cleaning				
h	65	75	38	NS
h/cow per week	0.02	0.03	0.17	NS
Winter feeding				
h	137	155	36	NS
h/cow per week	0.05	0.08	0.17	NS
Grassland				
h	123	173	36	NS
h/cow per week	0.05	0.09	0.17	0.05
Maintenance				
h	40	51	40	NS
h/cow per week	0.02	0.02	0.18	NS
Management				
h	96	117	38	NS
h/cow per week	0.03	0.06	0.17	NS
Milking				
h	424	461	36	0.003
h/cow per week	0.17	0.24	0.17	<0.0001
Miscellaneous				
h	134	110	38	NS
h/cow per week	0.05	0.06	0.17	NS
Veterinary				
h	29	56	41	NS
h/cow per week	0.01	0.02	0.19	NS

strategies to reduce labor demand had a substantial (i.e., <5%) negative impact on the financial returns from the farm.

When cow numbers were increased to take advantage of the time saved by contracting out tasks, there was a substantial positive effect on net profit. Cow numbers could be increased to 270, 221, and 210 (an increase of 94, 36, and 25 cows, respectively) when contracting the tasks of milking, calf rearing, and machinery work, respectively. Increases in profitability of 40, 15, and 20% were associated with greater use of contract milking, calf rearing, and machinery work, respectively, when cow numbers were increased.

DISCUSSION

The results from this study highlight economically viable options that pasture-based dairy farms may use to manage the labor-intensive spring period. Having the milking task contracted out had the greatest effect on daily hours worked on-farm in the spring and on overall farm labor efficiency. Having the task of calf rearing contracted out had the next largest effect. These alternatives reduced the farm hours worked per day with only marginal (i.e., <5%) negative implications on farm profitability when own labor costs were included. These strategies provide options for farmers in an environment of high labor demand on-farm and low availability of labor supply, particularly during the spring period.

We found that the farm hours worked per day could be shortened in the spring through greater use of contractors for the milking task, the rearing of calves, or machinery work. However, this conclusion was based on the fact that all of these options saved owned labor and owned labor was included in the model at a cost of €15/h. Economically viable options were highlighted that pasture-based dairy farms may use to manage the labor-intensive spring period. When these strategies were used in combination with increased cow numbers, there were positive effects on net farm profit. Alternatively, if no value was placed on the farm's own labor before analysis (i.e., the farmer not considering his/her own labor as having a value), then the financial impact of the analysis would be negative.

Feed costs represent the largest cost of milk production, followed closely by labor costs (Gillespie and Nehring, 2014; Hemme et al., 2014). Pasture-based systems have an advantage, globally, where feed costs are kept to a minimum through use of intensive pasture grazing (Dillon et al., 1995; Macdonald et al., 2011). Although the labor on Irish dairy farms has historically been primarily the farmer and family, recent expansions are associated with the need for increased hired labor (Teagasc, 2017). In the current study, whole-farm net profit was significantly higher on the most labor efficient farms than on the least efficient farms. There

Table 5. Total farm hours worked per day in the spring with and without the elimination of certain tasks and their influence on annual farm efficiency (n = 26)

Scenario	Farm hours worked (h/d)	Reduction in time from task elimination (h/d)	Annual farm efficiency (h/cow per year)	Average saving over a year (h/cow per year)
Original	16.6	—	23.3	—
Milking eliminated	11.0	5.6	20.6	2.7
Calf care eliminated	13.9	2.7	22.0	1.3
Machinery work[1] eliminated	14.6	2.0	21.8	1.5

[1]Machinery work includes winter feeding, fertilizer spreading, slurry spreading, soiled water spreading, agitating, reseeding, pit silage, spraying, farmyard manure spreading, hedge cutting, lime spreading, digger work, and other.

Table 6. The economic impacts of differing strategies to reduce labor requirement in the spring on spring-calving dairy farms

Item	Baseline	Contracted milking	Contracted milking/increased cow numbers	Contracted calf rearing	Contracted calf rearing/ increased cow numbers	Contracted machinery work	Contracted machinery work/ increased cow numbers
No. of cows	185	185	279	185	221	185	210
MS[1] sold (kg)	73,283	73,283	110,518	75,532	90,230	73,283	83,186
Total receipts (€)	403,322	403,322	608,253	373,699	446,419	403,322	457,825
Total costs (€)	300,980	303,845	465,090	274,508	323,495	303,460	340,518
Net profit (€)	102,891	100,006	143,605	99,644	123,329	100,430	117,858

[1]Milk solids.

was a tendency for the most labor efficient farms to have lower whole-farm costs per kilogram of MS. In the current study, both annual efficiency categories had similar MS produced per cow and per hectare, yet the more labor efficient farms had higher profitability per hectare. This is supported by a recent Irish study that found a positive relationship between milk production per cow and per hectare and profitability but they did not take into consideration the level of labor efficiency (O'Brien et al., 2015). Thus, focusing on labor efficiency is an important aspect to optimizing farm profitability.

In this study, the major focus was on the spring labor-demand period rather than the whole year, because of the seasonal nature and peak labor demand in the spring of pasture-based systems. Identifying labor-saving techniques for tasks relevant to this time period is of particular importance to help pasture-based farmers overcome this labor bottleneck. This study took into account ways in which to reduce hours worked by the farmer themselves, rather than reducing the hours of total work performed on the farm. Both options examined in this study offer realistic choices for farmers; however, economic gains are only predicted when the labor-saving options are used in conjunction with an increase in cow numbers.

In this study, the most labor efficient farms in the spring had a larger average herd size, were more labor efficient annually, and had a larger average land area than the least labor efficient farms in the spring (Table 2). The tasks in the current study that demanded the most labor in the spring were milking, calf care, grassland management, and winter feeding, similar to the previous research of O'Donovan et al. (2008). The tasks that differed significantly between the most and least spring-efficient farms on an hour-per-cow basis were milking, calf care, and grassland management; thus, these were the most influential tasks between the most and least efficient farms.

Because there were no significant differences in farm hours worked per day between spring-efficiency groups before or after tasks were contracted, the farms were regrouped as one sample for this part of the analysis. For some farmers in the study, reducing the farm hours worked per day may be the priority, whereas for others, the priority may be on maintaining the total hours worked while expanding the herd size.

Removing the task of milking from the present hours worked per day resulted in the greatest change, with a reduction of 5.6 h/d. Countries that have larger average herd sizes and more hired farm staff have specific people to perform particular tasks and streamline productivity (Reed, 1994). Here, we envisaged that a farmer could hire a person to perform the milking task and be specialized in that specific task (albeit at a slightly higher cost). This could make more time available for other tasks on-farm, shorten the working day, or allow an increase cow numbers.

When the task of calf care was taken over by contractors, a reduction of 2.7 h/d occurred in the spring. In 2015, the National Farm Survey of Ireland added additional questions to better understand the proportion of farmers utilizing collaborative farming arrangements such as contract rearing of heifers (NFS, 2016). The survey indicated that approximately 5% of dairy farms were utilizing contractors to rear their calves or heifers and they tended to be larger farms (Kinsella et al., 2017). In a study of US dairy farms that used a contract heifer rearing option (Wolf, 2003), the most frequent reasons for a farmer to outsource heifer rearing was to make space in facilities for an expanding milking herd, a lack of adequate space for heifer rearing, management and time, and labor reasons. With the potential decrease in labor on dairy farms when the task of rearing calves is removed, coupled with the direction the post-quota EU/Irish dairy industry is taking with herd expansions, contract rearing of calves and heifers should be considered a labor-efficient option and has been highlighted previously (Shalloo et al., 2007; Teagasc, 2013; Curran, 2016). Although only a small proportion of Irish dairy farms outsource calf and heifer rearing tasks to contract rearers, we predict this option will grow, especially as herd sizes increase and the desire of farmers to prioritize their facilities and grazing platform for the milking herd (Kinsella et al., 2017).

It has been documented that those who specialize in dairying (as opposed to multiple enterprises) and utilize business support mechanisms (such as paying for independent technical advice) have improved labor efficiency and profitability (Wilson, 2011; Kelly et al., 2012). In addition to hiring in a person for the specific tasks of milking or calf care, farmers have the option of hiring contractors to perform machinery work on farm. As observed in this study, there are costs associated with replacing machinery work performed on farm with contractor work; however, the savings associated with it should be noted as well. Contractors generally have larger equipment, reducing the time spent at the tasks; less machinery owned by the farm means lower depreciation and running costs; and finally, the farm labor that would have been spent at machinery tasks is now freed to perform other tasks on farm or remove these hired staff altogether (Forristal, 2015). Machinery work during the spring is primarily focused on grassland management, animal feeding, and slurry application; thus, choosing to reduce or eliminate machinery work that could be outsourced to contractors could be a labor saving and logical decision. Eliminating machinery work and having it outsourced to contractors has multiple implications. A study on machinery costs in Ireland by Forristal (1999) found that depreciation and interest accounted for nearly 60% of the total machinery costs on-farm. In that study, larger farms were, however, more machinery-efficient with lower levels of machinery investment per hectare. More recently, Forristal (2015) indicated that although contractors are able to spread costs over more acres with larger equipment, there is a cost to the farmer to consider.

The goal of this analysis was to present the effects of outsourcing certain tasks or outsourcing tasks in conjunction with increased cow numbers, on farm profitability. Although the elimination or outsourcing of certain tasks had a significant effect on spring farm hours worked per day and spring efficiency, it had little effect on the overall annual efficiency measure, largely because of the dilution of spreading it over 12 mo rather than the 3-mo peak labor period. However, reducing the daily labor demand on the farmer during this period of maximum workload could have a positive outcome for the farm overall. There has been an increased interest in improving the work-life balance of farmers by reducing the farm hours worked per day in the spring, while recognizing the opportunities for dairy herd expansion in the post-quota EU.

Expansion within a dairy industry places significant pressure on the availability of labor. For Irish farms in particular, even though the average herd size in 2017 was 80 cows, 25% of the dairy herds had more than 100 cows (Teagasc, 2017). Within this group, there is a requirement for additional labor as the herd size expands. The analysis in the current study has shown that the use of innovative solutions, whether through the use of contractors performing the milking tasks, the rearing of calves, or machinery work, can result in a significant reduction in farm hours worked per day at peak times, thus alleviating stress points within the system. In order for these scenarios to be effective in attracting and retaining people to perform the contracted tasks, the farm must be an attractive place to work and the farmer must not be placing unrealistic expectations on hired staff to perform less desirable tasks. This analysis was based on all own labor costs being valued on the farm at a rate of €15/h. If the farmer does not put a value on their own time or labor, the conclusions (substituting own labor with hired labor of different forms) arrived at in this analysis may be different. For example, if a farmer does not put a value on his or her own time and substitutes their own labor with the contracted hired labor described in this study, the results would appear extremely unprofitable. This analysis highlights how important it is to complete a full economic appraisal rather than depending on a cash cost basis.

Not explored in this study was the alternative option to reduce long hours worked by increasing labor efficiency and the economic impacts of reducing those hours through investments in improved facilities or the less tangible changes, such as farm management practices, work organization, and farmer behavior.

CONCLUSIONS

Farms that were more labor efficient were found to be more profitable. The results from this study highlight economically viable options that pasture-based dairy farms could use to manage the labor-intensive spring period. Removing the milking task from the farm labor requirement and having it contracted out had the greatest impact on average farm hours worked per day and overall farm labor efficiency. This was followed by contracting out the task of calf rearing. These alternatives reduced the farm hours worked per day with only marginal (i.e., $<5\%$) negative implications on farm profitability when the farmer's own labor costs were included. When these strategies were used in combination with maintaining work hours and increasing cow numbers, there were positive effects on net farm profit. Results from this study indicate viable options for grass-based, seasonal-calving dairy farms to manage opportunities for expansion while optimizing profitability and work-life balance.

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