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Dairy Check-off Investments for New Uses for Whey

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In recent decades, the productivity of U.S. dairy farms has increased rapidly and milk prices have fallen. In this context, many see the prospects for enhanced returns to dairy producers depending largely on enhanced demand for dairy products. Although U.S. per capita consumption of cheese increased nearly fourfold in the last half of the twentieth century, per capita consumption of all dairy products fell 17 percent over the same period, in part because of reduced consumption of fluid milk products. This decline in consumption occurred despite a decline in real farm-level prices of 27 percent. With traditional consumption of dairy products flat or falling, finding new uses for milk is a way of increasing demand for dairy products.

Dairy check-off programs, operating under federal and state legislation and regulation, invest revenue from a tax on raw milk in projects aimed at increasing demand for dairy products. Check-offs collect several hundred million dollars per year, most of which is devoted to media promotion programs and relatively little to R&D. Similarly, economic analyses of the dairy check-off have focused primarily on the effects of generic promotion; much less attention has been paid to the effects of dairy check-off expenditures on new product R&D.

Nonetheless, scientists are developing new uses for agricultural products at research institutions around the world including new uses for dairy products. Like media promotion, new uses promise to add value to agricultural products, raise product prices, and, ultimately, increase returns to the grower. When the costs of R&D for new uses are funded by producer assessments such as the dairy check-off, the expense is distributed among various producer and consumer groups. Analysis of the potential economic effects of check-off funded programs to develop new uses can provide a preview of the distribution of benefits and costs among these groups and allow evaluation of the payoff to each group's investment in R&D. In a recent study, we quantified the potential economic effects of research on new uses for dairy whey.

Investment in R&D for New Uses for Whey

We evaluated the economic returns to an ongoing research program at the University of California that has been funded primarily by the dairy check-off but also by general state and federal taxes that support the university. This research program is developing new uses for whey protein—a byproduct of cheese manufacturing—for films and coatings in food-related and other applications. For several of the technologies, progress in the laboratory indicates that commercial production is possible by 2005, and strong interest from potential industrial users suggests that commercial adoption is likely. Since current technology for films and coatings does not use whey or any other dairy product, successful marketing of the new technologies will create new demand for whey and for milk.

From 1990 through 2005 (projected date of first commercial adoption of whey coatings), the whey research project will have incurred a cost of $3.8 million (2002 present value), which includes actual outlays through 2002 and an estimate of whey research expenditures for 2003 through 2005 based on recent annual outlays. (We adjusted costs for inflation and used a 4 percent real discount rate to bring annual costs to a 2002 present value.) This figure represents the cost of the entire research program and includes the cost of developing new whey applications whose adoption and potential benefits we do not analyze here. Of the total research cost, $2.23 million (approximately 60 percent) will have been paid by research grants from the U.S. dairy industry through California Dairy Research Foundation (CDRF). CDRF, which allocates check-off funds mainly to a handful of university researchers for R&D, receives approximately three-quarters of its budget from national check-off revenue generated in California and the remaining one-quarter of its budget from national check-off revenue generated in all states. Of the total CDRF investment in whey research, the California Milk Advisory Board (CMAB) will have contributed $1.68 million (75 percent) and Dairy Management, Inc. (DMI) will have contributed the remainder, $0.56 million (25 percent).

CMAB and DMI are each funded by the dairy check-off, a national marketing assessment of

$0.15 per one hundred pounds of milk sold. Such assessments affect market prices and quantities and thus are ultimately borne partly by producers and partly by consumers. The proportion of the cost borne by each group depends on how market prices change, which in turn depends on the nature of supply and demand conditions in the industry. More precisely, the proportion of the check-off borne by producers equals $|\eta|/(\varepsilon + |\eta|)$, where η is the elasticity of demand (price responsiveness of buyers) for U.S. milk and ε is the elasticity of supply (price responsiveness of sellers) of U.S. milk. For example, based on an elasticity of supply of U.S. milk of 1.0 and an elasticity of demand for U.S. milk of –0.35, producers incur approximately 41 percent of the burden of the check-off. With these parameters, U.S. producers' incidence of the check-off investment in the whey research program is $0.92 million (41 percent of $2.23 million), of which $0.69 million (41 percent of $1.68 million) is from CMAB and $0.23 million (41 percent of $0.56 million) is from DMI.

Although there is a single national check-off, individual states and groups of states can retain up to one-third of the check-off revenue generated by local milk sales to fund promotion and research efforts chosen by local producer groups. CMAB, for example, manages one-third of the check-off revenue collected in California. The remaining two-thirds is managed by DMI, which has a national scope. Check-off revenue collected in California accounts for approximately 20 percent of DMI's funding (approximately equal to California's share of U.S. milk production). Given that approximately 75 percent of CDRF funding is through CMAB and 25 percent is from DMI, the cost of the whey research program to California producers is $0.60 million (0.75 x $0.69 million + 0.2 x (0.25 x $0.69 million + $0.23 million)).

In addition to check-off funding, University of California contributed a present value of $0.11 million in direct research grants and approximately $1.46 million toward the research program's indirect costs, including researcher and faculty salaries, lab and office space, and research dissemination efforts. To the extent that federal and California tax dollars support the university, federal and California taxpayers pay the university's contribution to the whey research project.

Modeling and Quantifying the Economic Effects of Increased Whey Demand on U.S. Dairy Markets

We develop a detailed simulation model to consider the likely market effects resulting from commercial adoption of the new whey protein products and measure the expected return from investment in research accruing to U.S. milk producers. In a related research project, we analyze the distribution of costs and benefits across California and U.S. producers and to consider also the broader effects of the research program on the economy.

The simulation model used information from researchers and industry sources to estimate the potential for adoption of the new technologies and quantify the associated increase in demand for whey. The model yields expected changes in prices and quantities of milk and dairy products resulting from adoption of the technologies. We adopted a simulation approach similar to that often used to measure the size and distribution of costs and benefits of R&D.

The simulation results are straightforward. Increased demand for whey results in a higher whey price, encouraging increased production of whey. Because whey and cheese are produced jointly and in approximately fixed proportions, cheese production must also increase, which puts downward pressure on cheese prices. Overall, the increased demand for milk by cheese and whey manufacturers drives up the price of milk, encouraging greater milk production. At the same time, the higher milk price raises costs for manufacturers of butter, ice cream, and other dairy products, resulting in higher prices and smaller quantities for these products. The magnitudes of the shift in milk demand, changes in the price of milk and quantity of it produced, and increased returns to producers depend on the economic and technological relationships that were embodied in the parameters of our model. Where possible, we assigned values to the parameters of the model based on published agricultural economics literature and public data. Where published estimates and data were lacking, we relied on knowledgeable industry sources and on our own calculations. The magnitude, but not the direction, of the results would vary under different parameter scenarios.

Quantitative Results and Discussion

Commercial adoption is likely by 2005 for several of these new uses for whey. For these technologies, we estimated the raw material cost to potential users for comparison with the cost of existing technologies. Based on these cost comparisons, together with discussions with potential users, we evaluated the potential for commercial adoption of each whey application, concluding that near-term adoption is likely for three applications: oxygen-barrier coatings on plastics, gloss coatings on confectioneries, and oxygen-barrier coatings on nuts in candy. Our discussions with industry also indicated that half of the relevant markets would switch to a whey protein coating. The additional demand for whey protein associated with adoption of the new applications is likely equivalent to between 1 and 4 percent of the estimated amount of whey protein currently available as a byproduct of cheese manufacture in the U.S.

Table 1 presents the effects of a 3 percent shift in demand for whey on prices and quantities of milk and dairy products. We also report in Table 1 the annual benefit to U.S. and California milk producers, as well as the total annual benefit to producers, processing and marketing firms, and consumers.

Consider, first, the direct effects of new uses for whey on the whey and cheese markets. Following a 3 percent increase in demand for whey, the price of

whey increases by 2.86 percent. Higher whey prices are accompanied by a reduction in cheese prices of 0.28 percent: as cheese manufacturers receive more for whey, more milk goes to cheese processing, leading to increased cheese production and hence lower cheese prices. However, since whey is a relatively small share (approximately 11 percent) of cheese processors' revenue, the implied reduction in cheese prices is relatively small. The quantities of cheese and whey produced increase by 0.14 percent.

Based on the percent changes in prices and quantities, we calculated the percent change in revenue for cheese and whey manufacturers and for milk producers. Whey revenue increases by 3.40 percent and cheese revenue falls by 0.18 percent. Since whey accounts for only a small share of a cheese/whey plant's revenue, revenue for cheese/whey manufacturers increases by only 0.21 percent.

Tracing the results through other markets, we find that raw milk prices and production each rise by 0.04 percent as a result of increased demand from cheese/whey processors. Dairy farm revenue rises by 0.08 percent. As higher milk prices drive up manufacturers' costs, prices of dairy products other than cheese and whey rise by 0.03 percent and production of those products fall by 0.01 percent. These are small percentage impacts, but remember that they apply to a very large industry and the initial spur is a single, relatively small program of research.

The bottom of Table 1 reports a measure of the annual gross benefits from the whey research program to U.S. dairy farms as a group and to California producers, calculated as the increase in total milk revenue net of marginal production costs (i.e., the change in producer surplus). U.S. producers gain $10 million (2002 dollars) each year because of increased demand for whey. Of that, we calculated that $1.9 million goes to California producers based on their share of U.S. milk production. Note that gross annual benefits were calculated as the change in producer surplus from increased demand for whey, not counting the cost to producers of the whey research program. We consider net benefits below.

Gross annual producer benefits from the shift in demand for whey were approximately proportional to the inverse of the elasticity of demand for whey. Doubling the elasticity of demand for whey from –1.0 to –2.0 reduces the producer gain by approximately half: U.S. producers would gain $5 million per year and California producers would gain $0.9 million per year. Halving the elasticity of demand for whey from –1.0 to –0.5 would double the producer gain.

Adoption of the whey technologies also had an impact on dairy processors, marketers, and consumers. Although milk and dairy consumers incur a portion of the cost of the dairy check-off, consumers have no direct say in how check-off revenue is spent. Traditional consumers of whey would suffer an annual loss in economic surplus of approximately 2.9 percent of whey expenditures from higher whey prices. Consumers of cheese would be better off, with an annual gain in consumer surplus equal to 0.3 percent of cheese expenditure. Consumers of other dairy products would be off because of higher prices, but the effects are tiny.

Aggregating welfare effects in the various linked markets provides an estimate of the gross (annual) benefit to the economy, including producers, processing and marketing firms, and consumers. Our estimate of the total gross benefit of the shift in whey demand, reported in the last line of Table 1, was $42.3 million. This measure includes benefits to milk producers, benefits and costs to various milk processing subsectors, and benefits and costs to dairy consumers. It does not include the cost of the research program. Further, although we do not explicitly model confectionery and plastics markets, demand for whey-protein coatings from these industries is implicit in our characterization of whey demand. Hence, our estimate of the total benefit included the welfare effects in these markets. As was the case with producer benefits, the total benefit from the shift in demand for whey is approximately proportional to the inverse of the elasticity of demand for whey.

We also simulate the annual effects of a 1 percent and a 4 percent shift in demand for whey but do not report the results here. The effects of those shifts on prices and quantities are linear in the magnitude of the shift in demand for whey; the effects on prices and quantities of a 1 percent increase in demand for whey were one-third the magnitude of those (reported in Table 1) for a 3 percent increase in demand.

The expected gains to dairy farms and total expected benefits reported in Table 1 represent annual benefits expressed in 2002 dollars. We calculated total gross benefits over the lifetime of adoption by projecting a pattern of adoption over time and discounting each year's benefits to a specified date. Although future adoption rates are uncertain, the strong interest shown thus far by confectionery and plastic manufacturers suggested that whey protein coatings will be marketed successfully.

We approximate total capitalized gross benefits by supposing a specific time pattern of adoption. We assume a time path of adoption such that demand increases by 1 percent for the first five years (2005–2009), by 3 percent for another five years (2010–2014), by 4 percent for ten years (2015–2024), and then back to 1 percent for ten years (2025–2034) before the whey products are fully replaced by newer technologies. Present values of producers' gross benefits and total gross benefits are reported at the top of Table 2. Under this adoption pattern, and based on a real annual discount rate of 4 percent, the 2002 present value of gross benefits to producers, processing and marketing firms, and consumers over the period 2005–2034 was $528.73 million. The 2002 present-value gross benefits to all U.S. producers over the same period was $127.39

million, of which $23.73 million accrued to milk producers in California. (Note: capitalized values presented here differ from those in Balagtas et al. because we used a smaller discount rate.)

The costs of the research project are attributable not only to the three whey uses considered here, which are near commercial adoption, but also to applications in earlier stages of development and those considered less likely to be adopted. Further, some of the research is more basic in nature and has potential for applications not discussed here or even foreseen. To calculate a return to the investment in research resulting in the three applications nearing adoption, we had to apportion research costs to those applications. A conservative approach was to attribute all costs to the three whey applications near adoption, which was equivalent to assuming that these were the only successful products of the research program and ignoring potential benefits from any other applications. In Table 2, we report costs under this conservative scenario, as well as under a scenario in which half of the research program's expenditure were attributed to the three applications.

The distribution of costs among producers, consumers, and taxpayers was discussed earlier, and the producers' portion of total research costs is reported in Table 2. Recall that total check-off investment in the research program is $2.23 million. We estimated that the producer incidence of the check-off is approximately 41 percent, or $0.92 million.

Table 2 also reports summary statistics that are commonly used to characterize returns to research and are useful for comparing returns to research on alternative investments. The present value of net benefits is simply the present value of gross benefits less the present value of research costs. The benefit-cost ratio is equal to the present value of gross benefits divided by the present value of costs, or the average return per dollar invested. The (real) internal rate of return (IRR) is the annual interest rate that would just make the net present value of the project zero, such that benefits equal costs in present value terms.

When 100 percent of research expenditures were attributed to the three applications considered here, the present value of total net benefits was $524.93 million, of which $126.47 million accrued to U.S. milk producers and $23.13 million to California milk producers. The total benefit-cost ratio was 139:1, the U.S. producer benefit-cost ratio was also 139:1, and the California producer benefit-cost ratio was 40:1. Note that the California producer benefit-cost ratio was smaller than the U.S. producer benefit-cost ratio because California producers bear nearly 70 percent of producers' costs while receiving benefits in proportion to their share of U.S. milk production—approximately 20 percent. The IRR for total benefits was 36 percent per annum, the IRR for U.S. producers' investment in the percent per annum, and the IRR for California producers' investment was 25 percent per annum. The interpretation is that U.S. producers' investment in the research program is preferable to any alternative investment yielding less than 34 percent per annum. Again, the IRR for California's producers was smaller than that for all U.S. producers because their proportion of producer costs exceeds their proportion of the producer benefits.

Attributing 50 percent of total research expenditures to the three whey applications considered here resulted in a larger present value of net benefits, a larger benefit-cost ratio, and a larger IRR for each group.

Different time patterns of adoption can have a large impact on the present value of net benefits, the benefit-cost ratio, and the IRR. However, given our estimates of annual benefits, returns to investment in whey research were positive and large for a wide range of adoption scenarios. Further, our measures of producer benefits were conservative in that we did not attribute to producers the benefits that accrue to cheese and whey manufacturers, which also accrue to producer-members of dairy cooperatives and dairy-farmer owners of other cheese manufacturing firms (such as Hillmar Cheese) that produce much of the cheese and whey.

Conclusion

New uses for agricultural products promise to add value to raw agricultural products, raise commodity prices, and raise farm producer returns. Producers, consumers, and taxpayers finance the research efforts that create new uses. *Ex ante* economic analysis anticipates the market effects of new uses and is the basis for evaluating investments in R&D before the benefits have been fully realized.

The research leading to the new whey uses, including potential uses not yet ready for adoption, was projected to cost a present value of $3.8 million by the adoption date of 2005. National and California dairy check-off programs will have contributed $2.23 million; of that, approximately 41 percent, or $0.92 million, can be attributed to dairy farms and the rest can be attributed to processors, marketing firms, and consumers. Taxpayers also have contributed through their support of the University of California, which has paid for some of the research program's costs.

This research has shown how the use of check-off revenue for demand-enhancing research can provide substantial returns to producers and to society as a whole. The results have potentially important implications as producers consider the allocation of check-off funds between, for example, R&D and promotion

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Table 1. Simulation Results: The Annual Effects of a Three Percent R&D-induced Increase in Whey Demand

	Percent Change
Prices	
Whey	2.86
Cheese	-0.28
Other Dairy	0.03
Raw Milk	0.04
Quantities	
Whey	0.14
Cheese	0.14
Other Dairy	-0.01
Raw Milk	0.04
Revenue	
Whey	3.40
Cheese	-0.18
Cheese and whey plant[2]	0.21
Other Dairy	0.02
Raw Milk	0.8
	$ million (year 2002 dollars)
Gross Annual benefits, US Milk Producers[3]	9.96
Gross Annual benefits, CA Milk Producers[3]	1.85
Gross Annual benefits, Total[4]	42.30

[1]These calculations are based on the parameters discussed in the text.
[2]Based on an average of 11 percent of cheese plant revenue from whey.
[3]Calculated as the change in producer surplus resulting from demand for whey, but excluding producers' cost of the research program
[4]Gross annual benefits to producers, processing and marketing firms, and consumers, excluding cost of the research program.

Table 2. Present Value Benefits and Costs of R&D for New Uses of Whey Protein

		Total	U.S. Producers	California Producers
Present Value, Gross Benefits	2002$ million	528.73	127.39	23.73
Attributing 100 percent of research costs to three marketed applications				
Present Value, Research Costs[2]	2002$ million	3.80	0.92	0.60
Present Value, Net Benefits[3]	2002$ million	524.93	126.47	23.13
Benefit-Cost Ratio		139	139	40
Internal Rate of Return (IRR)[4]	percent per annum	36	34	25
Attributing 50 percent of research costs to three marketed applications[3]				
Present Value, Research Costs[2]	2002$ million	1.90	0.46	0.30
Present Value, Net Benefits[3]	2002$ million	526.82	126.93	23.43
Benefit-Cost Ratio[3]		278	277	79
Internal Rate of Return (IRR)	percent per annum	42	39	29

Note: All present values in millions of 2002 dollars, and based on a real discount rate of four percent per annum.

[2] We estimate that the producers' cost of the research program is 41 percent of the total check-off investment. Our estimate of the producer incidence of the check-off, 41 percent, is based on an elasticity of milk supply of 1.0, an elasticity of milk demand of -.05, and an elasticity of demand for raw milk of -.35. We estimate California producers' costs based on the share of the total check-off investment that comes from California milk sales.

[3]Because of rounding, net benefits may not exactly equal gross benefits less costs. Also because of rounding, the benefit-cost ratio with 50 percent cost attribution may not be two times the benefit-cost ratio with 100 percent cost attribution.