Forecasts of California Dairy Manufacturing Costs Using Regression Analysis of Audited Dairy Manufacturing Cost Data

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July 2023

Background and Project Overview

Manufacturing costs of cheddar cheese, dry whey, butter, and nonfat dry milk are integral parts of the Class III and Class IV milk pricing formulas used to establish minimum prices under all Federal Milk Marketing Orders (FMMOs). FMMOs employ what are known as end-product pricing formulas to determine regulated minimum prices for milk marketed under the orders. These formulas begin with a dairy commodity price, or end-product price, and subtract from it an assumed manufacturing cost, also known as a manufacturing allowance or "make" allowance. The resulting difference is multiplied by a yield factor to obtain a price for the specified milk component being priced. If the regulated prices generated by the end-product pricing formulas are to accurately reflect the value of milk to manufacturing plants, it is important that the manufacturing costs be accurate and current.

The manufacturing costs used in the FMMO formulas today have been in place since 2008 and are reflective of manufacturing costs during the 2005–2007 timeframe. Given the overall impact of inflation since then, it is reasonable to assume that costs of manufacturing dairy products have increased, and that the manufacturing costs utilized in the FMMO Class III and Class IV price formulas are not representative of actual manufacturing costs today. An analysis of how dairy manufacturing costs have changed since 2006 could be useful in updating the make allowances in the formulas so that they are representative of current costs.

Before the California FMMO was established in November 2018, milk pricing in the state was regulated by the California Department of Food and Agriculture (CDFA). The California state marketing orders employed end-product pricing formulas, like those used in the FMMOs, to establish regulated minimum prices for milk produced and marketed in the state. Like those in the FMMOs, California milk pricing formulas contained make allowances to represent the cost of manufacturing dairy products in the state.

To support regular updates to the pricing formulas, CDFA conducted audited surveys of manufacturing costs, for butter, nonfat dry milk, and cheddar cheese, beginning in 1989. During the 1990s and early 2000s, CDFA conducted audited surveys at various times covering periods that spanned beyond a single calendar year. Also, the study periods could overlap from one year to the next, making it difficult to analyze annual changes in costs using econometric techniques. Beginning in 2002, CDFA began completing manufacturing cost surveys annually, covering calendar-year study periods.

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The CDFA weighted average manufacturing costs reported for cheddar cheese, dry whey, butter, and nonfat dry milk (NFDM) from 2002-2016 are shown in Table 1.

Table 1. CDFA Reported Manufacturing Costs 2002-2016.

	CDFA Survey Weighted Average Costs			
Year	Cheddar Cheese	Dry Whey 1/	Butter	NFDM
	---------- dollars per pound ----------			
2002	$0.1632		$0.1235	$0.1464
2003	$0.1706	$0.2675	$0.1299	$0.1560
2004	$0.1769	$0.2373	$0.1368	$0.1543
2005	$0.1914	$0.2851	$0.1408	$0.1659
2006	$0.1988	$0.3099	$0.1373	$0.1664
2007	$0.2003		$0.1316	$0.1568
2008	$0.2099		$0.1553	$0.1931
2009	$0.1966		$0.1811	$0.1984
2010	$0.1921		$0.1781	$0.2070
2011	$0.2029		$0.1775	$0.1942
2012	$0.2171		$0.1688	$0.1999
2013	$0.2291		$0.1724	$0.1997
2014	$0.2355		$0.1843	$0.2011
2015	$0.2394		$0.1842	$0.2078
2016	$0.2454		$0.1938	$0.2082

1/ Dry Whey Costs were reported for 2003-2006 only, there were too few plants after 2006.

Sources: California Manufacturing Cost Annual, California Department of Food and Agriculture, Division of Marketing Services, Dairy Marketing Branch, Issues 2003-2016, and CDFA Dairy Manufacturing Cost Exhibit (2002 data) released November 2003.

Given the availability of annual manufacturing cost data from CFDA, it is possible to use regression analysis to estimate dairy manufacturing costs. Regression analysis is a statistical method used to explore and quantify the relationship between a dependent variable, in this case dairy manufacturing costs, and one or more independent variables, such as energy and labor prices. It aims to find a mathematical model that best fits the data, allowing us to understand the impact of changes in the independent variables on the dependent variable. We can then use the estimates of the impacts associated with each of the independent variables to forecast manufacturing costs beyond the period for which we have manufacturing cost data.

Model and Data

The purpose of this analysis is to estimate current California dairy manufacturing costs from historical data of CDFA annual manufacturing costs, other input prices, and productivity data.

The FMMO hearing decision from 2008[2], illustrated how the current manufacturing cost (make) allowances were established, in part, utilizing CDFA manufacturing cost data. Hence, there is historical precedent for using CDFA cost data to establish FMMO make allowances.

CDFA dairy manufacturing cost data for 2003-2016 were used to estimate manufacturing cost for butter, NFDM, and cheddar cheese. These data were obtained from annual reports of manufacturing costs that were published by CDFA[3]. As noted previously, earlier CDFA cost studies cover periods that did not coincide with calendar years. Time periods for successive studies often overlapped making them unsuitable for econometric analysis. CDFA did publish manufacturing costs for calendar year 2002, but the level of detail for the various cost components was less that what was available in subsequent years. Calendar year 2016, was the final one for which CDFA published dairy manufacturing costs.

When examining the explanatory-variable data (see Appendix Table A-23), many of the variables appeared highly correlated, a phenomenon we refer to as multicollinearity. Multicollinearity is present when several independent variables in a model are correlated. The correlation coefficient is a measure of the degree of correlation between two data series. A correlation coefficient with an absolute value close to one (1) indicates variables that are highly correlated. Correlation coefficients among the major explanatory variables used in our modeling are presented in Table 2. Multicollinearity leads to difficulties in distinguishing the individual effects of each independent variable on the dependent variable, causing imprecision in the estimated coefficients. High multicollinearity can distort the interpretation of results, as it becomes challenging to determine the true relationships between variables and may lead to unreliable predictions.

Table 2.
Correlation Coefficients Among Explanatory Variables Impacting Manufacturing Costs.

Variable 1/	*NatGas*	*Electric*	*Mfg Wage*	*Lab Pro*	*US PPI*	*Food TFP*
NatGas	1.0000					
Electric	0.3668	1.0000				
Mfg Wage	0.3175	***0.9706***	1.0000			
Lab Pro	0.4247	***0.8757***	***0.9015***	1.0000		
US PPI	0.2353	***0.8969***	***0.9520***	***0.9420***	1.0000	
Food TFP	0.5493	-0.2639	-0.3004	-0.0612	-0.2861	1.0000

1/ These variables are defined beginning on page 7 of this report.

To deal with multicollinearity among the explanatory variables and the limited number of observations (years) in the data set, separate models of utility costs, labor costs, and other manufacturing costs were estimated for each dairy product. For each product, the predicted

[2] 3 Fed. Reg. 35306 eq seq. (June 20, 2008).
[3] California Manufacturing Cost Annual, California Department of Food and Agriculture, Division of Marketing Services, Dairy Marketing Branch, Issues 2003-2016 and CDFA Dairy Manufacturing Cost Exhibit (2002 data) released November 2003.
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values of each of the estimated cost components were summed to obtain a total manufacturing cost estimate. For regression analysis of cheddar, NFDM and butter MFG costs, explanatory variables capturing changes in energy, labor, and general material costs and productivity growth were examined.

It is important to note that no cost model was estimated for dry whey. CDFA audited and reported dry whey costs for four plants beginning in 2003 and discontinued the reporting of whey costs in 2007 due to insufficient plant numbers. Because there are only four years for which dry whey costs are available, no cost model for whey could be estimated. In this analysis, whey manufacturing costs were calculated by adding an incremental drying cost $0.03 per pound to the NFDM cost estimate. The value of $0.03 per pound was chosen as it the approximates difference between the nonfat dry milk and dry whey manufacturing allowances currently used in the FMMO pricing formulas.

One issue encountered when breaking down the total manufacturing cost for a given dairy commodity to its various parts, is that the constituent nonlabor processing costs of interest were not always reported separately by CDFA in its dairy manufacturing cost tables. However, the percentage of nonlabor processing costs attributable to various manufacturing cost subcategories, such as utilities, repairs & maintenance, depreciation & rent, and other plant expenses, were detailed in CDFA's annual cost summary reports. By multiplying these reported cost percentages by reported nonlabor costs, cost numbers for each of these subcategories could be obtained.

Occasionally, because the subcategory cost percentages were rounded in the CDFA reports, summing the calculated subcategory costs resulted in a number that was slightly above or below the reported total for nonlabor processing costs. In this circumstance, all the subcategory costs were adjusted by the percentage that the summed subcategory cost fell short of, or exceeded, the reported category cost. In the models estimated for this analysis, only the utility costs for 2003-2006 were impacted by this adjustment.

It is also important to note that the "other cost" category I have used in this analysis is not a category used by CDFA. Rather, it is the remaining cost after labor costs and utility costs have been subtracted from total manufacturing costs. It can thus be thought of as a residual cost category that encompasses all the manufacturing costs that are not utility costs or labor costs.

The cost models for each of the commodities (nonfat dry milk, butter, and cheddar cheese) were composed of three equations of the following general form:

Labor Cost = *a1 + b1(California Manufacturing Wage) +c1(Labor Productivity)*
Utility Cost = *a2 + b2(Energy Price)*
Other Cost = *a3 + b3(US PPI for Intermediate Goods) + c3(Total Factor Productivity).*

The parameters a1, a2, and a3 are constants, while b1, b2, b3, c1 and c3 are parameters that define the impact that the explanatory (independent) variables have on the associated manufacturing costs. Depending on the commodity, the energy price used in the model is the natural gas price, the electricity price or both. In some of the estimated equations, dummy variables, also known as indicator variables, were included to account for one-time temporary or permanent shifts in the cost data that could not be explained by changes in the other independent variables. A dummy variable has a binary value of one (1) if the structural shift is present in a particular year and zero (0) if the structural shift is absent. The total manufacturing cost of each dairy commodity is then derived from the following identity equation:

Total Manufacturing Cost = Labor Cost + Utility Cost + Other Cost.

Each regression equation was estimated using Ordinary Least Squares (OLS) regression. OLS regression is a widely used form of linear regression analysis. It finds the best-fitting line through a set of data points by minimizing the sum of the squared errors (or residuals) between the observed dependent variable values and the predicted values from the estimated linear equation. OLS calculates the coefficients of the regression equation, including the explanatory variable (slope) parameters and constant (intercept), that minimize the overall prediction errors, providing an efficient and straightforward way to estimate the relationship between the dependent variable (cost) and one or more explanatory variables. OLS regression is an econometric technique that has been widely used for modeling and forecasting purposes.

Model Specification

The various explanatory variables in each of the cost equations in the model are included because they are expected to be correlated with the underlying cost component that they are meant to represent. With utility costs, for example, the California industrial electricity rate is meant to represent the electricity cost faced by dairy product manufacturers in the state, just as the industrial natural gas price is meant to represent their natural gas costs. These state average rates for various forms of energy used by industry may not be the actual costs faced by California dairy plants, but they are thought to be related, and as such, serve as proxies for the underlying plant energy costs. Individual plant energy costs can be influenced by the specific energy rate charged by the plant's energy provider, or by risk management hedging programs that plant operator might engage in to obtain more predictable costs over time. However, these more detailed individual plant cost data are not available for this analysis, so instead, proxy variables are used to represent the underlying changes in energy costs in the regression model.

Plant labor costs will be impacted primarily by wages paid to plant workers and by the productivity (efficiency) of those workers. The California wage rate for nonsupervisory manufacturing workers serves as a proxy for the changes in plant labor cost, while nonfarm labor productivity accounts for gains in labor efficiencies that would be expected to reduce labor costs over time.

Other costs encompass a broad cost category with many components. It would be difficult to develop proxy measures for each individual cost category. Instead, to represent general changes in the costs of the various items that combine to form the other costs category, I have chosen the US producer price index (PPI) for intermediate goods. Intermediate goods, which are typically sold industry-to-industry for resale or to manufacturers, are used in the production process to make other goods that are ultimately sold to consumers. As such, intermediate goods represent many of the material goods that impact the cost of manufacturing and are a reasonable proxy to represent changes in manufacturing costs other than labor and utility costs.

To account for changes in productivity that might impact other dairy manufacturing costs, the Total Factor Productivity Index for Food, Beverage, and Tobacco manufacturing reported by Bureau of Labor statistics is included as one of the explanatory variables in the other cost equation. Total factor productivity is a description of the relationship between output and the combined factors of production (inputs), and thus would be a better representation than labor productivity of how productivity changes would impact other costs.

Examination of the cost data reveals abrupt changes in cost components that are not readily explained by changes in the price and productivity explanatory variables (see Figures A-1 through A-3 in the Appendix). In some cases, these cost shifts can be seen as a blip for a period of 2 or 3 years and in other cases they represent a permanent shift in the cost level. The inclusion of dummy variables in the model is meant to account for the impact of unique one-time or sustained changes in cost that are related to something other than changes in the price and productivity explanatory variables. In some cases, the dummy variables correspond to known events, such as the startup of a large new plant in the state. When new plants begin production, manufacturing costs are often higher on a per unit basis for some period. Higher costs can be due to a learning curve for plant personnel dealing with new equipment and procedures. They can also be related to suboptimal milk volumes being run through the plant, a common occurrence with new plant startups.

Examples of a more sustained structural change might include implementation of a new labor contract that shifts labor costs upward on a sustained basis, or an increase in municipal water and sewage rates that results in a permanent upward adjustment in utility costs. In such circumstances, temporary or sustained, the inclusion of the dummy variable has two key impacts: it increases the ability of the model to explain changes in the dependent variable (cost) and it leads to better parameter estimates for the other explanatory variables, which in turn lead to better manufacturing cost forecasts.

In addition to the specified models described, individual trend regressions for cheese, butter and nonfat dry milk were estimated as a point of comparison with the specified models. The purpose of the trend regressions was to fit a liner trend to the 2003-2016 CDFA manufacturing cost data by estimating an equation where each of the commodity manufacturing costs was estimated as a function of a constant (intercept) and calendar year. The resulting linear trends can then be extrapolated to provide forecasts of manufacturing cost under an assumption where cost increases would be expected to follow the linear trend.

Regression Results

The estimated models for each commodity are shown below.

Cheese Manufacturing Cost Model

	F stat	Adj. R-Square
Labor Cost = a_{11}+ b_{11}^{**}(MFG Wage) + c_{11}(Lab Pro) +e_{11}	**	.77
Utility Cost = a_{12} + b_{12}^{**}(NatGas) + c_{12}^{*}(Electric) + d_{12}(excess whey) +e_{12}	**	.70
Other Cost = a_{13}^{**}+ b_{13}^{**}(US PPI) +c_{13}^{**}US Food TFP) +e_{13}	**	.89

Butter Manufacturing Cost Model

	F-stat	Adj. R-Square
Labor Cost = a_{21}+ b_{21}^{**}(MFG Wage) + c_{21}(Lab Pro) + d_{21}^{*}(Bstruc) +e21	**	.88
Utility Cost = a_{22} + b_{22}^{*}(NatGas) + c_{22}^{**}(sewer rate) + d_{22} (New pt) +e_{22}	**	.80
Other Cost = a_{23}^{*}+ b_{23}^{**}(US PPI) +c_{23}^{*}(Food TFP) +d_{23}^{**}(New pt) +e23	**	.73

Nonfat Dry Milk Manufacturing Cost Model

	F-stat	Adj. R-Square
Labor Cost = a_{31}+ b_{31}^{**}(MFG Wage) + c_{31}^{*}(Lab Pro) + d_{31}^{**}(Nstruc) +e_{31}	**	.89
Utility Cost = a_{32}^{**} + b_{32}(NatGas) + c_{32}^{**}(New pt) +e_{32}	**	.58
Other Cost = a_{33}+ b_{33}^{**}(US PPI) +c_{33}(Food TFP) +d_{33}(New pt) +e_{33}	**	.71

where:

**	=	estimated parameter or regression statistic significant at the 5% level.
*	=	estimated parameter or regression statistic significant at the 10% level.
a_{ij}	=	estimated constant terms,
b_{ij} thru d_{ij}	=	estimated parameters associated with the explanatory variables
e_{ij}	=	regression error terms.
MFG Wage	=	Annual average hourly earnings for California nonsupervisory manufacturing workers.
Lab Pro	=	US Non-farm labor productivity annual index, BLS .
NatGas	=	California Industrial Users average annual price for natural gas, EIA, US Dept. of Energy.
Electric	=	California Industrial Users price for Electricity, EIA, US Dept. of Energy.
Excess whey	=	A dummy variable that accounts for higher sewar costs associated with unique whey disposal issues.

US PPI	=	The annual US Producer Price Index for Intermediate Goods, a proxy for general cost changes at dairy manufacturing plants.
Food TFP	=	The annual US Total Factor Productivity Index for Food, Beverage, and Tobacco Manufacturing, BLS.
New pt	=	A dummy variable that accounts for higher costs associated with start-up of large new plants
Bstruc	=	A labor structural change dummy accounts for discrete upward shift in butter labor cost.
Nstruc	=	A labor structural change dummy that accounts for a discrete upward shift in NFDM labor cost.
Sewer rate	=	A dummy variable that accounts for discreet upward shift in butter plant sewer costs.
BLS	=	The Bureau of Labor Statistics, US Department of Labor.
EIA	=	The Energy Information Agency, U.S. Department of Energy

The estimated Trend models are as follows.

			F-stat	Adj. R-Square
Cheese MFG Cost	=	$q_1^{**} + r_1^{**}(\text{year}) + e_1$	**	.88
Butter MFG Cost	=	$q_2^{**} + r_2^{**}(\text{year}) + e_2$	**	.84
NFDM MFG Cost	=	$q_3^{**} + r3^{**}(\text{year}) + e_3$	**	.81

where:

**	=	Estimated parameter or regression statistic is significant at the 5% level.
*	=	Estimated parameter or regression statistic is significant at the 10% level.
q_i	=	Estimated trend constant terms.
r_i	=	Estimated trend parameters associated with the calendar year variable.
e_i	=	Trend regression error terms.
year	=	The calendar year (2002-2016).

The estimated equations generally showed good fit and strong correlations, especially given the limited number of observations (years) in the data set. The measure of fit reported is the adjusted R-squared, which is a statistical metric often used to evaluate the goodness of fit of a regression model. It represents the proportion of the variance in the dependent variable (cost) that is explained by the independent (explanatory) variables (input prices, productivity, and others) considering both the number of predictors and the sample size. Unlike regular R-squared, adjusted R-squared penalizes the inclusion of less relevant predictors, thus providing a more accurate assessment of the model's performance. Higher values of adjusted R-squared (closer to 1) indicate a better fit of the model to the data, suggesting that the independent variables collectively have a stronger impact on explaining the variability in the dependent variable.

It can be challenging to estimate an equation with a limited number of observations, as done here, but adjusted R-squared values ranging from .70 to .89 for all but one of the equations suggest that the estimated models do a good job of explaining the variations in the costs from year to year. Across all three commodities, the model predicted labor costs were a better predictor of actual labor costs than was true of the other cost equations (utility cost and other cost). Generally, predicted utility costs were a poorer fit when compared with the actual utility cost data.

All the estimated cost equations are significant according to their associated F-statistics. The regression F-statistic is used to assess the overall significance of a linear regression model. It evaluates whether the estimated model is statistically better than a model with no predictors (intercept-only model). The F-statistic is calculated by comparing the variability explained by the regression model (regression sum of squares) to the variability left unexplained (residual sum of squares). A significant F-statistic indicates that at least one of the independent variables has a significant impact on the dependent variable.

In a regression equation, the t-statistic is used to evaluate the significance of individual parameter estimates (coefficients) associated with each explanatory variable. The t-statistic is calculated by dividing the estimated coefficient by its standard error. Typically, if the absolute t-value is greater than a critical threshold (e.g., 1.96 at a 5% significance level for a two-tailed test), the parameter estimate is considered statistically significant, and it is likely to have a meaningful impact on the dependent variable. Alternatively, if the t-value is smaller than the threshold, the coefficient may not be statistically significant, indicating that the variable may not have a substantial influence on the dependent variable.

Parameter Estimates and Manufacturing Cost Forecasts

Table 3.

Parameter Estimates from Cheese, Butter, and Nonfat Dry Milk Manufacturing Cost Models

Product	----- Cheddar Cheese -----			----- Butter -----			----- NFDM -----		
Equation	Labor	Utility	Other	Labor	Utility	Other	Labor	Utility	Other
Parameter									
Constant	0.0116	0.0256	0.4294 **	0.0209	0.0045	0.2209 *	0.0137	0.0408 **	0.1983
MFG Wage	0.0049 **			0.0061 **			0.0050 **		
Lab Pro	-0.0004			-0.0007			-0.0006 *		
NatGas		0.0028 **			0.0008 *			0.0008	
Electric		-0.0024 *							
US PPI			0.0016 **			0.0008 **			0.0011 **
US Food TFP			-0.0044 **			-0.0020 *			-0.0020
Excess whey		0.0013							
Bstruc				0.0088 *					
Sewer rate					0.0071 **				
New pt					0.0015	0.0113 **		0.0094 **	0.0089
Nstruc							0.0056 **		

* Estimated parameter is significant at the 10 percent level.
** Estimated parameter is significant at the 5 percent level.

The estimated model results including model descriptions, associated regression statistics, parameter estimates, and summary results by commodity are shown in appendix tables A1-A22. The parameter estimates for all the equations in the model are shown below (Table 3).

Looking at the labor cost equations for cheese, butter and NFDM, we see that the parameter estimates associated with wage rates are strongly significant and associated with increased labor costs as indicated by the positive sign of the estimates. Conversely, increases in labor productivity were associated with modest reductions in labor costs, as expected, though the labor productivity parameter estimates were not statistically different from zero in most cases.

In the utility cost models, parameters associated with statewide industrial energy rates were not significant as often as expected. One possible reason is that the specific utility energy providers for some of the dairy plants might offer energy rates to their dairy manufacturing customers that differ substantially from the statewide averages. Also, plants engaged in hedging their energy purchases are likely to have energy costs that do not track well with spot energy prices.

The largest cost category is other costs. In each of the other cost equations, the parameter estimate associated with the U.S. Producer Price Index for Intermediate Goods is positive and significant. The parameter estimates associated with Total Factor Productivity were all negative, as expected, and significant for cheese and butter costs, but not for NFDM.

The parameter estimates associated with the dummy variables are significant for some equations, but not for others. The explanatory dummy variables used in the model are shown in Table 4. In the estimated utility cost equation for cheese, parameter estimates associated with the excess whey dummy variable were not statistically significant. The excess whey variable corresponds to a three-year period from 2005-2007 when cheese plants had higher sewer costs associated with whey solids disposal, In the butter labor cost equation, the parameter, Bstruc, representing a permanent upward shift in labor costs beginning in 2009, was significant.

In the butter utility cost equation, the sewer cost dummy variable parameter was significant, but the new plant dummy variable parameter was not. The sewer cost dummy represents a permanent shift to higher sewer costs at butter plants beginning in 2009. The new plant dummy variable (New pt) accounts for higher costs associated with the opening of new butter/NFDM plants in 2008 and 2009. The new plant dummy variable parameter was significant in the other cost equation for butter. In the nonfat dry milk model, the labor cost structural shift dummy, Nstruc, was significant, as was the new plant dummy variable in the utility cost equation, though it was not significant in the NFDM labor cost equation.

Table 4.
Dummy Variables Used in Dairy Manufacturing Cost Models

Year	Excess Whey	Bstruc	New pt	Sewer rate	Nstruc
2002	0	0	0	0	0
2003	0	0	0	0	0
2004	0	0	0	0	0
2005	1	0	0	0	0
2006	1	0	0	0	0
2007	1	0	0	0	0
2008	0	0	1	0	0
2009	0	1	1	1	0
2010	0	1	0	1	0
2011	0	1	0	1	0
2012	0	1	0	1	1
2013	0	1	0	1	1
2014	0	1	0	1	1
2015	0	1	0	1	1
2016	0	1	0	1	1
2017	0	1	0	1	1
2018	0	1	0	1	1
2019	0	1	0	1	1
2020	0	1	0	1	1
2021	0	1	0	1	1
2022	0	1	0	1	1

Excess whey = dummy varriable that accounts for higher sewar costs associated with unique whey disposal issues.
Bstruc = a labor structural change dummy that represents a discrete upward shift in butter labor cost.
New pt = a dummy variable that represents higher costs associated with start-up of large new plants.
Sewer rate = a dummy variable that represents a discreet upward shift in butter plant sewer costs.
Nstruc = a labor structural change dummy that accounts for a discrete upward shift in NFDM plant labor cost.

The parameter estimates from the models can be multiplied by the corresponding explanatory variables from each cost equation to obtain model estimates for cost components (labor cost, utility cost, and other cost) for each commodity. The cost component estimates for each commodity can be summed to obtain estimates of total cost. Data for the explanatory variables for the years after 2016, when the CDFA manufacturing cost data ceases, can be used together with the estimated parameters to obtain forecasts for labor, utility and other cost for cheddar cheese, butter and NFDM that extend beyond the estimated sample. The estimates and forecasts from the model and from the trend regressions are presented in Table 5.

Within the 2003-2016 sample period, the model-predicted values for manufacturing costs are highly correlated with the actual cost values. The correlation coefficients of predicted to audited costs were 0.92 for cheese, 0.96 for butter, and 0.91 for NFDM (where a correlation coefficient of 1.0 denotes perfect correlation). The cost estimates from the model, unsurprisingly, show increasing costs since the last audited CDFA manufacturing cost data from 2016. Between 2016 and 2020, the model suggests that cheese manufacturing costs increased about $0.008 per pound from the 2016 audited cost, while butter increased $0.013 per pound and NFDM manufacturing costs increased by about $0.019 per pound during the same period. However, over the 2021-2022 period, cost increases accelerated substantially, increasing a further $0.047 per pound for cheese,

$0.030 per pound for butter, and $0.039 per pound for NFDM as wage rates and material cost indices escalated.

The model-predicted manufacturing costs for 2022 are $0.3006 per pound for cheese, $0.2364 per pound for butter, and $0.2653 per pound for NFDM with an imputed dry whey manufacturing cost (NFDM cost plus 3 cents per pound) of $0.2953. These estimates represent a substantial increase from the current manufacturing allowances of $0.2003 per pound for cheese, $0.1715 for butter, $0.1678 for NFDM, and $0.1991 for dry whey. They are also higher than the costs predicted by the linear trend costs, which increase year by year based on the slope of the trend line. The trend cannot capture the impacts of accelerating inflation, so these results are not surprising. Interestingly, the model-predicted costs for 2019 were lower than those predicted by the linear cost trends and showed very little increase from 2019 to 2020. Again, such a result is not surprising given what was happening in the economy at that time. The Federal Reserve was loosening its monetary policy again after the "taper tantrum" in 2018 and the onset of COVID-19 in 2020. The point here is that the model predictions on manufacturing cost are more responsive than the trend to what is happening with price levels in the economy.

Table 5.

Manufacturing Costs: Model Predicted Values and Trend Values, All Commodities

	Model Predicted Estimates/Forecasts ------------				***Linear Trend Cost Values --------------------------***			
Year	Cheese	Whey 1/	Butter	NFDM	Cheese	Whey 1/	Butter	NFDM
	------------- dollars per pound --------------				*------------- dollars per pound --------------*			
2003	$0.1708	$0.1847	$0.1302	$0.1547	$0.1730	$0.1858	$0.1299	$0.1558
2004	$0.1771	$0.1881	$0.1320	$0.1581	$0.1783	$0.1904	$0.1349	$0.1604
2005	$0.1907	$0.1959	$0.1388	$0.1659	$0.1836	$0.1951	$0.1398	$0.1651
2006	$0.1866	$0.1965	$0.1378	$0.1665	$0.1888	$0.1997	$0.1448	$0.1697
2007	$0.1914	$0.1999	$0.1404	$0.1699	$0.1941	$0.2044	$0.1498	$0.1744
2008	$0.2164	$0.2325	$0.1652	$0.2025	$0.1993	$0.2090	$0.1547	$0.1790
2009	$0.1943	$0.2230	$0.1733	$0.1930	$0.2046	$0.2137	$0.1597	$0.1837
2010	$0.2103	$0.2122	$0.1667	$0.1822	$0.2099	$0.2183	$0.1647	$0.1883
2011	$0.2178	$0.2188	$0.1709	$0.1888	$0.2151	$0.2230	$0.1696	$0.1930
2012	$0.2213	$0.2283	$0.1749	$0.1983	$0.2204	$0.2276	$0.1746	$0.1976
2013	$0.2273	$0.2332	$0.1801	$0.2032	$0.2257	$0.2323	$0.1796	$0.2023
2014	$0.2295	$0.2354	$0.1820	$0.2054	$0.2309	$0.2369	$0.1845	$0.2069
2015	$0.2272	$0.2348	$0.1833	$0.2048	$0.2362	$0.2416	$0.1895	$0.2116
2016	$0.2435	$0.2432	$0.1931	$0.2132	$0.2415	$0.2462	$0.1945	$0.2162
2017	**$0.2439**	**$0.2487**	**$0.1990**	**$0.2187**	$0.2467	$0.2509	$0.1994	$0.2209
2018	**$0.2547**	**$0.2565**	**$0.2056**	**$0.2265**	$0.2520	$0.2555	$0.2044	$0.2255
2019	**$0.2521**	**$0.2546**	**$0.2037**	**$0.2246**	$0.2573	$0.2602	$0.2094	$0.2302
2020	**$0.2536**	**$0.2568**	**$0.2067**	**$0.2268**	$0.2625	$0.2648	$0.2143	$0.2348
2021	**$0.2707**	**$0.2747**	**$0.2201**	**$0.2447**	$0.2678	$0.2695	$0.2193	$0.2395
2022	**$0.3006**	**$0.2953**	**$0.2364**	**$0.2653**	$0.2731	$0.2741	$0.2243	$0.2441

1/ Dry Whey Model Predicted and Trend Costs = Model Predicted and Trend Costs for NFDM + 3 cents/lb.

Summary

The purpose of this project was to estimate more current dairy manufacturing costs from audited California plant cost data. The models estimated provided reasonable fit and explanatory power given the limited number of observations (years) in the data set. The model results yield estimates of cost that are more responsive than trend projections to changes in economic conditions, such as price increases or decreases for energy, labor, and materials and changes in productivity. The model results and forecasts of manufacturing costs for cheddar cheese, dry whey, butter, and nonfat dry milk provide useful information for updating manufacturing cost allowances and provide an alternative methodology and a point of comparison for evaluating survey data on manufacturing costs. The estimated manufacturing costs projected from the model appear reasonable given the general cost inflation experienced in recent years and the length of time that has elapsed since the current manufacturing cost allowances were established.

The findings presented here are not the only information on manufacturing costs currently available. Recent work by Dr. Mark Stephenson shows that manufacturing costs in 2022 are considerably greater than the current make allowances used in the Class III and Class IV pricing formulas. The results produced by my modeling work are similar in that they show that current manufacturing costs are substantially higher than current make allowances. In the case of cheese, my estimates of 2022 manufacturing costs are higher than what Dr. Stephenson found, but for other costs, they are lower. The findings reinforce each other in the sense that they suggest that current make allowances no longer reflect current dairy plant manufacturing costs and should be increased.

Estimating models with a small sample size, as done here, is difficult and can sometimes yield results where the estimated relationship between the dependent variable and the explanatory variables is weak. However, the results of this modeling exercise are strong in that many of the parameter estimates overall regression metrics are statistically significant. Also, the resulting cost estimates appear sensible and reasonable given discussions I have had with industry personnel familiar with dairy manufacturing costs and considering Dr. Stephenson’s work. Still, econometric forecasts are projections based estimated relationships using historic plant data and are not actual data on current plant costs. Rather than being relied upon as a sole source of information for updating manufacturing costs allowances, the estimates from this modeling exercise are best used in concert with other sources of cost data such as Dr. Stephenson’s study.

APPENDIX

Figure A-1.

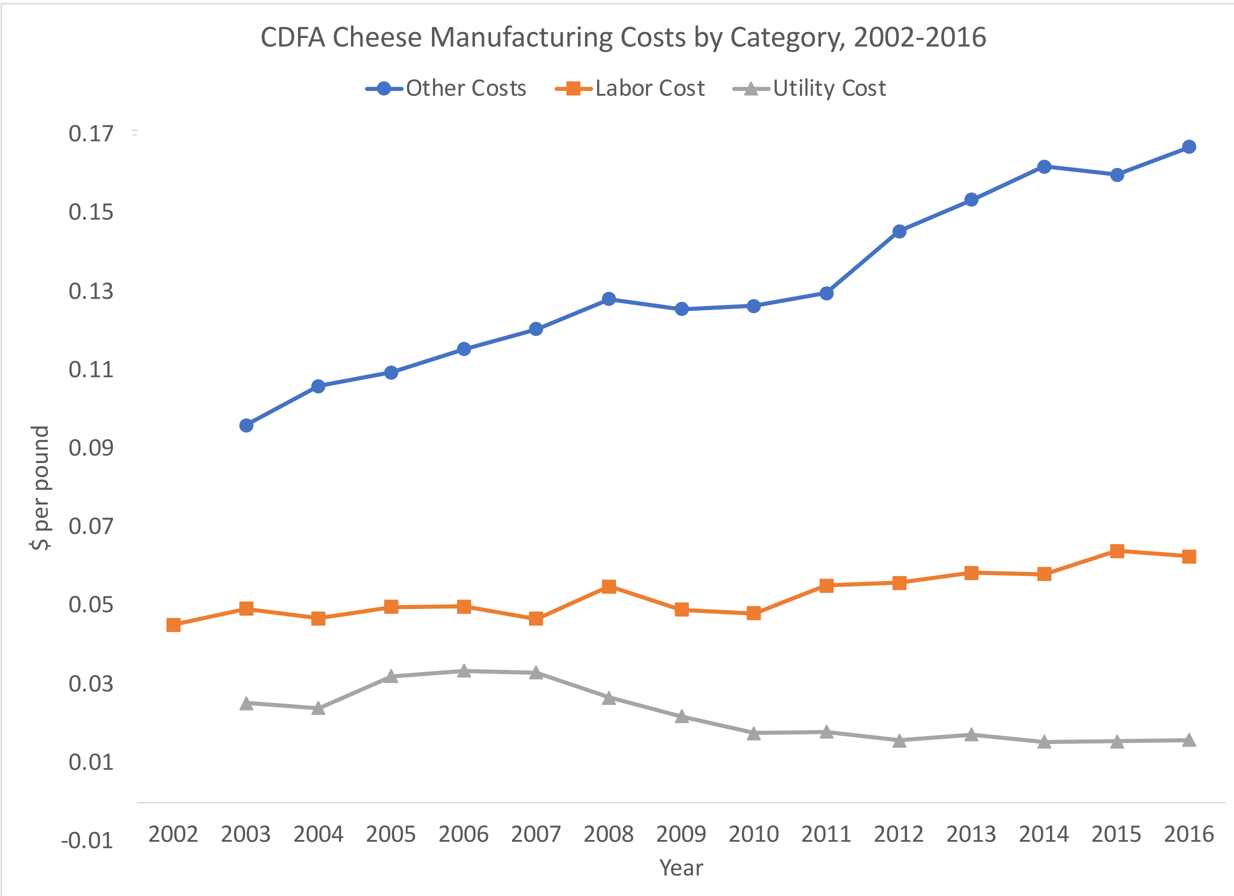
CDFA Cheese Manufacturing Costs by Category, 2002-2016
Other Costs
Labor Cost
Utility Cost
$ per pound
0.17
0.15
0.13
0.11
0.09
0.07
0.05
0.03
0.01
-0.01
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year

Figure A-2.

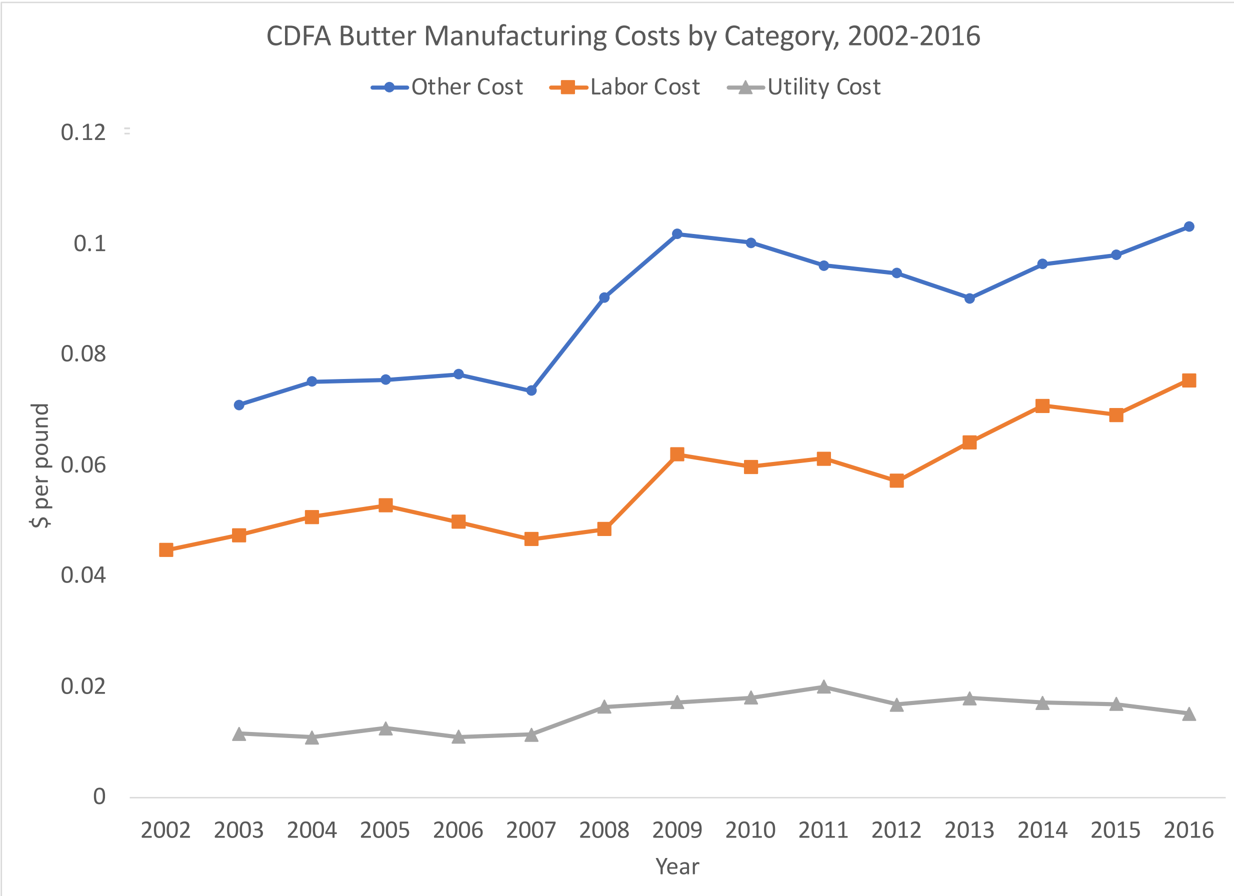
CDFA Butter Manufacturing Costs by Category, 2002-2016
Other Cost
Labor Cost
Utility Cost
$ per pound
0.12
0.1
0.08
0.06
0.04
0.02
0
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year

Figure A-3.

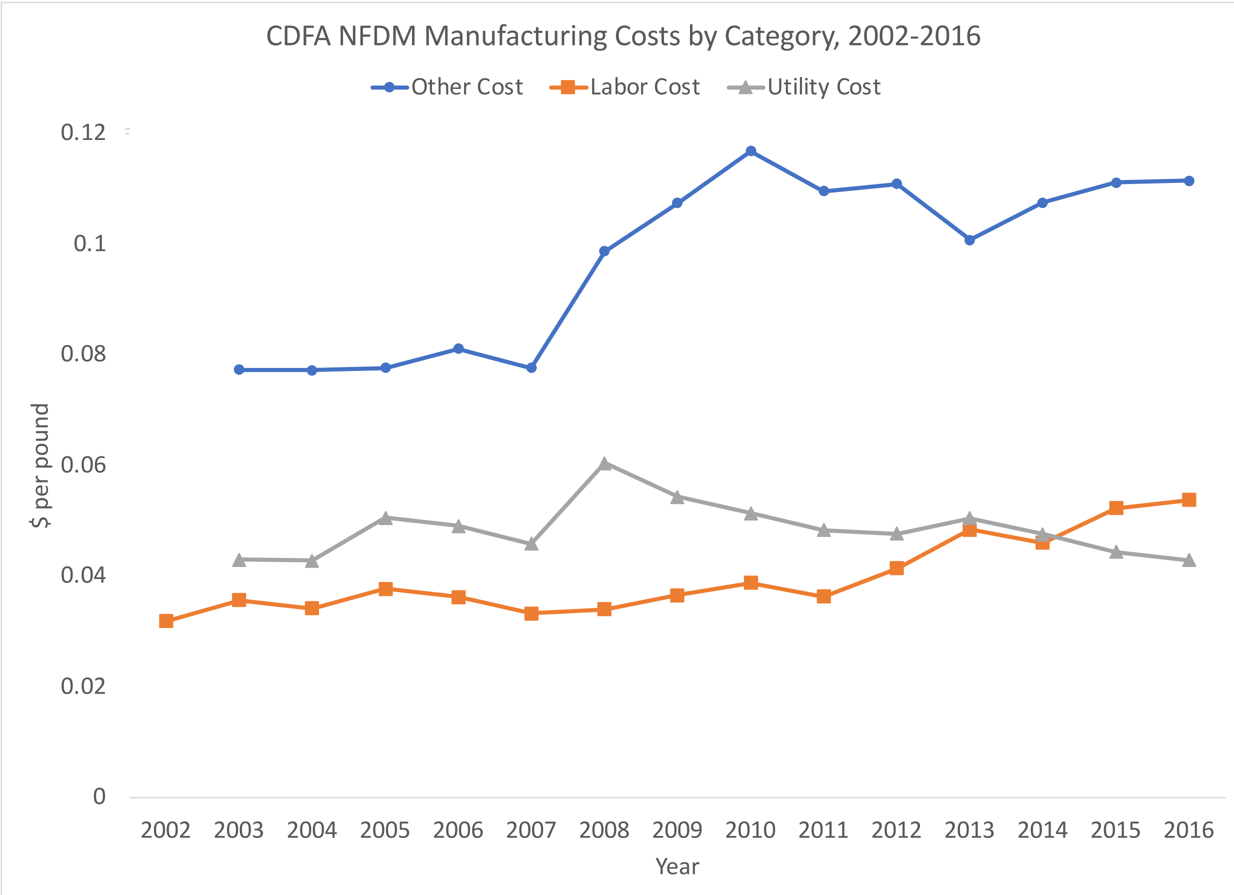
CDFA NFDM Manufacturing Costs by Category, 2002-2016
Other Cost
Labor Cost
Utility Cost
$ per pound
0.12
0.1
0.08
0.06
0.04
0.02
0
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year

Table A-1. Cheese Manufacturing Cost Model

		F-stat	Adj R Sqare
Labor Cost	= a11+ b11(MFG Wage)** + c11(Lab Pro) +e11	**	77
Utility Cost	= a12 + b12(NatGas)** + c12(Electric)* + d12(Excess whey) +e12	**	70
Other Cost	= a13**+ b13(US PPI)** +c13(Food TFP)** +e13	**	89
TOTAL MFG COST	= LABOR COST + UTILITY COST + OTHER MFG COST		

** Estimated parameter or regression statistic significant at the 5% level
* Estimated parameter or regression statistic significant at the 10% level

Where: aij represent estimated constant term, bij thru dij represent estimated parameters associated with explanatory variabl and eij represent error terms.

MFG Wage = average hourly earnings for California nonsupervisory manufactuirng workers, BLS
Lab Pro = US Non-farm labor productivity annual index, BLS, US Dept. of Labor
NatGas = California Industrial Users price for natural gas, EIA, US Dept. of Energy
Electric = California Industrial Users price for Electricity, EIA, US Dept. of Energy
Excess whey = dummy varriable that accounts for higher sewar costs associated with unique whey disposal issues
US PPI = US Producer Price Index for Intermediate Goods, a proxy for changes in other plant costs
Food TFP i=US Total Factor Productivity Index for Food, Beverage and Tobacco Manufacturing, BLS US Dept. of Labor

BLS is the Buereau of Labor Statistics, U.S. Department of Labor
EIA is the Energy Information Agency, U.S. Department of Energy

Table A-2. Summary Output Cheese Labor Cost.

Regression Statistics	
Multiple R	0.89601338
R Square	0.802839978
Adjusted R Square	0.769979974
Standard Error	0.002854802
Observations	15

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.00039824	0.00019912	24.4321329	5.8737E-05
Residual	12	9.7799E-05	8.1499E-06		
Total	14	0.00049604			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 90.0%*	*Upper 90.0%*
Intercept	0.011582274	0.01278759	0.90574348	0.3828976	-0.0162795	0.03944403	-0.0112089	0.03437343
MFG Wage	0.004913144	0.00157063	3.12812706	0.00872215	0.00149103	0.00833526	0.00211382	0.00771247
Lab Pro	-0.000386314	0.00035994	-1.0732851	0.3042525	-0.0011705	0.00039792	-0.0010278	0.0002552

Model: Labor Cost = a11+ b11(MFG Wage) + c11(Lab Pro)

RESIDUAL OUTPUT -CHEESE MFG LABOR COST

Observation	Actual Labor Cost *($/lb.)*	***Predicted Labor Cost ($/lb.)***	*Residuals*	MFG Non Supervisory California Wage ($/hr.) 1/	Nonfarm Labor Productivity Index, BLS *(2012=100)* 1/
2002	$0.0452	$0.0470	-0.001837	13.6208	81.453
2003	$0.0493	$0.0468	0.00253081	13.8017	84.446
2004	$0.0469	$0.0467	0.00017237	13.9917	86.970
2005	$0.0498	$0.0486	0.00124705	14.5125	88.869
2006	$0.0499	$0.0494	0.00052091	14.7500	89.751
2007	$0.0467	$0.0501	-0.0034385	15.0183	91.198
2008	$0.0550	$0.0517	0.00327357	15.4342	92.376
2009	$0.0491	$0.0528	-0.0036726	15.9050	95.656
2010	$0.0481	$0.0532	-0.0050869	16.2483	98.950
2011	$0.0552	$0.0527	0.00249683	16.1533	98.994
2012	$0.0559	$0.0548	0.00112889	16.6533	100.000
2013	$0.0584	$0.0571	0.00130761	17.1642	100.488
2014	$0.0581	$0.0578	0.00029347	17.3600	101.130
2015	$0.0640	$0.0608	0.00321398	18.0600	102.320
2016	$0.0626	$0.0648	-0.0021506	18.8950	102.677
2017		***$0.0710***		20.2625	103.806
2018		***$0.0728***		20.7492	105.345
2019		***$0.0725***		20.8558	107.514
2020		***$0.0749***		21.5533	110.116
2021		***$0.0825***		23.2508	112.212
2022		***$0.0855***		24.0280	114.133

1/ California MFG wage and labor productivity data for 2022 is average of monthly data 2021 Q4 through 2022 Q3

Table A-3. Summary Output-Cheese Utilty Cost.

Regression Statistics	
Multiple R	0.87483722
R Square	0.76534016
Adjusted R Square	0.69494221
Standard Error	0.00379056
Observations	14

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	0.000468621	0.00015621	10.8716254	0.001727218
Residual	10	0.000143683	1.4368E-05		
Total	13	0.000612304			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 90.0%*	*Upper 90.0%*
Intercept	0.02556479	0.015461966	1.6533982	0.12925472	-0.00888662	0.0600162	-0.0024594	0.053589
NatGas	0.00281927	0.000831952	3.38874695	0.00690036	0.00096557	0.00467298	0.00131139	0.00432715
Electic	-0.0024217	0.001151898	-2.1023276	0.06183484	-0.00498826	0.00014492	-0.0045094	-0.0003339
Excess whey	0.0012852	0.002395639	0.53647272	0.60336081	-0.00405262	0.00662301	-0.0030568	0.0056272

Model: Utility Cost = a12 + b12(NatGas) + c12(Electric) + d12(excess whey)

RESIDUAL OUTPUT-CHEESE MFG UTILITY COST

Observation	Actual Utility Cost *($/lb.)*	***Predicted Utility Cost ($/lb.)***	*Residuals*	Industrial CA Nat Gas *($/MCF)* 1/	Industrial CA Electric *(cents/kwh)*	Dummy Excess Whey
2003	$0.0253	$0.0226	0.00264424	7.19	9.59	0
2004	$0.0240	$0.0254	-0.00139333	7.89	9.27	0
2005	$0.0321	$0.0302	0.00193160	9.84	9.55	1
2006	$0.0335	$0.0286	0.00484764	9.30	10.09	1
2007	$0.0331	$0.0283	0.00484745	9.07	9.98	1
2008	$0.0267	$0.0329	-0.00616351	10.80	10.09	0
2009	$0.0219	$0.0201	0.00175936	6.56	10.42	0
2010	$0.0176	$0.0229	-0.00529094	7.02	9.80	0
2011	$0.0180	$0.0209	-0.00294341	7.04	10.11	0
2012	$0.0158	$0.0164	-0.00067770	5.77	10.49	0
2013	$0.0172	$0.0164	0.00085746	6.57	11.44	0
2014	$0.0154	$0.0172	-0.00180485	7.65	12.34	0
2015	$0.0155	$0.0142	0.00135136	6.41	12.17	0
2016	$0.0159	$0.0158	0.00003462	6.79	11.92	0
2017		***$0.0146***		7.05	12.73	0
2018		***$0.0137***		7.12	13.20	0
2019		***$0.0148***		7.69	13.40	0
2020		***$0.0123***		7.55	14.27	0
2021		***$0.0172***		9.75	14.82	0
2022		***$0.0225***		13.06	16.48	0

1/ California natural gas and electric price data for 2022 is average of monthly data 2021 Q4 through 2022 Q3

Table A-4. Summary Output- Cheese Manufactuirng Cost less Utility Cost and Labor Cost (Other Cost).

Regression Statistics	
Multiple R	0.952950895
R Square	0.908115409
Adjusted R Square	0.891409119
Standard Error	0.007414179
	14

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.00597609	0.00298804	54.3576967	1.98534E-06
Residual	11	0.00060467	5.497E-05		
Total	13	0.00658076			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 90.0%*	*Upper 90.0%*
Intercept	0.429404678	0.127717531	3.3621436	0.00633978	0.148300289	0.710509068	0.2000387	0.65877065
US PPI	0.001591925	0.000223468	7.12372793	1.933E-05	0.001100075	0.002083774	0.0011906	0.00199325
Food TFP	-0.00441147	0.001165931	-3.7836492	0.00302786	-0.00697767	-0.001845277	-0.0065054	-0.0023176

Model: Other Cost = a13+ b13(US PPI) +c13(Food TFP)

RESIDUAL OUTPUT CHEESE OTHER COST

Observation	Actual Other Cost *($/lb.)*	***Predicted Other Cost ($/lb.)***	*Residuals*	US PPI Intermediate Goods *(2015=100)* 1/	US Total Factor Productivity Index Food Bev Tob *(2012=100)* 2/
2003	$0.0960	$0.1015	-0.0054168	72.3214	100.608
2004	$0.1060	$0.1050	0.00101187	76.5975	101.313
2005	$0.1095	$0.1119	-0.002441	80.5103	101.141
2006	$0.1154	$0.1086	0.00685832	85.1672	103.495
2007	$0.1205	$0.1130	0.00752393	88.0033	103.480
2008	$0.1282	$0.1318	-0.0036097	95.0149	101.710
2009	$0.1256	$0.1214	0.00425703	90.7563	102.581
2010	$0.1264	$0.1342	-0.0078423	94.5553	101.131
2011	$0.1297	$0.1442	-0.0144712	100.9366	101.088
2012	$0.1454	$0.1501	-0.0046612	101.7157	100.000
2013	$0.1535	$0.1538	-0.0003901	102.4116	99.270
2014	$0.1620	$0.1544	0.00754515	103.4401	99.692
2015	$0.1599	$0.1523	0.00759038	100.0000	98.954
2016	$0.1669	$0.1629	0.00404559	98.3587	95.988
2017		***$0.1582***		101.5144	98.107
2018		***$0.1682***		105.5716	97.307
2019		***$0.1648***		105.3002	97.974
2020		***$0.1664***		104.4643	97.318
2021		***$0.1711***		121.8265	102.520
2022		***$0.1926***		135.3550	102.520

1/ PPI data for 2022 is average of monthly data 2021 Q4 through 2022 Q3

2/ TFP not yet reported for 2022. The 2021 value of the index is used in place of 2022 data.

Table A-5. SUMMARY OUTPUT - Cheese Manufacturing Cost Trend

Regression Statistics	
Multiple R	0.944498711
R Square	0.892077815
Adjusted R S	0.883776109
Standard Err	0.008499418
Observations	15

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.007762716	0.00776272	107.457161	1.1836E-07
Residual	13	0.000939121	7.224E-05		
Total	14	0.008701837			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 90.0%*	*Upper 90.0%*
Intercept	-10.37348917	1.020448506	-10.165617	1.4865E-07	-12.578034	-8.1689442	-12.180636	-8.5663428
Year	0.005265357	0.000507937	10.3661546	1.1836E-07	0.00416803	0.00636269	0.00436583	0.00616488

Model: Cheese MFG Cost = q1 + r1(Year)

RESIDUAL OUTPUT - CHEESE MANUFACTURING COST TREND

Observation	Actual MFG Cost	*Predicted MFG Cost*	*Residuals*	*Year*
2002	$0.1632	$0.1678	-0.0045558	2002
2003	$0.1706	$0.1730	-0.0024212	2003
2004	$0.1769	$0.1783	-0.0013865	2004
2005	$0.1914	$0.1836	0.0078481	2005
2006	$0.1988	$0.1888	0.00998274	2006
2007	$0.2003	$0.1941	0.00621738	2007
2008	$0.2099	$0.1993	0.01055202	2008
2009	$0.1966	$0.2046	-0.0080133	2009
2010	$0.1921	$0.2099	-0.0177787	2010
2011	$0.2029	$0.2151	-0.012244	2011
2012	$0.2171	$0.2204	-0.0033094	2012
2013	$0.2291	$0.2257	0.00342524	2013
2014	$0.2355	$0.2309	0.00455988	2014
2015	$0.2394	$0.2362	0.00319452	2015
2016	$0.2454	$0.2415	0.00392917	2016
2017		***$0.2467***		2017
2018		***$0.2520***		2018
2019		***$0.2573***		2019
2020		***$0.2625***		2020
2021		***$0.2678***		2021
2022		***$0.2731***		2022

Table A-6. Total Cheese Manufacturing Cost.

Year	Predicted MFG Cost	Actual MFG Cost	Difference between Actual and Predicted Cost	Cheese MFG Cost Trend
		------- *dollars per pound* -------		
2003	$0.1708	$0.1706	$0.0002	$0.1730
2004	$0.1771	$0.1769	$0.0002	$0.1783
2005	$0.1907	$0.1914	-$0.0007	$0.1836
2006	$0.1866	$0.1988	-$0.0122	$0.1888
2007	$0.1914	$0.2003	-$0.0089	$0.1941
2008	$0.2164	$0.2099	$0.0065	$0.1993
2009	$0.1943	$0.1966	-$0.0023	$0.2046
2010	$0.2103	$0.1921	$0.0182	$0.2099
2011	$0.2178	$0.2029	$0.0149	$0.2151
2012	$0.2213	$0.2171	$0.0042	$0.2204
2013	$0.2273	$0.2291	-$0.0018	$0.2257
2014	$0.2295	$0.2355	-$0.0060	$0.2309
2015	$0.2272	$0.2394	-$0.0122	$0.2362
2016	$0.2435	$0.2454	-$0.0019	$0.2415
2017	***$0.2439***			$0.2467
2018	***$0.2547***			$0.2520
2019	***$0.2521***			$0.2573
2020	***$0.2536***			$0.2625
2021	***$0.2707***			$0.2678
2022	***$0.3006***			$0.2731

Model: Sum of Predicted Values for Labor, Utility and Other MFG Costs
Trend: Total Cheese MFG Cost regressed against Year

Table A-7. Cheese Manufacturing Costs: Components and Total, Actual and Predicted Values.

	Actual Costs				*Predicted Costs*				*Trend*
Year	Labor	Utility	Other	Total	Labor	Utility	Other	Total	Total
	--------- *dollars per pound* ---------				---------- *dollars per pound* ---------				*$/lb.*
2002	$0.0452				$0.0470				
2003	$0.0493	$0.0253	$0.0960	$0.1706	$0.0468	$0.0226	$0.1015	$0.1708	$0.1730
2004	$0.0469	$0.0240	$0.1060	$0.1769	$0.0467	$0.0254	$0.1050	$0.1771	$0.1783
2005	$0.0498	$0.0321	$0.1095	$0.1914	$0.0486	$0.0302	$0.1119	$0.1907	$0.1836
2006	$0.0499	$0.0335	$0.1154	$0.1988	$0.0494	$0.0286	$0.1086	$0.1866	$0.1888
2007	$0.0467	$0.0331	$0.1205	$0.2003	$0.0501	$0.0283	$0.1130	$0.1914	$0.1941
2008	$0.0550	$0.0267	$0.1282	$0.2099	$0.0517	$0.0329	$0.1318	$0.2164	$0.1993
2009	$0.0491	$0.0219	$0.1256	$0.1966	$0.0528	$0.0201	$0.1214	$0.1943	$0.2046
2010	$0.0481	$0.0176	$0.1264	$0.1921	$0.0532	$0.0229	$0.1342	$0.2103	$0.2099
2011	$0.0552	$0.0180	$0.1297	$0.2029	$0.0527	$0.0209	$0.1442	$0.2178	$0.2151
2012	$0.0559	$0.0158	$0.1454	$0.2171	$0.0548	$0.0164	$0.1501	$0.2213	$0.2204
2013	$0.0584	$0.0172	$0.1535	$0.2291	$0.0571	$0.0164	$0.1538	$0.2273	$0.2257
2014	$0.0581	$0.0154	$0.1620	$0.2355	$0.0578	$0.0172	$0.1544	$0.2295	$0.2309
2015	$0.0640	$0.0155	$0.1599	$0.2394	$0.0608	$0.0142	$0.1523	$0.2272	$0.2362
2016	$0.0626	$0.0159	$0.1669	$0.2454	$0.0648	$0.0158	$0.1629	$0.2435	$0.2415
2017					$0.0710	$0.0146	$0.1582	$0.2439	$0.2467
2018					$0.0728	$0.0137	$0.1682	$0.2547	$0.2520
2019					$0.0725	$0.0148	$0.1648	$0.2521	$0.2573
2020					$0.0749	$0.0123	$0.1664	$0.2536	$0.2625
2021					$0.0825	$0.0172	$0.1711	$0.2707	$0.2678
2022					$0.0855	$0.0225	$0.1926	$0.3006	$0.2731

Table A-8. Butter Manufacturing Cost Model.

		F-stat	Adj R Square
Labor Cost	= a21+ b21(MFG Wage)** + c21(US Lab Pro) + d21(Bstruc)* +e21	**	88
Utility Cost	= a22 + b22(NatGas)* + c22(Sewer rate)** + d22 (new pt) +e22	**	80
Other Cost	= a23*+ b23(US PPI)** +c23(Food TFP)* +d23(New pt)**	**	73
TOTAL MFG COST	= LABOR COST + UTILITY COST + OTHER MFG COST		

** Estimated parameter or regression statistic significant at the 5% level or lower

* Estimated parameter or regression statistic significant at the 10% level or lower

Where: aij represent estimated constant term, bij thru dij represent estimated parameters associated with explanatory variables, and eij represent error terms.

MFG Wage = average hourly earnings for nonsupervisory MFG workers, BLS

Lab Pro = US Non-farm labor productivity annual index, BLS, US Dept. of Labor

NatGas = California Industrial Users price for natural gas, EIA, US Dept. of Energy

Bstruc = a dummy variable representing a discrete upward shift in labor costs

Sewer rate = a dummy variable representing a discreet upward shift in sewer utilitiy costs

New Pt = a dummy variable representing higher costs associated with start-up of large new plants

US PPI = US Producer Price Index for Intermediate Goods, a proxy for changes in other plant costs

Food TFP = US Total Factor Productivity Index for Food, Beverage and Tobacco Manufacturing, BLS US Dept. of Labor

BLS is the Buereau of Labor Statistics, U.S. Department of Labor

EIA is the Energy Information Agency, U.S. Department of Energy

Table A-9. SUMMARY OUTPUT-Butter Labor Cost.

Regression Statistics	
Multiple R	0.95116154
R Square	0.90470827
Adjusted R Square	0.87871961
Standard Error	0.00336873
Observations	15

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	0.001185162	0.00039505	34.8116628	6.5631E-06
Residual	11	0.000124832	1.1348E-05		
Total	14	0.001309993			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 90.0%*	*Upper 90.0%*
Intercept	0.02092242	0.028959614	0.72246904	0.4850829	-0.0428173	0.084662107	-0.0310857	0.07293056
MFG WAGE	0.00607545	0.001865676	3.25643326	0.0076473	0.00196912	0.010181772	0.00272491	0.00942599
Lab Pro	-0.0006833	0.000532377	-1.2834566	0.22571098	-0.001855	0.000488471	-0.0016394	0.0002728
Bstruc	0.00879559	0.004089096	2.15098545	0.05455336	-0.0002045	0.017795625	0.00145204	0.01613913

Model: Labor Cost = a21+ b21(MFG Wage) + c21(Lab Pro) + d21(Bstruc)

RESIDUAL OUTPUT-BUTTER LABOR COST

Year	Actual Labor Cost (*$/lb.*)	***Predicted Labor Cost ($/lb.)***	*Residuals*	MFG Non Supervisory California Wage ($/hr.) 1/	US Nonfarm Labor Productivity Index, BLS *(2012=100)* 1/	Bstruc Dummy
2002	$0.0447	$0.0480	-0.0033197	13.6208	81.453	0
2003	$0.0474	*$0.0471*	0.00032677	13.8017	84.446	0
2004	$0.0507	*$0.0465*	0.00419704	13.9917	86.970	0
2005	$0.0528	*$0.0484*	0.00443029	14.5125	88.869	0
2006	$0.0498	*$0.0492*	0.00059003	14.7500	89.751	0
2007	$0.0467	*$0.0499*	-0.0031515	15.0183	91.198	0
2008	$0.0485	*$0.0516*	-0.003073	15.4342	92.376	0
2009	$0.0620	*$0.0610*	0.00101209	15.9050	95.656	1
2010	$0.0598	*$0.0608*	-0.0010231	16.2483	98.950	1
2011	$0.0613	*$0.0602*	0.00108415	16.1533	98.994	1
2012	$0.0572	*$0.0626*	-0.0053662	16.6533	100.000	1
2013	$0.0642	*$0.0653*	-0.0011363	17.1642	100.488	1
2014	$0.0708	*$0.0661*	0.0047126	17.3600	101.130	1
2015	$0.0692	*$0.0695*	-0.0003271	18.0600	102.320	1
2016	$0.0754	*$0.0744*	0.00104383	18.8950	102.677	1
2017		***$0.0819***		20.2625	103.806	1
2018		***$0.0838***		20.7492	105.345	1
2019		***$0.0830***		20.8558	107.514	1
2020		***$0.0854***		21.5533	110.116	1
2021		***$0.0943***		23.2508	112.212	1
2022		***$0.0977***		24.0280	114.133	1

1/ California MFG wage and labor productivity data for 2022 is average of monthly data 2021 Q4 through 2022 Q3

Table A-10. SUMMARY OUTPUT -Butter Utility Cost.

Regression Statistics	
Multiple R	0.91804843
R Square	0.84281293
Adjusted R Square	0.7956568
Standard Error	0.001404
Observations	14

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	0.000105694	3.5231E-05	17.872821	0.00024213
Residual	10	1.97123E-05	1.9712E-06		
Total	13	0.000125406			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 90.0%*	*Upper 90.0%*
Intercept	0.00454838	0.004160853	1.09313628	0.29996729	-0.0047226	0.01381934	-0.002993	0.01208976
NatGas	0.00083009	0.000464859	1.78567641	0.10445894	-0.0002057	0.00186586	-1.245E-05	0.00167263
Sewer rate	0.00709686	0.001292366	5.49136936	0.00026498	0.00421729	0.00997643	0.0047545	0.00943922
New Pt	0.00151402	0.001160997	1.30407097	0.22142695	-0.0010728	0.00410089	-0.0005902	0.00361828

Model: Utility Cost = a22+ b22(NatGas) + c22(Sewer rate) + d22(New pt)

RESIDUAL OUTPUT-BUTTER UTILITY COST

Year	Actual Utility Cost *($/lb.)*	***Predicted Utility Cost ($/lb.)***	*Residuals*	CA Nat Gas *($/MCF)* 1/	Sewer Rate Dummy	New Pt Dummy
2003	$0.0115	*$0.0105*	0.00100328	7.19	0	0
2004	$0.0109	*$0.0111*	-0.0002005	7.89	0	0
2005	$0.0125	*$0.0127*	-0.0002137	9.84	0	0
2006	$0.0110	*$0.0123*	-0.0012844	9.3	0	0
2007	$0.0114	*$0.0121*	-0.0006773	9.07	0	0
2008	$0.0164	*$0.0150*	0.00137264	10.8	0	1
2009	$0.0172	*$0.0186*	-0.0013726	6.56	1	1
2010	$0.0180	*$0.0175*	0.00057154	7.02	1	0
2011	$0.0200	*$0.0175*	0.00251794	7.04	1	0
2012	$0.0168	*$0.0164*	0.00038915	5.77	1	0
2013	$0.0180	*$0.0171*	0.00090508	6.57	1	0
2014	$0.0171	*$0.0180*	-0.0008874	7.65	1	0
2015	$0.0169	*$0.0170*	-4.611E-05	6.41	1	0
2016	$0.0152	*$0.0173*	-0.0020775	6.79	1	0
2017		***$0.0175***		7.05	1	0
2018		***$0.0176***		7.12	1	0
2019		***$0.0180***		7.69	1	0
2020		***$0.0179***		7.55	1	0
2021		***$0.0197***		9.75	1	0
2022		***$0.0225***		13.06	1	0

1/ California natural gas price data for 2022 is average of monthly data 2021 Q4 through 2022 Q3

Table A-11. SUMMARY OUTPUT-Butter Manufacturing Cost less Utility and Labor Cost (Other Cost).

Regression Statistics	
Multiple R	0.88900605
R Square	0.79033176
Adjusted R Square	0.72743129
Standard Error	0.00616422
Observations	14

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	0.001432297	0.00047743	12.5647984	0.000996295
Residual	10	0.000379976	3.7998E-05		
Total	13	0.001812273			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 90.0%*	*Upper 90.0%*
Intercept	0.22088302	0.113534641	1.9455121	0.08034383	-0.032087927	0.473853961	0.01510589	0.426660139
US PPI	0.00075589	0.000189353	3.99194646	0.00255127	0.000333982	0.00117779	0.00041269	0.00109908
Food TFP	-0.0020187	0.001038535	-1.9438194	0.08056952	-0.004332723	0.000295276	-0.003901	-0.00013642
New Pt	0.01126886	0.005046433	2.23303488	0.04958662	2.47075E-05	0.022513015	0.0021224	0.020415325

Model: Other Cost = a23 +b23(US PPI) +c23(Food TFP)+d23(New pt)

RESIDUAL OUTPUT-BUTTER OTHER COST

Year	Actual Other Cost *($/lb.)*	***Predicted Other Cost ($/lb.)***	*Residuals*	US PPI Intermediate Goods *(2015=100)* 1/	US Total Factor Productivity Index Food Bev Tob *(2012=100)* 2/	New Pt Dummy
2003	$0.0710	*$0.0726*	-0.0015871	72.3214	100.608	0
2004	$0.0752	*$0.0744*	0.00083062	76.5975	101.313	0
2005	$0.0755	*$0.0777*	-0.0021756	80.5103	101.141	0
2006	$0.0765	*$0.0764*	0.00015204	85.1672	103.495	0
2007	$0.0735	*$0.0785*	-0.0049898	88.0033	103.480	0
2008	$0.0904	*$0.0986*	-0.0081893	95.0149	101.710	1
2009	$0.1019	*$0.0937*	0.00818935	90.7563	102.581	1
2010	$0.1003	*$0.0884*	0.01186575	94.5553	101.131	0
2011	$0.0962	*$0.0932*	0.00300949	100.9366	101.088	0
2012	$0.0948	*$0.0959*	-0.0011201	101.7157	100.000	0
2013	$0.0902	*$0.0976*	-0.0074212	102.4116	99.270	0
2014	$0.0964	*$0.0979*	-0.0015262	103.4401	99.692	0
2015	$0.0981	*$0.0968*	0.00127633	100.0000	98.954	0
2016	$0.1032	*$0.1015*	0.00168579	98.3587	95.988	0
2017		***$0.0996***		101.5144	98.107	0
2018		***$0.1042***		105.5716	97.307	0
2019		***$0.1027***		105.3002	97.974	0
2020		***$0.1034***		104.4643	97.318	0
2021		***$0.1060***		121.8265	102.520	0
2022		***$0.1162***		135.3550	102.520	0

1/ PPI data for 2022 is average of monthly data 2021 Q4 through 2022 Q3

2/ TFP not yet reported for 2022. The 2021 value of the index is used in place of 2022 data.

Table A-12. SUMMARY OUTPUT - Butter Manufacturing Cost Trend.

Regression Statistics	
Multiple R	0.922639928
R Square	0.851264437
Adjusted R S	0.83982324
Standard Err	0.009636523
Observations	15

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.006909296	0.0069093	74.4034411	9.713E-07
Residual	13	0.001207214	9.2863E-05		
Total	14	0.008116509			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 90.0%*	*Upper 90.0%*
Intercept	-9.820014167	1.156970554	-8.4876958	1.1631E-06	-12.319497	-7.3205312	-11.868932	-7.7710964
Year	0.0049675	0.000575892	8.62574293	9.713E-07	0.00372336	0.00621164	0.00394763	0.00598737

Model: Butter MFG Cost = q2+ r2(Year)

RESIDUAL OUTPUT - BUTTER MANUFACTURING COST TREND

Observation	**Actual MFG Cost**	*Predicted MFG Cost*	*Residuals*	**Year**
2002	0.1235	0.1249	-0.0014208	2002
2003	0.1299	0.1299	1.1667E-05	2003
2004	0.1368	0.1349	0.00194417	2004
2005	0.1408	0.1398	0.00097667	2005
2006	0.1373	0.1448	-0.0074908	2006
2007	0.1316	0.1498	-0.0181583	2007
2008	0.1553	0.1547	0.00057417	2008
2009	0.1811	0.1597	0.02140667	2009
2010	0.1781	0.1647	0.01343917	2010
2011	0.1775	0.1696	0.00787167	2011
2012	0.1688	0.1746	-0.0057958	2012
2013	0.1724	0.1796	-0.0071633	2013
2014	0.1843	0.1845	-0.0002308	2014
2015	0.1842	0.1895	-0.0052983	2015
2016	0.1938	0.1945	-0.0006658	2016
2017		***0.1994***		2017
2018		***0.2044***		2018
2019		***0.2094***		2019
2020		***0.2143***		2020
2021		***0.2193***		2021
2022		***0.2243***		2022

Table A-13. Total Butter Manufacturing Cost.

Year	***Predicted MFG Cost***	Actual MFG Cost	Difference between Actual and Predicted Cost	Butter MFG Cost Trend
		------- *dollars per pound* -------		
2003	*$0.1302*	$0.1299	$0.0003	$0.1299
2004	*$0.1320*	$0.1368	-$0.0048	$0.1349
2005	*$0.1388*	$0.1408	-$0.0020	$0.1398
2006	*$0.1378*	$0.1373	$0.0005	$0.1448
2007	*$0.1404*	$0.1316	$0.0088	$0.1498
2008	*$0.1652*	$0.1553	$0.0099	$0.1547
2009	*$0.1733*	$0.1811	-$0.0078	$0.1597
2010	*$0.1667*	$0.1781	-$0.0114	$0.1647
2011	*$0.1709*	$0.1775	-$0.0066	$0.1696
2012	*$0.1749*	$0.1688	$0.0061	$0.1746
2013	*$0.1801*	$0.1724	$0.0077	$0.1796
2014	*$0.1820*	$0.1843	-$0.0023	$0.1845
2015	*$0.1833*	$0.1842	-$0.0009	$0.1895
2016	*$0.1931*	$0.1938	-$0.0007	$0.1945
2017	***$0.1990***			***$0.1994***
2018	***$0.2056***			***$0.2044***
2019	***$0.2037***			***$0.2094***
2020	***$0.2067***			***$0.2143***
2021	***$0.2201***			***$0.2193***
2022	***$0.2364***			***$0.2243***

Model: Predicted Butter Total MFG Cost = Predicted Butter Labor Cost
+ Predicted Butter Utility Cost + Predicted Butter Other Cost

Trend: Total Butter MFG Cost = q2 + r2(year)

Table A-14. Butter Manufacturing Costs: Components and Total, Actual, and Predicted Values.

	Actual Costs				***Predicted Costs***				***Trend***
Year	Labor	Utility	Other	Total	Labor	Utility	Other	Total	Total
	------- dollars per pound -------				*------- dollars per pound -------*				*$/lb.*
2002	$0.0447				$0.0480				
2003	$0.0474	$0.0115	$0.0710	$0.1299	$0.0471	$0.0105	$0.0726	$0.1302	$0.1299
2004	$0.0507	$0.0109	$0.0752	$0.1368	$0.0465	$0.0111	$0.0744	$0.1320	$0.1349
2005	$0.0528	$0.0125	$0.0755	$0.1408	$0.0484	$0.0127	$0.0777	$0.1388	$0.1398
2006	$0.0498	$0.0110	$0.0765	$0.1373	$0.0492	$0.0123	$0.0764	$0.1378	$0.1448
2007	$0.0467	$0.0114	$0.0735	$0.1316	$0.0499	$0.0121	$0.0785	$0.1404	$0.1498
2008	$0.0485	$0.0164	$0.0904	$0.1553	$0.0516	$0.0150	$0.0986	$0.1652	$0.1547
2009	$0.0620	$0.0172	$0.1019	$0.1811	$0.0610	$0.0186	$0.0937	$0.1733	$0.1597
2010	$0.0598	$0.0180	$0.1003	$0.1781	$0.0608	$0.0175	$0.0884	$0.1667	$0.1647
2011	$0.0613	$0.0200	$0.0962	$0.1775	$0.0602	$0.0175	$0.0932	$0.1709	$0.1696
2012	$0.0572	$0.0168	$0.0948	$0.1688	$0.0626	$0.0164	$0.0959	$0.1749	$0.1746
2013	$0.0642	$0.0180	$0.0902	$0.1724	$0.0653	$0.0171	$0.0976	$0.1801	$0.1796
2014	$0.0708	$0.0171	$0.0964	$0.1843	$0.0661	$0.0180	$0.0979	$0.1820	$0.1845
2015	$0.0692	$0.0169	$0.0981	$0.1842	$0.0695	$0.0170	$0.0968	$0.1833	$0.1895
2016	$0.0754	$0.0152	$0.1032	$0.1938	$0.0744	$0.0173	$0.1015	$0.1931	$0.1945
2017					$0.0819	$0.0175	$0.0996	$0.1990	$0.1994
2018					$0.0838	$0.0176	$0.1042	$0.2056	$0.2044
2019					$0.0830	$0.0180	$0.1027	$0.2037	$0.2094
2020					$0.0854	$0.0179	$0.1034	$0.2067	$0.2143
2021					$0.0943	$0.0197	$0.1060	$0.2201	$0.2193
2022					$0.0977	$0.0225	$0.1162	$0.2364	$0.2243

Table A-15. Nonfat Dry Milk (NFDM) Manufacturing Cost Model

		F-stat	Adj R Sqare
Labor Cost	= a31+ b31(MFG Wage)** + c31(Lab Pro)* + d31(Nstruc)** +e31	**	89
Utility Cost	= a32** + b32(NatGas) + c32 (New pt)** +e32	**	58
Other Cost	= a33+ b33(US PPI)** +c33(Food TFP) +d33(New pt) +e33	**	71
TOTAL MFG COST	= LABOR COST + UTILITY COST + OTHER MFG COST		

** Estimated parameter or regression statistic significant at the 5% level or lower
* Estimated parameter or regression statistic significant at the 10% level or lower

Where: aij represent estimated constant term, bij thru dij represent estimated parameters associated with explanatory variables, and eij represent error terms.

MFG Wage = average hourly earnings for California nonsupervisory manufactuirng workers, BLS
Lab Pro = US Non-farm labor productivity annual index, BLS, US Dept. of Labor
Nstruc = a labor structural change dummy that represents a discrete upward shift in labor cost
NatGas = California Industrial Users price for natural gas, EIA, US Dept. of Energy
New pt = a dummy variable representing higher costs associated with start-up of large new plants
US PPI = US Producer Price Index for Intermediate Goods, a proxy for changes in other plant costs
Food TFP = US Total Factor Productivity Index for Food, Beverage and Tobacco Manufacturing, BLS, US Dept. of Labor

BLS is the Buereau of Labor Statistics, U.S. Department of Labor
EIA is the Energy Information Agency, U.S. Department of Energy

Table A-16. SUMMARY OUTPUT- NFDM Labor Cost.

Regression Statistics	
Multiple R	0.95553049
R Square	0.91303852
Adjusted R Square	0.88932176
Standard Error	0.00234322
Observations	15

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	0.000634132	0.00021138	38.4975982	3.9835E-06
Residual	11	6.03973E-05	5.4907E-06		
Total	14	0.000694529			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 90.0%*	*Upper 90.0%*
Intercept	0.01372349	0.012143249	1.13013343	0.28246045	-0.0130036	0.0404506	-0.0080844	0.03553137
MFG Wage	0.00498515	0.001600309	3.11511654	0.00983529	0.00146289	0.0085074	0.00211118	0.00785912
Lab Pro	-0.0005805	0.000307739	-1.886392	0.08590453	-0.0012578	9.6813E-05	-0.0011332	-2.7853E-05
Nstruc	0.00560556	0.002345331	2.39009331	0.03585547	0.00044352	0.0107676	0.00139362	0.0098175

Model: MFG LABOR COST = a31+ b31(MFG Wage) + c31(Lab Pro) + d31(Nstruc)

RESIDUAL OUTPUT- NFDM LABOR COST

Year	Actual Labor Cost *($/lb.)*	***Predicted Labor Cost ($/lb.)***	*Residuals*	MFG Non Supervisory California Wage *($/hr.)* 1/	US Nonfarm Labor Productivity Index, BLS *(2012=100)* 1/	Nstruc Dummy
2002	$0.0319	$0.0343	-0.0024405	13.6208	81.453	0
2003	$0.0357	$0.0335	0.00219553	13.8017	84.446	0
2004	$0.0342	$0.0330	0.00121358	13.9917	86.970	0
2005	$0.0377	$0.0345	0.00321955	14.5125	88.869	0
2006	$0.0362	$0.0352	0.00104759	14.7500	89.751	0
2007	$0.0333	$0.0357	-0.0023501	15.0183	91.198	0
2008	$0.0340	$0.0370	-0.0030392	15.4342	92.376	0
2009	$0.0366	$0.0375	-0.0008823	15.9050	95.656	0
2010	$0.0388	$0.0373	0.00151836	16.2483	98.950	0
2011	$0.0363	$0.0368	-0.0004825	16.1533	98.994	0
2012	$0.0414	$0.0443	-0.0028966	16.6533	100.000	1
2013	$0.0484	$0.0466	0.00184007	17.1642	100.488	1
2014	$0.0460	$0.0472	-0.0011635	17.3600	101.130	1
2015	$0.0523	$0.0500	0.00233771	18.0600	102.320	1
2016	$0.0538	$0.0539	-0.0001176	18.8950	102.677	1
2017		***$0.0601***		20.2625	103.806	1
2018		***$0.0616***		20.7492	105.345	1
2019		***$0.0609***		20.8558	107.514	1
2020		***$0.0629***		21.5533	110.116	1
2021		***$0.0701***		23.2508	112.212	1
2022		***$0.0729***		24.0280	114.133	1

1/ California MFG wage and labor productivity data for 2022 is average of monthly data 2021 Q4 through 2022 Q3

Table A-17. SUMMARY OUTPUT-NFDM Utility Cost.

Regression Statistics	
Multiple R	0.80532621
R Square	0.64855031
Adjusted R Square	0.58465037
Standard Error	0.00315355
Observations	14

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.00020187	0.00010094	10.1494661	0.00317868
Residual	11	0.000109394	9.9449E-06		
Total	13	0.000311264			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 90.0%*	*Upper 90.0%*
Intercept	0.04080266	0.004718779	8.64686651	3.0956E-06	0.03041669	0.05118862	0.03232827	0.04927704
NatGas	0.00082207	0.000613669	1.33959047	0.20739753	-0.0005286	0.00217274	-0.00028	0.00192414
New pt	0.00942782	0.002507251	3.76022049	0.00315346	0.00390939	0.01494624	0.00492508	0.01393055

Model: Utility Cost = a32 + b32(Nat Gas) + c32(New pt)

RESIDUAL OUTPUT-NFDM UTILITY COST

Year	Actual Utility Cost (*$/lb.*)	***Predicted Utility Cost ($/lb.)***	*Residuals*	CA Nat Gas (*$/MCF*) 1/	New Pt Dummy
2003	$0.0430	*$0.0467*	-0.0037062	7.19	0
2004	$0.0428	*$0.0473*	-0.0044537	7.89	0
2005	$0.0506	*$0.0489*	0.00168717	9.84	0
2006	$0.0491	*$0.0484*	0.00064863	9.30	0
2007	$0.0459	*$0.0483*	-0.0023588	9.07	0
2008	$0.0604	*$0.0591*	0.00129122	10.80	1
2009	$0.0543	*$0.0556*	-0.0012912	6.56	1
2010	$0.0513	*$0.0466*	0.00476845	7.02	0
2011	$0.0483	*$0.0466*	0.00171	7.04	0
2012	$0.0476	*$0.0455*	0.00209603	5.77	0
2013	$0.0505	*$0.0462*	0.00428637	6.57	0
2014	$0.0476	*$0.0471*	0.00049454	7.65	0
2015	$0.0444	*$0.0461*	-0.0016901	6.41	0
2016	$0.0429	*$0.0464*	-0.0034825	6.79	0
2017		***$0.0466***		7.05	0
2018		***$0.0467***		7.12	0
2019		***$0.0471***		7.69	0
2020		***$0.0470***		7.55	0
2021		***$0.0488***		9.75	0
2022		***$0.0515***		13.06	0

1/ California natural gas price data for 2022 is average of monthly data 2021 Q4 through 2022 Q3

Table A-18. SUMMARY OUTPUT- NFDM Manufacturing Cost less Utility and Labor Cost (Other Cost).

Regression Statistics	
Multiple R	0.88242766
R Square	0.77867858
Adjusted R Square	0.71228215
Standard Error	0.00837717
Observations	14

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	0.002469048	0.00082302	11.7277182	0.00129796
Residual	10	0.00070177	7.0177E-05		
Total	13	0.003170818			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 90.0%*	*Upper 90.0%*
Intercept	0.19825498	0.154293509	1.28492105	0.22778337	-0.14553238	0.54204234	-0.08139601	0.477905964
US PPI	0.00111735	0.00025733	4.34209606	0.00146156	0.00054399	0.00169072	0.00065095	0.001583754
Food TFP	-0.0020346	0.001411368	-1.4415986	0.17998921	-0.00517935	0.001110098	-0.00459268	0.000523423
New pt	0.0088964	0.006858099	1.29721016	0.2236872	-0.0063844	0.024177194	-0.00353364	0.021326435

Model: OTHER COST = a33+ b33(US PPI) +c33(US Food TFP)+d33(New pt)

RESIDUAL OUTPUT - NFDM OTHER COST

Year	Actual Other Cost *($/lb.)*	***Predicted Other Cost ($/lb.)***	*Residuals*	US PPI Intermediate Goods *(2015=100)* 1/	US Total Factor Productivity Index Food Bev Tob *(2012=100)* 2/	New Pt Dummy
					(2012=100)	
2003	$0.0773	$0.0745	0.002811	72.3214	100.608	0
2004	$0.0773	$0.0778	-0.0005564	76.5975	101.313	0
2005	$0.0776	$0.0825	-0.0049181	80.5103	101.141	0
2006	$0.0811	$0.0829	-0.0017722	85.1672	103.495	0
2007	$0.0776	$0.0860	-0.0084263	88.0033	103.480	0
2008	$0.0987	$0.1063	-0.0076157	95.0149	101.710	1
2009	$0.1075	$0.0999	0.00761568	90.7563	102.581	1
2010	$0.1169	$0.0983	0.0185239	94.5553	101.131	0
2011	$0.1096	$0.1054	0.00416626	100.9366	101.088	0
2012	$0.1109	$0.1084	0.00241334	101.7157	100.000	0
2013	$0.1008	$0.1104	-0.0096167	102.4116	99.270	0
2014	$0.1075	$0.1111	-0.0035818	103.4401	99.692	0
2015	$0.1111	$0.1087	0.00236856	100.0000	98.954	0
2016	$0.1115	$0.1129	-0.0014116	98.3587	95.988	0
2017		***$0.1121***		101.5144	98.107	0
2018		***$0.1182***		105.5716	97.307	0
2019		***$0.1166***		105.3002	97.974	0
2020		***$0.1170***		104.4643	97.318	0
2021		***$0.1258***		121.8265	102.520	0
2022		***$0.1409***		135.3550	102.520	0

1/ PPI data for 2022 is average of monthly data 2021 Q4 through 2022 Q3

2/ TFP not yet reported for 2022. The 2021 value of the index is used in place of 2022 data.

Table A-19. SUMMARY OUTPUT - NFDM Manufacturing Cost Trend.

Regression Statistics	
Multiple R	0.90914855
R Square	0.82655108
Adjusted R Square	0.81320886
Standard Error	0.00988427
Observations	15

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.00605244	0.00605244	61.9500212	2.67118E-06
Residual	13	0.001270084	9.7699E-05		
Total	14	0.007322524			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 90.0%*	*Upper 90.0%*
Intercept	-9.156735	1.186715042	-7.7160352	3.3141E-06	-11.720477	-6.592993	-11.258328	-7.0551417
Year	0.00464929	0.000590698	7.87083358	2.6712E-06	0.00337316	0.00592541	0.0036032	0.00569537

Model: NFDM MFG COST = q3 + r3(Year)

RESIDUAL OUTPUT - NFDM MFG COST TREND

Observation	**Actual Cost**	***Predicted MFG Cost***	***Residuals***	**Year**
2002	0.1464	$0.1511	-0.004735	2002
2003	0.1560	$0.1558	0.00021571	2003
2004	0.1543	$0.1604	-0.0061336	2004
2005	0.1659	$0.1651	0.00081714	2005
2006	0.1664	$0.1697	-0.0033321	2006
2007	0.1568	$0.1744	-0.0175814	2007
2008	0.1931	$0.1790	0.01406929	2008
2009	0.1984	$0.1837	0.01472	2009
2010	0.2070	$0.1883	0.01867071	2010
2011	0.1942	$0.1930	0.00122143	2011
2012	0.1999	$0.1976	0.00227214	2012
2013	0.1997	$0.2023	-0.0025771	2013
2014	0.2011	$0.2069	-0.0058264	2014
2015	0.2078	$0.2116	-0.0037757	2015
2016	0.2082	$0.2162	-0.008025	2016
2017		***$0.2209***		2017
2018		***$0.2255***		2018
2019		***$0.2302***		2019
2020		***$0.2348***		2020
2021		***$0.2395***		2021
2022		***$0.2441***		2022

Table A-20. Total NFDM Manufacturing Cost.

Year	***Predicted MFG Cost***	Actual MFG Cost	Difference between Actual and Predicted Cost	CA NFDM MFG Cost Trend
		-------------- dollars per pound	*--------------*	
2003	*$0.1547*	$0.1560	-$0.0013	$0.1558
2004	*$0.1581*	$0.1543	$0.0038	*$0.1604*
2005	*$0.1659*	$0.1659	$0.0000	*$0.1651*
2006	*$0.1665*	$0.1664	$0.0001	*$0.1697*
2007	*$0.1699*	$0.1568	$0.0131	*$0.1744*
2008	*$0.2025*	$0.1931	$0.0094	*$0.1790*
2009	*$0.1930*	$0.1984	-$0.0054	*$0.1837*
2010	*$0.1822*	$0.2070	-$0.0248	*$0.1883*
2011	*$0.1888*	$0.1942	-$0.0054	*$0.1930*
2012	*$0.1983*	$0.1999	-$0.0016	*$0.1976*
2013	*$0.2032*	$0.1997	$0.0035	*$0.2023*
2014	*$0.2054*	$0.2011	$0.0043	*$0.2069*
2015	*$0.2048*	$0.2078	-$0.0030	*$0.2116*
2016	*$0.2132*	$0.2082	$0.0050	*$0.2162*
2017	***$0.2187***			***$0.2209***
2018	***$0.2265***			***$0.2255***
2019	***$0.2246***			***$0.2302***
2020	***$0.2268***			***$0.2348***
2021	***$0.2447***			***$0.2395***
2022	***$0.2653***			***$0.2441***

Model: Predicted NFDM Total MFG Cost = Predicted NFDM Labor Cost
+ Predicted NFDM Utility Cost + Predicted NFDM Other Cost

Trend: Total NFDM MFG Cost = q3+ r3(year)

Table A-21. NFDM Manufacturing Costs: Components and Total, Actual, and Predicted Values.

	Actual Costs				*Predicted Costs*				*Trend*
Year	Labor	Utility	Other	Total	Labor	Utility	Other	Total	Total
	------- dollars per pound -------				------- dollars per pound -------				$/lb.
2002	$0.0319				$0.0343				
2003	$0.0357	$0.0430	$0.0773	$0.1560	$0.0335	$0.0467	$0.0745	$0.1547	$0.1558
2004	$0.0342	$0.0428	$0.0773	$0.1543	$0.0330	$0.0473	$0.0778	$0.1581	$0.1604
2005	$0.0377	$0.0506	$0.0776	$0.1659	$0.0345	$0.0489	$0.0825	$0.1659	$0.1651
2006	$0.0362	$0.0491	$0.0811	$0.1664	$0.0352	$0.0484	$0.0829	$0.1665	$0.1697
2007	$0.0333	$0.0459	$0.0776	$0.1568	$0.0357	$0.0483	$0.0860	$0.1699	$0.1744
2008	$0.0340	$0.0604	$0.0987	$0.1931	$0.0370	$0.0591	$0.1063	$0.2025	$0.1790
2009	$0.0366	$0.0543	$0.1075	$0.1984	$0.0375	$0.0556	$0.0999	$0.1930	$0.1837
2010	$0.0388	$0.0513	$0.1169	$0.2070	$0.0373	$0.0466	$0.0983	$0.1822	$0.1883
2011	$0.0363	$0.0483	$0.1096	$0.1942	$0.0368	$0.0466	$0.1054	$0.1888	$0.1930
2012	$0.0414	$0.0476	$0.1109	$0.1999	$0.0443	$0.0455	$0.1084	$0.1983	$0.1976
2013	$0.0484	$0.0505	$0.1008	$0.1997	$0.0466	$0.0462	$0.1104	$0.2032	$0.2023
2014	$0.0460	$0.0476	$0.1075	$0.2011	$0.0472	$0.0471	$0.1111	$0.2054	$0.2069
2015	$0.0523	$0.0444	$0.1111	$0.2078	$0.0500	$0.0461	$0.1087	$0.2048	$0.2116
2016	$0.0538	$0.0429	$0.1115	$0.2082	$0.0539	$0.0464	$0.1129	$0.2132	$0.2162
2017					$0.0601	$0.0466	$0.1121	$0.2187	$0.2209
2018					$0.0616	$0.0467	$0.1182	$0.2265	$0.2255
2019					$0.0609	$0.0471	$0.1166	$0.2246	$0.2302
2020					$0.0629	$0.0470	$0.1170	$0.2268	$0.2348
2021					$0.0701	$0.0488	$0.1258	$0.2447	$0.2395
2022					$0.0729	$0.0515	$0.1409	$0.2653	$0.2441

Table A-22. Imputed Whey Manufacturing Cost.

Year	NFDM Prediicted MFG Cost	NFDM Linear Trend Cost	Assumed Incremental Drying Cost	Dry Whey = Predicted NFDM + 3 Cents	Dry Whey = Trend NFDM + 3 Cents
	----------------		$ per pound	---------------	
2003	$0.1547	$0.1558	0.03	$0.1847	$0.1858
2004	$0.1581	$0.1604	0.03	$0.1881	$0.1904
2005	$0.1659	$0.1651	0.03	$0.1959	$0.1951
2006	$0.1665	$0.1697	0.03	$0.1965	$0.1997
2007	$0.1699	$0.1744	0.03	$0.1999	$0.2044
2008	$0.2025	$0.1790	0.03	$0.2325	$0.2090
2009	$0.1930	$0.1837	0.03	$0.2230	$0.2137
2010	$0.1822	$0.1883	0.03	$0.2122	$0.2183
2011	$0.1888	$0.1930	0.03	$0.2188	$0.2230
2012	$0.1983	$0.1976	0.03	$0.2283	$0.2276
2013	$0.2032	$0.2023	0.03	$0.2332	$0.2323
2014	$0.2054	$0.2069	0.03	$0.2354	$0.2369
2015	$0.2048	$0.2116	0.03	$0.2348	$0.2416
2016	$0.2132	$0.2162	0.03	$0.2432	$0.2462
2017	$0.2187	$0.2209	0.03	$0.2487	$0.2509
2018	$0.2265	$0.2255	0.03	$0.2565	$0.2555
2019	$0.2246	$0.2302	0.03	$0.2546	$0.2602
2020	$0.2268	$0.2348	0.03	$0.2568	$0.2648
2021	$0.2447	$0.2395	0.03	$0.2747	$0.2695
2022	$0.2653	$0.2441	0.03	$0.2953	$0.2741

Table A-23. Explanatory Variables Used In Estimation California Manufacturing Costs for Butter, NFDM, and Cheddar Cheese

Year	US EIA California Industrial Nat Gas	US EIA California Industrial Electricity Price	CA MFG Production,Nonsupervisory Wkrs, ave hourly earnings	US PPI Intermediate Goods	US Nonfarm Business Labor Productivity Index	US total factor productivity, food, beverage and tobacco mfg BLS
	$/1k cu feet.	*cents/kwh*	*$/hr.*	*2015=100*	*2012=100*	*2012=100*
2002	4.93	9.81	13.62	70.654	81.453	98.707
2003	7.19	9.59	13.80	72.321	84.446	100.608
2004	7.89	9.27	13.99	76.598	86.970	101.313
2005	9.84	9.55	14.51	80.510	88.869	101.141
2006	9.30	10.09	14.75	85.167	89.751	103.495
2007	9.07	9.98	15.02	88.003	91.198	103.480
2008	10.80	10.09	15.43	95.015	92.376	101.710
2009	6.56	10.42	15.91	90.756	95.656	102.581
2010	7.02	9.80	16.25	94.555	98.950	101.131
2011	7.04	10.11	16.15	100.937	98.994	101.088
2012	5.77	10.49	16.65	101.716	100.000	100.000
2013	6.57	11.44	17.16	102.412	100.488	99.270
2014	7.65	12.34	17.36	103.440	101.130	99.692
2015	6.41	12.17	18.06	100.000	102.320	98.954
2016	6.79	11.92	18.90	98.359	102.677	95.988
2017	7.05	12.73	20.26	101.514	103.806	98.107
2018	7.12	13.20	20.75	105.572	105.345	97.307
2019	7.69	13.40	20.86	105.300	107.514	97.974
2020	7.55	14.27	21.55	104.464	110.116	97.318
2021	9.75	14.82	23.25	121.827	112.212	102.520
2022	13.06	16.48	24.03	135.355	114.133	102.520

Notes: Data for elextricity and natural gas prices is annual summary data from the US Energy Information Agency (EIA), Industrial Users
Data for labor costs are from the Bureau of Labor Statistics (BLS), Manufacturing Production and nonsupervisory workers, average hourly earnings
The Producer Price Index for Intermediate Goods is used a a proxy for general price inflation in material costs, data is from the BLS
The labor and total factor productivity incdices are from the BLS
Data for 2022 are estimated from monthly or quartely values from October 2021-Spetember 2022, as full-year 2022 data was not available when the models were estimated.
Total factor productivity (TFP) data for 2022 has not yet been reported, so TFP data for 2021 was used as the 2022 value.
The models estimated also include dummy variables to account for structural change or one-time shocks impacting manufacturing costs in California--these are not shown in this table, but are shown in Table 4 of this report.
Both EIA and BLS update their cost and index series frequently. These data were accurate when the models were estimated in December 2022.