Evaluating Generic Dairy Advertising Impacts on Retail, Wholesale, and Farm Milk Markets

Harry M. Kaiser, Olan D. Forker, John Lenz, and Chin-Hwa Sun

Abstract. *This article develops a dynamic econometric model of the national dairy industry to simulate the impacts of generic advertising on the demand for milk and dairy products, farm and consumer prices, and producer welfare Two advertising scenarios are analyzed (1) a historic scenario, and (2) a pre-National Dairy Promotion and Research Board (NDPRB) scenario, where generic advertising expenditures are held constant at their quarterly levels during the year prior to the NDPRB's inception The results indicate that the program has been effective in raising farm prices, increasing dairy product demand, and reducing cheese and butter purchases by the Government*

Keywords. *Generic dairy advertising, dairy industry model, program impacts, dairy price support program*

Since 1984, dairy farmers in the mainland United States have paid mandatory promotion assessments of 15 cents on every 100 pounds of milk marketed commercially to fund the National Dairy Promotion and Research Board (NDPRB) Legislative authority for these assessments, which exceed $200 million annually, is contained in the Dairy and Tobacco Adjustment Act of 1983 To increase milk and dairy product consumption, the NDPRB invests in generic dairy advertising and promotion, nutrition research, education, and new product development

A substantial amount of research on the effectiveness of generic dairy advertising has been conducted within the past 20 years A report prepared for the International Dairy Federation summarizes the results of 47 studies of generic dairy advertising programs (Forker and Kinnucan, 1991) 27 for fluid milk, 10 for butter, 5 for cheese, 3 for cream, and 1 for yogurt All of the studies provided some measure of the market impact of generic advertising

Methodology and estimation techniques have evolved to provide more reliable estimates of the economic relationship between sales or consumption and advertising expenditures, while controlling for other demand factors such as own-price, income level, price of substitutes, and demographics Early studies with single-equation demand functions estimated for single products and limited market areas (Kinnucan and Fearon, 1986, Kinnucan and Forker, 1986, Thompson and Eiler, 1975) evolved into single-equation, single-product, multiple-market studies Ward and Dixon (1989) combined data from 12 fluid milk markets for a pooled cross-section and time-series analysis Liu and Forker (1990) developed single equations for three separate markets and used the equations to arrive at an optimal advertising allocation strategy among the three markets In an earlier study, Liu and Forker (1988) incorporated a supply response function to account for any production response that might be generated by advertising-induced demand expansion All of the fluid milk studies used aggregate market data to represent demand In each of the fluid milk studies, models were specified as quantity-dependent, that is, advertising was assumed to directly influence the volume of sales but not price

Other studies have estimated the impact of generic advertising of manufactured dairy products (cheese, butter, and cream) on demand (Blaylock and Blisard, 1990, Chang and Kinnucan, 1990, Kinnucan and Fearon, 1986, Liu and others, 1990, Strak and Gill, 1983, Yau, 1990) Two studies estimated a single demand equation for cheese that included a variable for generic cheese advertising expenditures (Blaylock and Blisard, 1990, Kinnucan and Fearon, 1986) A similar study was conducted for cream (Yau, 1990) Another study used multiple equations to account for the simultaneous impact of advertising on butter and other edible oils (Chang and Kinnucan, 1990) These studies have provided useful information to evaluate the performance of generic dairy advertising programs Most studies, however, fail to simultaneously determine the impact of generic advertising on price and quantity

Liu and others (1990, 1991) proposed a multiple-product, multiple-market level model that would simultaneously account for the direct demand impact and the cross-product impacts of concurrent advertising programs for several dairy products The model concurrently takes into account the

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price and quantity impacts at three levels of trade—retail, wholesale, and farm The study was one of the first to explicitly incorporate the government price support program into the manufactured product market [1] Liu and others concluded that generic advertising has different effects on market variables depending on whether the market is competitive or in a government-support regime where market prices are below support prices

This article extends the Liu analysis by developing a disaggregated industry model at the retail, wholesale, and farm levels with markets for fluid products, frozen products, cheese, and butter A dynamic econometric model of the U S dairy industry is estimated using quarterly data from 1975 through 1990 The econometric results are then used to simulate the impacts of generic advertising on demand for milk and dairy products, farm and consumer prices, and producer welfare Two advertising scenarios are analyzed (1) a historic scenario in which generic advertising expenditures for fluid milk products, cheese, and butter are set equal to their actual levels for the simulation period, and (2) a pre-NDPRB scenario in which fluid product, cheese, and butter generic advertising expenditures are held constant at their quarterly levels during the year prior to the NDPRB inception A comparison of the two scenarios provides insight into the national program's impacts on demand, supply, and prices at the retail, wholesale, and producer levels

The Conceptual Model

The econometric model presented here is similar in structure to the Liu industry model, with two important differences First, while the Liu model classified all manufactured products into one category (Class II), our model disaggregates manufactured products into three classes frozen products, cheese, and butter This disaggregation provides insight into the impacts of advertising on individual product demand Second, instead of a raw milk supply function for the farm market, our model disaggregates farm milk supply into cow numbers and production per cow, which allows for more information on how the two components of milk supply are affected by generic advertising

In the farm market of our model, Grade A (fluid eligible) milk is produced by farmers and sold to wholesalers The wholesale market is disaggregated into four submarkets fluid, frozen products, cheese, and butter [2] It is assumed that the two major Federal programs that regulate the dairy industry (Federal milk marketing orders and the dairy price support program) are in effect Since this is a national model, we assumed that there is one Federal milk marketing order regulating all milk marketed in the Nation Under this program, fluid wholesalers pay the higher Class I price, while cheese wholesalers pay the lower Class III price [3] The dairy price support program is incorporated into the model by constraining the wholesale cheese and butter prices to be greater than or equal to the government purchase prices With the Federal Government offering to buy unlimited quantities of storable manufactured dairy products at announced prices, the program indirectly supports the farm milk price by increasing farm-level milk demand (fig 1)

Retail markets are defined by sets of supply and demand functions and equilibrium conditions that require that supply equal demand Since the market is disaggregated into fluid, frozen products, cheese, and butter, there are four sets of these equations, with each set having the following general specification

$$Q^{rd} = f(P^r | S^{rd}), \quad (1\ 1)$$
$$Q^{rs} = f(P^r | S^{rs}), \quad (1\ 2)$$
$$Q^{rs} = Q^{rd} \equiv Q^r, \quad (1\ 3)$$

where Q^{rd} and Q^{rs} are retail demand and supply, P^r is the retail own-price, S^{rd} is a vector of retail demand shifters including generic and brand advertising, S^{rs} is a vector of retail supply shifters including the wholesale own-price, and Q^r is the equilibrium retail quantity

The wholesale market is also defined by four sets of supply and demand functions and equilibrium conditions The wholesale fluid and frozen product markets have the following general specification

$$Q^{wd} = Q^r, \quad (2\ 1)$$
$$Q^{ws} = f(P^w | S^{ws}), \quad (2\ 2)$$
$$Q^{ws} = Q^{wd} \equiv Q^w \equiv Q^r, \quad (2\ 3)$$

where Q^{wd} and Q^{ws} are wholesale demand and supply, P^w is the wholesale own-price, and S^{ws} is a

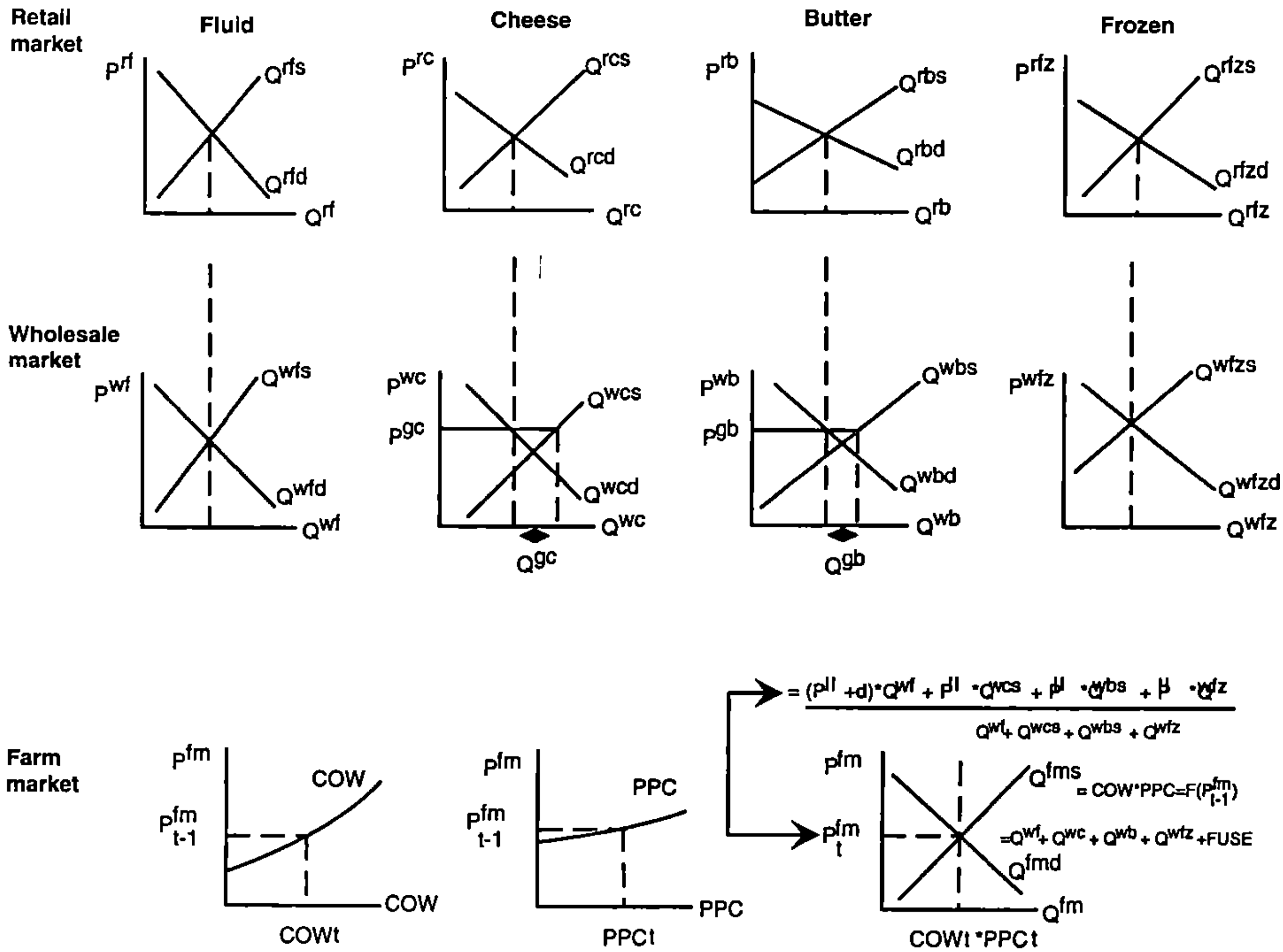
[1] A model by Thompson (1975) considered the effect of the dairy price support program on the farm milk price by including the support price as an explanatory variable in a farm price equation

[2] All quantities in the model are expressed on a milkfat-equivalent basis Consequently, nonfat dry milk is not considered in the model

[3] Most Federal milk marketing orders utilize three product classes with Class I being fluid products, Class II being soft dairy products, and Class III being hard dairy products A two-class system is used in this study, with all fluid products considered Class I and all manufactured products considered Class II

Figure 1

Conceptual model of the dairy industry (All quantities on a milkfat-equivalent basis)



vector of wholesale supply shifters In the wholesale fluid supply equation, S^{ws} includes the Class I price, which equals the Class II milk price (that is, the Minnesota-Wisconsin price) plus a fixed fluid differential In the frozen products, cheese, and butter wholesale supply functions, S^{ws} includes the Class II price, which is the most important variable cost to dairy processors Wholesale-level demand functions do not have to be estimated since the equilibrium conditions constrain wholesale demand to be equal to the equilibrium retail quantity The assumption that wholesale demand equals retail quantity implies a fixed-proportions production technology Recent research by Wohlgenant and Haidacher (1989) suggests that this may not be a realistic assumption However, the data used as a proxy for national demand are commercial disappearance statistics, which do not distinguish between wholesale and retail levels Consequently, the assumption of fixed-proportions production technology is necessary

Direct impacts of the dairy price support program occur in the wholesale cheese and butter markets At this level, the Commodity Credit Corporation (CCC) provides an alternative source of demand at announced purchase prices Consequently, the equilibrium conditions for the butter and cheese wholesale markets are different than those for the fluid and frozen wholesale markets

$$Q^{wd} = Q^{r}, \qquad (3\ 1)$$

$$Q^{ws} = f(P^{w} | S^{ws}), \qquad (3\ 2)$$

$$Q^{ws} = Q^{wd} + \Delta INV + QSP \equiv Q^{w}, \qquad (3\ 3)$$

where Q^{wd} and Q^{ws} are wholesale demand and supply, P^{w} is the wholesale own-price, S^{ws} is a vector of wholesale supply shifters including the Class II milk price, ΔINV is change in commercial inventories, QSP is quantity of product sold by specialty plants to the Government, and Q^{w} is the equilibrium wholesale quantity The variables ΔINV and QSP represent a small proportion of total milk production and are assumed to be exogenous in this model[4]

The dairy price support program is incorporated in the model by constraining the wholesale cheese and butter prices to equal or exceed their government purchase prices

$$P^{wc} \geqslant P^{gc}, \quad (4\ 1)$$
$$P^{wb} \geqslant P^{gb}, \quad (4\ 2)$$

where P^{gc} and P^{gb} are the government purchase prices for cheese and butter

Because of the dairy price support program, four regimes are possible (1) $P^{wc} > P^{gc}$ and $P^{wb} > P^{gb}$, (2) $P^{wc} > P^{gc}$ and $P^{wb} = P^{gb}$, (3) $P^{wc} = P^{gc}$ and $P^{wb} > P^{gb}$, or (4) $P^{wc} = P^{gc}$ and $P^{wb} = P^{gb}$ In the cheese and butter markets, specific versions of equilibrium condition 3 3 apply to the first regime, which is the competitive case In the second case, where the cheese market is competitive but the butter market is not, the wholesale butter price is set equal to the government purchase price for butter and the equilibrium condition is changed to

$$Q^{wbs} = Q^{wbd} + \Delta INV_b + QSP_b + Q^{gb} \equiv Q^{wb}, \quad (3\ 3b)$$

where Q^{gb} is government purchases of butter which becomes the new endogenous variable, replacing the wholesale butter price For the third case, where the butter market is competitive but the cheese market is not, the wholesale cheese price is set equal to the government purchase price for cheese and the equilibrium condition is changed to

$$Q^{wcs} = Q^{wcd} + \Delta INV_c + QSP_c + Q^{gc} \equiv Q^{wc}, \quad (3\ 3c)$$

where Q^{gc} is Government purchases of cheese which becomes the new endogenous variable, replacing the wholesale cheese price For the last case, where both the cheese and butter markets are not competitive, the wholesale cheese and butter prices are set equal to their respective government purchase prices and the equilibrium conditions are changed to (3 3b) and (3 3c)[5]

The farm raw milk market is disaggregated into a national cow number equation, a national average-production-per-cow equation, and an identity that equates milk supply to the product of cow numbers and production per cow

$$COW = f(E[P^{fm}] \mid S^{cow}), \quad (5\ 1)$$
$$PPC = f(P^{fm} \mid S^{PPC}), \quad (5\ 2)$$
$$Q^{fm} = COW * PPC, \quad (5\ 3)$$

where COW is the number of dairy cows in the United States, $E[P^{fm}]$ is the expected farm milk price, S^{COW} is a vector of cow supply shifters, PPC is average production per cow, S^{PPC} is a vector of production-per-cow shifters, and Q^{fm} is farm milk supply It is assumed that farmers have naive price expectations, that is, $E[P^{fm}]_t = P^{fm}_{t-1}$ Thus, the farm milk supply is predetermined and can be estimated using ordinary least squares This assumption makes the simulation recursive, with the wholesale and retail markets forming a system, and the farm market independent from the system

The farm milk price is a weighted average of the class prices for milk, with the weights equal to the utilization of milk among products

$$P^{fm} = [(P^{II} + d) * Q^{wfs} + P^{II} * Q^{wfzs} + P^{II} * Q^{wcs} + P^{II} * Q^{wbs}]/[Q^{wfs} + Q^{wfzs} + Q^{wcs} + Q^{wbs}], \quad (5\ 4)$$

where P^{II} is the Class II price, d is the Class I fixed fluid differential (therefore the Class I price is equal to $P^{II} + d$), Q^{wfs} is wholesale fluid supply, Q^{wfzs} is wholesale frozen product supply, Q^{wcs} is wholesale cheese supply, and Q^{wbs} is wholesale butter supply

Finally, the model is closed by the following equilibrium condition

$$Q^{fm} = Q^{wfs} + Q^{wfzs} + Q^{wcs} + Q^{wbs} + FUSE + OTHER, \quad (5\ 5)$$

where FUSE is onfarm use of milk and OTHER is milk used in dairy products other than fluid, frozen, butter, and cheese Both of these variables

[4]Some cheese and butter plants sell products only to the Government regardless of the relationship between the wholesale market price and the purchase price These balancing plants remove excess milk from the market when supply is greater than demand and process the milk into cheese and butter, which is then sold to the Government Because of this, the quantity of milk purchased by the Government was disaggregated into purchases from these specialized plants and other purchases In a competitive regime, the "other purchases" are expected to be zero, while the purchases from specialty plants may be positive The QSP_c and QSP_b variables were derived by computing the average amount of government purchases of cheese and butter during competitive periods, that is, when the wholesale price was greater than the purchase price for these two products

[5]Because the market structure is different under each of these four regimes, using conventional two-stage least squares to estimate the equations may result in selectivity bias Theoretically, a switching simultaneous system regression procedure should be applied, which is described in Liu However, this procedure is not used here because it is beyond the scope of this project Applying this procedure to the level of disaggregation of this model's manufactured product market would have been extremely cumbersome, and the costs of doing so were judged to be greater than the potential benefits

represent a small share of total milk production and are treated as exogenous

Econometric Results

The farm market equations are estimated using ordinary least squares and quarterly data from 1970 through 1990 Retail and wholesale market equations are estimated simultaneously using two-stage least squares and quarterly data from 1975 through 1990 The retail-wholesale system has a shorter time series because advertising expenditures for the retail demand functions are not available prior to 1975 All equations are specified as a double-logarithm functional form Estimation results are presented in table 1 with t-values given in parentheses under each coefficient R^2 is the adjusted coefficient of determination and DW is the Durbin-Watson statistic (See table 2 for definitions of variables in the econometric model)

Table 1—Econometric results for the dairy industry model

Retail fluid demand

$$\ln (Q^{rfd}/POP) = \underset{(-19\ 70)}{-\ 2\ 380} - \underset{(-2\ 20)}{036} \ln (P^{rf}/P^{bev}) + \underset{(6\ 56)}{252} \ln (INC/CPI) - \underset{(-13\ 13)}{067} \ln TREND$$

$$+ \underset{(10\ 60)}{021} SIN1 + \underset{(15\ 90)}{031} COS1 + \underset{(8\ 13)}{005} \ln DGFAD + \underset{(8\ 13)}{008} \ln DGFAD_{-1} + 009 \ln DGFAD_{-2}$$

$$+ \underset{(8\ 13)}{008} \ln DGFAD_{-3} + \underset{(8\ 13)}{005} \ln DGFAD_{-4}$$

$R^2 = 94$, DW = 1 46

Retail frozen demand

$$\ln (Q^{rfzd}/POP) = \underset{(-18\ 30)}{-\ 4\ 433} - \underset{(-2\ 31)}{364} \ln (P^{rfz}/P^{foo}) + \underset{(\ 24)}{019} \ln (INC/CPI) - \underset{(-28\ 38)}{146} SIN1$$

$$- \underset{(-31\ 12)}{158} COS1 + \underset{(1\ 77)}{0029} \ln (DBFZAD) + \underset{(1\ 77)}{0046} \ln (DBFZAD)_{-1} + \underset{(1\ 77)}{0052} \ln (DBFZAD)_{-2}$$

$$+ \underset{(1\ 77)}{0046} \ln (DBFZAD)_{-3} + \underset{(1\ 77)}{0029} \ln (DBFZAD)_{-4} + (1/(1 + \underset{(3\ 79)}{458} L))\ U^{rfzd}$$

$R^2 = 96$, DW = 1 52

Retail cheese demand

$$\ln (Q^{rcd}/POP) = \underset{(-5\ 29)}{-\ 2\ 609} - \underset{(-\ 93)}{200} \ln (P^{rc}/P^{mea}) + \underset{(2\ 68)}{591} \ln (INC/CPI) + \underset{(1\ 06)}{039} \ln TREND$$

$$+ \underset{(4\ 93)}{290} DUM_{82\ 2} - \underset{(-7\ 07)}{434} DUM_{83\ 1} + \underset{(\ 26)}{0004} \ln DGCAD + \underset{(\ 26)}{0007} \ln DGCAD_{-1} + \underset{(\ 26)}{0008} \ln DGCAD_{-2}$$

$$+ \underset{(\ 26)}{0007} \ln DGCAD_{-3} + \underset{(\ 26)}{0004} \ln DGCAD_{-4} + \underset{(1\ 05)}{007} \ln DBCAD + \underset{(1\ 05)}{012} \ln DBCAD_{-1}$$

$$+ \underset{(1\ 05)}{013} \ln DBCAD_{-2} + \underset{(1\ 05)}{012} \ln DBCAD_{-3} + \underset{(1\ 05)}{007} \ln DBCAD_{-4} + (1/(1 + \underset{(1\ 07)}{158} L))\ U^{rcd}$$

$R^2 = 77$, DW = 1 74

Retail butter demand

$$\ln (Q^{rbd}/POP) = \underset{(-11\ 78)}{-\ 3\ 640} - \underset{(-\ 66)}{077} \ln (P^{rb}/INC) + \underset{(4\ 44)}{082} COS1 + \underset{(2\ 70)}{034} COS2$$

continued

$$+ 0016 \ln(DGBAD) + 008 \ln(DBBAD) - 044 \ln TREND - 361\, DUM_{80\,2} - 392\, DUM_{89\,2}$$
(1 09) (50) (-2 41) (-3 61) (-3 88)

$R^2 = 55$, $DW = 1\,93$

Retail fluid supply

$$\ln Q^{rfs} = 1\,266 + 793 \ln(P^{rf}/P^{wf}) - 057 \ln(P^{fe}/P^{wf}) + 0284 \ln TREND + 009\, SIN1$$
(4 16) (3 45) (-4 21) (5 06) (2 37)

$$+ 0385\, COS1 + 392 \ln(Q^{rfs})_{-1} + 070 \ln(Q^{rfs})_{-4}$$
(6 62) (3 15) (58)

$R^2 = 96$, $DW = 1\,93$

Retail frozen product supply

$$\ln Q^{rfzs} = 1\,100 + 323 \ln(P^{rfz}/P^{wfz}) - 056 \ln(P^{fe}/P^{wfz}) - 149\, SIN1 - 155\, COS1$$
(77 03) (1 14) (-1 23) (-13 43) (-13 97)

$$+ 289\, (U^{rfzs})_{-1}$$
(2 12)

$R^2 = 87$, $DW = 1\,59$

Retail cheese supply

$$\ln Q^{rcs} = -640 + 322 \ln(P^{rc}/P^{wc}) - 086 \ln(P^{lab}/P^{wc}) + 012\, SIN1 + 010\, COS1$$
(-1 09) (1 41) (- 48) (1 10) (93)

$$+ 258 \ln(Q^{rcs})_{-1} + 473 \ln(Q^{rcs})_{-4} + 306\, DUM_{82\,2} - 460\, DUM_{83\,1}$$
(3 57) (7 15) (5 47) (-8 08)

$R^2 = 87$, $DW = 2\,12$

Retail butter supply

$$\ln Q^{rbs} = -2\,998 + 1\,255 \ln(P^{rb}/P^{wb}) - 558 \ln(P^{lab}/P^{wb}) - 079 \ln(P^{fe}/P^{wb})$$
(-1 20) (1 51) (-1 13) (-1 00)

$$+ 052\, COS1 + 033\, COS2 + 332 \ln(Q^{rbs})_{-1} - 371\, DUM_{80\,2} - 389\, DUM_{89\,2}$$
(2 47) (2 76) (3 20) (-3 95) (-4 14)

$R^2 = 64$, $DW = 1\,88$

Wholesale fluid supply

$$\ln Q^{wfs} = 283 + 157 \ln(P^{wf}/(P^{II}+d)) - 014 \ln(P^{fc}/(P^{II}+d)) - 001 \ln TREND$$
(2 13) (4 29) (-1 40) (- 31)

$$+ 038\, COS1 + 003\, COS2 + 580 \ln(Q^{wfs})_{-1} + 201 \ln(Q^{wfs})_{-4}$$
(7 28) (2 28) (6 17) (1 97)

$R^2 = 96$, $DW = 2\,35$

Wholesale frozen supply

$$\ln Q^{wfzs} = 278 + 053 \ln(P^{wfz}/P^{II}) - 060\, SIN1 - 158\, COS1 - 024\, COS2$$
(2 90) (72) (-2 84) (-5 18) (-4 31)

$$+ 291 \ln(Q^{wfzs})_{-1} + 267 \ln(Q^{wfzs})_{-4} + 032 \ln TREND$$
(2 30) (1 46) (2 99)

continued

Table 1—Econometric results for the dairy industry model—continued

R^2 = 97, DW = 2 23

Wholesale cheese supply

$$\ln Q^{wcs} = \underset{(49)}{362} + \underset{(36)}{126} \ln (P^{wc}/P^{II}) + \underset{(4\ 68)}{042} \text{ SIN1} - \underset{(-5\ 21)}{037} \text{ COS1} + \underset{(5\ 59)}{030} \text{ COS2} + \underset{(7\ 71)}{661} \ln (Q^{wcs})_{-1}$$

$$+ \underset{(3\ 85)}{313} \ln (Q^{wcs})_{-4} - \underset{(-1\ 78)}{026} \text{ DTP} - \underset{(-3\ 72)}{060} \text{ MDP}$$

R^2 = 95, DW = 1 41

Wholesale butter supply

$$\ln Q^{wbs} = \underset{(3\ 11)}{1\ 211} + \underset{(1\ 65)}{207} \ln (P^{wb}/P^{II}) + \underset{(15\ 19)}{222} \text{ SIN1} + \underset{(1\ 39)}{037} \text{ COS1} + \underset{(4\ 23)}{509} \ln (Q^{wbs})_{-1}$$

$$+ \underset{(3\ 42)}{004} \text{ TREND} - \underset{(-1\ 96)}{075} \text{ DTP} - \underset{(-1\ 471)}{052} \text{ MDP}$$

R^2 = 86, DW = 1 99

Cow numbers

$$\ln COW = \underset{(2\ 64)}{244} + \underset{(13\ 73)}{1\ 600} \ln COW_{-1} - \underset{(-4\ 91)}{929} \ln COW_{-2} + \underset{(3\ 08)}{306} \ln COW_{-3} + \underset{(1\ 81)}{012} \ln (P^{fm}/P^{feed})_{-1}$$

$$- \underset{(-1\ 27)}{004} \ln (P^{COW}/P^{fr}) - \underset{(-4\ 33)}{009} \text{ DTP}$$

R^2 = 99, DW = 1 91

Production per cow

$$\ln PPC = \underset{(5\ 80)}{4\ 652} + \underset{(4\ 01)}{412} \ln PPC_{-1} + \underset{(1\ 34)}{031} \ln (P^{fm}/P^{feed}) + \underset{(5\ 68)}{003} \text{ FTREND} + \underset{(2\ 80)}{019} \text{ SIN1}$$

$$- \underset{(-20\ 23)}{062} \text{ COS1} + \underset{(4\ 97)}{011} \text{ COS2} - \underset{(-2\ 34)}{020} \text{ MDP}$$

R^2 = 98, DW = 1 77

Table 2—Variable definitions for the econometric model

Endogenous variables

Q^{rfd} = retail fluid demand measured in bil lbs of milkfat equivalent,

P^{rf} = consumer retail price index for fresh milk and cream (1982-84 = 100),

Q^{rfzd} = retail frozen dairy product demand measured in bil lbs of milkfat equivalent,

P^{rfz} = consumer retail price index for frozen dairy products (1982-84 = 100),

Q^{rcd} = retail cheese demand measured in bil lbs of milkfat equivalent,

P^{rc} = consumer retail price index for cheese (1982-84 = 100),

Table 2—Variable definitions for the econometric model—continued

Q^{rbd} = retail butter demand measured in bil lbs of milkfat equivalent,

P^{rb} = consumer retail price index for butter (1982-84 = 100),

Q^{rfs} = retail fluid supply measured in bil lbs of milkfat equivalent, ($Q^{rfs} = Q^{rfd}$),

P^{wf} = wholesale fluid price index (1982 = 100),

Q^{rfzs} = retail frozen dairy product supply measured in bil lbs of milkfat equivalent, ($Q^{rfzs} = Q^{rfzd}$),

P^{wfz} = wholesale frozen dairy products price index (1982 = 100),

Q^{rcs} = retail cheese supply measured in bil lbs of milkfat equivalent, ($Q^{rcs} = Q^{rcd}$),

Table 2—Variable definitions for the econometric model—continued

P^{wc} = wholesale cheese price measured in cents/lb ,
Q^{rbs} = retail butter supply measured in bil lbs of milkfat equivalent ($Q^{rbs} = Q^{rbd}$),
P^{wb} = wholesale butter price measured in cents/lb ,
Q^{wfs} = wholesale fluid supply measured in bil lbs of milkfat equivalent, ($Q^{wfs} = Q^{rfs} = Q^{rfd}$),
P^{II} = Class II price for raw milk measured in dollars/cwt ,
Q^{wfzs} = wholesale frozen dairy product supply measured in bil lbs of milkfat equivalent, ($Q^{wfzs} = Q^{rfzs} = Q^{rfzd}$),
Q^{wcs} = wholesale cheese supply measured in bil lbs of milkfat equivalent, ($Q^{wcs} = Q^{rcs} = Q^{rcd}$),
COW = U S cow numbers measured in thousands,
P^{fm} = U S average all milk price measured in dollars/cwt
PPC = U S average milk production-per-cow measured in lbs ,

Exogenous variables and other definitions

POP = U S population measured in millions,
P^{bev} = consumer retail price index for nonalcoholic beverages (1982-84 = 100),
INC = disposable personal income per capita, measured in thousand dollars,
CPI = consumer price index for all items (1982-84 = 100),
TREND = time trend variable for the retail and wholesale-level equations, equal to 1 for 1975, quarter 1, ,
SIN1 = harmonic seasonal variable representing the first wave of the sine function,
COS1 = harmonic seasonal variable representing the first wave of the cosine function
DGFAD = generic fluid advertising expenditures deflated by the media price index, measured in thousand dollars,
P^{foo} = consumer retail price index for food (1982-84 = 100),
DBFZAD = brand frozen product advertising expenditures deflated by the media price index, measured in thousand dollars,
L = lag operator,
U^{rfzd} = error term for retail frozen demand,
P^{mea} = consumer retail price index for meat (1982-84 = 100)
$DUM_{82\,2}$ = intercept dummy variable equal to 1 for 1982, quarter 2 equal to 0 otherwise
$DUM_{83\,1}$ = intercept dummy variable equal to 1 for 1983, quarter 1, equal to 0 otherwise,
DGCAD = generic cheese advertising expenditures deflated by the media price index, measured in thousand dollars
DBCAD = brand cheese advertising expenditures deflated by the media price index, measured in thousand dollars
u^{rcd} = error term for retail cheese demand,
COS2 = harmonic seasonal variable representing the second wave of the cosine function,

Table 2—Variable definitions for the econometric model—continued

$DUM_{80\,2}$ = intercept dummy variable equal to 1 for 1980 quarter 2, equal to 0 otherwise,
$DUM_{89\,2}$ = intercept dummy variable equal to 1 for 1989 quarter 2, equal to 0 otherwise,
DGBAD = generic butter advertising expenditures deflated by the media price index measured in thousand dollars
DBBAD = brand butter advertising expenditures deflated by the media price index, measured in thousand dollars
P^{fe} = producer price index for fuel and energy (1967 = 100)
U^{rfzs} = error term for retail frozen supply,
P^{lab} = average hourly wage in food manufacturing sector (dollars/hour),
d = Class I fixed price differential for raw milk measured in dollars/cwt
DTP = intercept dummy variable for the Dairy Termination Program equal to 1 for 1986, quarter 2 through 1987, quarter 3 equal to 0 otherwise,
MDP = intercept dummy variable for the Milk Diversion Program equal to 1 for 1984, quarter 1 through 1985, quarter 2, equal to 0 otherwise,
Q^{wbs} = wholesale butter supply measured in bil lbs of milkfat equivalent, ($Q^{wbs} = Q^{rbs} = Q^{rbd}$)
P^{feed} = U S average price per ton of 16 percent protein dairy feed,
P^{fr} = U S index of prices received by farmers,
P^{cow} = U S average slaughter cow price measured in dollars/cwt ,
FTREND = time trend variable for the farm-level equations, equal to 1 for 1970, quarter 1 ,

Retail market demand functions are estimated on a per capita basis Retail demand for each product is specified to be a function of the retail product price, the price of substitutes, per capita disposable income deflated by the Consumer Price Index, seasonal harmonic variables to account for seasonal demand, a time trend variable to capture changes in consumer tastes and preferences over time, and generic and brand advertising expenditures In all demand functions except butter, own-prices are deflated by the price of substitute products For the butter demand function, the own-price is deflated by per capita income since the substitute price approach yields inferior statistical results Based on the autocorrelation and partial autocorrelation functions, a first-order autoregressive error structure is imposed for the retail frozen demand function

The generic and brand advertising variables are specified two ways for each equation, with the form that resulted in the best statistical fit being used The first approach specifies advertising expenditures as a second-order polynomial distributed lag with both endpoint restrictions imposed The second method simply uses current advertising expenditures as the explanatory variable For the retail fluid demand function, generic advertising is specified as a second-order polynomial distributed lag with both endpoint restrictions imposed, while brand advertising is omitted because the estimated coefficient is negative and insignificant In the retail frozen products demand function, a second-order polynomial distributed lag model with both endpoint restrictions imposed is used for brand advertising Generic advertising expenditures for frozen products are omitted because they are negative and not statistically significant In the retail cheese demand function, a second-order polynomial distributed lag model with both endpoint restrictions imposed is used for both generic and brand advertising Two intercept dummy variables to capture outliers for quarter 2 of 1982 and quarter 1 of 1983, are also included in the retail cheese demand function Retail cheese demand for these two quarters was well out of the range of all other observations Current generic and brand advertising expenditures in the retail butter demand equation yield a better statistical fit than the model with lag structures In addition, two intercept dummy variables are included in the retail butter demand function to account for two outliers, quarter 2 of 1980 and quarter 2 of 1989

Based on the estimation, brand cheese and generic fluid advertising have the largest coefficients of all advertising[6] The sum of the current and lagged coefficients for brand cheese advertising is 0 05, while the sum of the current and lagged coefficients on generic fluid advertising is 0 035 Frozen product advertising coefficients sum to 0 02 Both generic cheese and brand butter advertising are statistically insignificant, and generic butter advertising has a relatively small sum of 0 0016

The retail supply for each product is estimated as a function of the retail price the wholesale price, which represents the major variable cost to retailers, the producer price index for fuel and energy, the average hourly wage in the food manufacturing sector, a time trend variable, seasonal harmonic variables, and lagged retail supply The producer price index for fuel and energy is a proxy for variable energy costs while the average hourly wage captures labor costs in the retail supply functions The seasonal harmonic variables capture seasonality in retail supply, while the lagged supply variables represent capacity constraints The time trend variable is a proxy for technological change in retailing Not all of these variables remain in each of the final estimated retail supply equations In addition, intercept dummy variables appear in the cheese and butter retail supply equations to account for outliers in these two markets Finally, a first-order moving average error structure is imposed on the retail frozen product supply equation

The wholesale supply for each product is estimated as a function of the wholesale price, the appropriate Class price for milk (Class II or Class I = Class II + d) which represents the main variable cost to wholesalers, the producer price index for fuel and energy, a time trend variable, seasonal harmonic variables, and lagged wholesale supply The producer price index for fuel and energy is included because energy costs are important variable costs to wholesalers, and the seasonal harmonic variables capture seasonality in wholesale supply Lagged wholesale supply reflects capacity constraints, and the trend variable is a measure of technological change in dairy product processing

For the farm milk market, the cow number equation is estimated as a function of the number of cows in previous periods a one-period lagged ratio of the farm milk price to the price of 16 percent protein feed, the ratio of the price of slaughter cows to the index of prices received by farmers, and an intercept dummy variable to account for the quarters when the 1986-87 Dairy Termination Program was in effect Lagged cow numbers are included as biological capacity constraints to current cow numbers, while the feed price represents one of the most important variable costs in milk production The price of slaughter cows deflated by the index of prices received is included because it represents an opportunity cost of retaining cows

The production-per-cow equation is estimated as a function of production per cow in the previous period, the ratio of the farm milk price to the price of 16-percent protein feed, a time trend variable, seasonal harmonic variables to account for seasonality in production per cow, and an intercept dummy variable to account for the quarters when the 1984-85 Milk Division Program was in effect Lagged production per cow is included as a capacity constraint, the feed price is included because it represents one of the most important variable costs, and the time trend is included to capture genetic improvements over time Note that the milk-feed price ratio is not lagged in the production-per-cow equation because some changes in production per cow can be made instantaneously, while changes in cow numbers cannot

[6]These coefficients are partial advertising elasticities from the structural retail demand equations They are not the total elasticities from the reduced-form price equations

In terms of statistical fit, most of the estimated equations are reasonable with respect to R^2, and all signs are as expected In all but two equations, the adjusted coefficient of determination is above 0 77, and all but three are above 0 86 The two equations that are the most difficult to estimate are the retail butter demand and supply equations The retail butter demand equation has the lowest R^2 (0 55), and the retail butter supply equation has an R^2 of 0 64 On the whole, the equations are deemed reasonable for the simulation model

Validation of the Simulation Model

To validate the model, a dynamic in-sample simulation is performed from the third quarter of 1984 (1984 3) through the fourth quarter of 1990 (1990 4), the period in which the NDPRB has been in operation Results should be judged in terms of how close the predicted endogenous variables are to their historic values The dynamic simulation is conducted as follows First, all exogenous variables are set equal to their historic levels for the simulation period Second, all lagged dependent variables and the predetermined farm milk supply for the first simulation period (1983 4) are set equal to their actual levels for the previous period (1983 2) and the retail-wholesale system of equations (product-specific versions of equations 1 1-4 2, as well as 5 5) is solved simultaneously using the Newton method Third, predicted values for wholesale quantities and the Class II price are substituted into the farm milk price equation (equation 5 4) to obtain the farm price Fourth, the current-period predicted farm milk price is substituted into the cow number and production-per-cow equations to obtain the farm milk supply for the subsequent period Finally, the predicted endogenous variables become the lagged endogenous variables for the subsequent period, and the predetermined farm milk supply becomes the milk supply for the second period of the simulation This process is repeated until the last period of the simulation (1990 4) is reached

To measure how close each predicted endogenous variable is to its historic level, the root-mean-square-percent-simulation error (RMSPSE) measure is computed, which is equal to the following formula

$$RMSPSE = \{(1/N) \sum_{t=1}^{N} ((YS_t - YA_t)/YA_t))^2\}^{1/2},$$

where YS_t is the simulated value of endogenous variable Y, YA_t is the actual historic value for endogenous variable Y, and N is the number of periods in the simulation

Table 3 shows the RMSPSE for all endogenous variables in the model Generally, the RMSPSE's

Table 3—Quarterly average of the historic and predicted endogenous variables from the dynamic simulation and root-mean-square-percent-simulation error (RMSPSE)

Endogenous variable	Unit	Historic average	Simulation average	RMSPE
				Percent
Q^{rf}	bil lbs	13 41	13 43	0 9
Q^{rfz}	bil lbs	3 31	3 26	3 0
Q^{rcd}	bil lbs	9 43	9 56	4 7
Q^{wcs}	bil lbs	9 92	9 77	4 2
Q^{rbd}	bil lbs	4 93	3 40	30 9
Q^{wbs}	bil lbs	6 57	6 75	7 1
P^{rf}	1982-84 = 100	108 6	107 1	15 1
P^{rfz}	1982-84 = 100	117 5	122 4	6 8
P^{rc}	1982-84 = 100	111 1	105 2	8 4
P^{rb}	1982-84 = 100	101 8	84 5	17 2
P^{wf}	1982 = 100	108 5	106 8	16 3
P^{wfz}	1982 = 100	112 0	104 1	14 2
P^{wc}	$/lb	1 30	1 21	11 2
P^{wb}	$/lb	33	1 31	3 5
P^{II}	$/cwt	11 67	11 61	22 9
Q^{fs}	bil lbs	35 84	38 40	9 1
P^{fm}	$/cwt	12 85	12 61	21 2
CCC	bil lbs	2 15	3 57	201 7
COW	1,000 head	10472	11361	10 4
PPC	number	3428	3377	2 9

for the supply and demand quantities are quite reasonable. With the exception of retail butter demand, all retail, wholesale, and farm supply and demand quantities have RMSPSE's under 10 percent. However, retail butter demand has an RMSPSE of 30.9 percent. Recall that the retail butter market equation had the poorest statistical fit of all equations in the model. Consequently, it is not surprising that retail butter demand has a high RMSPSE. With respect to prices, the RMSPSE's tend to be higher, ranging from 3.5 percent for the wholesale butter price to 24.5 percent for the Class II price. Several outliers in the dynamic simulation cause these relatively high RMSPSE's. Except for these outliers, the simulated prices track the actual prices better than the RMSPSE's indicate. Finally, the high RMSPSE for CCC purchases is due to the small magnitude of this variable, that is, a small deviation from the actual value leads to a large RMSPSE.

Analysis of Advertising Scenarios

To evaluate the impacts of the generic dairy promotion program on the retail, wholesale, and farm markets, the historic simulation is compared with a pre-NDPRB scenario. In the historical simulation scenario, generic advertising levels are set equal to their real (inflation-adjusted) values for 1984.3 through 1990.4.[7] In the pre-NDPRB scenario, generic advertising levels are set equal to their real values in the year preceding the enactment of the national program. That is, quarterly generic fluid, cheese and butter advertising expenditures for the entire simulation period are held constant at their quarterly real levels in the third and fourth quarters of 1983 and the first and second quarters of 1984. A comparison of the two scenarios indicates the NDPRB's impact on dairy markets. Generic frozen product advertising is not included in the retail frozen product demand function. Consequently, generic advertising expenditure levels for frozen products are not included in the advertising scenarios.

Figures 2-4 present generic advertising expenditure levels for the two scenarios for fluid, cheese, and butter. Historic generic fluid advertising expenditures tend to be about twice as large as those in the pre-NDPRB scenario (fig. 2), especially from 1986 on. In the early periods of the simulation, generic cheese advertising expenditures are higher for the historic than the pre-NDPRB scenario (fig. 3). However, from mid-1987 through 1990, generic cheese advertising expenditure levels are similar between scenarios. On the other hand, generic butter advertising is vastly different between the two scenarios (fig. 4). There was no generic advertising for butter prior to 1984.3. Consequently, generic butter advertising is set equal to zero for the pre-NDPRB scenario, while the historic scenario generally has positive levels of generic butter expenditures throughout the simulation period.[8]

Results of the two simulations show that the doubling of generic fluid advertising due to the national program results in a 2-percent increase in fluid demand. The increase in fluid demand causes the retail fluid price to increase by 6 percent. The increase in fluid demand also causes the wholesale fluid price to increase by 5 percent (table 4).

Frozen product demand, which does not contain generic frozen product advertising as a demand shifter, declines slightly (0.31 percent) with the national program since total milk demand increases by 1 percent under the national program, causing farm and wholesale-level prices for all products to rise. The average increase in the wholesale frozen price is 1 percent which results in the retail frozen price rising an average of 0.4 percent.

The modest increase in cheese demand (0.1 percent) under the national program is due to several factors. First, generic cheese advertising expenditures are only slightly higher under the national program. Second, the elasticity of demand with respect to generic advertising is very low. Finally, there is a slight average increase in the retail cheese price of 0.1 percent. Wholesale cheese supply decreases by 2.05 percent under the national program due to the Class II price increase of 2.33 percent. The Class II price is the most important wholesale cheese supply shifter. The leftward shift in wholesale cheese supply, however, is not enough to cause the wholesale cheese price to increase because even after the shift, the Government still purchases excess cheese supply. Hence, the wholesale cheese price is the same as the purchase price for cheese in both advertising scenarios. The national program results in an average decrease of 0.21 billion pounds (per quarter) of cheese purchased by the Government due to a slight increase in commercial cheese

[7] All advertising expenditures (generic and brand) come from various issues of Leading National Advertisers. Due to their survey procedures, these expenditures are regarded as being lower than actual expenditures. However, alternative data sources for brand and generic advertising expenditures are not available. As is pointed out by Maddala (1977, pp. 292-94), this creates an error in variable problem that may bias the estimated advertising coefficients downward (as opposed to upward bias, as one might intuitively expect). Consequently some care should be exercised in interpreting these coefficients.

[8] Actually, generic butter advertising expenditures were set to one dollar rather than zero since this is a double logarithm model.

Figure 2

Generic fluid milk advertising expenditures, historic and pre-NDPRB scenarios

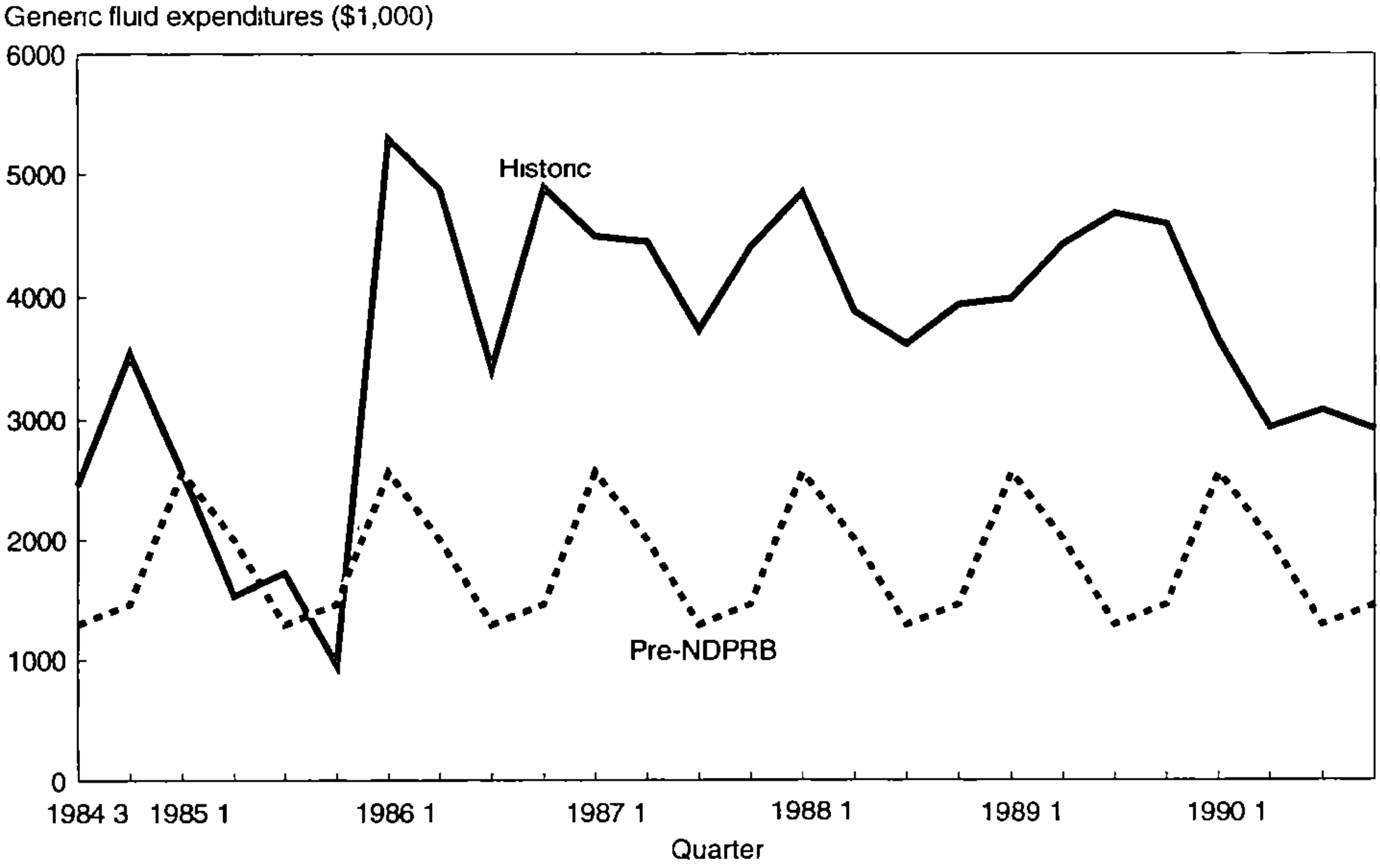


Figure 3

Generic cheese advertising expenditures, historic and pre-NDPRB scenarios

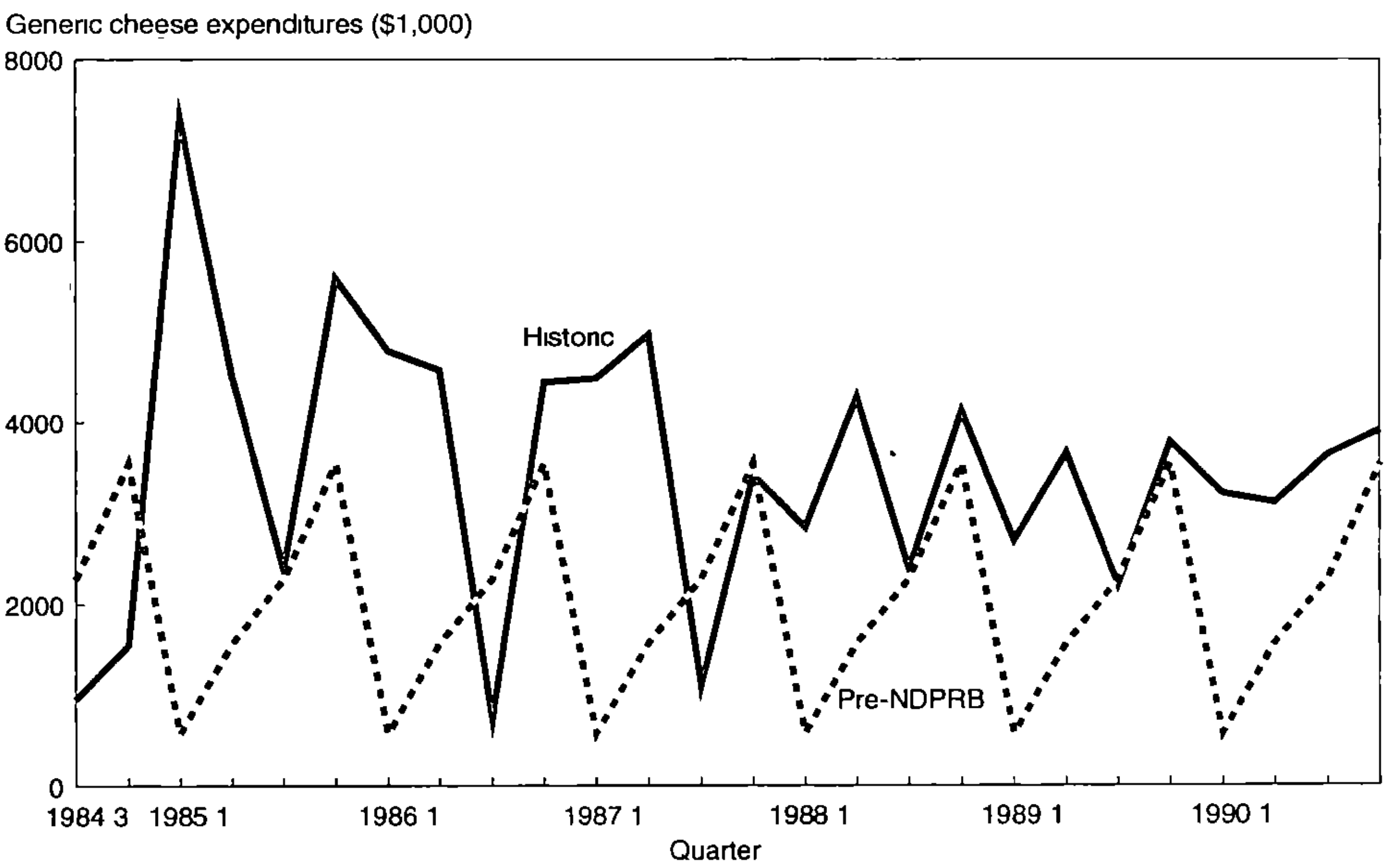


Figure 4
Generic butter advertising expenditures, historic and pre-NDPRB scenarios

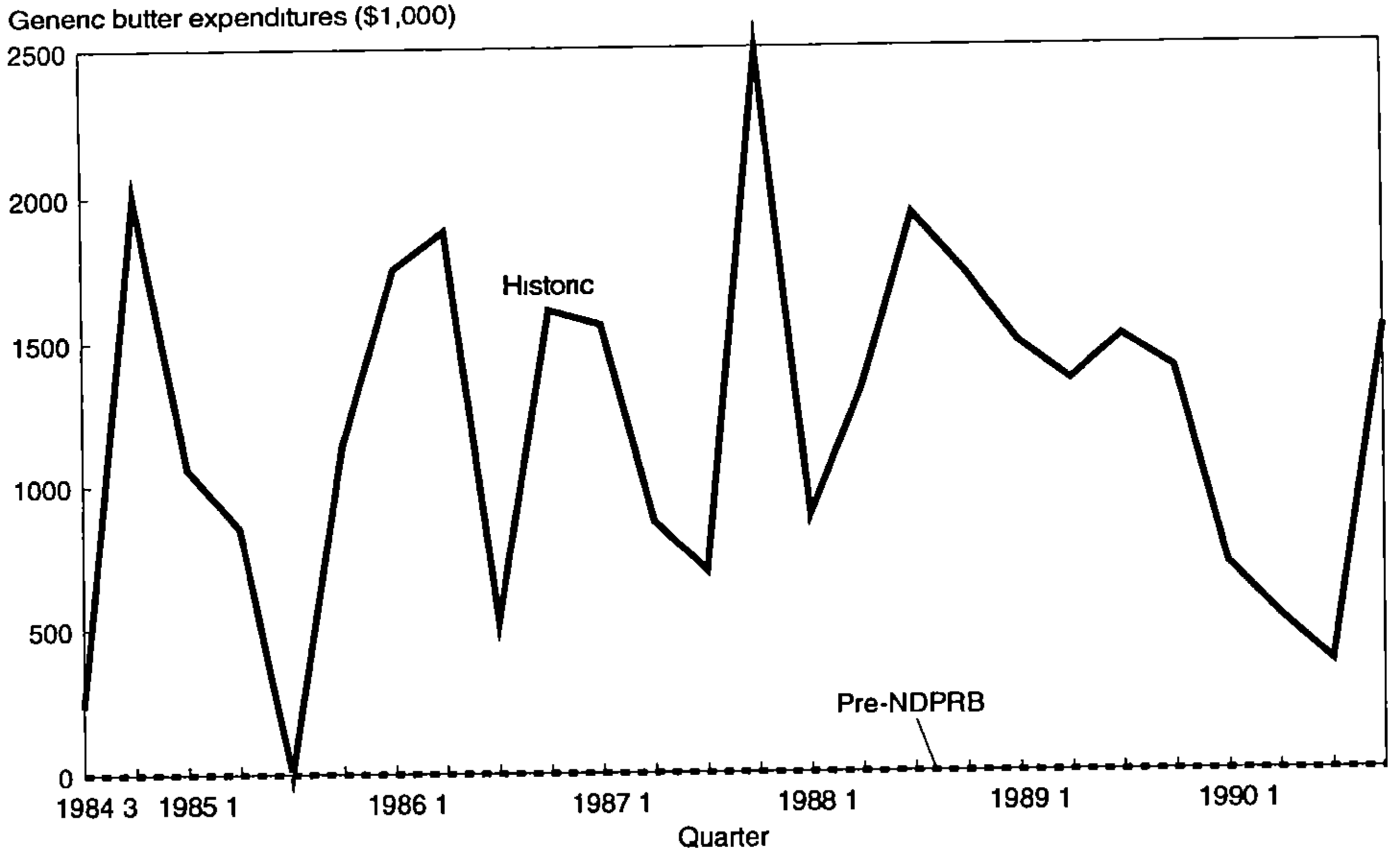


Table 4—Quarterly average of endogenous variables for the two advertising scenarios, 1984.3-1990.4

Endogenous variable	Unit	Historic simulation average	Pre-NDPRB simulation average	Percent change
				Percent
Q^{rf}	bil lbs	13 43	13 16	2 00
Q^{rfz}	bil lbs	3 26	3 27	0 31
Q^{rcd}	bil lbs	9 56	9 55	0 10
Q^{wcs}	bil lbs	9 77	9 97	-2 05
Q^{rbd}	bil lbs	3 40	3 37	0 90
Q^{wbs}	bil lbs	6 75	6 81	-0 89
P^{rf}	1982-84 = 100	107 1	100 6	6 07
P^{rfz}	1982-84 = 100	122 4	121 9	0 41
P^{rc}	1982-84 = 100	105 2	105 1	0 10
P^{rb}	1982-84 = 100	84 5	84 0	0 60
P^{wf}	1982 = 100	106 8	101 5	4 96
P^{wfz}	1982 = 100	104 1	103 1	0 96
P^{wc}	$/lb	1 21	1 21	0 00
P^{wb}	$/lb	1 31	1 31	0 00
P^{II}	$/cwt	11 61	11 34	2 33
Q^{fs}	bil lbs	38 40	38 19	0 55
P^{fm}	$/cwt	12 61	12 33	2 22
Q^{gc}	bil lbs	0 23	0 44	-91 3
Q^{gb}	bil lbs	3 34	3 44	-2 99
CCC	bil lbs	3 57	3 88	-8 70
COW	1,000 head	11361	11315	0 40
PPC	number	3377	3373	0 12

demand and the 2 05-percent decrease in wholesale supply of cheese

Butter demand increases by 0 9 percent under the national program due to higher generic butter advertising expenditures (generic butter advertising was zero prior to the national program) The increased demand causes an increase of 0 6 percent in the retail butter price There is no rise in the wholesale butter price, which is equal to the government purchase price under both advertising scenarios While butter demand increases, wholesale butter supply actually decreases by 0 9 percent under the national program As for cheese, the decrease in wholesale butter supply is the result of the Class II price increasing by 2 33 percent The modest increase in butter demand and decrease in wholesale butter supply cause butter purchases by the Government to fall by 0 1 billion pounds (per quarter) under the national program

The introduction of the NDPRB also has an impact on the farm market The Class II and farm milk prices increase by 2 33 percent and 2 22 percent under the national program due to an increase of 1 percent in milk demand Farm supply in turn, rises by about 0 45 percent in cow numbers and 0 1 percent increase in production per cow

Conclusions

Econometric results indicate that the national generic dairy promotion program has affected the retail, wholesale, and farm markets for dairy products At the retail level, the demand for fluid milk and butter increased modestly due to this program The demand for cheese also increased due to the national program, but the increase was marginal On the other hand, the demand for frozen products decreased slightly due to price increases that outweighed advertising effects The overall effect of the program was to increase total demand for milk by 1 percent All retail and wholesale prices were higher due to the national program The national program also was effective in raising both farm prices and farm milk supply The program resulted in a farm milk price that was 2 22 percent higher than in the absence of the national program Hence, it appears that the program has been an effective means to both raise farm prices and modestly increase the demand for milk and dairy products, as well as to reduce cheese and butter purchases by the Government

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