# An Econometric Analysis of the Impact of Changes in the EC's Milk Quota

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# AN ECONOMETRIC ANALYSIS OF THE IMPACT OF CHANGES IN THE EC'S MILK QUOTA

## 1. Introduction

Worried by rapidly increasing milk and beef policy costs, but constrained by political considerations, the European Community (EC) Council of Agriculture ministers introduced a milk quota regime effective in April 1984. The extent to which a quota regime reduces economic efficiency and influences world trade depends upon how it is implemented. The method of implementation is also a major determinant of the policy's effect on world trade. Regulations favorable to production in grass-based dairy regions will, other things being equal, reduce world cereal demand. Regulations favorable to butterfat production may distort world, animal, and vegetable fat markets.

The official quota regime review of March 1992 left the regulations essentially unaltered. However, as the duration of the regime lengthens, the costs of reduced structural mobility increase. Economic and political pressures to liberalize production right transferability have become more potent. Most EC countries now permit at least limited intranational quota exchange. The United Kingdom has sought to reduce impediments to intra-EC quota flow. The Danish State Institute for Agricultural Economics has proposed a national quota exchange and suggested the importation of quota. The proposals met with wide approval in Danish agribusiness circles. With the advent of the borderless EC milk marketplace under the EC 1992, and the continued growth in the disparity among member states in terms of the difference between the prices received and the prices that would justify existing production levels, tensions will be placed on the existing rules prohibiting cross border quota transferability.

In 1990, the EC was approximately 115 percent self-sufficient in milk products. It exported 471,000 metric tons (MT)[1] of milkfat and 890,000 MT of nonfat solids. The EC is also a major player in world beef and grain markets. Altered quota transferability regulations may significantly impact all of these markets, but in a manner that can only be determined empirically.

The primary objective of the paper is to assess how cross-border quota transferability would influence EC production and consumption of milkfat, nonfat solids, beef, and feed grains. In addition, the paper presents estimates of supply equations for beef, pork, and milk that are consistently estimated across the enlarged EC. The paper also offers a straightforward procedure for estimating supply response under output restrictions and shows how one can predict output supply response to policy shocks under quota regimes. The objective of this report is to provide insight on the magnitude and directions of these implications.

A Johansen-style elasticity model was developed. The more critical elasticities have been estimated, others were borrowed from the existing literature. The data used for estimation are mainly from the SPEL data set (SPEL) compiled by the EC. Transportation costs were inferred using EUROSTAT data as reported in *Agra Europe 1991 Dairy Review*. Analysis is conducted by shocking the model with certain key exogenous variables.

The paper has three major sections. In section two, a review of the milk production environment in the EC is provided. EC milk policy is reviewed further with emphasis on the quota regulations. Also, previous related studies are reviewed. The third section explains how the model was built and provides the supply response estimates. Finally, the quota transferability simulation results of policy changes are presented and discussed.

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[1] All statistics in this paragraph are from *Agra Europe 1991 Dairy Review*.

# 2. Review

## 2.1. The EC Milk Market

To provide a picture of milk production in the EC prior to the quota regime, statistics are presented in Tables 2.1 and 2.2. The calendar year 1983 was the last year before the regime's introduction. Spain and Portugal did not become member countries until January 1, 1986.

Though not highly concentrated regionally, milk production is centered in Northern Europe. With decreasing transportation and transaction costs, greater concentration may occur if permitted. Herd size tends to be smaller in the south than the north. Compared with other northern countries, West Germany's average herd size is small. The United Kingdom has by far the largest average herd size. The countries where milk production is most important as a percentage of total agricultural output are Ireland, the Netherlands, Denmark, and West Germany. Of this group, Ireland is by far the most dependent on agriculture. West Germany, France, and Italy combined hold approximately three-fourths of all dairy farms. When quotas were introduced, milk prices were highest in Italy and lowest in Ireland, the EC countries least and most self-sufficient in milk products, respectively.

## 2.2. Policy Review

A major goal of the CAP is the maintenance of agricultural income, primarily through the use of price support. Several instruments are used to support internal EC prices. Dairy product imports are subject to variable levies intended to prevent prices in EC markets from falling substantially below official minimum import prices. In June 1991, for example, the EC minimum import price for butter was 3284.3 ECU/metric ton and a levy of 2344.4 ECU/metric ton was payable. Dairy product exports are generally eligible for export subsidies to make them competitive on international markets. In June 1991, exported butter was eligible for a refund of 1650 ECU/metric ton. Internally, prices are supported through EC purchase for storage (intervention), aid for private storage (APS),

Table 2.1. The nature of milk production in EC Member States, 1983

| | BEL/LUX | DEN | WG | GRE | FRA | IRE | ITA | NETH | UK | EC10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total production, 1000T | 4161 | 5427 | 26935 | 1958 | 29175 | 5637 | 11408 | 13240 | 17727 | 115168 |
| Nation dairy herd, '000HD | 995 | 988 | 5735 | 237 | 7195 | 1535 | 3068 | 2521 | 3429 | 25775 |
| Number of herds, '000 | 49.500 | 33.720 | 412.590 | 76.450 | 428.270 | 86.240 | 426.111 | 62.71 | 60.05 | 1641.72 |
| Share of EC ag output | 0.033 | 0.039 | 0.180 | 0.048 | 0.253 | 0.023 | 0.213 | 0.086 | 0.126 | 1.00 |
| Share of EC milk output | 0.031 | 0.050 | 0.245 | 0.022 | 0.221 | 0.040 | 0.126 | 0.122 | 0.143 | 1.00 |
| MCA adjusted price* | 22.69 | 28.25 | 25.60 | 24.80 | 24.92 | 21.25 | 33.19 | 26.48 | 23.42 | — |

*Price of milk with 3.7% butterfat.

Table 2.2. The nature of milk production in EC Member States, 1990

| | BEL/LUX | DEN | WG | GRE | SPA | FRA | IRE | ITA | NETH | PORT | UK | EC12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total quota | 2983 | 4524 | 21834* | 537 | 4551 | 23865 | 5286 | 8488 | 11121 | 1779 | 14405 | 99373 |
| Ag as percentage total employment[1] | 2.8 | 6.0 | 3.7 | 25 | 13.0 | 6.4 | 15.1 | 9.3 | 4.7 | 18.9 | 2.2 | 7.0 |
| Nation dairy herd, '000HD[2] | 904 | 769 | 6342* | 242 | 1750 | 5276 | 1387 | 2924 | 1917 | 396 | 2889 | 24796 |
| Average fat content, percentage[3] | 6.85 | 4.43 | 4.10 | 3.54 | 3.49 | 3.94 | 3.54 | 3.59 | 4.37 | 3.40 | 4.00 | 3.97 |
| Average protein content, percentage[3] | 3.39 | 3.37 | 3.32 | 3.38 | 3.06 | 3.10 | 3.23 | 2.98 | 3.44 | 3.06 | 3.27 | 3.23 |

* United Germany.

[1] 1989 figures.

[2] December 1990 estimate.

[3] 1990 estimate.

consumption subsidies, and supply control. Intervention is a costly support instrument. Its use has been curtailed in recent years especially for low-quality produce where markets are difficult to find. Due to their costliness, consumption subsidies have also fallen out of favor. APS solves the problem of eventual retail sales, but disposals depress future price levels. Supply control has become the dominant price support instrument.

The quota regime introduced in 1984 set national base quotas at the 1981 milk year (April 1981-March 1982) total plus 1 percent. The base quota was phased in over two years. Also, to help particularly affected regions (southern Ireland, northern Ireland, and Luxembourg), a quota reserve of 393,000 tons was distributed. Upon EC entry in 1986, Spain was granted a generous quota. Portugal need not vigorously apply the quota regime until 1995. Portugal has expanded production dramatically (c 6.4 percent/annum since 1986) but it still accounts for less than 1.5 percent of total EC milk production. Because of statistical and implementation problems, Italy did not comply with the regime during the years up to 1992. The area formerly known as East Germany became subject to the regime in March 1991. It was allocated a quota of 20 percent below its 1989 production level.

Since the regime's inception, the EC has operated several programs to reduce the amount of outstanding quota. These have involved the termination through purchase of quota rights, mandatory uncompensated quota reductions, and mandatory compensated quota reductions. These quota level changes were not prorated across countries. The poorer and more agriculturally-dependent countries were granted concessions, so their shares of production rights have risen over time. The EC was also obliged to create production rights because it was found to have unlawfully denied production rights to farmers who had engaged in a temporary milk nonmarketing scheme in the late 1970s and early 1980s.

The EC has also engaged in quota redistribution schemes. Production rights purchased by national governments were given to farmers in impoverished areas and to farmers with relatively small quota allocations.

During the middle and late 1980s, the global demand for milk fat was weak. To control budget expenditures, CAP legislation effective from October 1, 1986 was passed so that the quota related to butterfat production, not milk volume. Compared with the 1985/86 production year, for every 1 g extra butterfat per kg of milk a farmer produces, the raw milk quota allocated to the farmer falls by 1.8 percent.

Rules concerning transferability vary considerably between countries. In all countries, production rights are transferred with the sale, lease, or inheritance of an entire farm. This is also true when concerning a piece of land, though to varying degrees countries seek to ensure that the level of quota associated with the land is commensurate. Leasing of quota independent of land is permitted in some countries. Outright sale of unattached quota is forbidden in all countries.

### 2.3. Literature Review

The economics of the EC dairy policy has attracted considerable attention since its initiation. The *European Review of Agricultural Economics* devoted an issue to this subject in 1985. The EC has made a major report public on this topic (*Eurostat*, 1989). Munk (1985) modeled the implications for agricultural income of changes in national quota allocation. Burrell (1989) considered the microeconomic motives for quota transfer. Langer (1989), Amies (1989), Burton (1989), and DeBoer and Krijger (1989) considered quota transfers within countries. Murphy (1989, 1990) sought to understand the direction in which freely-traded quota would flow in the EC. The questions of magnitude and degree of benefits from free intra-EC quota trade have not been addressed.

## 3. The Model

The Johansen modeling approach was used. That is, the percent change in output was expressed as a linear equation in output elasticities with respect to output and input prices. Two outputs are considered: milk and beef. So

$$\begin{aligned} &Q_j^i = \sum_{k=1}^{n} P_j^i \,(e_{j,k}^i) \ , \ i = M \ , \ B \\ &\text{where } i = \text{output} \\ &\qquad\quad\, j = \text{country} \\ &\qquad\quad\, k = \text{output or input price.} \end{aligned} \tag{3.1}$$

Q represents percent change in quantity. P represents percent change in price. The e symbolizes elasticity. Output i is M for milk and B for beef. Eleven countries are considered. Belgium and Luxembourg are aggregated. No data was available to model a united Germany. Country j is BL for Belgium and Luxembourg, DE for Denmark, FR for France, GR for Greece, IR for Ireland, IT for Italy, NE for the Netherlands, PO for Portugal, SP for Spain, UK for the United Kingdom, and WG for West Germany. The index k can be M (milk), B (beef), F (feed), or T (time). The time variable is not a percentage change but a level change with the year as unit.

The elasticities are inferred from an econometric country-wide disaggregated EC livestock model. Beef, milk, pig meat, poultry meat, and sheep meat are included.

The annual model consists of behavioral equations, identities, and biological restrictions. Supply only is considered. Dynamic adjustment cannot, therefore, be captured in poultry production. A reduced form specification is used. It is proposed that

$$\text{Poulprod}_t = f(\text{Poulpr, Feedpr, Poulprod}_{t-1}, \text{X}) \tag{3.2}$$

where $\text{Poulprod}_t$ = tons wholesale level poultry meat produced at t

Poulpr = nominal weighted average feed price per ton

X = a country specific vector of other factors

t = time

Sheepmeat production, being a very small component of the EC meat production sector, is specified as reduced form also. It is proposed that

$$\text{Muttprod}_t = f(\text{Muttpr, Feedpr, Muttprod}_{t-1}\text{, Shewepre, X}) \quad (3.3)$$

where Muttprod$_t$ = tons wholesale level sheepmeat produced at t

Muttpr = nominal weighted average NC price in NC/ton of feed

Shewepre = ewe premium subsidy in price subsidy equivalent NC/ton.

Pig meat and beef production are modeled structurally. The pig meat component is described next. Quantity response to pork price and other supply determinants emerges first in breeding herd alterations. If price rises, then piglets will be retained as gilts rather than sold for slaughter. Sows that might otherwise have been culled will be retained also. Because of the time involved in gestation and fattening, there is a lag in the production response. The short-run quantity effect of a rise in the expected future pork price is expected to be negative.

Sowherd is modeled as:

$$\text{Sowsherd}_t = f(\text{Sowsherd}_{t-1}\text{, Sowsherd}_{t-2}\text{, Porkpr, Feedpr, X}) \quad (3.4)$$

where Porkpr = nominal weighted average EC-12 price in NC/ton. This specification is founded upon the assumptions of partial stock adjustment and adaptive price expectations. The approach is outlined in Maddala (1988) and applied to livestock modeling in Wahl (1989). Denote optimum sowherd level at time t as Sowsherd*$_t$. A partial adjustment specification is

$$\text{Sowsherd}_t - \text{Sowsherd}_{t-1} = \gamma(\text{Sowsherd*}_t - \text{Sowsherd}_{t-1}) \quad (3.5)$$

where $0 < \gamma < 2$. The size of the gap that must be closed decreases geometrically. It will never disappear. Partial adjustment is a means of modeling for constraints. Sows cannot be manufactured instantaneously. Biological and resource constraints will give rise to a time lag. The above geometric specification is not theoretically superior to other specifications. However, it is simple and has been used widely in the modeling of agriculture for many years. There is much empirical evidence to suggest that it is appropriate (Nerlove, 1958).

The production lag poses another problem. The producer is motivated by future profit which is uncertain. Decisions must be made on expectations. Risk neutrality is assumed. Expected profitability is subjective. An assumption on the nature of the expectation forming process is necessary. Let $\Pi$ indicate profit. Adaptive expectation postulates that

$$E_t\left(\Pi_{t+1}\right) - E_{t-1}\left(\Pi_t\right) = \Theta\left[\Pi_t - E_{t-1}\left(\Pi_t\right)\right] \tag{3.6}$$

where $0 < \Theta < 1$. Expected future profit equals profit that had been expected for the present period plus a positive fraction of the deviation of actual present profit from expected present profit. Sufficient data is not available to calculate beef sector profitability. Price is used as a best alternative. Let

$$\text{Sowsherd}^*_t = f(E_t(\text{Porkpr}_{t+1}), X_t) = \alpha_0 + \alpha_1 E_t(\text{Porkpr}_{t+1}) + \alpha_2 Z_t \tag{3.7}$$

where Z is a representative exogenous variable. Manipulate (3), (4), and (5) to get

$$\text{Sowsherd}_t = B_0 + B_1 \text{Porkpr}_t + B_2 \text{Sowsherd}_{t-1} + B_3 \text{Sowsherd}_{t-2} + B_4 X_t \tag{3.8}$$

The coefficient of (3.6) is functions of $\gamma$, $\Theta$, $\alpha_0$, $\alpha_1$, *and* $\alpha_2$. Live piglet births, Pigsborn, is estimated from

$$\text{Pigsborn}_t = \text{Pig1pig1}_t \bullet \text{Sowsherd}_{t-1} \tag{3.9}$$

where Pig1pig1 = live piglets born per sow per year. The stock of pigs not yet fit for slaughter, Porkherd, is a function of pigsborn and is endogenous. Other factors may also influence Porkherd. For example, a high pork price may reduce mortality.

$$\text{Porkherd}_t = f\,(\text{Pigsborn}_t, \text{Pigsborn}_{t-1}, X) \tag{3.10}$$

Now given that pig imports and exports are known, pig slaughtering in a year must follow from the identity.

$$\begin{aligned}\text{TPigslg}_t = {} & \text{Sowsherd}_{t-1} - \text{Sowsherd}_t + \text{Porkherd}_{t-1} - \text{Porkherd}_t \\ & + \text{Pigsborn}_t + \text{Pigsimp}_t - \text{Pigsexp}_t\end{aligned} \tag{3.11}$$

where Pigsimp and Pigsexp are live pigs imported and exported. Finally, from known per animal meat yields, Porkpork, pork production is calculated

$$\text{Porkprod}_t = \text{Porkpork}_t \bullet \text{TPigslgt}_t \tag{3.12}$$

Beef production is arrived at in a similar manner. Beef is a principal product, and also a joint product in the milk production process. First consider beef production from beef cows. By analogy to the pork production process.

$$\text{Beefherd}_t = \lambda_0 + \lambda_1 \, Beefpr + \lambda_2 \, Beefherd_{t-1} + \lambda_3 \, Beefherd_{t-2} + \lambda_4 Z_t \qquad (3.13)$$

$$\text{Beefborn}_t = \text{Beefcalv}_t \bullet \text{Beefherd}_{t-1} \qquad (3.14)$$

$$\text{CattherdB}_t = \text{F} \, (\text{Beefborn}_t, \text{Beefborn}_{t-1}, \text{X}) \qquad (3.15)$$

$$\text{TcatslgtB}_t = \text{Beefherd}_{t-1} - \text{Beefherd}_t + \text{CattherdB}_{t-1} - \text{CattherdB}_t$$

$$+ \text{Beefborn}_t + \text{Cattimp}_t - \text{Cattexp}_t \qquad (3.16)$$

$$\text{BeefprodB}_t = \text{Beefbeef}_t \bullet \text{TcatslgtB}_t \qquad (3.17)$$

where

Beefherd = number of beef cows

Beefpr = nominal weighted average NC price in NC/ton

Beefborn = number of live calvings from the beef herd

Beefcalv = live calves born per beef cow per year

CattherdB = animals from beef cows not yet fit for slaughter

Cattimp, Cattexp = live cattle imports and exports

Beefbeef = meat yield per slaughtered CattherdB animal

TcatslgtB = cattle from beef herd slaughtered per year

BeefprodB = beef production in wholesale level tons

A problem arises in modeling output level from the dairy herd. Prior to the imposition of milk quotas, milk output had been endogenous. Now, given a binding quota, it is exogenous. Dairy herd size, and so beef output from the dairy herd, were determined by different processes after quota imposition. Before 1984, the estimated procedure was

$$\text{Milkvol}_t = \delta_0 + \delta_1 \, milkvol_{t-1} + \delta_2 \, milkvol_{t-1} + \delta_3 \, milkpr_t + \delta_4 Beefpr \qquad (3.18)$$

$$\text{Milkherd}_t = (\text{milkvol}_t \,/\, \text{milkmilk}_t) \tag{3.19}$$

$$\text{Milkborn}_t = \text{Milkcalv}_t \bullet \text{milkherd}_{t-1} \tag{3.20}$$

$$\text{CattherdM}_t = f\,(\text{milkborn}_t, \text{milkborn}_{t-1}, \text{milkborn}_{t-2}, X) \tag{3.21}$$

$$\text{TCatslgtM}_t = \text{milkherd}_{t-1} - \text{milkherd}_t + \text{cattherdM}_{t-1} - \text{CattherdM}_t + \text{milkborn}_2 \tag{3.23}$$

$$\text{Milkmilk}_t = f(X) \tag{3.23}$$

$$\text{BeefprodM}_t = \text{Milkbeef}_t \bullet \text{TcatslgtM}_t \tag{3.24}$$

where

Milkvol = volume of milk produced

Milkpr = nominal weighted average EC-12 price in ECU/ton

Milkherd = number of milk cows

Milkmilk = yield per cow

Milkborn = number of live calvings from the milkherd

Milkcalv = live calves born per milk cow per year

CattherdM = animals from milk cows not yet fit for slaughter

TcatslgtM = cattle from milk herd slaughtered per year

Milkbeef = meat yield per slaughtered CattherdM animal

BeefprodM = beef production in wholesale level tons.

Three pairs of equations in the dairy and beef modules must be aggregated.

$$\text{TCatslgt}_t = \text{TcatslgtB}_t + \text{TcatslgtM}_t \tag{3.25}$$

$$\text{Cattherd}_t = \text{CattherdM}_t + \text{CattherdB}_t \tag{3.26}$$

$$\text{Beefprod}_t = \text{BeefprodB}_t + \text{BeefprodM}_t \tag{3.27}$$

This last aggregation is permissible because Milkbeef is approximately equal to Beefbeef.

After 1984, milk volume should approximately equal quota. Replace equations in the dairy module with

$$\text{Milkvol} = \text{Quota}$$

$$\text{Milkyield} = f(X,D)$$

where Quota = restricted milk output level

D = variables to account for the imposition of quota.

For each country, this model was then shocked four times. It was shocked for 1 percent changes in milk, beef, and feed prices. It was also shocked for a time change of one year. Long-run elasticities were constructed from the long-term responses. While none of the elasticities were of incorrect sign, some were thought to be too extreme. Because the economic and political forces, the geography, and the climate in these countries are more similar than dissimilar, error in the estimation of elasticities is assumed to be reduced by taking an unweighted mean across countries of each elasticity, adding it to the original elasticity estimate, and halving.

$${}_ie'_{j,k} = \frac{1}{2}\left[\ {}_ie'_{j,k} + \left(\sum_f \ {}_ie'_{f,k}/12\right)\right] \tag{3.28}$$

where the prime denotes the modified elasticity. Both the unmodified and modified elasticity sets are presented in Tables 3.1 and 3.2. The aggregate EC-wide beef and milk responses are modeled by two equations of the form

$$iQ_{EC} = \sum_j \ {}_iQ_j \ ({}_iR_j) \ / \ (\sum_j \ {}_iR_j) \tag{3.29}$$

Table 3.1. Milk own- and cross-price elasticities by country

| Country | Elasticity Status | Milk | Beef | Feed | Time |
|---|---|---|---|---|---|
| BL | unmodified | 0.023 | 0.0 | -0.023 | 0.0 |
| | modified | 0.3925 | 0.0 | -0.2725 | 1.02 |
| DE | unmodified | 0.61 | 0.0 | -0.4285 | 0.0 |
| | modified | 0.686 | 0.0 | -0.4285 | 1.02 |
| FR | unmodified | 1.706 | 0.0 | -0.967 | 0.0 |
| | modified | 1.234 | 0.0 | -0.7455 | 1.02 |
| GR | unmodified | 0.644 | 0.0 | -0.644 | 0.0 |
| | modified | 0.703 | 0.0 | -0.584 | 1.02 |
| IR | unmodified | 0.474 | 0.0 | -0.241 | 7.3 |
| | modified | 0.618 | 0.0 | -0.383 | 4.67 |
| IT | unmodified | 1.01 | 0.0 | -0.0602 | 0.0 |
| | modified | 0.886 | 0.0 | -0.293 | 1.02 |
| NE | unmodified | 0.278 | 0.0 | -0.499 | 0.0 |
| | modified | 0.52 | 0.0 | -0.5115 | 1.02 |
| PO | unmodified | 0.0 | 0.0 | -0.258 | 8.50 |
| | modified | 0.381 | 0.0 | -0.394 | 5.27 |
| SP | unmodified | 0.944 | 0.0 | -0.046 | 6.7 |
| | modified | 0.853 | 0.0 | -0.285 | 4.37 |
| UK | unmodified | 1.00 | 0.0 | -1.00 | -0.006 |
| | modified | 0.881 | 0.0 | -0.762 | 1.017 |
| WG | unmodified | 1.69 | 0.0 | -1.67 | 0.0 |
| | modified | 1.18 | 0.0 | -1.18 | 1.02 |

where: i = milk or beef; j = country; $iQ_j$ = percent change in production of i in country j; and $_iR_j$ = base level of production of i in country $_j$ as reported in *Agra Europe 1991 Dairy Review*. Their data was obtained from Eurostat, the EC statistics collection agency.

The aggregate effects on butterfat and protein were modeled in a manner similar to equation (3.3). The butterfat equation is

$$BFPERC = \left[ \sum_j (MQ_j)\,(MR_j)\,(BFR_j) \,/\, \left[(MR_j)\,(BFR_j)\right] \right] \tag{3.30}$$

Table 3.2. Beef own- and cross-price elasticities by country

| Country | Elasticity Status | Milk | Beef | Feed | Time |
|---|---|---|---|---|---|
| BL | unmodified | 0.024 | 0.01 | -0.034 | 1.02 |
| | modified | 0.1825 | 0.1955 | -0.3195 | 0.535 |
| DE | unmodified | 0.795 | 0.045 | -0.499 | 0.0 |
| | modified | 0.568 | 0.213 | -0.552 | 0.025 |
| FR | unmodified | 0.068 | 3.485 | -2.058 | 0.0 |
| | modified | 0.2045 | 1.933 | -1.3315 | 0.025 |
| GR | unmodified | 0.0 | 0.086 | -0.086 | -3.4 |
| | modified | 0.1705 | 0.2335 | -0.3455 | 1.725 |
| IR | unmodified | 0.327 | 0.148 | -0.496 | 0.749 |
| | modified | 0.334 | 0.2645 | -0.55 | 0.4 |
| IT | unmodified | 0.0 | 0.165 | -0.140 | 0.0 |
| | modified | 0.1705 | 0.273 | -0.3725 | 0.025 |
| NE | unmodified | 0.412 | 0.0 | -0.742 | 0.0 |
| | modified | 0.3765 | 0.1905 | -0.6735 | 0.025 |
| PO | unmodified | 0.0 | 0.0 | -0.034 | 2.19 |
| | modified | 0.1705 | 0.1905 | -0.3195 | 1.12 |
| SP | unmodified | -0.15 | 0.144 | -0.176 | 0.0 |
| | modified | 0.0955 | 0.2625 | -0.3905 | 0.025 |
| UK | unmodified | 1.09 | 0.112 | -1.202 | -0.006 |
| | modified | 0.7155 | 0.2465 | -0.9035 | 0.038 |
| WG | unmodified | 1.182 | 0.001 | -1.183 | 0.0 |
| | modified | 0.7615 | 0.191 | -0.894 | 0.025 |

where BFPERC = percentage change in EC butterfat production; $MR_j$ = base milk production level in country $_j$; $BFR_j$ = base butterfat percentage in country $_j$ as reported in the *Agra Europe 1991 Dairy Review*.

The percent change in the price of feed, $\Delta$FP, is assumed to be a linear function of the percent change in the EC prices of wheat (WH), barley (BA), corn (C), and oats (O). $\Delta$FP is assumed to be invariant across countries. If feed price changes by 5 percent in one country, then it is assumed to change by 5 percent in all 11 countries.

$$FP = 0.159\ WHP + 0.108BPA + 0.008CP + 0.021CP \tag{3.31}$$

The price-price elasticities were inferred from estimations made by Peeters (1990).

To arrive at the effect of policy changes on wheat, barley, corn, and oats demand, the elasticities in Table 3.3 are used for the EC as a whole. These elasticities apply to all uses, not just to livestock feed use. They are partly estimated, partly assumed, and they are reported in Thomson (1985).

Table 3.3. Cross elasticities of EC total grain demands with respect to beef and milk prices

| Price/Quantity | Wheat | Barley | Corn | Oats |
|---|---|---|---|---|
| Milk | 0.235 | 0.585 | 0.585 | 0.596 |
| Beef | 0.165 | 0.406 | 0.406 | 0.414 |

The existence of the milk quota policy creates a wedge between the actual milk price and the price which would justify existing levels of product. This latter price is called the shadow price. To compute the implications of policy changes, the shadow price concept must be used. The percent change in shadow price is

$$MP_j = 100\left((SP_{j,1} - SP_{j,0})/\ SP_{j,0}\right) \tag{3.32}$$

where $SP_{j,1}$ = shadow price in $_j$ before an event; $SP_{j,0}$ = shadow price in $_j$ after an event.

The divergence between actual and shadow milk prices exists when the maximum production level is specified and binding. In this study, it is assumed that for any output or input, prices change by a uniform percentage across all countries. Thus, when aggregating grain demand across the EC, no share weighting is necessary for the beef and grain elasticities. For milk, because of the shadow price problem, weighting is necessary. The aggregate grain demand equations are of the form

$$iD = e_{im} \left[ \sum_j MP_j \left(MS_j\right) / \left(\sum_j MS_j\right)\right] + \sum_k e_{ik} \left(iP\right) \tag{3.33}$$

where iD = percentage change in EC demand for cereal i; $l_{ik}$ = elasticity of $_k$ with respect to $_j$; where $_j$ = M, B, WH, BA, C, 0.

$MS_j$ = demand for $_i$ in country $_j$

iP = percent change in price of $_i$.

If quota cannot move between EC countries, then each country is block separable and the shadow price of each country can be solved using the equations relating to that country in the set of equations (3.1) together with

$$iQ_j = k \tag{3.34}$$

where k is a constant, i is milk, and $_j$ is the country in question. The solved percentage price change together with the base price gives the base shadow price under quota. While the base year for the quota is 1983/84, for the purposes of this study, a newer base more relevant to the present situation must be established. The milk production year, April 1990 to March 1991, was chosen. Percentage beef and cereal price changes are calculated. Percent milk production level changes are also calculated. Then the eleven block separable models discussed previously are solved. The new base shadow prices are computed. These are in the form

$$DP_j = MP_{r83/84} \left(1 + MP_j\right) \tag{3.36}$$

where $DP_j$ = base shadow milk price in 1990/91; $MP_{r83/84}$ = real milk price in 1983/84; $MP_j$ = percentage change in 1990/91 shadow price from actual 1983/84 milk price.

Each simulation has distinctive constraint conditions. The new shadow price associated with each simulation is endogenous. It is labeled $P_j$ where $_j$ indexes the country. Thus, the percent change in shadow price from 1990/91 base is

$$MP_j = 100\ (P_j - DP_j)\ /\ DP_j \tag{3.37}$$

The per unit volume quota value may also be established. If free across-the-border quota trading is permitted, then quota values will be identical in all countries. Compared with the cost of transferring milk titles, transfer costs are small. The competitive quota price will be the price received for milk, less the marginal cost of milk production, less the marginal cost of transportation, less other less tangible marginal costs.

$$QV_j = RP_j - P_j - TC_j \tag{3.38}$$

where $QV_j$ = quota value in country $_j$; $RP_j$ = received milk price in country $_j$; $P_j$ = shadow price in country $_j$ = marginal cost of production; $TC_j$ = sum of other sundry marginal costs associated with country $_j$.

Neither $RP_j$ nor $TC_j$ have yet been completely specified. To calculate $RP_j$, one can avail oneself of a key CAP policy variable; the intervention milk price equivalent. Liquid milk may be decomposed into butter and skim milk. The EC sets intervention prices for both. In each case, the actual intervention buying-in or tender price is somewhat less (usually 0 - 15 percent less). From the buying-in price, subtract a margin for marketing and processing. This gives raw materials values for butter and skim milk. Adding these two values gives the raw materials value for liquid milk. In June 1991, the raw material value for liquid milk with 3.7 percent butterfat and average protein content was 23.63 ECU/kg of which 10.76 ECU was from butter and 12.87 ECU was from skim milk. Thus, at that time, the approximate value of milk of any nutrient profile was

$$RP_j = 10.76 \frac{(BFR_j)}{3.7} + 12.87 \frac{(PROTR_j)}{3.23} \tag{3.39}$$

where $RP_j$ = received milk price in country $_j$; $BFR_j$ = percent of butterfat in milk of country $_j$; $PROTR_j$ = percent of protein in milk of country $_j$.

The 1990/91 year EC average protein content of milk was 3.23 percent. To estimate $TC_j$, 1983/84 data is used. In that year, the problem of shadow prices did not exist. Hedonic price regressions were conducted. Milk prices were regressed on protein and fat percentages. There were 11 observations, one for each country. While butterfat percentage data was available for 1983, protein percentage data could not be found. Instead, 1985 protein percentage data was used. For Spain and Portugal, 1986 protein percentage data was used.

The regression residuals were assumed to be the $TC_j$ in 1983. They are presented in Table 3.4. Note that Ireland has the highest and Italy the lowest residuals or sundry costs. This is consistent with these countries being respectively the EC's most and least dairy self-sufficient countries. Since 1983, transportation has improved and other barriers to trade (red tape, etc.) have probably fallen. To account for this, the residuals were multiplied by two-thirds.

Another interesting piece of information is the profit implication of a regulation change for each country. When quota trade is permitted,

Table 3.4. Inferred marginal sundry costs of milk marketing in 1983

| | BL | DE | FR | GR | IR | IT | NE | PO | SP | UK | WG |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ECU/ 100kg | +3.37 | -2.16 | +1.1 | +1.27 | +4.49 | -7.73 | -1.91 | -1.20 | +3.52 | +1.38 | -2.13 |

$$DPI_j = \left[ RP_j - TC_j - QV_j - \int_{Q_o}^{Q_1} MC_j(Q)dQ \right] Q_o \left[ \frac{MQ_i}{100} \right] \tag{3.40}$$

where $DPI_j$ = change in profit for country $_j$; $Q_o$ = initial production level; $Q_1$ = final production level; and $MC_j(Q)$ = marginal cost function in country $_j$. The integration is discreetly approximated.

## 4. Simulations

### 4.1. Establishing the Base

The model was solved using GINO (LINDO 1990). The base year 1990/91 shadow prices were solved. Table 4.1 gives the percent difference between the 1990/91 milk quota allocation and 1983/84 milk production. It also gives the percent change in real price necessary in the open market to account for this volume change. The data for Greece and Portugal were of poor quality. To a large extent, these countries were exempt from the quota regime during the 1980s. Their farmers may have been seeking a high production base. For both countries, simulations suggest that real shadow price has risen over the seven-year period. These results were considered unrealistic, and were ignored. Their 1990/91 shadow price was assumed to be the actual 1983/84 price. The milk quota in Italy was higher than 1983/84 production. The EC and Italy are presently reassessing Italy's dairy production data reporting procedures. Italy's quota allocation may be reduced without compensation.

Table 4.1. Estimated 1990/91 shadow price of milk

| | BL | DE | FR | GR | IR | IT | NE | PO | SP | UK | WG |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1983/84 - 90/91 | | | | | | | | | | | |
| Percent change in production | -6.1 | -13.4 | -8.5 | +19.1 | -1.0 | +3.5 | -13.9 | +82.5 | +6.1 | -14.2 | -13.3 |
| Percent change in beef price | -50.6 | -46.5 | -45.4 | -43.9 | -44.7 | -42.3 | -46.8 | -20.1 | -36.1 | -40.6 | -47.4 |
| Percent change in wheat price | -36.8 | -36.9 | -28.2 | -31.9 | -32.1 | -31.2 | -34.9 | -8.5 | -23.6 | -39.7 | -36.6 |
| Percent change in barley price | -36.5 | -36.4 | -29.3 | -31.0 | -36.9 | -30.9 | -36.7 | +9.1 | -28.2 | -35.6 | -40.3 |
| Percent change in corn price | -28.9 | -29.9 | -24.7 | -35.5 | -29.9 | -30.9 | -29.9 | -25.2 | -31.8 | -29.9 | -37.5 |
| Percent change in oats price | -31.3 | -35.9 | -16.1 | -36.7 | -28.6 | -20.3 | -36.7 | -9.4 | -25.3 | -32.2 | -34.7 |
| Percent change in shadow price in ECU/100kg | -41.2 | -36.8 | -17.6 | +9.1 | -60.7 | -7.03 | -50.8 | +118.9 | -31.3 | -33.8 | -26.8 |
| 1990/91 shadow milk price | 13.3 | 18.1 | 19.6 | 24.95 | 8.35 | 30.5 | 13.85 | 30.4 | 14.5 | 16.1 | 20.6 |
| Estimated quota value in ECU/100kg | 9.4 | 11.9 | 4.4 | 4.75 | 13.55 | 3.4 | 10.95 | 0.0 | 10.3 | 7.2 | 5.5 |
| Estimated 1990 price in ECU/100kg | 22.7 | 30.0 | 24.0 | 29.7 | 21.9 | 33.9 | 24.8 | 30.2 | 24.8 | 23.3 | 26.1 |

Murphy (1990) conducted two alternative measurements of 1987 EC milk production competitivity. In Table 4.2, the rankings she compiled are compared to the rankings arrived at in this study. It can be seen that the two studies are broadly in line. France, West Germany, Belgium, and the United Kingdom were consistently ranked close to the bottom. Denmark, the Netherlands, and Ireland were consistently ranked close to the top.

### 4.2. Quota Transferability

In this simulation, as in all other simulations considered below, beef and grain prices are kept constant while time is also static. Apart from the sundry costs estimated earlier, there are no impediments to quota flow. Two different concepts of quota are considered; the volume quota and the BF quota. Results are presented in Tables 4.3 and 4.4. From Table 4.3, it can be seen that transferability under a volume quota slightly increases both solid constituents of the representative EC liter of milk. Quota tends to flow toward producers of more solid dense milk. Beef production also

Table 4.2. Ranking of milk production competitiveness in EC

| Present Study | | Present Study Omitting Countries | Murphy 1 | Murphy 2 |
|---|---|---|---|---|
| BE | 5 | 4 | 6 | 7 |
| DE | 2 | 2 | 2 | 1 |
| FR | 9 | 7 | 7 | 6 |
| GR | 8 | - | - | - |
| IR | 1 | 1 | 3 | 3 |
| IT | 10 | - | - | - |
| NE | 3 | 3 | 1 | 2 |
| PO | 11 | - | - | - |
| SP | 4 | - | - | - |
| UK | 6 | 5 | 3 | 4 |
| WG | 7 | 6 | 4 | 5 |

Table 4.3. Aggregate results of transferability under volume and BF quotas

| | Volume Quota | BF Quota |
|---|---|---|
| Percent change in milk volume | - | -0.4 |
| Percent change in butterfat | +0.4 | - |
| Percent change in beef production | +2.3 | +2.1 |
| Percent change in wheat demand | -0.3 | -0.4 |
| Percent change in barley demand | -0.1 | -9.2 |
| Percent change in corn demand | -9.0 | -9.2 |
| Percent change in oats demand | -2.5 | -2.7 |
| Percent change in protein | +0.6 | +0.2 |

rises slightly. Demand for grains falls. As can be seen in Table 4.4, milk quota will migrate north where grass rather than grain tends to be the principal feed source. Corn, with a small initial share of feed consumption, falls most in percentage terms. This is because it is a feed used mainly in Southern Europe. The results for the butterfat quota are similar. Milk volume falls slightly because quota tends to flow toward butterfat dense producers. Table 4.4 shows that Ireland and the Netherlands expanded their base by the largest fraction.

The next step is to estimate the quantity of production in each country that would equate quota values. This was achieved by use of an 11-country, four-commodity nonspatial model. The model was set up as a series of equalities that equated both the price dependent version of the demand and supply curves presented earlier and a series of equations that equated quota values across countries. The model then solved for the set of production quantities that created equilibrium in the quota market. Individual country results are presented in Table 4.4 for both the volume and butterfat quotas. Ireland, Denmark, and the Netherlands would greatly increase milk production, while Italy, France, and Greece would sell quota. Welfare of all producers would increase with producers in the Netherlands, Italy, Ireland, and France benefiting most.

Table 4.4. Intra-EC results of transferability under volume and butterfat quotas

| Butterfat Quota | BL | DE | FR | GR | IR | IT | NE | PO | SP | UK | WG |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Percent change in milk production | +8.5 | +12.9 | -17.8 | -23.4 | +40.9 | -27.1 | +28.3 | -17.3 | -4.7 | +7.4 | -2.0 |
| Shadow price ECU/100kg | 16.2 | 21.5 | 16.8 | 16.6 | 13.9 | 21.2 | 21.4 | 16.6 | 13.7 | 17.5 | 20.3 |
| Change in farm profit (m ECU) volume quota | +4 | +10 | +60 | +5 | +60 | +108 | +119 | +21 | +1 | +7 | +1 |
| Percent change in milk production | +8.8 | +13.2 | -17.3 | -23.2 | +41.6 | -26.9 | +28.6 | -17.2 | -4.3 | +7.8 | -1.5 |
| Shadow price ECU/100kg | 16.2 | 21.5 | 16.9 | 16.7 | 14.0 | 21.3 | 21.5 | 16.7 | 13.8 | 17.5 | 20.4 |
| Change in farm profit (m ECU) | +4 | +10 | +57 | +5 | +62 | +106 | +121 | +21 | +1 | +8 | 0 |

Table 4.5 shows the aggregate results for both the milk volume and butterfat quotas. In both cases, EC beef production would increase moderately and grain consumption would be reduced by almost 10 percent. This is true because most corn is used in Southern Europe.

Table 4.5. Aggregate results of a 10 percent quota cut and transferability under volume and butterfat quotas

| | No Transferability | Volume Quota | Butterfat Quota |
|---|---|---|---|
| Percent change in milk volume | -10.0 | -10.0 | -10.4 |
| Percent change in butterfat | -10.0 | -9.6 | -10.0 |
| Percent change in beef production | -4.5 | -2.4 | -2.5 |
| Percent change in wheat demand | -2.5 | -2.7 | -2.8 |
| Percent change in barley demand | -6.6 | -6.5 | -6.9 |
| Percent change in corn demand | -7.2 | -14.4 | -14.7 |
| Percent change in oats demand | -6.1 | -8.5 | -8.8 |
| Percent change in protein | -10.0 | -9.4 | -9.8 |

The Netherlands is heavily populated and its agriculture is intensive. Because of environmental considerations, this quota transfer may not be permitted. Denmark, Belgium, and the United Kingdom also increased production. Italy, France, Greece, and Portugal lost significant fractions of their production base. Due to milk composition and transportation and marketing costs, shadow prices do not converge completely. Having solids dense milk, Denmark and the Netherlands can justify high marginal costs. Though Italian milk is the least solid dense in the EC, its dairy product deficit and the cost of transport justifies high marginal costs. Change in farm profit is estimated using change in quota allocation, change in costs, and the rental received or paid on quota flow. Thus, this change in profit is permanent and occurs every year. Italy, the Netherlands, Ireland, and France stand to profit, mostly because they are the furthest from equilibrium at the moment. The other countries will gain only marginally. Under a butterfat quota EC farm profit rises by 396 m ECU, while under a volume quota it rises by 395 m ECU. Consumer price is not assumed to change, so consumer welfare does not change. EC budget implications are worse for a volume quota because butterfat and protein production rise by 0.4 percent and 0.6 percent, respectively, compared with 0 percent and 0.2 percent under the butterfat quota. Further, milk volume production falls by 0.4 percent under a butterfat quota and the rise in beef production is not as big.

### 4.3. Production Cuts Under Transferability and Nontransferability

A 10 percent production cut is considered. Three situations are modeled: a 10 percent cut for each country, a cut of milk volume quota with flows permitted, and a cut of butterfat quota with flows permitted. In the latter two scenarios, the aggregate EC quota reduction and the relaxation of quota sales restrictions will interact. The results are given in Tables 4.5 and 4.6.

It can be seen that nontransferability is more effective in reducing dairy butterfat and protein production. Beef production also falls most sharply under nontransferability, while grain demand is least affected. After a 10 percent uncompensated quota cut in each country, farm profitability must fall in all countries. Only Portugal, Greece, and Italy are not significantly affected. The Netherlands, West Germany, United Kingdom, and France stand to lose over 100 m ECU/annum. When quota flow is allowed, it is possible that individual countries gain. That is, the benefits from transfers outweigh the quota cut loss. This occurs in Italy, Greece, and Portugal where quota is not binding.

### 4.4. Transferability and an Increase in EC Dairy Prices

Four simulations were run: each of the two quota concepts and increased butterfat prices as well as each of the two quota concepts and increased protein prices. The results are given in Table 4.7. The control results are given in Table 4.3. They suggest that although there are nontrivial differences

Table 4.6. Intra-EC results of a 10 percent quota cut and transferability under volume and butterfat quotas

| | BL | DE | FR | GR | IR | IT | NE | PO | SP | UK | WG |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No Transferability | | | | | | | | | | | |
| Percent change in milk production | -10 | -10 | -10 | -10 | -10 | -10 | -10 | -10 | -10 | -10 | -10 |
| Shadow price ECU/100kg | 9.9 | 15.4 | 18.0 | 21.4 | 7.0 | 27.1 | 11.2 | 22.4 | 12.8 | 14.3 | 18.9 |
| Change in farm profit (m ECU) | -32 | -50 | -101 | 0 | -66 | 0 | -169 | 0 | -29 | -123 | -148 |
| Volume Quota + Transferability | | | | | | | | | | | |
| Percent change in milk production | +3.1 | +6.0 | -29.3 | -28.6 | +27.4 | -32.4 | +21.5 | -19.6 | -15.5 | -2.6 | -12.9 |
| Shadow price ECU/100kg | 14.3 | 19.6 | 15.0 | 14.8 | 12.1 | 19.4 | 19.6 | 14.8 | 11.9 | 15.6 | 18.5 |
| Change in farm profit (m ECU) | -24 | -35 | -31 | +3 | -16 | +74 | -22 | +13 | -28 | -116 | -147 |
| Butterfat Quota + Transferability | | | | | | | | | | | |
| Percent change in milk production | +2.9 | +5.6 | -29.8 | -28.8 | +26.8 | -32.7 | +21.1 | -19.7 | -16.0 | -3.1 | -13.4 |
| Shadow price ECU/100kg | 14.3 | 19.5 | 14.9 | 14.7 | 12.0 | 19.3 | 19.5 | 14.7 | 11.8 | 15.5 | 18.4 |
| Change in farm profit (m ECU) | -24 | -35 | -27 | +3 | -18 | +86 | -25 | +12.9 | -27 | -118 | -146 |

in milk composition across countries under a quota regime, aggregate milk composition is not sensitive to the price ratio of the constituents.

Table 4.7. Aggregate results of dairy price changes when quota is transferable

| | Volume Quota and 10% Rise in Butterfat Prices | Volume Quota and 10% Rise in Skim Milk Powder Prices | Butterfat Quota and 10% Rise in Butterfat Prices | Butterfat Quota and 10% Rise in Skim Milk Powder Prices |
|---|---|---|---|---|
| Percent change in milk volume | 0.0 | 0.0 | -0.5 | -0.4 |
| Percent change in butterfat | +0.5 | +0.4 | 0.0 | – |
| Percent change in beef production | +2.3 | +2.3 | +2.1 | +2.1 |
| Percent change in wheat demand | -0.3 | -0.3 | -0.4 | -0.4 |
| Percent change in barley demand | -0.2 | -0.2 | -0.5 | -0.4 |
| Percent change in oats demand | -2.5 | -2.5 | -2.8 | -2.8 |
| Percent change in protein | +0.6 | +0.6 | +0.2 | +0.2 |

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