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# **Time Series Analysis of a Policy-Created Asset: The Case of the California Dairy Quota**

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**TIME SERIES ANALYSIS**  
**OF A POLICY-CREATED ASSET:**  
**THE CASE OF THE CALIFORNIA DAIRY QUOTA**

March 1997

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Abstract

A model of California milk quota is fitted for monthly observations with state space techniques. The multivariate model uses quota milk price, overbase price, and the value of the quota asset to characterize the dairy farm portfolio. The model performed well, with small errors and no residual autocorrelation.

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### Abstract

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## **Time Series Analysis of a Policy-Created Asset: The Case of California Dairy Quota**

Capitalization of policy-created assets is a prevalent issue in economics. Agriculture and natural resources have provided several examples of capitalization affected by policy in land values, pollution permits, and tradeable quotas. Although economics has recognized this feature in many governmental policies, empirical analysis of capitalization is often left out of policy debates. Understanding how assets are affected by policy can shed light on the distribution of rents to those receiving the benefits. In this way, a fuller understanding of the rents received by the beneficiaries can be made (Barichello).

Recognizing the importance of asset capitalization, this paper will analyze the California milk marketing quota via time series analysis. The value of quota is estimated and fitted with a state space time series models. The multivariate models of features underlying the dairy farm portfolio are presented.

The time series analysis in this paper makes this work unique. Heretofore, asset evaluation has centered around discovering the rates of return and discount rates of the asset. Moschini and Meilke found the rate of return for milk quotas in Ontario. Barichello used the capital asset model as a way of understanding the risk associated with holding Canadian milk quota. Other economists have used different techniques for evaluating the value of an asset. Rucker, Thurman, and Sumner utilized the wealth

distribution, that would be caused by eliminating the intercounty transfer restrictions of tobacco allotment, and welfare calculations to help understand the value of the asset if trade were allowed.

### **California Dairy Quota Policy**

The classified pricing system in California consists of five classes of milk. Minimum prices are established by the California Department of Food and Agriculture (CDFA) using formulae and public hearings. Like federal orders, California calculates a blend price based on market wide utilization of milk by class. Unlike federal orders, where producers in an order receive the same blend price, California producers receive prices dependent on the quantity of quota the producer holds and how much milk is marketed relative to the quota holding. Quota does not influence production directly nor does it affect milk prices paid by consumers. The main effect of quota is milk revenues among dairy producers (Sumner and Wolf).

The California marketing quota has many characteristics that are similar to other assets in agriculture. Subject to the program regulation, quota can be transferred among milk producers, has low liquidity, and entitles owners to receive a quota return. The quota revenue is based on the difference between the quota and the typically lower overbase (non-quota milk) price. The differential is multiplied by the volume of milk sales covered by the quota. In addition, the value of quota can be increased by the occasional allocation of new quota. However, unlike other agricultural assets, quota is not related to

a physical object. Legislation created quota; dairy regulation has changed several times since the program started in 1969; and policy can terminate the quota program.

The first transfer of quota was in August 1969. In the following years, farmers actively participated in the market as a way to adjust their portfolios. After 1975, the market began to settle as marked by the reduction of the number of transfers (Ekboir, Sumner, and Wolf). Beginning in 1995, the value of quota began to fall; this change in the asset value is the underlying issue of this paper.

On January 1, 1994, the difference between the price of quota milk and the price of overbase was fixed to \$1.70 per hundredweight. This policy was enacted to remove the volatility of the differential which had gone negative for some months in the early 1990s. This fixed differential decreased the variability of the benefit stream created by the quota. In order to fix the differential, the quota price and overbase price formulae were adjusted, resulting in less volatility of each price (see Figure 1).

### **The Role of Quota in the Farm Portfolio**

Consider a portfolio of assets related to the dairy enterprise comprised of quota and the dairy farm, holding the other components of the farmer's portfolio constant. Before the 1994 policy shift directly linking the quota price to the overbase price, this portfolio was naturally diversified. When the overbase price fell, the dairy farm returns fell; however, the returns to quota ownership, the differential, increased. A larger differential meant quota revenue increased, and if the change persisted, the asset also rose

in value. Therefore, the agent gained from possession of the quota input because the asset shielded the agent from downward overbase price movements. If the quota price fell, the stream of benefits from the farm, profit, was not directly affected; however, quota revenue declined causing a fall in the asset value. Note, though, the quota owner still made at least as much money as an equivalent producer without quota. Downward quota price pressure revealed that this portfolio did not shield the agent from all risks. In particular, this portfolio did not shield the agent from dairy policy risk. If policy diminished the value of quota, the other portfolio components were not affected nor compensated for the loss.

Now consider the current policy, a fixed differential. When the overbase price falls, quota milk price also falls. Thus, the agent faces a loss in the value of both assets as represented by a fall in the flow of the benefits from the assets. The fixed differential positively links the two components of the portfolio. The agent has effectively lost diversity in the portfolio. This outcome is exacerbated by the existence of policy risk. Possession of quota once granted the agent diversification. Now that one of the benefits of the quota has been eliminated, the value of the quota diminishes. This explanation may be part of the reason for the decline in the value of quota since the beginning of 1995.

A counter argument is that the fixed differential reduced the variability of the quota asset and revenue. Therefore, the overall risk of the portfolio is diminished, and the quota is valued more. This reasoning ignores the significance of quota ownership, that is, portfolio diversification. Therefore, reducing the variance of the quota revenue actually increases the variability of the entire portfolio.

**Data**

Monthly observations on the price of quota without cows (\$/lb), the milk quota price (\$/lb), and the overbase price for the period from January 1971 to August 1996 were obtained from the California Department of Food and Agriculture as reported in the California Dairy Information Bulletin and from the Bureau of Milk Pooling. The prices were kept in nominal terms because the data are without trends. The autocorrelations and partial autocorrelations did not indicate any concern of non-stationarities. Data are available from the starting date of the quota program; however, this introductory data were not used in order to allow adequate time for the market to become established. Of the 308 observations, 233 from January 1971 to December 1990 were used for fitting the model, while the 75 observations from January 1990 to August 1996 were reserved for out of sample testing. Only the first 31 out of sample observations are used for forecasting. The other 44 observations have been reserved for future work.

**Estimation**

As a first step, a univariate ARMA model was estimated for the asset price series. Using Box-Jenkins identification, the in sample data indicate that the best model is an AR(2) with a moving average term at the sixth lag. The model fits the data well as indicated by low variance and no autocorrelation of the error. However, the model has difficulties at a few periods where policy changed.

For the vector analysis, a states space model is used. This linear systems approach uses a formal approximation of a specific arrangement of autocovariances or autocorrelations. This time series technique, which can be related back to a VARMA model, is based on an optimality condition that rationalizes model selection (Aoki and Havenner, p. 32).

The model specification and estimation was based on 233 observations. 75 months were reserved for out of sample validation. The model is derived from a triangular, structural model of the two milk prices influencing the value of the quota asset. In the reduced form, the model stacks the three series into a vector  $\mathbf{y}_t$  of dimension  $(m \times 1)$ .  $\mathbf{z}_t$  is the  $(n \times 1)$  vector of unobservable states while the  $\mathbf{e}_t$  is an  $(m \times 1)$  vector of serially uncorrelated error terms. The state space model is written below as two matrix equations named the state and observation equations, respectively, as follows:

$$(1) \quad \mathbf{z}_{t+1|t} = \mathbf{A}\mathbf{z}_{t|t-1} + \mathbf{B}\mathbf{e}_t$$

$$(2) \quad \mathbf{y}_t = \mathbf{C}\mathbf{z}_{t|t-1} + \mathbf{e}_t$$

$\mathbf{z}_{t+1|t}$  is a vector of conditional means of the states, and A, B, and C are matrix coefficients to be estimated (Foster, Havenner, and Walburger, p. 1014).

The coefficients of the A, B, and C matrices are suppressed because they are attached to states that are unobservable. However, the eigenvalues of the A matrix indicate stability because the eigenvalues are less than one in absolute value. The eigenvalues of the A model are (-0.662, -0.0107, 0.748, 0.879, 0.971).

## Forecasts

The model specification is a good fit. The root mean squared error (RMSE) and the mean absolute deviation (MAD) are all small as compared to the means, and  $R^2$ s are all high. Asset value is a difficult series to fit; however, the model still performs reasonably well. Unlike the other summary statistics, the Henriksson-Merton confidence intervals (HMCONFID) focuses not on the magnitude of the errors but on the correct forecast of the direction of change in one period to the next. The values reported are the confidence levels for rejecting the null hypothesis of no ability to predict the direction. The autocorrelations for the error terms are all small, indicating that most of the dynamics of the model have been captured. These statistics are suppressed for the in sample, but the out of sample forecasts results are presented in the following table.

<b>Table 1. Summary of the Out of Sample State Space Forecast Results</b>					
Nf=2 Np=2 States=5					
<b>SERIES</b>	<b>MEAN</b>	<b>RMSE</b>	<b>R<sup>2</sup></b>	<b>MAD</b>	<b>HMCONFID</b>
Quota Price	0.773	0.0391	0.392	0.026	0.206
Overbase Price	0.594	0.0364	0.905	0.0274	0.996
Asset Value*	3.150	0.274	0.528	0.211	0.767

\*The asset price was scaled by 100 to make the results compatible with the other prices.

The out of sample forecast results are also good. Table 1 shows the calculated statistics. The RMSEs and MADs are high for the out of sample forecast. Nevertheless, the RMSEs for the forecast lower than the means of the series. The error autocorrelations are insignificant. The  $R^2$  are very different for the three variables. In particular the quota and asset  $R^2$ s are low for the out of sample. The low values are not a major concern. The HMCONFID for quota price forecast is very low; however, the other variables predict direction well (see Figures 1-3).

The best result of the forecast is the reasonably large HMCONFID statistic for the asset value forecast. This model is mostly concerned with predicting the value of the asset. Although the  $R^2$  is low, the large in the HMCONFID statistic is beneficial. For the second phase of this project, a good prediction of the direction of the asset price is necessary to understand how policy shocks will affect the asset price movement. The out of sample forecast is good; the relatively high confidence interval value helps improve the value of the forecast.

### **Policy Assessment**

Using the state space model, structural error estimates of policy shocks can be estimated from the reduced form errors. Keating shows that, from the Cholesky decomposition of the covariance matrix of VAR residuals, estimates of the structural

disturbance shocks can be calculated, when the structural model is partially recursive (or block recursive) and the shocks are uncorrelated. The model presented above is block recursive because the asset does not affect the two milk prices. The two milk prices, however, do affect the value of the asset. Given the reduced form, the estimates of the structural disturbance will be estimated, and the policy analysis conducted.

### **Further Work**

The state space model gives a specification of how the three series fit together. Understanding this reduced form is integral in estimating the structural policy shifts. This estimation is in progress. Keating uses a VAR model to estimate the structural policy shocks. This paper uses the state space specification in the VAR's stead, but this change in technique causes no problem in estimating the shocks.

Incorporating legislative effects on a policy-generated asset is an important issue in understanding the distribution of rents to beneficiaries. With this analysis, the value of policy-created assets can be forecasted. The Keating result allows the data to reveal how policy shifts affect the value of the asset.

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