

An analysis of Japanese tuna prices using vector autoregressions main author

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Abstract

Japan is both the largest producer and consumer of tuna in the world. However, Taiwan has been a major exporter to Japan of *Thunnus albacares* and *Thunnus obesus* recently. For example, the market shares of Taiwan's supply are 20% for *T. albacares*, and 44% for *T. obesus* in 1992. Hence, it is important for Taiwan's fishery companies to forecast Japanese demand for tuna and to make as much profit as possible from the exports.

Moreover, it should be noted that Japanese officials often criticize that too many imports could hurt domestic producers. Thus, there are conflicts in the trade of tuna products between Japan and Taiwan. To provide insightful understanding for both parties and hopefully facilitate the settlement of conflicts, an analysis of price movements is in need since prices possess important information and usually serve as primary indicators in both decision making and trade talk.

The current study attempts to use vector auto-regressions for analyzing the movements of Japanese tuna prices by taking Taiwan's imports into account. Presumably, the empirical results will provide important indicators for fishery companies and notable evidences for Taiwan's authority to negotiate with Japan.

I. Introduction

Although Japan is both the largest producer and consumer of Tuna in the world, she has recently relied on Taiwan as one of the major sources for *Thunnus albacares* (Yellow-Fin Tuna) and *Thunnus obesus* (Big-Eye Tuna) imports. For example, the

market shares of Taiwan's supply are 20% for Yellow-Fin, and 44% for Big-Eye in 1992. As such, Japanese officials and fishermen often criticize that too many imports could hurt domestic producers, leading to the conflicts in the trade of tuna products between Taiwan and Japan. To provide insightful understanding for both parties and hopefully facilitate the settlement of conflicts, an analysis of price movements is in need since prices possess important information and usually serve as primary indicators in both decision making and trade talk.

Agricultural economists have made extensive use of the time-series analysis to model commodity price series (Harris and Leuthold, 1985; Shonkwiler and Spreen, 1982). For instance, univariate auto-regressive moving-average (ARMA) models can be used to gain insights into the dynamic properties of complex systems, requiring less subjective judgement on the specification of models. However, this type of model tends to fail to consider information about other potentially important variables. Vector auto-regressions (VAR) models have been suggested as the approach toward incorporating such information.

According to economic theory, commodity prices and quantities are supposed to influence each other. Hence, it is important to explain price and quantity series at same time. However, it should be noted that the lead-lag relationships between prices and quantities need to be examined at the first place to accurately model the movements of time series. Therefore, first of all, this study is intended to examine causal relationships between Japanese tuna prices and imports from Taiwan. Secondly, when specific evidence on leads and lags of studied variables are observed, VARs are used to analyze the movements of tuna prices and quantities in Japan.

In what remains, the next section presents methods for testing causality between two time-series variables and those for modeling a VAR. Then, the empirical results from fitting VARs to tuna (Big-Eye and Yellow-Fin) prices and quantities are evaluated in section III. The final section discusses the implications of the results and concludes the paper.

II. Causality tests and Var modeling

Geweke (1980, pp.4-20) has redefined the Granger causality in a testable way, in which variable X is said to cause variable Y , with respect to a given universe including at least X and Y , if current values of Y can be better predicted by using past values of X than by not doing so, all other information in the universe being used in either case. Consequently, a procedure which merely utilizes OLS (Ordinary Least Squares) regressions on levels of the two series is suggested. Given the above definition, the test procedure for causality from X to Y is to use the following specifications:

$$(1.1) \quad Y_t = \beta_{10} + \sum_{i=1}^p \beta_{1i} Y_{t-i} + \epsilon_{1t}$$

$$(1.2) \quad Y_t = \beta_{20} + \sum_{i=1}^p \beta_{2i} Y_{t-i} + \sum_{j=1}^q \Gamma_{2j} X_{t-j} + \epsilon_{2t}$$

Where β_{1i} and β_{2i} are parameters of Y_t and its lagged values, Γ_{2j} are parameters relating past values of X_t , and ϵ_{1t} and ϵ_{2t} are

$$(2) \quad F = (SSE_1 - SSE_2/q) / (SSE_2/N-p-q-1)$$

white noise. The test statistic F , is computed as

where SSE_1 and SSE_2 are the sum of squares for errors from OLS regressions on

(1.1) and (1.2), N is the number of observations on Y . Under the null hypothesis $F^{\wedge} = \dots = F_2 y = 0$, the test statistic is distributed as an F distribution with $(q/N - p - q - 1)$ degrees of freedom. For sufficient large values of F , the null hypothesis that X does not cause Y is then rejected.

The use of equations (1.1) and (1.2) requires that values of p and q are chosen large enough to remove substantial auto-correlation in the regression residuals. The F -statistic could be seriously overvalued if substantial auto-correlation is present (Granger and Newbold, 1974; Bessler and Brandt, 1982). Therefore, the Ljung-Box-Pierce test statistic is in need to examine the presence of serial correlation in the residual series. The Geweke's method has been used by Bessler and Brandt (1982) to examine the causal relationships in U.S. livestock markets. The present paper will employ the same method to examine the lead-lag relationships between prices, domestic supply, and import from Taiwan for Japanese Big-Eye and Yellow-Fin markets.

Since a VAR lets the data specify the dynamic structure of a system, it is given by

$$(3) \quad Y_{it} = \alpha_{i0} + \sum_{j=1}^k \alpha_{ij} Y_{it-j} + \epsilon_{it} \quad i = 1, \dots, m$$

where Y_{it} is observations on the m series at time t , k is the number of lags for all variables Y_{it} and ϵ_{it} is the error term. Equation (1) can be estimated by OLS because the set of independent variables are the same in each equation (Pindyck and Rubinfeld, 1991). As to choosing k , it is essential to have lags long enough to fully capture the dynamics of the system being modeled. However, the longer the lags, the greater the number of parameters that must be estimated, and the fewer the degrees of freedom. For example, if $m=3$ and $k=4$, there are 39 parameters to estimate. Therefore, researchers must trade off between having a sufficient number of lags and having a sufficient number of free parameters. In practice, it had better to constrain the number of lags to be less than what is ideal given the nature of the dynamics (see Pindyck and Rubinfeld 1991, p.355). As a result, a priori information about lead-lag relationships between studied variables are very useful in specifying the number of lags for VARs.

III. Empirical results

The price and quantify data used in the empirical analysis are retail prices, domestic supply, and import from Taiwan of Big-Eye and Yellow-Fin in Japan. As the purpose of this study is to forecast the nominal prices, it is unnecessary to deflate prices series (Tomek and Robinson, 1981, p.320). The Granger regression test is applied to 1983-93 monthly data. The invariate relationships studied in current paper are between Japanese price and Japanese domestic supply, between Japanese price and import-from-Taiwan, and between Japanese domestic supply and import-from-Taiwan. In the VAR specification, there are three time-series for each market. However, the number of lags for very independent variable in each equation is chosen based on the results from causality tests. The estimation period runs from the January of 1983 through the April of 1992.

In doing causality tests, lead-lag relationships were specified by the data rather than a priori reasoning. Twenty-four OLS regressions were estimated to test the causal relationships. One-way causality tests (following equations (1.1) and (1.2)) were performed at lag of 2 and at lag of 4. The F -statistic for these tests and the diagnostic Q -statistic of Ljung and Box for serial correlation in residuals are illustrated in Table 1. As shown in Table 1, a strong one-way causal relationship runs from Japanese domestic supply to Japanese price, while a weak one-way

causal relationship from Japanese price to Japanese domestic supply in Big-Eye market. A strong one-way causal relationship runs from Japanese supply to Japanese price, and a weaker one-way causal relationship runs from import-from-Taiwan to Japanese domestic supply in Yellow-Fin market. The finding of causality tests results is that import-from-Taiwan shows no evidence of leading Japanese tuna prices. The strongest lead and lags is from Japanese domestic supply to Japanese prices at lags 2 to 4. The specific evidence on leads and lags of studied variables has provided an important information in modeling VARs for the Big-Eye and Yellow-Fin markets.

Since the number of lags for each equation is different, SUR (Seeming Unrelated Regression) estimates will gain more efficiency than OLS. Estimates of VARs parameters were obtained via the SYSTEM command in *SHAZAM* version 7.0. The estimates of VAR models for each series, along with system R^2 s and root-mean-square percent errors (RMSPE), are presented in Table 2. The system R^2 is 0.87 for Big-Eye market and 0.88 for Yellow-Fin market, which indicate that the fitted VARs explain historical movements quite well for whole system. However, examining RMSPEs, the estimation results indicate that the estimated parameters of Japanese price equation explain historical movements better than those of Japanese domestic supply and import-from-Taiwan equations do in both markets. Such low explaining power peculiar to those two equations, given that the overall R^2 is fairly high, presumably is due to the fact that the harvest of tuna depends greatly on many variables such as weather, water temperature, fish population size, etc, which are not incorporated in the macro sample and thus the estimating model. Admittedly, this is a weakness embedded in the empirical study using a macro sample.

To examine the performance of *ex post* forecasting, out-of-sample forecasts derived from VARs are computed for the period of May of 1992 through December of 1993. The actual and forecasted Big-Eye retail price, domestic supply, and import-from-Taiwan series are depicted in Figure 1 to 3. Similar plots for Yellow-Fin retail price, domestic supply, and import-from-Taiwan are illustrated in Figure 4 to 6. Out-of-sample RMSPEs are calculated for each equation. The figures are 4.19%, 43.64%, and 52.72% for price, domestic supply, and import-from-Taiwan equations, respectively, in Big-Eye market. The figures for Yellow-Fin market are 6.67%, 54.75%, and 36.2% for price, domestic supply, and import-from-Taiwan, respectively. Obviously, results show that price equations outperform than domestic supply and import-from-Taiwan equations. This result is not beyond expectation due to the weakness of macro sample used in this empirical study.

IV. Conclusions

In this study, causality tests have been applied to time series of prices, domestic supply, and import-from-Taiwan for Big-Eye and Yellow-Fin markets in Japan. According to the evidence of lead-lag relationships between these series, VARs are used to explain the movements of particular variables in these two markets. The results of causality test indicate that import-from-Taiwan shows no evidence of leading Japanese tuna prices. They further indicate that the strongest lead-lag relationship is from Japanese domestic supply to Japanese prices, which is quite noteworthy. Such a finding provides an important evidence for Taiwan's authority to negotiate with Japan.

The estimation results show that the price series of tuna can be explained by VAR processes adequately. However, low explaining power peculiar to domestic supply and import-from-Taiwan equations, given the fairly high overall R^2 is present due to

the weakness embedded in the empirical study using a macro sample. Supposedly, information from biology and oceanography is useful in improving performance of VARs.

The current study uses vector auto-regressions to analyze the movements of Japanese tuna prices by taking Taiwan's imports into account. That Japanese tuna prices can be forecasted by merely lagged prices and domestic supply makes some important applications of this study. Since prices possess important information and usually serve as primary indicators in both decision making and trade talk, Taiwan's authority and fishery companies can be benefited by fully utilizing past information for forecasting on Japanese prices and quantities. Further applications of other econometric models to analyze tuna markets may also yield fruitful results to benefit both Japan and Taiwan interest groups, and thus deserve more research efforts.

Table 1: One-way Granger Causality Tests on Big-Eye and Yellow-Fin Prices and Quantities

	Big Eye			Yellow Fin		
	Lags	F-Test	Q(10)	Lags	F-Test	Q(10)
JP→JQ	2	7.89*	11.27	2	1.41	24.85
	4	2.40	8.96	4	1.82	4.89
JQ→JP	2	13.83*	8.51	2	4.98*	10.44
	4	7.61*	7.06	4	2.58*	5.87
JP→TQ	2	0.97	16.32	2	0.95	19.80
	4	1.01	8.91	4	1.68	17.14
TQ→JP	2	0.66	15.01	2	0.20	13.18
	4	0.46	13.18	4	0.68	8.33
JQ→TQ	2	1.30	11.89	2	1.41	21.70
	4	1.16	8.94	4	1.12	20.42
TQ→JQ	2	0.73	21.82	2	3.13*	17.13
	4	0.79	12.11	4	0.74	3.07

Note: Variable abbreviations are JP (Japanese price), JQ (Japanese domestic supply) , and TQ (Quantity imported from Taiwan). * denotes F-statistic above critical value at 5% significance level, $F(0.05; 2, 115) \approx 3.09$ and $F(0.05; 4, 111) \approx 2.46$. $Q(10)$ denotes the Ljung-Box-Pierce test statistics for serial correlation in residuals, $\chi^2(0.05, 10) = 18.13$.

Table 2- Estimation Results of VAR to Japanese Prices, Domestic Supply and Import-From-Taiwan, Jan. 1983 through April 1992

Big-Eye

$$\begin{aligned}
 \text{JPt} = & 871.33 + 0.3763 \text{JPt-1} + 0.2255 \text{JPt-2} - \\
 & 0.0178 \text{JPt-1} \\
 & (61.89) (0.0764) \quad (0.0676) \quad (0.0044)
 \end{aligned}$$

$$(0.0045) \quad -0.0198 \text{ JQ } t-2 - 0.0152 \text{ JQ } t-3 - 0.0091 \text{ JQ } t-4$$

$$(0.0042) \quad (0.004)$$

RMSPE =

7.21%

$$\text{JQ}_t = 7898.2 - 3.112 \text{ JP}_{t-1} + 2.0234 \text{ JP}_{t-2}$$

$$(1053.0) \quad (1.508) \quad (1.304)$$

RMSPE 36.95%

$$\text{TQ}_t = 489.05 + 0.4885 \text{ TQ}_{t-1} + 0.2301 \text{ TQ}_{t-2}$$

$$(147.4) \quad (0.0966) \quad (0.0964)$$

RMSPE =

90.54%

System Rusquare = 0.8667

Yellow-Fin

$$\text{JP}_t = 256.17 + 0.8509 \text{ JP}_{t-1} - 0.0325 \text{ JQ}_{t-1} - 0.0209 \text{ JQ}_{t-4}$$

$$(37.89) \quad (0.0451) \quad (0.011) \quad (0.009)$$

RMSPE = 10.57%

$$\text{JQ}_t = 2226.4 + 0.2058 \text{ JQ}_{t-1} + 0.1245 \text{ JQ}_{t-2}$$

$$(269.0) \quad (0.0898) \quad (0.0552)$$

RMSPE = 37.87%

$$\text{TQ}_t = 570.68 + 0.4457 \text{ TQ}_{t-1} + 0.2464 \text{ TQ}_{t-2}$$

$$(173.3) \quad (0.0961) \quad (0.0998)$$

RMSPE=150.15%

System R-square = 0.88

Note: variable abbreviations are JP (Japanese price), (japanese domestic supply) and JQTQ (Quantity imported from Taiwan). Figures in parentheses are standard deviations. RMSPE denotes root-mean-square percent error.

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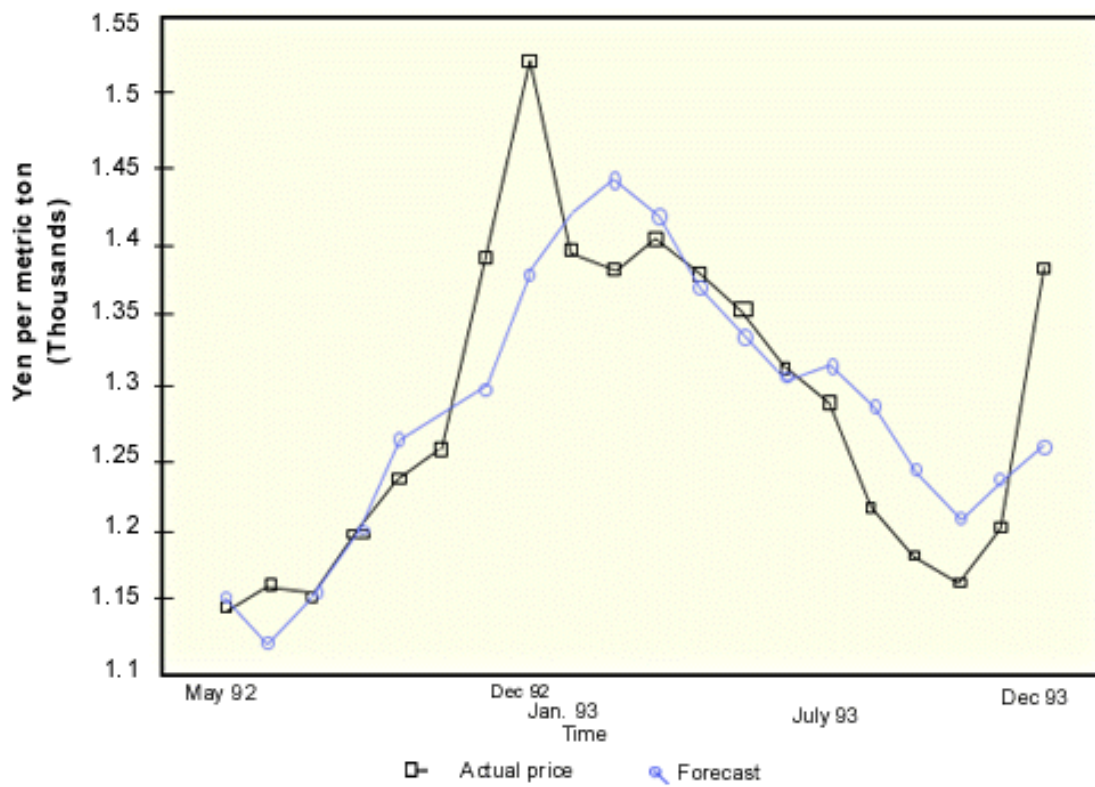


Figure 1. Out-of-Sample Forecasts of Big-Eye Prices, May 1992 through dec.1993

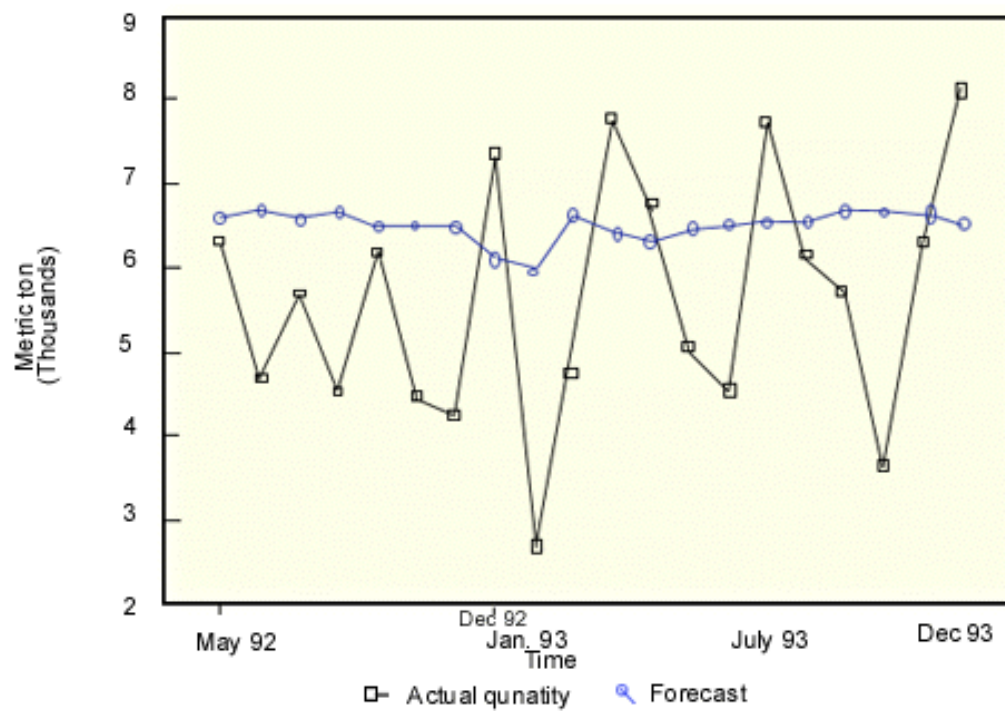


Figure 2. Out-of-Sample Forecast of Big-Eye Domestic Supply, May 1992 through dec.1993

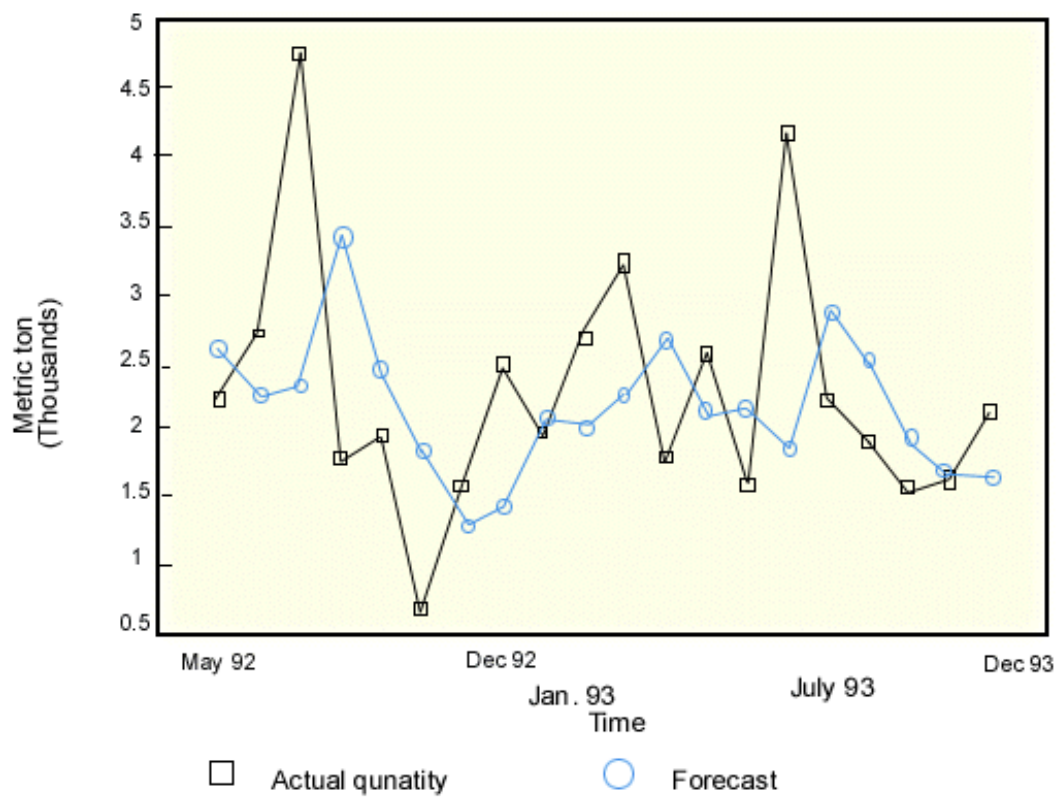


Figure 3. Out-of-Sample Forecast of Big-Eye Import-from-taiwan, May 1992 through dec.1993

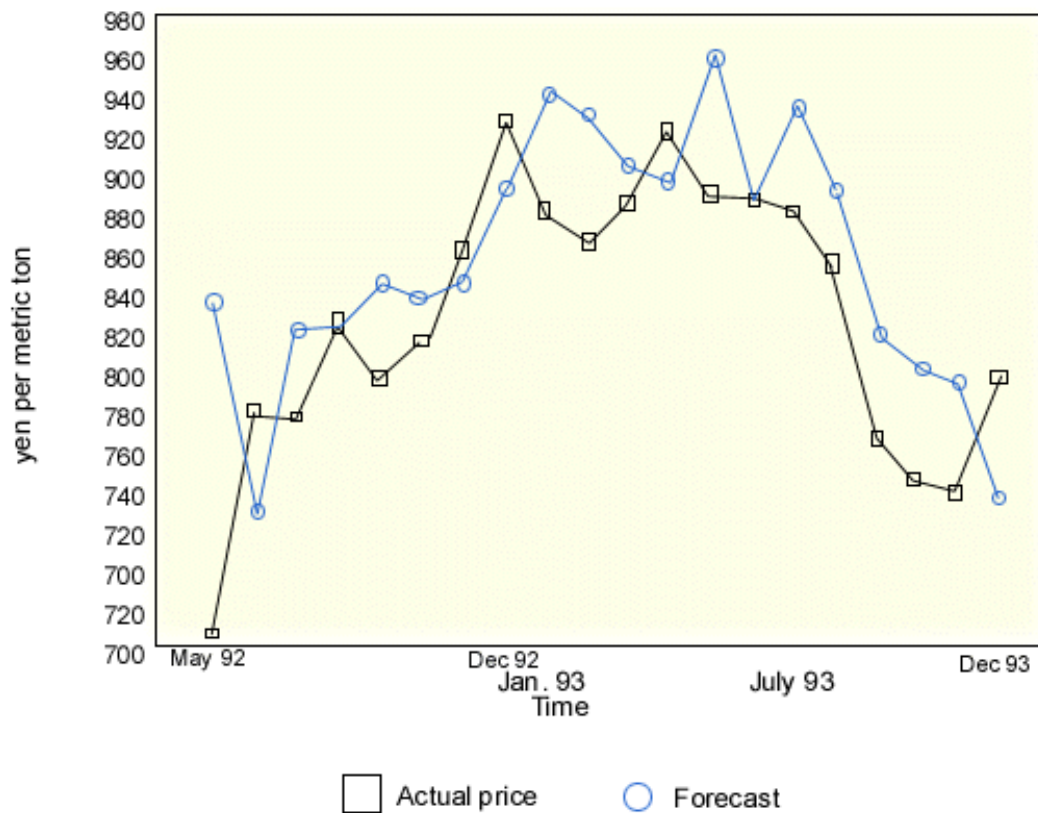


Figure 4. Out-of-Sample Forecast of yellow-Fin Prices, May 1992 through dec.1993

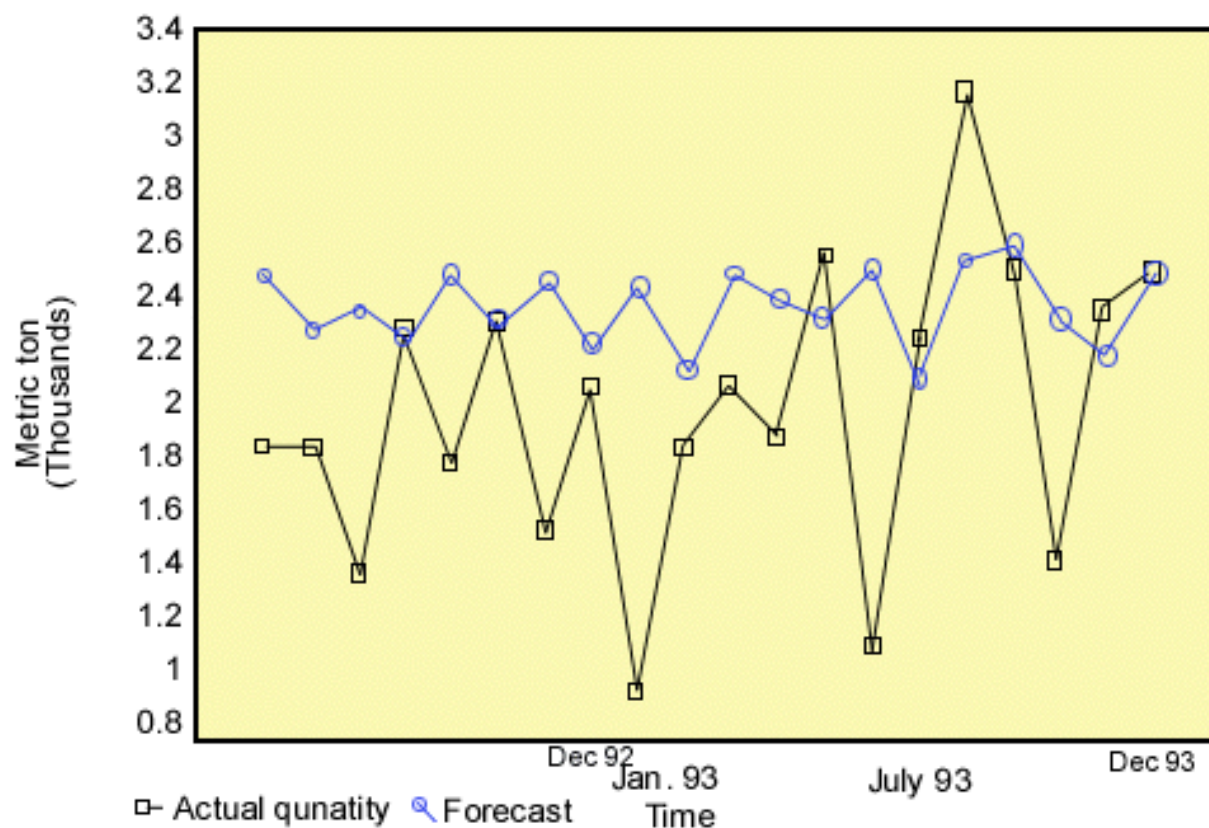


Figure 5. Out-of-Sample Forecast of yellow-Fin Domestic Supply, May 1992 through Dec. 1993

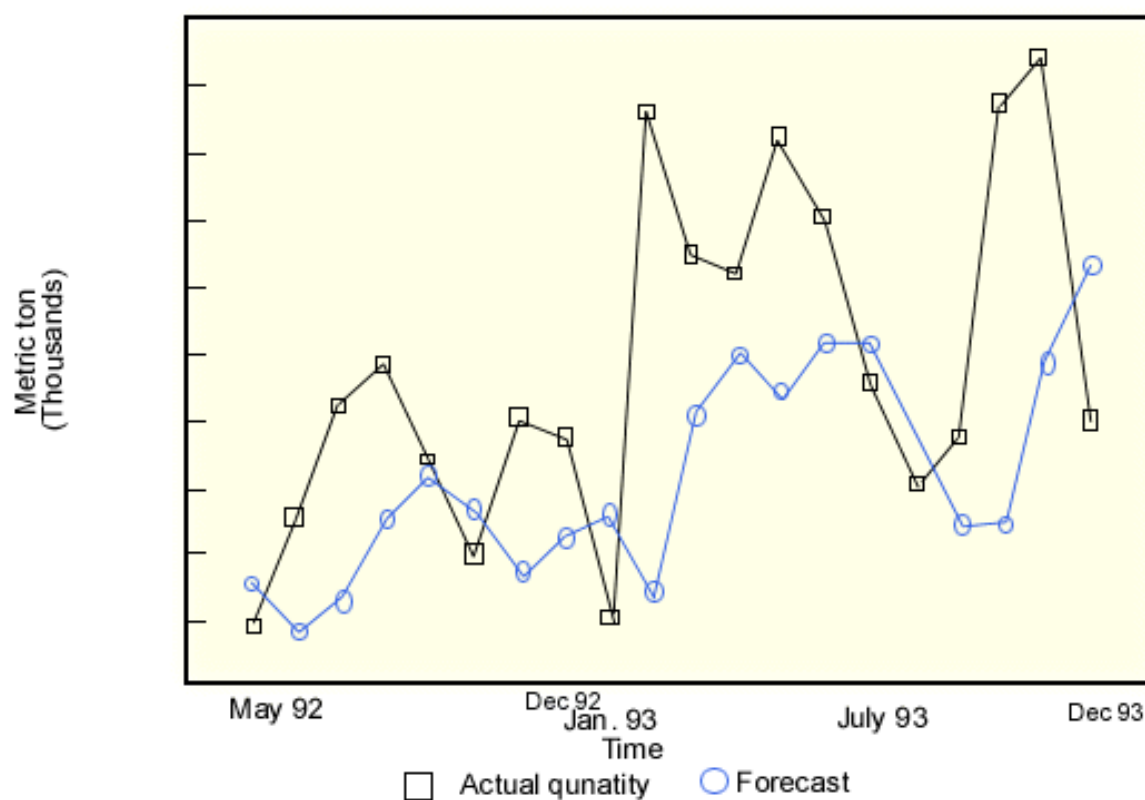


Figure 6. Out-of-Sample Forecast of yellow-Fin Import-from-Taiwan, May 1992 through dec. 1993