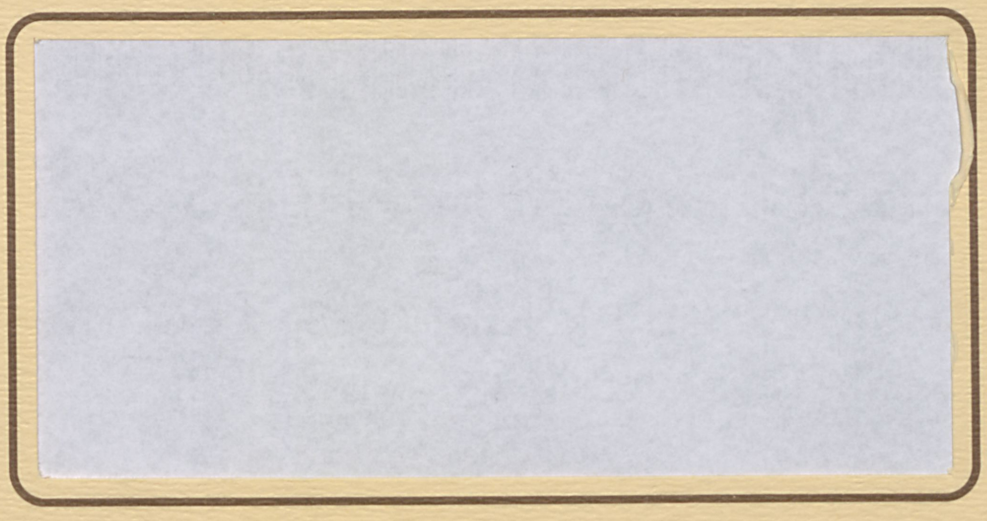
RURAL ECONOMY



STAFF PAPER

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East Asian Poultry Markets: Technology Transfer and Demand Dynamics

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EAST ASIAN POULTRY MARKETS: TECHNOLOGY TRANSFER AND DEMAND DYNAMICS

Abstract

A two-equation model of price determination and demand is estimated for poultry in 5 East Asian countries. An Error Correction Model of demand is used to test the hypothesis that dynamics are important in explaining consumer behavior. Results show that real poultry prices have declined in East Asia due to the transfer of cost-reducing technology from the U.S. Demand dynamics are important only in the most rapidly changing economies and income growth has been the most important determinant of demand growth.

leads to this result. In the U.S., real prices of poultry halved between 1965 and 1985, due to declining production costs, which in turn were the result of increased feed efficiency. Quantities consumed in the U.S. have responded to prices, which have been predetermined by declining costs of production, driven by technological change.

Thurman's model and findings are applicable to East Asian countries, for two reasons. First, these countries face a very elastic supply of poultry imports from the U.S., and the price of these imports is determined by U.S. production costs. Second, technological change in broiler production has not been confined to the U.S.-- it is readily transferrable overseas. This technology consists of hybrid chicks, imported (at least initially) from the U.S. or Europe, raised in containment facilities, and fed a compound feed diet whose principal components are soybean meal and corn. The new technology has more rapid reproduction, efficient feed conversion, and essentially unlimited feed supplies at world prices.[1] Because feed is available in most countries at world prices, the transfer of technology tends to reinforce the determination of prices by world market production costs. The rapid transfer of this technology has tended to equalize production costs across countries.

The presence of an elastic supply of imports and the ability to import production technology suggests that domestic poultry prices in East Asian countries are determined by world market production costs. The estimated price determination equation for each country is:

$$P_p = a_0 + a_1 P_c + a_2 FC + u_t \qquad (1)$$

where P_p is the real price of poultry, P_c is the real domestic border price of corn (which accounts for 70% of feed costs), and FC is the U.S. poultry feed conversion ratio (number of pounds of feed needed to produce one pound of broiler meat). The price of poultry should be directly related to both variables.

The hypothesis that prices are predetermined is tested with Hausman's specification test. The best demand model for each country is reestimated with the residuals from the price determination equations. If these residuals are insignificant, prices can be treated as predetermined and quantity dependent demand models are appropriate.

Equation 1 will not explain prices well if governments in importing countries intervene to limit imports in order to protect the domestic poultry industry. Certain kinds of intervention will prevent domestic prices from following world market prices. This could slow the process of technology transfer by preventing competition for the domestic industry. The price determination results will yield some insights into the effects of government policy.

In estimating the demand equation, it is particularly interesting to test for evidence of dynamics. Because both prices and incomes are changing rapidly, we hypothesize that dynamics may be important in demand. In order to test this hypothesis, the Error Correction Model (ECM) is estimated (see Harvey, pg. 289-294, for a complete derivation of this model). The ECM provides a parsimonious methodology for parameterizing dynamic economic relationships, which incorporates short-run dynamics and long-run equilibrium. The ECM estimated for each country is:

$$\Delta q_t = b_0 + \Sigma\, b_i\, \Delta X_{it} + (\alpha - 1)\,(q_{t-1} - \Sigma\, e_i\, X_{it-1}) + v_t \qquad (2)$$

where all variables are in logarithms, Δ are first differences of the variables, q_t is per capita consumption of poultry and the X_i are the real retail prices of poultry, beef and pork; and real per capita income. The short run changes are given by the b_i, and the e_i are the long-run elasticities. The term α-1 can be interpreted as the speed of adjustment back toward equilibrium. The model allows quantities to grow more or less rapidly than the long run growth path, but the resulting error correction $(q_{t-1} - \Sigma\, e_i\, X_{it-1})$ forces quantity back towards this path.

Equation 2 is nonlinear in the parameters, and therefore, the following estimation strategy is employed. The two-step procedure suggested by Engle and Granger is used to calculate initial estimates. The long-run parameters are estimated from the static model in levels. Engle and Granger show that these are consistent estimates of the long-run effects, even though the short-run dynamics are omitted. Equation 2 is then estimated with $q_{t-1} - \Sigma\, e_i\, X_{it-1}$ replaced by the lagged residuals from the static model. The resulting consistent estimates were then used as starting values for direct nonlinear estimation of Equation 2.

Anderson and Blundell point out that several simpler dynamic models are nested within the ECM. If:

$$b_i = e_i \qquad \forall i, \tag{3}$$

then equation 2 becomes an autoregressive (AR) model:

$$q_t = b_0 + \Sigma\, e_i X_{it} - \alpha \Sigma\, e_i X_{it-1} + \alpha\, q_{t-1} + v_t \tag{4}$$

Or if:

$$b_i = (1 - \alpha)\, e_i \qquad \forall i, \tag{5}$$

then equation 2 becomes the partial adjustment (PA) model:

$$q_t = b_0 + (1 - \alpha) \Sigma\, e_i X_{it} + \alpha\, q_{t-1} + v_t \tag{6}$$

If α is equal to 0 and either the restrictions implied by (3) or (5) hold; then the short run dynamics drop out and equation 2 reduces to the static model:

$$q_t = b_0 + \Sigma\, e_i X_{it} + v_t \tag{7}$$

The advantage of the direct nonlinear estimation of Equation 2 is that it allows tests of restrictions on the coefficients. These tests reveal which model best explains demand behavior in the five East Asian countries.

Data on per capita consumption of poultry are derived from FAO statistics on production plus net imports, divided by population. Meat and poultry price data are from country sources including: the Japanese Statistical Yearbook, the Singapore Monthly Digest of Statistics, Hong Kong import unit values from FAO, Korean statistical series reprinted by the MERC of Iowa State, and Agricultural Statistics of Thailand. Income and consumer price index data are from the IMF's Financial Statistics. Import unit values for corn are used as the corn border price in each country; the feed conversion ratio is from USDA (Lasley et al). All data are annual; the years included in each data set are indicated in Table 1.

Recent Poultry Market Trends in 5 East Asian Countries

Total poultry production grew at more than 6% annually in the five East Asian countries (Table 1). While technological change undoubtedly aided this growth, the degree of technology transfer in poultry production is hard to measure. One of two

ratios provides some indication of adoption-- inventory of traditional birds to total birds, or number of birds per production unit. Adoption is most advanced in Japan, where the number of birds per production unit increased from 14 in 1960 to 1,200 in 1983 (Nelson and Unnevehr). It also seems likely that almost all of the chicken production in Hong Kong and Singapore uses the containment technology, because these city-states had virtually no traditional agricultural sector. South Korea and Thailand have also made major strides in adopting the new technology. In South Korea, the chicken inventory per household has risen from 9.5 birds in 1962 to 127 birds in 1984. In Thailand, the share traditional birds in the poultry inventory dropped from 42% in 1970 to 24% in 1980. Bishop et al report extremely rapid changes in the Thai poultry industry in the early 1970s: By 1976, 96% of all growers produced more than 5000 birds annually as compared to only 2% of growers in 1970.

Changes in poultry demand have been just as dramatic as changes in supply, due to falling prices and rising incomes. The level of per capita income varies from over $16,000 in Japan to $842 in Thailand (Table 1), but all five countries have shared in the rapid economic growth of the region. Rates of real per capita GNP growth are all above 4% during the last 25 years. Real prices of poultry products declined by more than 20% over the last 15 years in all countries except South Korea (Table 1).

These trends in prices and incomes spurred growth in per capita consumption of poultry. Per capita consumption has grown at more than 5% annually in all countries, and total consumption at more than 7% (Table 1), a remarkable rate of increase for a single product. In three countries, Japan, Singapore, and Hong Kong, demand grew faster than supply, and net imports increased (Table 1). South Korean government policy has prevented imports, and thus limited demand growth to the slowest rate among these countries. Thailand has seen an expansion in net exports in spite of rapid growth in demand.

Government policies have played a role in determining these trade patterns. The entrepot city states, Singapore and Hong Kong, allow domestic prices to follow world prices. Thailand does not restrict or tax poultry exports, and hence prices there follow world market trends. In Japan and South Korea, however, domestic prices are higher

than world prices. Japan imposes a modest tariff on poultry imports.[2] The absence of imports in South Korea is due to government protection of the domestic industry. Anderson and Hayami (pg 132) estimate that Korean poultry prices were more than double world prices in the early 1980s.

Estimation Results

Table 2 summarizes the tests of restrictions on the estimated coefficients of the ECM. The results divide the countries into two groups. In three countries, Japan, South Korea, and Thailand, the AR model is rejected, the PA model is not rejected, and the static model is not rejected. This indicates that the complex dynamics of the ECM are unnecessary and a static model of poultry demand is most appropriate in these three countries.

In Singapore and Hong Kong, the static model is clearly rejected, but neither the PA nor the AR models are rejected. Thus the test results do not provide much guidance as to which dynamic model is most appropriate for these two countries. As would be expected, OLS static demand estimates for Singapore and Hong Kong produced serially correlated residuals. Correction for autoregression yielded reasonable statistical and economic results.[3] The autoregressive models for the two city-states are reported in Table 3, along with static demand results from the other three countries.

Three generalizations about poultry demand stand out from the results in Table 3. First, income effects are strong and significant in all 5 countries. Income elasticities are consistently greater in absolute value than own-price elasticities. Second, own price effects are not significant (except in Japan) and all own-price elasticities are less than 1. In general, the magnitudes of the own-price and income elasticities are reasonable, with the possible exception of the income elasticity in Japan.[4] This high income elasticity is comparable to many previous estimates reported by Dyck (1988, pp 22-24) in a review of meat elasticity estimates for Japan. Third, prices and income explain a large proportion of poultry demand in these five countries; the R^2 are all greater than .90.

The demand estimates include prices of beef and pork.[5] Only two of the cross-price effects are significant. Beef is a strong and significant substitute for poultry in South Korea. Real beef prices in that country tripled over the data period, which contributed to growth in poultry consumption. The coefficient of pork in the Thai demand equation is significant and negative. This is probably a spurious result, arising from simultaneous technological change in pork production, similar to that in poultry production, which led to declining real pork prices.[6]

In summary, the demand results do not support the hypothesis that dynamics have been uniformly important in the growth of East Asian poultry consumption. The static model adequately explains demand changes in three of the countries. Dynamics in demand were important in the city-states, however. These nations have rapidly changing open economies, high income growth rates, and have reached the highest levels of poultry consumption in the region. The changes taking place in Singapore and Hong Kong have generated some lags or errors in the adjustment process.

Furthermore, the demand results demonstrate that income effects have been much more important in driving consumption growth than the decline in real prices. Income effects are uniformly larger than price effects and more statistically significant. These results will have important implications for future growth prospects, which are explored below.

Estimates of poultry price determinants in the five countries are in Table 4. Significant autocorrelation in the residuals required correction in all five price determination equations. In all of the countries except South Korea, world market production costs explained a large proportion of price variation. The price of corn was significant only in Hong Kong, and marginally significant in Japan and South Korea. Technological change, as represented by the feed conversion ratio, was the most important explanatory variable in four of the countries.

Although Japan taxes poultry imports, this method of intervention and the process of technological change have not prevented domestic prices from reflecting world production cost trends. In South Korea, on the other hand, the R^2 was much lower than in the other countries. The prohibition of poultry imports has insulated Korean prices

from world market trends. However, some technology transfer has taken place, which accounts for the marginal significance of both variables in the Korean equation.

Residuals from the price determination equations were uniformly insignificant in the demand equation. Thus the estimation of quantity-dependent demand curves is appropriate. This result supports the assumption that prices are exogenously determined by world production costs, either through imports or domestic adoption of technology. A declining real price of poultry reflecting technological change is thus an international phenomenon, and not confined to the U.S.

Implications for Future Growth in Consumption

Given the relatively low levels of poultry consumption in most of these countries (as compared to 32 kgs of chicken in the U.S.), further growth in poultry consumption seems feasible. The estimates of demand parameters can be used to estimate future growth in consumption, if assumptions are made about income growth and price trends. Income growth is assumed to continue at the 1980-88 level during the coming decade. Average growth rates in the 1980s were lower than the 25 year average, but world economic growth is unlikely to return the levels of the 1960s.

Price trends are more difficult to forecast. In a recent USDA bulletin, Stillman and Weimar discussed the past and future trends in real broiler production costs. They report that real production costs in 1982 $ declined from 15 cents per pound in 1967 to only 7 cents a pound in 1989. If past trends in cost reduction continue, they estimate that the real wholesale price of broilers will decline by 4 cents (a decline of 9%) over the 1990 price. As the wholesale price is very close to the U.S. export unit value, it seems likely that this decline would also be reflected in world prices. However, the actual rate of cost decline has slowed during the last five years, and thus it might also be reasonable to predict constant real prices.

Table 5 shows calculated per capita consumption growth rates under two scenarios: first, continued income growth but constant real prices; second, continued income growth and an annual 1% price decline between 1991 and the year 2000. It should be noted that this assumed price decline would be less than past rates of price

change in all countries except South Korea (Table 1). Because income elasticities are larger than price elasticities and income growth rates are higher than probable price changes, the income effects will provide the lion's share of future growth.

The results in Table 5 can be compared with past rates of growth to show whether markets for poultry will continue to expand in East Asia. The projections indicate that the three major importers will continue to experience high consumption growth rates very similar to past growth rates. However, rates of growth in South Korea and Thailand will be slower than in the past. The South Korea result assumes no change in protection. If domestic prices fell by half to world price levels, then consumption would surely increase. However, such liberalization would likely be accompanied by reduced beef prices. As the cross-price effects of beef price changes are larger than own-price effects (Table 3), trade liberalization might not benefit potential poultry exporters very much. The lower growth rate in Thailand indicates that domestic consumption is unlikely to cut into imports, and thus Thailand will remain a major competitor in East Asian markets.

Conclusions

The two equation model of poultry demand and price determination has revealed some important stylized facts about the markets for poultry in East Asia. First, tests of restrictions on an Error Correction Model of demand reveal that demand dynamics are important only in the two most rapidly changing economies-- Singapore and Hong Kong. Elsewhere, static demand systems with prices and incomes adequately explained demand growth. Income growth has been the most important determinant of demand growth and income elasticities are large and significant for poultry products in all countries.

The price determination model and specification tests showed that poultry prices have been predetermined by cost-reducing technological change. This change has reduced real prices of poultry in four of these countries, either through the import price or through reducing domestic costs of production. Only in South Korea, where imports have been prohibited, have real prices remained virtually constant. The transfer of

broiler technology to the other countries means that declining real poultry prices is an international phenomenon, and not isolated to the U.S.

The results indicate that there is still potential for further growth in consumption in the 3 major Asian importers, Japan, Singapore, and Hong Kong. Although feed and technology can be imported, production growth in these countries is likely to be constrained by available resources, especially land. Thus there are continued positive prospects for poultry exporters like the U.S. South Korea's market potential cannot be realized until trade barriers for poultry are eliminated, but the positive effects of general trade liberalization would likely accrue to beef exporters to that country. Thailand's consumption growth will probably not interfere with its developing poultry export industry, and thus continued technological change in the U.S. will be needed to maintain a competitive advantage.

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FOOTNOTES

1. Traditional chicken production, on the other hand, consists of native birds allowed to roam free and scavenge. The reproductive rate is low, and scavenged feed supply limits growth in output.

2. The 1980 tariff was 20% on all chicken meat other than frozen bone-in and 13.5% on bone-in chicken legs. These tariffs have been reduced to 14% and 10%, respectively, as part of the Tokyo round of GATT negotiations (Bishop et al).

3. Estimates of the partial adjustment model for Hong Kong produced serially correlated residuals and thus were inferior statistically to the autoregressive model. The partial adjustment model for Singapore produced reasonable statistical estimates and a long run price elasticity very close to that reported in Table 3. The coefficient of q_{t-1} was insignificant in the partial adjustment model estimates for the other three countries, which further confirms that the static model is most appropriate for these countries.

4. The long run income elasticity estimate from the ECM is 1.85, which is also quite high.

5. Fish is the most important source of protein in these five countries, accounting for one-half or more of total volume of meat, fish, and poultry consumed. Because a wide variety of fish products are consumed, there are difficulties in finding a representative fish price. An index of fish prices is available from country sources for Japan, South Korea, and Singapore. However, this index increased in real terms over time, which probably indicates that income growth has led to substitution among fish products towards higher quality fish. Thus cross-price estimates would be biased downward. For the sake of simplicity, we are assuming in this study that the "specialty" meats (chicken, beef, and pork) are weakly separable from fish, the main source of protein.

6. Dropping the beef and pork prices from the Thai demand equation yielded significant own-price elasticity estimates, indicating some multicollinearity problems in the Thai data.

Table 1: Summary of Poultry Market Indicators

	Japan	Singapore	Hong Kong	S. Korea	Thailand
Production (1000MT)					
1970-74	590	21	13	56	79
1984-88	1415	56	59	145	440
Ann. Growth (%)	6.4	7.3	11.4	7.0	13.1
Per Cap. Consumption (kg)					
1970-74	5.7	12	10.9	1.7	2.1
1984-88	13.1	35.1	23.2	3.5	7
Ann. Growth (%)	6.1	8.0	5.5	5.3	9.0
Total Consumption (1000MT)					
1970-74	613	26	45	56	79
1984-88	1585	91	128	145	371
Ann. Growth (%)	7.0	9.4	7.8	7.0	11.7
GNP per Capita					
1984-88 (US$)	16125	7815	7419	2785	842
Ann. Growth (%) 65-88	4.3	7.2	6.3	6.8	4.0
Ann. Growth (%) 80-88	2.9	5.7	5.3	7.9	3.5
Retail Prices					
Real Price Total % Change 70/74-84/88	-39	-24	-21	-03	-34
Real Price Ann. % Change	-3.5	-2.0	-4.3	-0.4	-5.1
Net Imports (1000MT)					
1970-74	23	4	32	0	0
1984-88	170	35	69	0	-69
Data Series Cover	61-88	62-88	66-88	61-87	70-88

Table 2: Tests of Alternative Dynamic Models

Country	PA[1]	AR[1]	Static[2]
Japan	6.337	12.016	7.180
Korea	7.828	14.437	8.709
Thailand	4.341	16.993	4.596
Hong Kong	1.948	1.969	54.324
Singapore	3.502	0.640	22.040

[1]Test statistic for restrictions in Equation 3 or 4 in the text. Statistic is distributed asymptotically chi-squared with 4 degrees of freedom. A 5% cutoff is given by 9.49.
[2]Test statistic for restrictions leading to Equation 7 in the text. Statistic is distributed asymptotically chi-squared with 5 degrees of freedom. A 5% cutoff is given by 11.07.

Table 3: Estimates of Poultry Demand Parameters for 5 Asian Countries

Coefficient and t-statistic:	Japan	Singapore[1]	Hong Kong[1]	S. Korea	Thailand
Own-Price	-0.55	-0.47	-0.56	-0.35	-0.63
	(-2.03)	(-0.42)	(-1.13)	(-1.16)	(-1.08)
Income	2.16	1.36	0.95	0.48	1.07
	(8.73)	(2.80)	(4.26)	(3.09)	(1.75)
Beef	0.24	0.24	-0.23	0.79	0.49
	(0.78)	(0.31)	(-0.91)	(3.47)	(0.98)
Pork	-0.10	0.06	0.16	-0.18	-1.64
	(-0.38)	(0.08)	(0.51)	(-0.58)	(-2.98)
R^2	.99	.94	.93	.92	.91
Durbin-Watson	1.50	1.68	1.74	2.06	1.64

[1]Cochran-Orcutt corrected estimates.

Table 4: Estimates of Poultry Price Determinants[1]

Coefficient and t-statistic:	Japan	Singapore	Hong Kong	S. Korea	Thailand
Corn Price	0.09 (1.77)	-0.12 (-1.59)	0.34 (3.52)	0.19 (1.56)	0.10 (1.20)
Feed Conversion	5.64 (5.61)	2.70 (2.55)	2.10 (2.54)	2.05 (1.48)	4.57 (2.81)
R^2	.96	.89	.79	.39	.95
Durbin-Watson	2.06	1.83	1.65	1.73	1.79
Residuals' t-statistic in demand equation	0.62	-1.11	1.04	-0.70	0.24

[1]Cochran-Orcutt corrected estimates.

Table 5: Estimated Future Growth in Per Capita Consumption (annual average % growth)

	Japan	Singapore	Hong Kong	S. Korea	Thailand
Income Growth Only	6.3	7.8	5.0	3.8	3.7
Income Growth Plus Declining Price	6.9	8.3	5.6	4.2	4.3

Note: Estimated using elasticities in Table 3; income growth assumed equal to 80-88 average in Table 1; price decline assumed to equal -1% per year.