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by

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No. 2000-9 – August 2000

Working Paper Series in

Agricultural and Resource Economics

ISSN 1442 1909

http://www.une.edu.au/febl/EconStud/wps.htm

 ISBN 1 86389 702 X

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Abstract

Although a relatively small producer, Australia exports but about 90% of its cotton production, making it the third largest cotton exporter. This means that export performance plays a major role in determining the profitability of the Australian cotton industry. The primary aim was to determine the competitive position of Australian cotton in the Japanese market, based on the AIDS model using data from 1972 to 1998. The main findings were that the United States had a relatively strong market position and that to improve its market position, Australia should become more cost competitive and/or improve its quality image through promotion

Key Words: almost ideal demand system, cotton marketing, import demand, Japan

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* The author wishes to thank Dr Garry Griffith, NSW Agriculture for providing useful comments and Mr Michael Chua, School of Economic Studies, University of New England for providing the formulas for calculating standard errors for AIDS demand elasticities.

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Introduction

The Australian cotton industry has become one of the fastest growing sectors in Australian agriculture in recent years (Beare 1999). This growth is likely to continue because cotton production is seen to be more profitable than conventional farm enterprises such as wheat, wool and beef, even though water availability may constrain growth in some regions. Cotton exports in 1997 were 592.9 kt, generating about $1.3 billion dollars in export revenues (ABARE 1998). Although a relatively small producer, about 90% of Australia's cotton production were exported making it the third largest cotton exporter, following the United States and Uzbekistan. This means that export performance plays a major role in determining the profitability of the Australian cotton industry.

The primary aim of this study is to determine the competitive position of Australian cotton, relative to US cotton, in the Japanese market, based on the Almost Ideal Demand System (AIDS) (Deaton and Muellbauer 1980a). The specific objectives are: (1) to test for various theoretical restrictions suggested by demand theory; (2) to estimate import demand elasticities of cotton from major suppliers in the Japanese market; and (3) to derive policy implications for marketing Australian cotton in Japan. The results of the study are expected to provide useful information for policy makers in government and industry organisations assisting the Australian cotton industry to adapt in a highly competitive and changing environment.

A brief overview of the market positions of Australian and US cotton in the Japanese market is provided next. Then the AIDS model and the data used in the empirical analysis are introduced. This is followed by a discussion of the study's main findings, including estimated results and policy implications. Finally, some concluding remarks are provided.

The cotton market

The major cotton producing countries in 1996/1997 were China, the United States, India, Pakistan, Uzbekistan, Australia and Turkey, contributing about three quarters of the world's total cotton output (ABARE 1998). The major exporting countries were the United States, Uzbekistan, and Australia, together accounting for over half of the world's total cotton exports. Major importing countries were located mainly in North and South East Asia and the European Union. They included China, Japan, Hong Kong, South Korea, Taiwan, Indonesia, Thailand, Italy and France.

Nearly 90 percent of Australia's cotton exports were sent to Asia, with the remainder going to Western Europe (six percent) and other regions. Western Europe used to be an important market for Australia. However, exports of Australia to that region have significantly reduced as Asian markets expand (CRDC 1995, p.15). Imports by Asian countries accounted for 48 percent of the world's total cotton imports in 1996/97.

The major export markets of Australian cotton in Asia were Indonesia, Japan, China, Thailand, South Korea and Taiwan. Although Indonesia was the leading buyer of Australian cotton in recent years, the focus of this study is on the Japanese market as Japan has been the major customer for Australian cotton for more than two decades. This long-term trading relationship not only allows Australia's market position in the Japanese market to be examined more fully but also provides data that are necessary for such an analysis. In 1996/97, cotton exports to Japan accounted for 16 percent of total Australian cotton exports.

The major cotton suppliers to Japan are the United States and Australia. Together, they accounted for nearly 85 percent of the total imports. The remaining 15 percent came from India, Mexico, Pakistan, Uzbekistan and others, each with a limited market share. Cotton exports to Japan accounted for about 12 percent of total US cotton exports. One of the problems confronting the Japanese textile industry is increasing competition from countries such as China, India, Pakistan, and Indonesia in the domestic and export markets, resulting in a steady decline in demand for cotton in Japan. One of the objectives of this analysis is to determine the impact of declining cost competitiveness of the Japanese textile industry on demand for Australian cotton and what it means for the Australian cotton industry.

The empirical model

The Almost Ideal Demand System (AIDS) (Deaton and Muellbauer 1980a) was selected as the specification for the empirical analysis. The AIDS model has been used extensively in applied demand analysis in recent years because of its theoretical consistency and functional flexibility. It satisfies the axioms of choice exactly and allows exact aggregation over consumers. Its flexibility provides an arbitrary first-order approximation to any demand system and enables the testing of the homogeneity and symmetry conditions through linear restrictions on fixed parameters. As such, the AIDS model is considered appropriate for the empirical estimation of demand parameters and testing of theoretical restrictions in this study.

The AIDS model is derived from a well-behaved expenditure function defined by

$$(1) \qquad \log c(u, p) = \alpha_0 + \sum \alpha_k \log p_k + ½ \sum \sum \gamma_{kj}^* \log p_k \log p_j + u \beta_0 \prod p_k^{\beta k},$$

where c (u, p) is the expenditure function that belongs to the PIGLOG class, p is the vector of prices, and u is the utility level; and α, β, and γ^* are parameters of the expenditure function. A system of Hicksian demand functions, q_i, can be obtained by taking the derivative of the expenditure function with respect to prices. That is,

(2) $\partial c(u, p) / \partial p_i = q_i (u, p), i = 1, 2, \ldots, n.$

Multiplying both sides of equation (2) by (p_i / c (u, p)) produces the demand equations in share form,

(3) $\partial \log c (u, p) / \partial \log p_i = p_i q_i / c(u, p) = w_i (u, p).$

Since for a utility-maximising consumer at optimum the minimum cost, c(u, p), will be equal to total expenditure, x, c(u, p) in equation (3), which is not unobservable, can be replaced with x, which is observable. Also, u can be expressed in terms of variables and other parameters in equation (1). Hence, after substitution for c(u, p) and u and with term manipulation, the budget share equations, which are now a function of p and x, are defined by

(4) $w_i (p, x) = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log (x / P),$

where P is the Translog price index, defined by

(5) $\log (P) = \alpha_0 + \sum_i \alpha_i \log p_i + ½ \sum_i \sum_j \gamma_{ij} \log p_i \log p_j$, and

(6) $\gamma_{ij} = ½(\gamma_{ij}^* + (\gamma_{ji}^*) = \gamma_{ji}.$

The system of equations thus derived is the AIDS model of Deaton and Muellbauer (1980a).

The theoretical restrictions, which are implied by the theory, are satisfied if the following conditions hold:

Adding-up: $\sum_i \alpha_i = 1, \ \sum_i \gamma_{ij} = 0, \ \sum_i \beta_i = 0;$

Homogeneity: $\sum_j \gamma_{ij} = 0$, for i = 1, 2, …, n; and

Symmetry: $\gamma_{ij} = \gamma_{ji}$, for all $i \neq j$.

The homogeneity and symmetry conditions can be tested empirically. However, the adding-up condition is not testable since the data add up by construction.

The negativity conditions will be satisfied if the matrix C, defined by

(7) $c_{ij} = \gamma_{ij} + \beta_i \beta_j \log (x / P) - w_i\delta_{ij} + w_i w_j$,

is negative semidefinite, where δ_{ij} is the Kronecker delta that takes the value of one if $i = j$ and zero otherwise (Deaton and Muellbauer (1980b, p.76). Further, the C matrix is related to the Slutsky matrix, S, as $c_{ij} = p_i p_j s_{ij} / x$. As such, the matrix whose elements are the γ_{ij} is not required to be negative semidefinite. Moreover, the symmetry condition of the matrix S does not imply that the matrix C is be symmetric.

The demand elasticities for the AIDS model are calculated, based on the formulas in Deaton and Muellbauer (1980a), as

(8) Expenditure elasticities: $\eta_i = 1 + (\beta_i / w_i)$;

(9) Own-price elasticities: $e_{ii} = -1 + (\gamma_{ii} /w_i) - (\beta_i / w_i) (\alpha_i + \sum_k \gamma_{ki} \log p_k)$; and

(10) Cross-price elasticities: $e_{ij} = (\gamma_{ij} /w_i) - (\beta_i / w_i) (\alpha_j + \sum_k \gamma_{kj} \log p_k)$.

The AIDS model presented in equations (4) and (5) means that the model is non-linear both in parameters and variables. To avoid the complications of estimating a system of non-linear functions, a linearized version of the AIDS model (LA/AIDS) is usually used in applied work as an approximation for equation (4). In such a case, the Translog price index P defined in equation (5) is replaced by the Stone price index, P*, defined by

(11) $\log (P^*) = \sum_i w_i \log p_i$.

It is argued that the approximation would be reasonable if prices were highly collinear and as such P* would be proportional to the Translog price index (Deaton and Muellbauer (1980a). That is,

(12) $\log P^* \cong \lambda \log P$.

Because P* does not involve unknown parameters, it can be calculated before estimation. Therefore, instead of estimating a set of non-linear equations, one would estimate

(13) $w_i(p, x) = \alpha_i + \sum \gamma_{ij} \log p_j + \beta_i \log (x / P^*)$, i = 1, 2,…, n.

Various formulas for calculating elasticities associated with the LA/AIDS model have been suggested (Green and Alston 1990, 1991; Hahn 1994). Some treat the LA/AIDS as a model in its own right and elasticities are calculated accordingly. Others use the LA/AIDS to estimate the parameters and calculate elasticities based on the formulae derived from the original AIDS model. Either approach has been criticised for being internally inconsistent or lacking in approximation property (Eales and Unnevehr 1993; Buse 1994; Hahn 1994; Moschini 1995).

The debate on the LA/AIDS model started when Alston and Green (1990, 1991) “suspected” some econometric problems in estimating the LA/AIDS model. Later, it became apparent that there were various problems associated with the use of the Stone price index. For instance, Eales and Unnevehr (1993) showed that there is a simultaneity problem because the shares in the Stone price index would be correlated with the error term since shares also appear on the left hand side and are functions of the error term. Buse (1994), on the other hand, argued that if the proportionality between P and P*, as proposed by Deaton and Muellbauer (1980a), is not exact, then there is an errors-in-variable problem, resulting from the Stone price index being correlated with the error term. Pashardes (1993) also showed that the Stone price index approximation results in an omitted variable problem. These claims mean that the LA/AIDS estimates will be biased and inconsistent.

In addition to the econometric problems, the LA/AIDS model also was found to be theoretically undesirable. Hahn (1994) showed that while the AIDS model has desirable theoretical properties, the LA/AIDS does not. This is because the LA/AIDS model satisfies restrictions of, and is consistent with, demand theory only locally. Finally, Moschini (1995) argues that the LA/AIDS model is not derived from a well-specified representation of preferences and as such cannot be treated as a demand system in its own right. Moreover, the Stone price index was shown not to be a good approximation for the Translog price index because it is not invariant to changes in units of measurement and hence not a valid index number. Various suggestions were proposed to resolve some of these issues. However, Hahn (1994) strongly advised that for sensible results only the original AIDS model, not any of its linear approximations, should be estimated. Based on these arguments, the empirical results for this study are obtained from estimating the original complete non-linear version of the AIDS model.

The empirical AIDS model for cotton imports to the Japanese market is specified in equations (13) – (15) as follows

(13) $W_{USA} = \alpha_1 + \gamma_{11} \log (P_{USA}) + \gamma_{12} \log (P_{AUS}) + \gamma_{13} \log (P_{ROW}) + \beta_1 \log\{ x / P\} + e_{1t}$,

(14) $W_{AUS} = \alpha_2 + \gamma_{21} \log (P_{USA}) + \gamma_{22} \log (P_{AUS}) + \gamma_{23} \log (P_{ROW}) + \beta_2 \log\{ x / P\} + e_{2t}$,

and

(15) $W_{ROW} = \alpha_3 + \gamma_{31} \log (P_{USA}) + \gamma_{32} \log (P_{AUS}) + \gamma_{33} \log (P_{ROW}) + \beta_3 \log\{ x / P\} + e_{3t}$,

where the W_{USA}, W_{AUS} and W_{ROW} are market shares (in value terms) of the United States, Australia and ROW, respectively; P_{USA}, P_{AUS} and P_{ROW} are unit import values of cotton from the United States, Australia and ROW, respectively; x is the value of total cotton imports in Japan; P is the Translog price index; and e_{1t}, e_{2t} and e_{3t} are the error terms, which are assumed to be normally distributed with constant means and variances and may be contemporaneously correlated.

This model is developed under the assumption that decisions on imports by the Japanese textile industry are made based on a two-stage budgeting procedure (Deaton and Muellbauer 1980b, pp. 122-126). In the first stage, total expenditure is allocated over broad groups of commodities such as cotton, wool and synthetics. In the second stage, group expenditure on cotton, which is now assumed to be exogenous, are allocated over individual commodities, such as cotton from the United States, Australia and other sources.

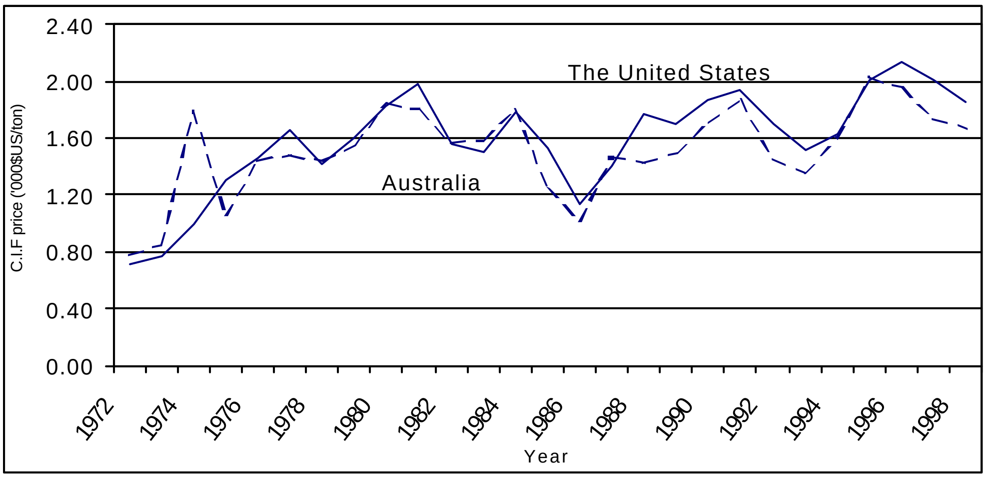
Data and data sources

The data used in the analysis are annual data from 1972 to 1998 on cotton import prices and quantities into Japan from major cotton suppliers, the United States and Australia and all others. The data were collected from Statistical Papers: 'Commodity Trade Statistics' published by the United Nations from 1973 to 1995. However, after 1995, the statistical papers were not available in the public domain. Therefore, the data from 1995-1998 were purchased directly from the office of the Commodity Trade Statistics, United Nations, New York.

The unit import values (equivalent to average c.i.f prices) are calculated by dividing the total import value by total import volume for each individual supply source. Based on the data from 1972 to 1998, the average unit import values were $US1582.40/tonne, $US1516.70/tonne and $US1621.50/tonne for cotton from the United States, Australia and ROW, respectively. Average market shares (in value terms) during the same period were around 41 percent, 12 percent and 47 percent for the United States, Australia and ROW, respectively. Summary statistics for unit import values and market shares are presented in Table 2. Also shown in Table 2 is that during the sample period, market shares tended to be more variable than prices, as indicated by the coefficients of variation (COV).

Unit import prices and market shares of US and Australian cotton in the Japanese market are presented in Figures 1 and 2.

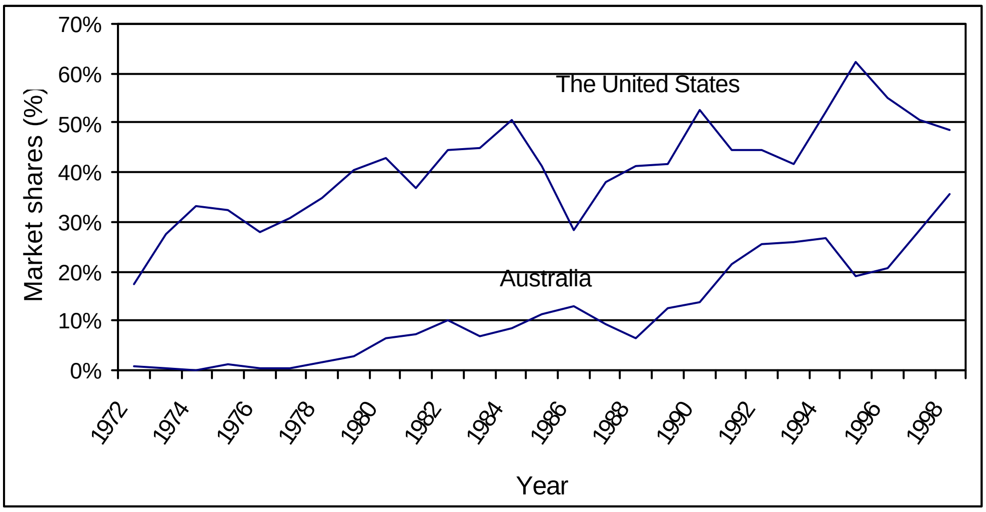
Figure 1. The import cotton prices for the United States and Australia, 1972-1998



It is evident that the two cotton prices follow each other quite closely, with US prices generally higher than the Australian prices. The price differentials may be a reflection of the differences in quality and transport costs. In any event, Australian cotton appears to have a cost advantage over US cotton.

From Figure 2, it can be seen that the United States is the dominant cotton supplier in the Japanese cotton market and a substantial gap exists between the United States and Australia in terms of market share. However, the gap appears to be closing up in recent years as Australian cotton production and exports have expanded.

Figure 2. Market shares of the United States and Australia, 1972-1998



Estimated results

Since one of the objectives of this study is to test the validity of general restrictions implied by the theory, three versions of the AIDS Model were developed and estimated. The first sub-model is the original AIDS without any constraints on the parameters except the adding-up restrictions, which are automatically satisfied. Sub-model 2 imposes the adding-up and homogeneity restrictions. And sub-model 3 imposes the adding-up, homogeneity and symmetry restrictions jointly. The homogeneity restriction is tested based on the values of the log-likelihood functions of sub-models 1 and 2 and joint homogeneity/symmetry restrictions are tested based on sub-models 1 and 3, using sub-model 1 as the unrestricted model. Because these restrictions are not independent of each other and the imposition of symmetry and adding-up restrictions automatically forces the homogeneity condition to be satisfied, the symmetry condition was tested based on sub-models 2 and 3, using sub-model 2 as the “unrestricted” model. The restrictions imposed on the sub-models are listed in Table 3 and the sub-models are defined in Table 4.

Note that because the all the price coefficients appear in the Translog price index, the number of degrees of freedom associated with each restriction does not necessarily coincide with the number of equations listed in Table 3. The number of parameters for each sub-model is indicated in column 2 of Table 4. Also, to facilitate the calculation of the standard errors for demand elasticities, all prices and total expenditure are normalised using their mean values before estimation. And elasticities are then evaluated based on the mean values of the normalised variables.

Finally, because the contemporaneous variance-co-variance matrix of the error terms is singular (due to the fact that budget shares add up to one), the models are estimated by deleting one equation from the system. The equation deleted is the demand equation for cotton from ROW. The remaining set of equations are estimated as a non-linear seemingly unrelated regression system using SHAZAM (White 1997). The iterative procedure is equivalent to the maximum likelihood estimation. The test results based on likelihood ratios are presented in Table 4.

- **Hypothesis tests**

As can be seen from Table 4, all the calculated Chi-squared values are greater than the corresponding critical values, suggesting that the homogeneity and symmetry conditions either alone or jointly are strongly rejected by the data.

The rejection of the homogeneity or symmetry condition found in this study is not new. That is, empirical demand studies often found that theoretical restrictions do not hold (Deaton and Muellbauer 1980b, pp.68-73; Cozzarin and Gilmour 1998). Cozzarin and Gilmour found homogeneity (symmetry) was tested in 29 (36) percent of the models that were surveyed and was rejected 57 (51) percent of the time. However, the rejection of the homogeneity or symmetry restriction does not necessarily mean that the theory is wrong; rather, it may be the case that the data and model combined do not support the theory either because of data property and/or model specification.

In terms of data problems, it is argued, as discussed in Deaton and Muellbauer (1980a), that market data that are used in most demand studies may not be suitable for analysing individual behaviour, on which the theory is based. Moreover, measurement errors in data and the use of proxy variables may have made it difficult to obtain reasonable empirical results. Model misspecifications include ignoring dynamic effects and omitting variables such as stock, lagged dependent variable and price expectations. Also, Syriopoulos and Sinclair (1993) argued that despite being a flexible demand system, the AIDS model is in fact quite rigid and restrictive as it requires the vector of explanatory variables to be identical in all equations. Such restrictions are likely to result in over-simplified or mis-specified models.

Buse (1998) also contended that the use of the Stone price index and various problems associated with it, as discussed before, also contributed to the rejection of theoretical restrictions in the LA/AIDS model. Other possible causes are expenditure endogeneity (Attfield 1985), the presence of nonstationarity (Ng 1995) and the inappropriate use of test criteria (Phlips 1983, p.55). Because of invalid test procedures, Phlips concluded that most test results were not reliable and should not be taken seriously. It was suggested that to have meaningful measurements, all the general restrictions must be imposed in the demand system regardless of the test results.

Despite the merits of using prior information, imposition of restrictions when they are not true or supported by the data produces estimates that are biased (Griffiths, Hill and Judge 1993, p.376). Taking these two considerations into account, the middle ground is taken in this study. That is, estimated results from both the restricted and the unrestricted models are estimated. However, the results from the unrestricted model are discussed fully in the text because of its econometric properties. Results from the restricted model are presented in the Appendix A for comparison purposes. Note that results from both models are similar qualitatively, with few exceptions.

- **Estimated demand elasticities**

As can be seen from Table 5, the estimated price coefficients are mostly statistically insignificant at the 10 percent level, except for the cross-prices coefficient in the Australian and ROW equations with respect to the US price. The coefficients associated with total expenditure are highly statistically significant. These results are consistent with the findings that the demand response to total expenditure is relatively easy to measure with precision while price responses are more difficult to obtain (Deaton and Muellbauer 1980b, p. 78).

Moreover, some of the signs associated with individual coefficients may appear to be counter-intuitive. However, since elasticities of the AIDS model are non-linear functions of estimated parameters and variables, as indicated in equations (8) – (10), estimated individual coefficients may not have the usually economic interpretation and may not have the same sign as corresponding elasticities. For example, the diagonal elements of the price matrix are not the own-price responses and should not be expected to be negative as in a linear demand function. Another example is that, although it was indicated by Deaton and Muellbauer (1980a) that βs are positive for luxuries and negative for necessities, some commodities may be inferior when interpreted in elasticity terms. This turns out to be the case for Australian cotton in this study. As such, we will focus our discussions based on elasticity figures. Finally, because the primary objective of this analysis is to investigate the relative market position of US and Australian cotton in the Japanese market, only results that are directly relevant to these two suppliers will be discussed in detail. Results that are related to ROW supplier would only be discussed where appropriate.

Demand elasticities, along with their standard errors, for cotton imports in the Japanese market are presented in Table 6. They are calculated based on the mean values of the normalised prices, where all prices are unity. Although normalisation does not alter the estimated results, Asche and Wessells (1997) showed that the expressions for price and expenditure elasticities from the LA/AIDS model are identical to the AIDS model at the point of normalisation.

First, the estimated expenditure elasticities for the United States and Australia are 0.73 and –0.87, respectively. These results indicate that US cotton is a normal good while Australian cotton is an inferior good. This means when total expenditure on cotton imports in Japan increases by one percent, *ceteris paribus*, the quantity demanded of US cotton will increase by 0.73 percent and that of Australian cotton will decrease by 0.87 percent. These results may imply that US cotton was perceived to be of better quality than

Australian cotton. This is because income (expenditure) elasticities are thought generally to be higher for the best or preferred grade and smaller for lower grades (Tomek and Robinson 1990, p.130). This means that the United States may have a stronger market position in the Japanese market for being the preferred supplier with better products. A positive correlation between product quality and expenditure elasticity was reported in Chang and Hsia (2000), where Australian beef export to Taiwan was found to be an inferior good while US beef and New Zealand beef were normal goods.

However, being perceived as an inferior product may not be all that bad. This is particular true considering the recent economic performance in Japan, which had led to a significant reduction in Japan's total cotton imports. As a result, cheaper products from Australia might in fact be preferred to higher quality but more expensive products. As such, Australia can be seen to have an advantage over the short to medium term. However, when the Japanese economy recovers and the demand for higher quality cotton increases accordingly, Australia will need to pay more attention to upgrading its product quality and image in order to improve its market position in the longer term.

Secondly, estimated own-price elasticities for the Unites States and Australia are –0.71 and –1.28, respectively. The result suggests that the demand for US cotton is own-price inelastic while the demand for Australian cotton is own-price elastic. Alston et al. (1990) estimated own-price elasticities for US cotton in Japan to be –2.92 (based on the LA/AIDS model) and –1.12 (based on the Armington model). There are no comparable figures for Australian cotton.

That the demand for Australian cotton is own-price elastic means that cotton exports to Japan would be greatly and negatively affected by an increase in its own price, *ceteris* *paribus*. It also means that the demand for Australian cotton, as well as export revenues, can be effectively increased with a price reduction. However, given that the own-price elasticity is statistically insignificant at the usual level, the result should be interpreted with caution.

Thirdly, the results from Table 6 show that US and Australian cotton are substitutes for each other. This is reflected in the positive values of the cross-price elasticities. Specifically, the estimated cross-price elasticities are 0.19 and 2.80. This means a one percent increase in the price of the US cotton, *ceteris paribus*, will lead to a 2.80 percent increase in the quantity demanded of Australian cotton. By contrast, a one percent increase in Australian cotton price, *ceteris paribus*, will result in a 0.19 percent increase in the quantity demanded of US cotton. Note that the cross-price elasticity of US cotton with respect to the Australian price is statistically insignificant at the usual level. As such, Australian cotton is seen as a strong substitute for US cotton; however, the reverse is not true. What this means is that, Japan tends to switch to Australian cotton when US cotton becomes relatively more expensive, but an increase in the Australian price relative to the US price does not encourage the substitution of Australian cotton by US cotton.

The fact that the demand for Australian cotton is more sensitive to changes in its own price and that Australian cotton is seen as a strong substitute for US cotton suggest that the demand for Australian cotton may be improved by lowering its prices. This means that increasing production efficiency, and hence cost competitiveness, may be one chief means of improving the industry’s export performance in the Japanese market.

The estimated results from the unrestricted AIDS model can be summarised as follows: (1) that Australian cotton is seen as an inferior good and (2) that the United States is obviously a strong competitor for Australia in the Japanese cotton market. Furthermore, the opportunity exists for the Australian cotton industry to improve its market position by appropriate management and marketing strategies. These include increasing production efficiency along the supply chain to lower costs as well as embarking on promotion campaigns to improve quality image. The next question is: how should industry funds be allocated between research, which increases production efficiency on the supply side, and promotion, which expands demand (Hill, Piggott and Griffith 1995). However, the question is beyond the scope of this study and further research is needed to examine the issue.

Conclusions

Australia and the United States are the major cotton suppliers to Japan, together accounting for nearly 90 percent of total cotton imports in the Japanese market in recent years. Although the United States has a dominant position in the past two decades, Australia has recently increased its market share in Japan. Therefore, it can be said that the market position of Australia has improved and can be improved further if appropriate policies are formulated and exercised. The primary aims of this study were to determine the competitive position of the Australia cotton relative to the United States in the Japanese market and to provide policy recommendations for improving its export performance. The analysis was based on the original AIDS model using data from 1972 to 1998. In the process, theoretical restrictions suggested by the theory were also tested.

In terms of hypothesis testing, the homogeneity and symmetry restriction were rejected strongly. Possible reasons for the rejections were discussed in detail. In terms of estimated demand elasticities, the study found that Australian cotton is seen as an inferior good while US cotton is a normal good. The study also found that the demand for Australian cotton is more own-price elastic than the demand for US cotton. Moreover, Australian cotton was found to be a stronger substitute for US cotton, but the reverse in not true. Being an inferior product may be an advantage in the short to medium term when the Japanese economy is weak. It was concluded that to be competitive in the longer term it is necessary for the Australian cotton industry to lower the costs and/or improve its quality image through effective promotional campaigns. However, further research is needed to determine the allocation of funds between research and promotion.

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Table 1. The world market for cotton lint, 1996/1997

	Production	Consumption	Export	Import
	in kt			
World	19472	19205	5856	6354
USA	4124	2799	1495	174
China	4202	--[a]	2	787
Australia	608.3	33.0	505.0	--
Japan	--	323	--	292

[a] Figures are not available.

Source: Australian Commodity Statistics, ABARE, 1998; http://apps.fao.org; http://www.icac.org/icac/cottoninfo/press/press.html.

Table 2. Summary statistics of cotton prices and market shares in the Japanese market,[a] 1972-98

	Mean	St deviation	COV[b]	Minimum	Maximum
W_{USA}	40.99	9.94	0.24	17.51	62.13
W_{AUS}	11.72	10.24	0.87	0.20	35.62
W_{ROW}	47.29	18.42	0.39	15.67	81.70
P_{USA}	1582.40	361.20	0.23	718.41	2136.50
P_{AUS}	1516.70	317.20	0.21	774.52	2022.50
P_{ROW}	1621.50	365.10	0.23	769.11	2126.60

[a] Market shares are measured in percentages and prices are measured in US dollars/tonne.
[b] COV = Coefficient of Variation = Mean / St. deviation.

Table 3. Theoretical restrictions imposed on various versions of the AIDS model

Adding-up restrictions	Homogeneity restrictions	Symmetry restrictions
$\alpha_1 + \alpha_2 + \alpha_3 = 1$, $\beta_1 + \beta_2 + \beta_3 = 0$, $\gamma_{11} + \gamma_{21} + \gamma_{31} = 0$, $\gamma_{12} + \gamma_{22} + \gamma_{32} = 0$, and $\gamma_{13} + \gamma_{23} + \gamma_{33} = 0$.	$\gamma_{11} + \gamma_{12} + \gamma_{13} = 0$, $\gamma_{21} + \gamma_{22} + \gamma_{23} = 0$, and $\gamma_{31} + \gamma_{32} + \gamma_{33} = 0$.	$\gamma_{12} = \gamma_{21}$, $\gamma_{13} = \gamma_{31}$, and $\gamma_{23} = \gamma_{32}$.

Table 4. Likelihood ratio test results for various combinations of theoretical restrictions

Sub-models	No. of parameters	Calculated X^2	Calculated X^2
Sub-model 1: Adding-up restrictions	10	--	
Sub-model 2: Adding-up + Homogeneity restrictions	8	$X^2_{(2)} = 20.64$*	--
Sub-model 3: Adding-up + Homogeneity + Symmetry restrictions	7	$X^2_{(3)} = 26.23$*	$X^2_{(1)} = 5.60$*
* indicates that the differences in log likelihood values are statistically significantly different at the five percent level. At the 95% level of confidence, the critical X^2 values are: $X^2_{(1)} = 3.84$; $X^2_{(2)} = 5.99$; and $X^2_{(3)} = 7.81$.			

Table 5. Estimated coefficients of the unrestricted AIDS model (without symmetry or homogeneity restrictions), 1972-1998

	USA	Australia	ROW[b]
US price	0.07 (0.70)[a]	0.24 (2.13)	-0.31 (-1.75)
AUS price	0.07 (0.66)	-0.06 (-0.50)	-0.01 (-0.04)
ROW price	0.11 (0.85)	-0.14 (-0.98)	0.03 (0.12)
Total expenditure	-0.11 (-2.95)	-0.22 (-5.15)	0.33 (4.92)
Constant	0.42 (44.02)	0.12 (10.50)	0.46 (27.16)

[a] Figures in parentheses are t-ratios.

[b] Parameters associated with the demand equation for ROW cotton are derived from the adding-up restrictions. Their corresponding standard errors are calculated based on the following formula: Var (x ± y) = Var (x) + Var (y) ± 2 Cov (x, y) (Kmenta 1986, p.71).

Table 6. Estimated elasticities for the unrestricted AIDS model (without symmetry or homogeneity restrictions), 1972-1998

	Price elasticities			Expenditure
	US	Australia	ROW	Elasticities
US	-0.71 (-2.99)	0.19 (0.81)	0.41 (1.20)	0.73 (7.87)
Australia	2.80 (3.27)	-1.28 (-1.27)	-0.34 (-0.26)	-0.87 (-2.03)
ROW	-0.95 (-2.62)	-0.01 (-0.24)	-1.27 (-2.41)	1.70 (11.89)

Appendix A.1. Estimated coefficients of the restricted AIDS model (with symmetry or homogeneity restrictions), 1972-1998

	USA	Australia	ROW
US price	-0.18 (-1.24)a	0.05 (0.58)	0.13 (0.67)
AUS price	0.05 (0.58)	-0.01 (-0.13)	-0.04 (-0.26)
ROW price	0.13 (0.67)	-0.04 (-0.26)	-0.09[b] (0.30)
Total expenditure	-0.22 (-4.49)	-0.25 (-6.63)	0.47 [b] (6.46)
Constant	0.41 (27.57)	0.11 (9.93)	0.48 [b] (22.07)

[a] Figures in parentheses are t-ratios.

[b] Parameters associated with the demand equation for ROW cotton are derived from the adding-up restriction. Their corresponding standard errors are calculated based on the following formula: Var (x ± y) = Var (x) + Var (y) ± 2 Cov (x, y) (Kmenta 1986, p.71).

Appendix A.2. Estimated elasticities the restricted AIDS model (with symmetry or homogeneity restrictions), 1972-1998

	Price elasticities			Expenditure
	US	Australia	ROW	Elasticities
US	-1.21 (-3.57)	0.19 (0.85)	0.57 (1.21)	0.46 (3.67)
Australia	1.32 (1.67)	-0.87 (-0.99)	0.69 (0.51)	-1.13 (-2.81)
ROW	-0.14 (-0.38)	-0.20 (-0.64)	-1.66 (-2.64)	2.00 (12.63)