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Effects of changes in wool prices and wages on Japanese demand for wool

An overview

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An annual econometric model of the Japanese wool textile industry and imports of greasy and semiprocessed wool to Japan from various countries was used to examine the effect of changes in wool prices on Japanese imports of wool. The partial price elasticity (holding demand and supply elsewhere constant) of Japanese demand for Australian wool was estimated to be –0.23 in the short term (less than one year), rising to –1.20 after one year because there are lagged responses to changes in price along the wool processing chain.

Japan has imported more Australian wool than any other country for more than two decades. However, direct imports of Australian wool have fallen over this time and are likely to continue to fall as the wool textile industry in Japan adjusts, based on the assumption that wage rates will continue to rise and that the yen will continue to appreciate. Offsetting this decline, Japan has increased its indirect imports of Australian wool by importing more finished wool products and semiprocessed wool from countries which import Australian greasy wool.

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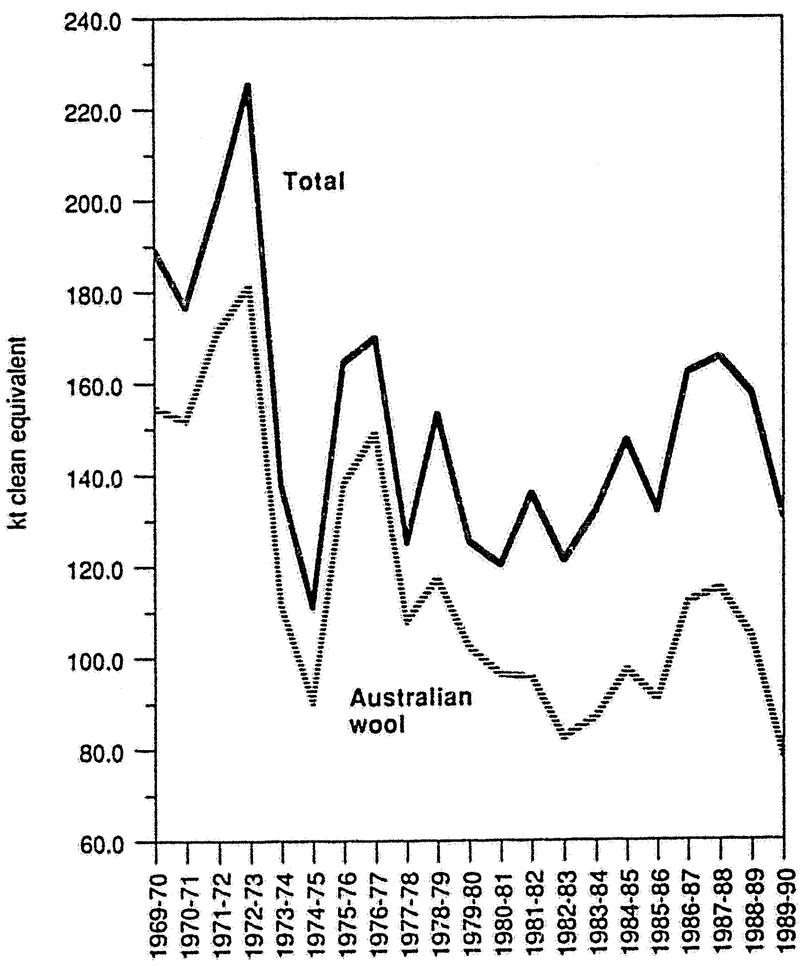
Introduction

Japan has been the largest single national market for Australian wool every year for at least the past two decades (though the European Community as a whole purchases more Australian wool than Japan). However, Japanese imports of Australian wool have varied substantially from year to year (figure A), and this has had an important influence on the economic well-being of the Australian wool industry. An understanding of Japan's wool textile industry and its demand for Australian wool may be helpful in marketing Australian wool, in selling the accumulated wool stocks and in accurate forecasting of wool prices.

Figure A: **Japanese imports of greasy and semiprocessed apparel wool**



Retail consumption of wool in Japan accounts for a significant proportion of total world wool consumption, amounting to 9 per cent in 1989. As would be expected, Japan's retail demand for wool is influenced by the prices of wool, cotton and synthetic fibre apparel and by personal consumption expenditure. In turn, the prices of wool, cotton and synthetic fibre apparel are influenced by the corresponding raw fibre prices and processing costs, including labour costs and interest rates. Retail consumption of wool in Japan is also influenced by factors such as the changing relative importance of western and traditional Japanese clothing (Higuchi 1986) and the fact that carpets account for a much smaller proportion of total wool consumption in Japan than in most other developed countries.

As the costs of processing in Japan have risen relative to those elsewhere, retail demand for wool in Japan has been reflected decreasingly in imports of greasy and semiprocessed wool and increasingly in imports of wool products. Increased relative processing costs have resulted from rising wages in Japan, the appreciation of the yen against the currencies of wool producing and processing countries and increasingly stringent environmental requirements in Japan.

Changes in retail demand for wool in apparel and other end products are not directly translated into changes in demand for greasy and semiprocessed wool. This is because stockholding and production smoothing behaviour by processors substantially affects the response. An understanding of the potential for commercial stockholding to replace stockholding by statutory organisations in wool growing countries is important in evaluating likely market effects of the diminishing marketing role of these organisations.

In addition to the decline in Japan's total imports of raw (greasy plus semiprocessed) wool, Australia's direct share in the volume of Japan's raw wool imports has fallen from over 85 per cent in the early 1970s to around 65 per cent in 1989-90.[1] A major reason for Australia's falling share is that Australia still exports most of its wool in greasy form while Japan imports more and more wool in semiprocessed form. In contrast to Australia's falling share, New Zealand, South Africa, the European Community, South Korea, Taiwan and ASEAN countries have increased their exports of semiprocessed wool to Japan.

In order to analyse these influences on Japanese demand for Australian wool, a complete model of Japanese wool demand, focussing on volume shares of the Japanese greasy and

1 In this study, the volume of greasy and semiprocessed wool is calculated as the clean wool equivalent of the volume of wool on sheepskins, greasy or fleece-washed wool, slipe, scoured or carbonised wool, wool tops, carded sliver, noils and wastes.

semiprocessed wool market held by Australia and other raw wool exporters, has been constructed and is explained in the rest of the paper.

Overview of the model

The model is an econometrically estimated partial equilibrium model of Japanese wool demand and of the shares of wool exporters to Japan. The wool processing chain (see figures B and C) was divided into four broad categories for estimation: final stage processing; textile processing; semiprocessed and greasy wool use; and semiprocessed and greasy wool trade shares of exporting countries. The account of the model given here is not exhaustive, but concentrates on the more noteworthy features.

Annual data are used for each equation, and the sample period generally ranges from around 1970 to around 1990. Annual data were chosen in preference to monthly or quarterly data because it was simpler to estimate longer term price relationships with annual data and because only annual data were readily available for some of the variables in the model; in particular, for exports of New Zealand wool separated into apparel and carpet categories.

The greasy and semiprocessed wool components of the model are on a financial (July–June) year basis, whereas the yarn, fabric and final product components of the model are on a calendar year basis. Given that the lag between exports of greasy and semiprocessed wool and production of yarns and fabrics, resulting from shipping, handling, stockholding and processing delays, may be of the order of six months, it was decided not to try to put the data on a uniform basis.

The model has separate components for apparel and carpet wool. For the purposes of this study, apparel wool is defined as wool of 34 microns or finer average fibre diameter, while carpet wool is defined as wool of 35 microns or coarser average fibre diameter.

Final stage processing

Final consumption

The final consumption of wool in Japan is estimated for three categories of end product: main apparel (men's outerwear, women's outerwear, hand-knitting yarns and adults' knitwear), carpets, and other products (including traditional Japanese clothing, fabrics sold at the retail level, blankets and felts). Demand for other products was estimated separately from demand for main apparel because different factors affect these demands — so much

Figure B: Apparel wool flows in the Japanese model

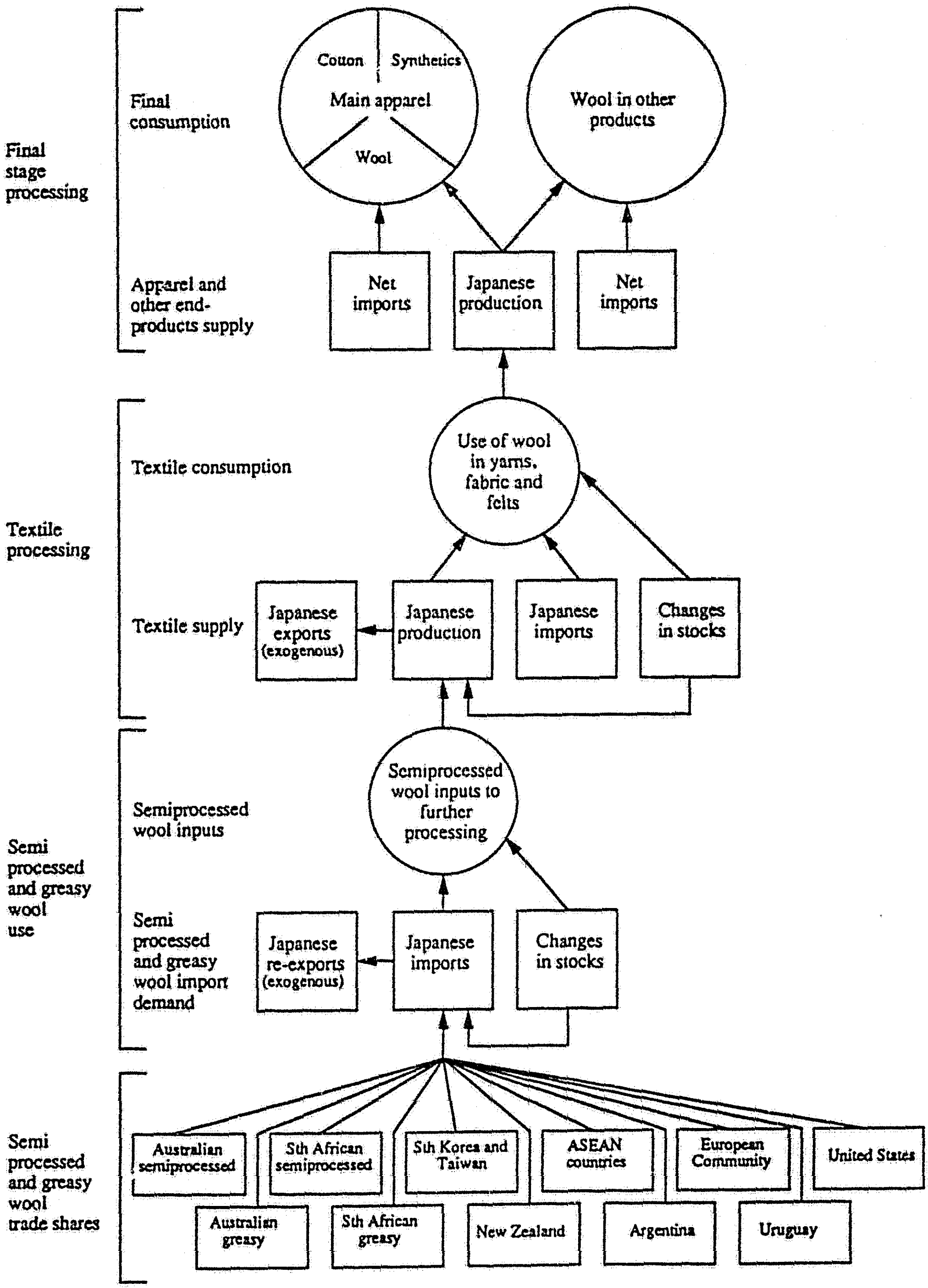
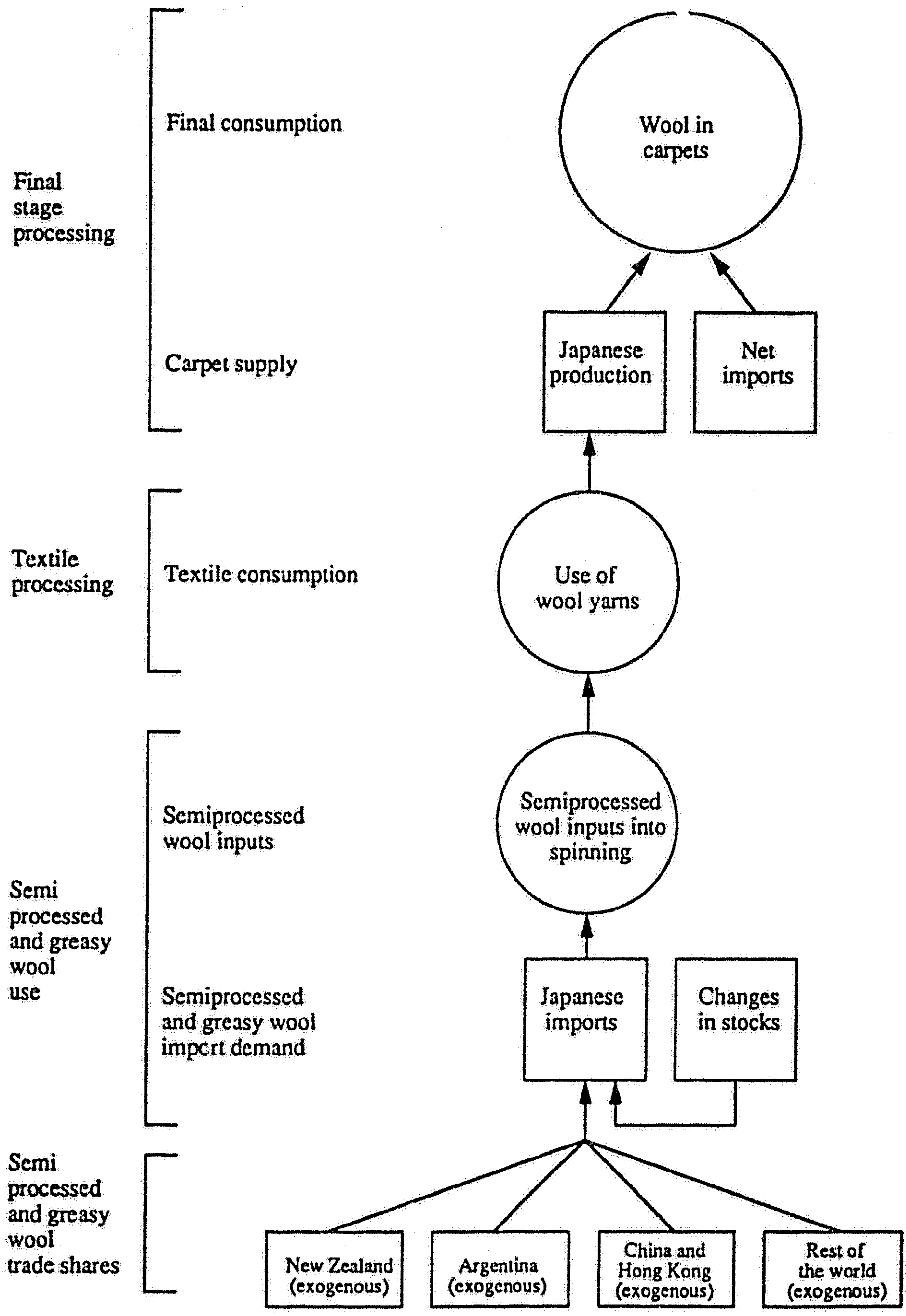


Figure C: Carpet wool flows in the Japanese model



so that different functional forms were used for the equations. Demand for carpets was estimated separately on account of the difference between carpet wool and apparel wool (the latter being used also for the other products). Final consumption of wool in apparel, carpets and other end uses was postulated to depend on the prices of end products made from wool and from other fibres, on real personal consumption expenditures and on real wool promotion expenditure. This was a modification of the approach used by AWC–BAE (1987), where final consumption was estimated as a function of raw fibre prices. The estimated response to real wool promotion expenditure was negligible, and this variable was dropped from all equations in the final model.

The wool flows in final demand and the later processing stages of the Japanese wool textile industry are shown in figures B and C. The estimated equations at the final consumption stage are presented in appendix A.1. For main apparel, a dynamic Almost Ideal Demand System (Deaton and Muellbauer 1980) was used. The shares of total personal consumption expenditure spent on wool, cotton and synthetic fibre apparel were estimated with symmetry and homogeneity conditions imposed. The parameter of partial adjustment was assumed to be the same for all fibres.

For the two other categories of products, however, a systems approach could not be used because it was not feasible to obtain accurate information on prices or quantities of cotton or synthetic fibre in other wool-competitive end uses.

The relationships between the unit values of imports of fibre-specific apparel and raw fibre prices have been estimated. The logarithms of the unit values of apparel imports were estimated as functions of the logarithms of the price of the relevant raw fibre, wages in apparel manufacture and interest rates (which represented finance and stockholding costs and also were used as a proxy for the cost of capital) in the main apparel manufacturing countries. Results are presented in appendix A.2. These price linkage equations are necessary in the simulation of the effects of changes in raw fibre prices on final consumption.

Since carpets are more durable than apparel, a model of partial adjustment toward a desired level of consumer stocks was estimated. The desired level of stocks of wool carpets was assumed to be related to the logarithms of the price of carpet wool (as a proxy for the price of wool carpets) and real personal consumption expenditure. This functional form is explained in Connolly and Guy (1989). The estimated equation is nonlinear and did not solve satisfactorily when it was first estimated, apparently due to collinearity between the constant term and other variables. A solution was obtained by subtracting the mean value in the sample period from each variable in the equation, thereby removing the need for a constant term. Wool price was dropped from the estimated equation as its coefficient was not significant.

For other products, a model of partial adjustment toward a desired annual rate of purchases was used.

Net imports
Linear partial adjustment of purchases specifications were used for net imports within each of the three categories (appendix A.2). The level of wool apparel imports was estimated as a function of the prices of wool, cotton and synthetic fibre apparel. However, prices are not the only explanatory variables for net imports of wool apparel, as some of the imports are within Japanese firms operating in other countries. Because such offshore operations are a consequence of firms seeking to maintain profitability by locating productive capital where costs are minimised, the extent of such intrafirm imports will depend on wages, exchange rates, environmental regulations and tax concessions. Relative apparel manufacture wages and exchange rates with the relevant countries were therefore included in the estimated equation, as the most readily available proxies for these costs.

Data on domestic production of apparel wool products are not readily available in a form which is up to date and consistent with consumption and trade data. Hence, domestic production was not estimated, but was taken to be net domestic consumption minus net imports of apparel wool products (that is, main apparel and other products). Similarly, the domestic production of carpet wool was calculated as the net domestic consumption minus net imports of wool in carpets.

Wool use and textile processing

The next stage of the estimation of Japanese wool demand was the modelling of the intermediate processes between domestic production of final products and net imports of greasy and semiprocessed wool. These flows are illustrated in the middle part of figures B and C, and the estimated equations are presented in appendix B.

Here, only the modelling of apparel wool flows will be described. The relationships are similar to those reported in Carland (1977), Carland and Pagan (1979) and Hall (1988) except that some stages were amalgamated. These authors distinguished woollen and worsted products, but examined the wool industry only as far as fabric production. It is difficult to extend the separation of woollen and worsted products to the retail level, since data for final products and net imports of apparel are not separated into woollen and worsted products. Furthermore, data on exports of greasy and semiprocessed wool are not separated into combing and carding wool. Hence, woollen and worsted stages were combined in the present study.

Wool yarn producers were assumed to attempt to keep their production levels smooth in the presence of fluctuations in total sales. Such a response was assumed by Carland and Pagan (1979) and Hall (1988), and the estimation and interpretation of a production smoothing response is given in their papers.

An equation was estimated for imports of wool yarns and fabrics (whereas Carland and Pagan took imports as exogenous). Exports of wool yarns and fabrics, as well as of greasy and semiprocessed wool, were assumed to be exogenous, because the level of exports is determined by conditions in the markets (principally Hong Kong) for Japanese processed wool. Exports of greasy and semiprocessed wool, wool yarns and wool fabrics are in any case small relative to production of wool yarns and fabrics.

Stocks of greasy and semiprocessed wool were assumed to be determined by a production smoothing response and a response to the expected discounted price of raw wool in accordance with the competitive stockholding rule (Newbery and Stiglitz 1981). Regarding the formation of price expectations, both adaptive and extrapolative expectations were tested, with the extrapolative expectations model showing better results.

Imports of greasy and semiprocessed wool are determined by price, past yarn production and stocks, and the variables already mentioned as influencing location of manufacturing.

Semiprocessed and greasy wool trade shares

Imports of greasy and semiprocessed apparel wool were allocated among exporting countries, as shown in the bottom part of figure B. (For carpet wool, import shares were not modelled, because of the dominance of New Zealand and the irregularity of other contributions.) Import shares were assumed to be determined on the demand side. Australian and South African wool is separated into greasy and semiprocessed components. Separate data on New Zealand's exports of greasy and semiprocessed wool were not readily obtainable, and it was therefore necessary to aggregate all categories of New Zealand wool together. Exports from the other regions are mainly semiprocessed wool.

The unavailability of data on prices and trade flows for different categories of greasy and semiprocessed wool in some countries prevented the use of cost minimisation models like the Almost Ideal Demand System (used above for retail demand) for greasy and semiprocessed wool demand. As a result, a partial adjustment mechanism is employed for trade in greasy and semiprocessed wool. The functional form applied is similar to that used by Simmons and Ridley (1987); that is, the logarithm of the quantity share is regressed against relative prices. Use of the logarithm of the quantity share ensures that the predicted and simulated quantity shares are greater than zero. Furthermore, variables have been included to capture Japan's shift from importing mainly greasy wool to importing mainly semiprocessed raw wool, as Japan's comparative advantage in wool processing has declined with economic maturity. These variables are textile wages in Japan and other wool processing countries, and a dummy variable to capture a change in pollution regulations in the late 1970s which led to a shift in demand from greasy wool to processed wool by Japan.

Estimation of trade shares using ordinary least squares is likely to be biased, as the error terms of the separate equations may be related. However, a systems methods of estimation was not possible, as there were insufficient observations. Estimation results are given in appendix C. (Argentina and Uruguay do not appear because their shares are very small, and were held at their average values rather than attempting to model them.)

Validation of the model

The validity of the model was tested by: examining the plausibility and significance of estimated parameters; analysing regression diagnostics; dynamically simulating wool trade over the estimation period (with some out-of-sample 'backcasting'); calculating sample averages for all variables and running a dynamic simulation for 100 periods to check for dynamic stability; and examining estimated elasticities for plausibility. The key features of these tests, which the model passed satisfactorily, are discussed below.

Plausibility of estimated parameters

The estimated parameters, shown in appendices A, B and C, had the expected signs and magnitudes in all equations, except that in the equation for net imports of greasy and semiprocessed apparel wool the estimate on the lagged dependent variable was –0.62. The unexpected negative sign can be interpreted as reflecting the effects of unrecorded stocks of raw wool and lags between exports of wool from source countries and production of wool yarns and felts in Japan. That is, a high level of wool imports in any one year is likely to lead to a high level of unrecorded stocks in that year and lower wool imports in the following year as those unrecorded stocks are depleted. The negative sign does not prevent the model from being dynamically stable because the absolute value of the parameter is less than one.

Dynamic simulations

The model was run both statically and dynamically using a simulation period of 1971-72 to 1988-89 for financial year variables and 1972 to 1989 for calendar year variables. This range includes periods of low or declining demand (1971-72, 1974-75, the mid-1980s and 1988-89) and of high or rising demand (1972-73 and 1973-74, 1975-76 and 1976-77, 1979-80 and the late 1980s). It also includes both the period when minimum reserve prices were set in Australia and some years before this period. Use of this simulation period involved 'backcasting' for some of the equations for greasy and semiprocessed apparel wool trade shares (see appendix C for ranges). Using dynamic simulation, the model solved satisfactorily.

The root mean square percentage errors for some key variables are presented in table 1. In the case of net imports of wool in main apparel, the relatively high root mean square percentage error can be attributed to the fact that net imports were very small in a number of years before the mid-1980s. Similarly, exports of Australian semiprocessed wool to Japan were often very small early in the sample period. In this circumstance, the root mean square percentage error is not a good indicator of model performance. In contrast, the coefficient of determination (R^2) between actual and simulated values for net imports of wool in main apparel was 0.96. The actual and dynamically simulated results for this

Table 1: **Root mean square percentage errors for key variables in dynamic simulation** a

Variable	Description	Root mean square error
		%
S_w^a	Quantity sold at retail of virgin wool in main apparel per person in Japan	5.1
T^a	Net imports of wool in main apparel	22.5
T^{ra}	Net imports of greasy and semiprocessed apparel wool	8.6
X^{gA}	Exports of Australian greasy wool to Japan	11.1
X^{sA}	Exports of Australian semiprocessed wool to Japan	20.4
X^{rA}	Exports of Australian greasy and semiprocessed wool to Japan	8.8

a The simulation period was 1971-72 to 1988-89 for financial year variables and 1972 to 1989 for calendar year variables.

variable are shown in figure D, and those for another key variable, the imports of greasy and semiprocessed wool, in figure E.

Figure D: Actual and simulated net iports of wool in main apparel

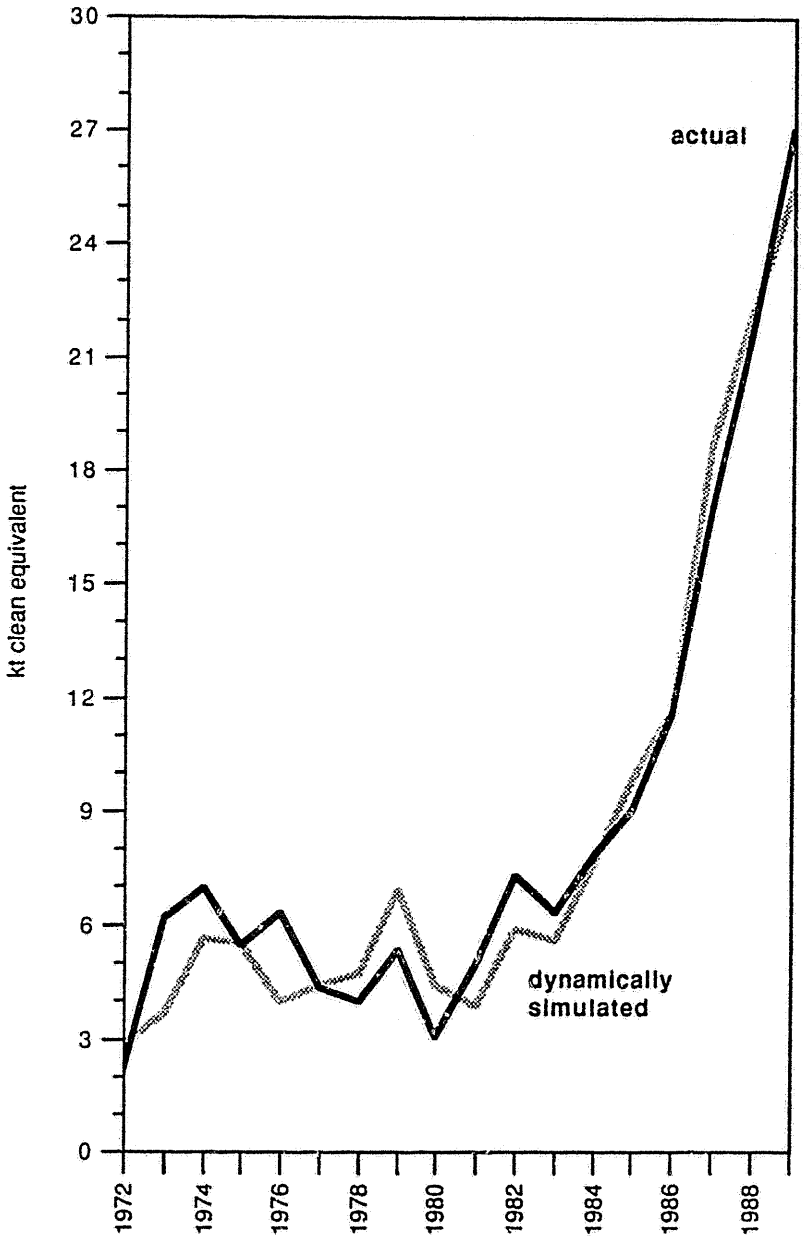
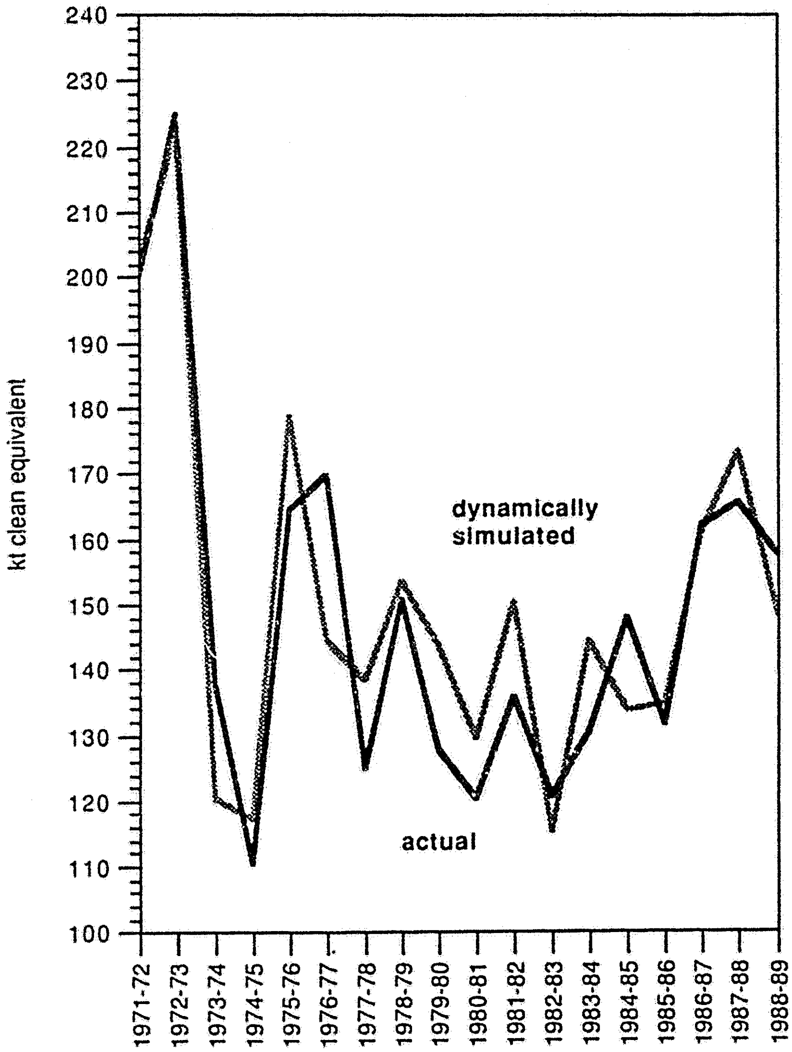


Figure E: Japan's imports of greasy and semiprocessed apparel wool



The dynamic performance of the model was also examined by dynamically running the complete model for 100 periods with all exogenous variables set to their mean values over the sample period. The model solved satisfactorily in this test, implying that the Japanese demand for wool and the shares of demand for greasy and semiprocessed wool from wool exporting countries are dynamically stable. The wider question of whether total world demand and supply of wool can be represented by a dynamically stable model is not addressed in this paper.

The results from this run were used as the baseline for calculating the elasticities.

Effects of price and wage changes

Elasticities were obtained for key variables by running the model dynamically, perturbing the relevant variable. Baseline simulations were based on the average values of variables in the sample period. Simulated values of the endogenous variables were then compared with baseline values to calculate elasticities. This method of calculating elasticities takes account of dynamic interactions between equations in the model. These elasticities are partial elasticities in the sense that they do not take account of demand and supply in the rest of the world.

Elasticities in the Japanese wool textile industry

To simplify calculation of elasticities for the Japanese wool textile industry, a smaller version of the model containing only the equations for the Japanese wool industry was constructed. The calculated elasticities of total Japanese demand for greasy and semiprocessed apparel wool (measured as net imports) with respect to changes in prices and other relevant variables are shown in table 2.

Table 2: **Elasticities of net import demand for greasy and semiprocessed apparel wool in Japan** [a]

	Elasticity with respect to:			
Time	**Raw apparel wool price**	**Lending interest rate in Japan**	**Real personal consumption expenditure per person**	**Synthetic fibre price**
Current period	0.21	–0.37	0.00	0.00
One year lag	–0.41	–0.08	0.86	0.10
Two year lag	–0.37	–0.26	0.48	0.16
Five year lag	–0.55	–0.14	0.79	0.15
Long term	–0.62	–0.16	1.02	0.15

a Elasticity estimates are calculated for the variable T^{ra} (see appendix B). Real personal consumption expenditure and synthetic fibre prices are measured on a calendar year basis, while the other variables are measured on a financial year basis. The values for the one year lag refer to the effect, for example, of the synthetic fibre price in calendar year 1989 on net import demand in financial year 1989–90. For the Japanese interest rate, period average values from a calendar year variable are used as a proxy for the values referring to the end of a financial year.

The estimated demand elasticity with respect to the price of greasy and semiprocessed wool is positive in the current period. This reflects an immediate stockholding response to changes in the raw wool price by buyers who increase stocks in anticipation of further price rises. Stockholders were assumed to extrapolate price changes in forming their expected price, so that a rising wool price is a signal to increase imports of wool so as to increase the precautionary stock level. Alternative assumptions about the formulation of price expectations by processors might change this result. However, as has been mentioned, a model of adaptive price expectations by processors was tested, but the results were poorer than those from the extrapolative expectations model. This positive elasticity occurs only in the period of the price change, and all remaining elasticities are negative and less than one in absolute value. Thus, with time, consumption of greasy and semiprocessed wool and net imports of wool products fall in response to rises in wool prices. The elasticity follows a cyclical path through time as a result of the interaction of stockholding and production smoothing responses along the wool processing chain.

For the elasticity with respect to real personal consumption expenditure per person, the cyclical path through time has a smaller amplitude. This is because real personal consumption expenditure is assumed only to affect final demand, whereas the wool price affects variables throughout the processing pipeline, either directly or indirectly. The response is inelastic except in the very long term. An inelastic response for Japan and other developed countries was also estimated by AWC–BAE (1987).

A negative and inelastic demand response was estimated with respect to interest rates in Japan. In the model, interest rates have a negative influence on greasy and semiprocessed wool imports because a higher interest rate lowers the expected discounted price of wool and reduces the desired level of stocks. In the period after the interest rate changes, the lower opening level of commercial stocks leads to higher net imports, other things being equal, and so the magnitude of the interest rate elasticity falls. The interaction of these variables results in further cycles in the response of imports to interest rate changes.

A positive and inelastic cross-price elasticity was estimated with respect to synthetic fibre prices. The small size of this figure implies that synthetic fibres are not close substitutes for wool in main apparel.

Elasticity of demand for Australian wool

One of the variables of most interest to Australian policy makers is the own-price elasticity of Japanese demand for Australian wool. The own-price elasticity of demand for Australian wool was calculated in a policy experiment by raising the clean price of Australian wool and dynamically running the full model. These elasticities are unconditional in the sense in that they take account of responses in all stages of wool processing and consumption, but are partial in that they do not allow for supply response in other wool producing countries. The wool prices in other wool producing countries were kept unchanged, although it is possible that, with time, increases in Australian greasy wool prices may lead to increases in the prices of wool in other countries. Results of this simulation are shown in table 3.

Table 3: **Own-price elasticities of demand for Australian greasy and semiprocessed apparel wool in Japan** a

Time	Elasticity
Current period	–0.23
One year lag	–1.20
Two year lag	–0.89
Five year lag	–1.34
Long term	–1.52

a All variables in this table are on a financial year basis.

The projected elasticities are negative for all periods, and are elastic in the medium and long term. Like that of import demand for wool from all sources, the elasticity of demand for Australian wool follows a cyclical path through time as a result of the interaction of stockholding and production smoothing responses along the wool processing chain.

Relative wool prices in exporting countries

The wool exports to Japan of a particular wool exporting country are affected by the relative prices of wool in Australia and other wool exporting nations. The own-price and cross-price elasticities of Japanese demand for wool imported from the European Community (table 4) have been simulated. As Australia is the largest producer of wool in the world, the effect of the Australian price on imports from other producers is much greater than the converse. Although the own-price and cross-price elasticities of Japanese demand for wool imported from South Africa and New Zealand were also simulated, the results are not presented here.

Table 4: Own-price and cross-price elasticities of demand for Japanese imports of greasy and semiprocessed wool from the European Community a

	Elasticity with respect to price of wool from:			
Time	Australia	South Africa	European Community	New Zealand
Current period	2.03	0.05	-1.81	0.13
One year lag	2.44	0.04	-2.86	0.07
Two year lag	4.04	0.10	-3.39	0.15
Five year lag	4.91	0.09	-4.08	0.09
Long term	5.46	0.06	-4.27	0.01

a All variables in this table are on a financial year basis.

This is because a model of Japanese demand is a partial equilibrium model. For major producers such as South Africa and New Zealand, a general equilibrium model is necessary to obtain reasonable elasticity estimates. A partial equilibrium model is likely to overestimate these elasticities, because it fails to capture changes in prices of wool in New Zealand and South Africa in response to changes in the Australian price. This difference between partial equilibrium and general equilibrium results does not apply to the same extent for wool exports from the European Community, because much of the wool exports are originally produced in Australia and semiprocessed in the European Community.

For imports of wool from the European Community, both the cross-price elasticity with respect to the Australian price and the own-price elasticity are high in absolute value, implying that small changes in either the European or the Australian price have a large effect on the volume imported by Japan from Europe. Thus, as the Australian price was kept above its equilibrium price when the reserve price scheme was in effect, Japanese buyers substituted European wool, as well as wool from other sources, for Australian wool. This inference should be treated with some caution, as part of the increase in imports from Europe may have been in the form of re-exports of Australian wool. Now that the reserve price scheme has been terminated, there has been a fall in the relative price of Australian wool, which may lead to a rise in Australia's share of the Japanese market. However, prices for wool from other producing nations have also fallen, so that the effect on the relative prices of Australian wool has been less than the effect on the absolute prices. Furthermore, some of any such increase in share might be at the expense of Australian exports to other processing countries. On the other hand, it must be remembered that absolute price falls in wool from all exporters will lead to an increase in the quantity imported in Japan.

Changes in Japanese wages

Adjustments have occurred within the Japanese wool textile industry as a consequence of Japan's declining competitiveness in textile and garment manufacture. Textile and apparel wages, which affect all stages of the wool textile industry except final consumption of wool products, have been rising consistently in Japan. This contrasts with other countries' wages which, when converted to yen per hour, have generally been falling. This is because the yen has been appreciating against the currencies of almost all other major exporters of wool manufactures.

A simulation was undertaken in which textile and apparel wages in Japan were changed while all other variables, including wool prices, wages in other countries and exchange rates, were kept unchanged. Wages in both apparel and textile manufacturing were raised by 10 per cent in the simulation, and the full model was run dynamically to provide response elasticities. Since technical change and substitution of capital for labour are not incorporated in the model, these simulation results can only provide a picture of what would be likely to happen in the absence of such responses. However, it should be noted that commercial apparel manufacture is still labour intensive, with limited opportunity to substitute capital for labour.

The variables examined which relate to the Japanese wool textile industry were the levels of imports of wool in main apparel and in yarns and fabrics, and Japanese production of wool yarn. Since there is little opportunity to substitute capital for labour in apparel manufacture, it could be expected that the imports of wool main apparel would be more responsive than imports of wool yarns and fabrics. Production of wool yarn in Japan would be expected to fall as a result of rising textile wages in Japan, since that should lead to higher prices for Japanese wool products compared with imported wool products. In turn, this is expected to lead to higher imports and lower domestic production of wool products in Japan.

Regarding the effect on Australia, the variables examined were the total imports of greasy and semiprocessed apparel wool, imports of Australian greasy wool and imports of Australian semiprocessed wool. From the estimated coefficients, prior to simulation, it is unclear whether rising wages in Japan will lead to more or less imports of greasy and semiprocessed wool in total. This is because the demand for wool for uses other than yarn production (that is, for outward processing and for the production of non-woven products) is estimated to rise in response to increasing relative textile wages in Japan. Rises in Japanese wages are estimated to lead to increases in the share of Australian semiprocessed wool but decreases in the share of Australian greasy wool in Japanese imports. The net effect on the total quantities imported, however, depends on interactions with other variables in the system.

The results of these policy simulations for the Japanese wool textile industry are shown in table 5. Responses to changes in Japanese wages are expressed as elasticities—that is, the percentage change in the variable of interest (imports or production) with respect to a 1 per cent change in textile and apparel wages in Japan. Increases in Japanese wages lead to increases in net imports of wool in main apparel and imports of wool yarns and fabrics, as expected. The elasticity is higher for net imports of wool in main apparel, as expected on the basis of the limited opportunity to substitute capital for labour in apparel manufacturing. The production of wool yarn is lowered by an increase in textile and apparel wages in Japan, as expected. This response is inelastic, even though the import responses are elastic. The reason for this difference is that, on average in the sample period, imports were a small relative to the production of wool yarns.

The results of these policy simulations for Australian wool trade are shown in table 6. Total imports of greasy and semiprocessed wool from all countries do not respond much to changes in Japanese wages. This is largely because the negative effect of rising wages on production of wool yarns and fabrics is counteracted by the positive effect of rising wages on imports of greasy and semiprocessed wool for outward processing. To complicate the picture, increased wages lead to lower stocks of wool and wool products in Japan. Since these stock changes are small, they are not included in table 5. The interaction of these effects through time means that the sign on the response of total imports to Japanese wages

Table 5: Effect on Japanese textile industry of increases in wages in textile and apparel manufacturing in Japan [a]

Time	Elasticity of: Net imports of wool in main apparel	Imports of wool yarns and fabrics	Production of wool yarn in Japan
Current period	0	–0.02	–0.01
One year lag	3.11	2.03	–0.20
Two year lag	3.81	2.11	–0.23
Five year lag	4.01	2.24	–0.23
Long term	4.01	2.29	–0.23

a All variables in this table are on a calendar year basis.

Table 6: Effect on Australian wool trade of increases in wages in textile and apparel manufacturing in Japan a

	Elasticity of:			
Time	Total imports of greasy and semiprocessed wool by Japan	Imports of greasy wool from Australia	Imports of semiprocessed from Australia	Imports of greasy and semiprocessed from Australia
Current period	0	0	0	0
One year lag	0.31	–0.02	2.16	0.43
Two year lag	–0.08	–0.62	1.69	–0.01
Five year lag	0.06	–0.55	1.87	0.16
Long term	0.04	–0.60	1.84	0.04

a Textile and apparel wages are measured on a calendar year basis, while wool imports are on a financial year basis. The values for the one year lag refer to the effect, for example, of textile wages in calendar year 1989 on imports in financial year 1989-90.

changes through time, while remaining inelastic. The response of imports of greasy and semiprocessed wool from Australia mirrors total imports closely, which is to be expected given that Australia is the largest wool exporter. However, imports of greasy wool from Australia fall while imports of semiprocessed wool rise. This represents a substitution of relatively cheaper Australian labour for relatively more expensive Japanese labour in wool scouring and topmaking.

Implications and conclusions

An econometric model of the Japanese wool textile industry and trade shares of greasy and semiprocessed apparel wool exporters to Japan has been constructed and found to provide satisfactory dynamic simulations of wool demand in Japan over the period 1972 to 1989. The model has also been shown to be dynamically stable in a baseline simulation in which exogenous variables were set equal to their mean values in the simulation period.

The model includes all stages of Japanese wool demand from final consumption to trade shares of greasy and semiprocessed wool exporters. However, it does not include supply responses in the wool producing and processing countries. It allows for different responses to prices and other variables at different stages along the processing pipeline. Stockholding responses to expected prices and consumption are modelled. As a result of this sophistication in modelling, the cycles in the response of demand through time to changes in exogenous variables are captured.

Japanese demand for greasy and semiprocessed apparel wool from all sources is estimated to be inelastic with respect to both the price of wool and real personal consumption expenditure per person in Japan, especially in the short term. The initial response to a change in the price of wool may be an increase in wool purchases as a consequence of precautionary stockholding behaviour. In contrast, the own-price response of Japanese demand for Australian wool is estimated to be elastic in the medium and long term. The explanation for this difference is that substitution between Australian wool and wool from other countries depends on the relative price of Australian wool. However, the own-price elasticity of Japanese demand for Australian wool is estimated to be less than one in absolute value in the year of the price change. This difference between short term and long term elasticities of demand has implications for price forecasting and stockpile disposal policy. Regarding the latter, a drop in price induced by a given level of releases of stocks is likely to have little effect on Japanese imports of Australian wool in the short term but may have a much larger long term effect.

Since Japanese textile and apparel wages are likely to continue to rise relative to those in other wool manufacturing countries, it is likely that the production of wool yarn in Japan will fall in the absence of technical change or substitution of capital for labour in Japan. This will increase the adjustment pressures on the Japanese wool textile industry. Japanese wool yarn production is likely to be replaced by imports of wool yarns, fabrics and apparel, with possibly only a small net effect on total worldwide demand for wool.

Some of the ways that the Japanese wool textile industry is likely to respond to an increase in wages is to increase imports of wool for outward processing, possibly to increase production of non-woven products, and to lower stocks of wool as production of wool yarns falls. The net effect of all of these interacting factors on total imports of wool or imports of Australian greasy and semiprocessed wool is likely to be small.

The main effect on Australia of an increase in Japanese wages, according to the model simulations, is higher imports of Australian semiprocessed wool and lower imports of greasy wool. Although the model shows such a response, and such a response has happened in the past, the realisation of these opportunities for an expansion of early stage processing in Australia depends on investment decisions and regulations regarding wool processing and transport in Australia. Relative wool prices in Australia and other countries are another consideration. Also, Australia's high wages compared with those in New Zealand, South Africa, ASEAN and other wool processing countries could limit Australia's ability to respond to this opportunity.

Appendix A

Final stage processing

A.1 Final consumption

(a) Retail consumption of main apparel a

Range = 1971 to 1989.

Share of fibre(t)	Intercept	Lagged dependent variable	$\text{Log } P_{wt}^{ar}$	$\text{Log } P_{ct}^{ar}$	$\text{Log } P_{st}^{ar}$	Log (Japan's CPIt)b	($RPCEH_t$)	DW	Durbin's h statistic	$\bar{R}^2$
$Wool_t$	-0.006	0.494*	0.006	-	0.008*	-0.014	-0.004	1.32 c	1.54	0.789
	(-0.34)	(7.38)	(1.59)		(2.78)		(-1.04)			
$Cotton_t$	0.006	0.494*	-	0.002*	0.001	-0.003	0.001	2.18	-0.41	0.441
	(1.37)	(7.38)		(2.24)	(1.06)		(0.62)			
$Synthetic_t$	0.060*	0.494*	0.008*	0.001	0.008*	-0.017	-0.015*	1.32 c	1.54	0.958
	(-3.44)	(7.38)	(2.78)	(1.06)	(3.14)		(-4.00)			

Figures in parenthesis are t-statistics; * denotes significance at the 5 per cent level.
a For the linear approximate AIDS shares of retail apparel consumption as shown, elasticities can be calculated using the formulae in Green and Alston (1990). b Constrained to equal negative sum of price coefficients. Japan's CPI is a proxy for the price of other consumer items. c DW statistic in inconclusive range. Following work by Inder (1984), the DW statistic is quoted, along with Durbin's h, for equations with lagged dependent variables.

Definitions of fibres' shares in retail consumption

$$\text{Wool}_t = (S_{wt}^{a}.P_{wt}^{ar}.0.235/1000)/PCE_t$$

$$\text{Cotton}_t = (S_{ct}^{a}.P_{ct}^{ar}.0.235/1000)/PCE_t$$

$$\text{Synthetic}_t = (S_{st}^{a}.P_{st}^{ar}.0.235/1000)PCE_t$$

Variable name	Description	Unit	Data source
S_w^a	Quantity sold at retail of virgin wool in main apparel per person in Japan a	kt clean equivalent	IWS(1990)
S_c^a	Quantity sold at retail of cotton in main apparel per person in Japan a	kt clean equivalent	IWS, personal communication
S_s^a	Quantity sold at retail of synthetic fibres in main apparel per person in Japan a	kt clean equivalent	IWS, personal communication
P_w^{ar}	Retail price of wool clothing in Japan b	yen/kg	
P_c^{ar}	Retail price of cotton clothing in Japan b	yen/kg	
P_s^{ar}	Retail price of synthetic clothing in Japan b	yen/kg	
PCE	Personal consumption expenditures, Japan a	trillion (10^{12})yen	IMF (1991)
RPCEH	Real personal consumption expenditures per person, Japan a	index in yen per person, 1980=1	Calculated from IMF (1991)

a Data aggregation is on the basis of calendar year totals. b Data aggregation is on the basis of calendar year averages. Estimates based on unit value of imports of fibre-specific apparel from Japan Tariff Association (1990) and average margin between import unit values and retail prices using data from Statistics Bureau, Management and Coordination Agency, Japan (1990b).

(b) Retail consumption of wool in carpets

Range = 1971 to 1989.

$$(S_t^{cr} - 0.138) = [(1-\rho/2)/(1+\rho/2)](S_{t-1}^{cr} - 0.135) + [\rho.j021(1+\delta/2)/(1+\rho/2)]$$
$$[\Delta(\log(100RPCEH_t)) - 0.029]$$
$$+[\rho.j021.\delta/(1+\rho/2)][\log(100RPCEH_{t-1}) - 0.144]$$

S^{cr} = Quantity sold at retail of virgin wool in carpets per person in Japan (kg clean equivalent, calendar year total: IWS, personal communication).

Coefficient	Value	t-statistic
ρ	0.307	2.15
δ	0.07	value set, not estimated
j021	2.037	2.01

Durbin's h not calculable, $\overline{R}^2 = 0.760$, DW = 1.44 (in inconclusive range).

(c) Retail consumption of wool in other products

Range = 1971 to 1989.

$$S_t^{or} = -0.001 + 0.841\ S_{t-1}^{or} - 0.096 \log(P_t^{o}) + 0.265\ \log(RPCEH_t)$$
$$(-0.03)\ (7.92)^{\#} \qquad (-1.32) \qquad (2.08)$$

Durbin's h = –0.65, $\overline{R}^2 = 0.973$, DW = 2.27
[#] Significant at the 5 per cent level.

Variable name	Description	Unit	Data source
P^o	Stone's index of prices of other wool apparel (calendar year average)		Constructured from data in other Japan Wool Spinners' Association et al. (1991) and in Statistics Bureau, Management and Coordination Agency, Japan (1990a)
S^{or}	Quantity sold at retail of virgin wool in other products per person in Japan (calendar year total)	kg clean equivalent	Total quantity from IWS (personal communication) divided by population (IMF 1990)

A.2 End products supply

(a) Net imports of wool end products

Range = 1971 to 1989.

Net imports(t)	Intercept	Lagged dependent variable	$W_{at-1}^{J/Z}$	Wool price(t)	Cotton price (t) a	Synthetic price(t) a	Exchange rate(t-1)	DW	Durbin's h	$\overline{R}^2$
T^a	-9.777	0.224	11.619*	-0.972 a	1.101	1.446	4.983*	1.81 c	0.51	0.965
	(-1.77)	(1.70)	(2.28)	(-1.91)		(0.96)	(0.68)	(3.11)		
T^c	0.427	0.801*	2.044*	-0.00349* b	–	–	–	2.35	-0.90	0.788
	(0.49)	(6.57)	(3.12)	-						
T^o	-2.440*	0.417*	1.734*	–	–	–	–	1.97	0.08	0.513
	(-3.42)	(3.27)	(2.89)							

* Significant at the 5 per cent level. a Estimate based on unit value of imports of fibre-specific apparel from Japan Tariff Association (1990) multiplied by average nominal tariff rates in Japan (Austrade, personal communication). b Average price of carpet wool imports, Japan. c In inconclusive range.

Variable name	Description	Unit	Data source
$W_a^{J/Z}$	Wages in apparel manufacture in Japan relative to other wool apparel manufacturing regions (calendar year average)	index in yen per hour	Wages from United Nations International Labour Organization (1990); exchange rates from IMF (1991) or ABS (1991a)
T^c	Net imports of wool in carpets and rugs by Japan (calendar year total)	kt clean equivalent	Japan Wool Spinners Association et al. (1991)
T^a	Net imports of wool in main apparel by Japan (calendar year total)	kt clean equivalent	Japan Wool Spinners Association et al. (1991)
T^o	Net imports of wool in other products by Japan (calendar year total)	kt clean equivalent	Japan Wool Spinners Association et al. (1991)

(b) Apparel import unit values as a function of input prices

Range = 1971 to 1981.

Unit value — apparel of fibre j	Intercept	Log P_{jt}^{ra}	Log W_{at}^{Z}	Log r_t^{Z}	DW	$\overline{R}^2$
Log P_w^a	0.112	0.275*	0.686*	0.208*	1.95	0.976
	(0.70)	(6.06)	(19.63)	(3.45)		
Log P_c^a	–3.010*	0.285*	0.301*	0.309	2.05	0.829
	(–4.19)	(3.44)	(4.10)	(2.07)		
Log P_s^a	0.175	0.550*	–0.017	0.334*	2.06	0.768
	(0.68)	(4.93)	(–0.26)	(3.10)		

* Significant at the 5 per cent level

Variable name	Description (calendar year averages)	Unit	Data source
W_a^Z	Average apparel wage in main wool apparel exporting countries	yen/hour	United Nations (1990); IMF (1990); Directorate General of Budget, Accounting and Statistics (1991).
r^Z	Average interest rate of main wool apparel exporting countries	per cent per year	IMF (1990); Asian Development Bank (1990); Directorate General of Budget (1991)
P_s^a	Average cif import unit value for synthetic apparel, Japan	1000 yen/kg	Japan Tariff Association (1990)
P_w^a	Average cif import unit value for wool apparel, Japan	1000 yen/kg	Japan Tariff Association (1990)
P_c^a	Average cif import unit value for cotton apparel, Japan	1000 yen/kg	Japan Tariff Association (1990)
P_j^{ra}	Raw fibre price for fibre j (world average)	yen/kg	US Department of Agriculture (1990); AWC (1990); ABS (1991a); IWS (personal communication)

Appendix B

Raw wool use and textile processing

Variable name	Description	Unit	Date source
I^r	Closing inventory of greasy and semiprocessed wool in Japan a	kt clean	Japan Wool Spinner's Association et al. (1991)
I^y	Closing inventory of wool yarns and fabrics in Japan a	kt clean	Japan Wool Spinner's Association et al. (1991)
r	Average lending interest rate in Japan b	per cent a year	IMF (1991)
M^y	Imports of wool in yarns and fabrics by Japan c	kt clean equivalent	Japan Wool Spinners Association et al. (1991)
p^{rM}	World average price of apparel wool in yen d	yen/kg	Weighted average of each exporting country's price
P_w^a	Price of imported raw apparel wool, Japan	yen/kg	Japan Tariff Association (1990); Australian data from AWC (1990) and National Council of Wool Selling Brokers (1990); French price data from Comité Central de la Laine et des Fibres Associées (1990); South African price data from South African Wool Board (1990); UK price data from Wool Record (1991); New Zealand data from NZWB (1990); Argentine data from FLA (1990); data for other countries from Japan Wool Spinners Association et al. (1991) and Commonwealth Secretariat (1990).
P_w^c	Average price of carpet wool imports, Japan d	yen/kg	Weighted average of each exporting country's price
C^y	Quantity of wool yarns and fabrics consumed in the production of wool main apparel and other non-carpet product, Japan c	kt clean equivalent	Japan Wool Spinners Association et al. (1991)
C^{rc}	Processing pipeline demand for greasy and semiprocessed carpet wool, Japan c	kt clean equivalent	Japan Wool Spinners Association et al. (1991)

Q^y	Quantity of wool yarn produced in Japan c	kt clean equivalent	Japan Wool Spinners Association et al. (1991)
$W^{J/Z}$	Relative wages in textile manufacture in Japan compared to other wool apparel manufacturing regions b	index in yen per hour	Wages from United Nations International Labour Organization (1990) and Werner International (1991); exchange rates from IMF (1991) or ABS (1991a)
S^y	Total sales of wool yarns and fabrics, Japan c	kt clean equivalent	Japan Wool Spinners Association et al. (1991)
T^{ra}	Net imports of greasy and semiprocessed apparel wool by Japan e	kt clean equivalent	Japan Wool Spinners Association et al. (1991)
M^{rc}	Exports of greasy and semiprocessed apparel wool to Japan from world e	kt clean equivalent	Australian data from ABS (1991b); New Zealand data from NZWB (1990); Argentine data from FLA (1990); data for other countries from Japan Wool Spinners Association et al. (1991) and Commonwealth Secretariat (1990).

a End of financial year. b Calendar year average. c Calendar year total. d Financial year average. e Financial year total.

B.1 Textile processing

Production of wool yarns

Range = 1971 to 1989.

$$Q_t^y = 21.99 + 0.028\ Q_{t-1}^y + 1.069\ S_{t-1}^y + 1.058\ \Delta S_{t-1}^y - 0.062\ I_{t-1}^y$$

(1.53)(0.12) (4.39)# (10.87)# (-2.43)#

Durbin's h na, $\overline{R}^2 = 0.964$, DW = 1.97. # Significant at the 5 per cent level.

Imports of wool yarns and fabrics

Range = 1971 to 1990.

$$M_t^y = 18.31 + 11.43\ W_{t-1}^{J/Z} + 59.14\ \log(P_{wt-1}^{a} / P_{t-1}^{rM}) + 0.061\ C_t^y$$

(-4.41) (5.08)# (1.73)# (3.00)#

$\bar{R}^2 = 0.852$, DW = 1.91.

Closing inventories of greasy and semiprocessed wool
Range = 1970-71 to 1989-90.

$$I_t^r = 13.83 + 0.123\ I_{t-1}^r + 0.342\ I_{t-2}^r + 0.029\ Q_{t-1}^y + 0.056\ Q_{t-2}^y$$
(2.65)# (0.86) (1.61) (0.47) (0.93)

$$+0.021\ \Delta(P_{wt}^a) - 1.792 r_t$$
(4.85)# (–2.51)#

Durbin's h = –0.09, $\bar{R}^2 = 0.754$, DW = 2.03.

B.2 Semiprocessed and greasy wool imports

Net imports of greasy and semiprocessed apparel wool
Range = 1970-71 to 1989-90.

$$T_t^{ra} = 138.85 \quad -0.618\ T_{t-1}^{ra} + 1.11\ Q_{t-2}^y + 0.979\ \Delta(Q_{t-1}^y) \ -0.479\ I_{t-1}^r$$
(6.13) (–5.26)# (8.16)# (6.37)# (–1.03)

$$+0.031\ \Delta(P_{wt}^a) \ -0.064\ P_{wt-1}^a + 39.03\ W_{t-1}^{J/Z} \ -6.823 r_t$$
(3.44)# (–5.74)# (4.55)# (–3.07)#

Durbin's h = –0.72, $\bar{R}^2 = 0.962$, DW = 2.27a.

Imports of greasy and semiprocessed carpet wool
Range = 1971-72 to 1989-90.

$$M_t^{rc} = 29.93 + 0.786\ C_{t-2}^{rc} + 0.311\ \Delta(C_{t-1}^{rc}) \ -0.234\ I_{t-1}^r$$
(2.98)# (2.10) (0.64) (–1.19)

$$+0.011\ \Delta(P_{wt}^c) - 1.465\ W_{t-1}^{J/Z} \ -1.319 r_t$$
(1.40) (–1.60) (–1.07)

$\bar{R}^2 = 0.459$, DW = 2.07a.

Significant at the 5 per cent level. a In inconclusive range.

Appendix C

Semiprocessed and greasy apparel wool trade shares

Range = 1970-71 to 1989-90, except for Australian semiprocessed and South Korea/Taiwan imports, where the range starts in 1972-73.
Variables are financial year averages unless otherwise specified.

Log (Import shares from country $i)_t$	Intercept	Lagged dependent variable	Lagged price ratio: log (country i_{t-1}/ all imports$_t$)	Price ratio: log (country i_t/ all imports$_t$	Log Japanese textile wage$_{(t-1)}$	Wage ratio: log (country i_{t-1}/ world textile wages$_{t-1}$)	Dummy	DW	Durbin's h statistic	$\bar{R}^2$
Australia (greasy)	–0.061	0.844 *	–	–2.644 *	–0.125 a	–	–	1.94	0.15	0.955
	(–1.20)	(7.50)		(–3.02)	(–1.95)					
Australia (semiprocessed)	–2.531	–	–0.169	–	2.151 *	–	0.342*b	1.66 c	–	0.941
	(–41.60)		(–0.96)		(15.59)		(2.42)			
New Zealand	–3.393 *	–	–	–1.022	–	–1.411*d	0.660*e	2.36 c	–	0.843
	(27.75)			(–2.07)		(–3.30)	(6.55)			
South Africa (greasy)	–1.567	0.624 *	–	–	–0.667	–	–	2.04	–0.14	0.742
	(–2.19)	(3.40)			(1.63)					
South Africa (semiprocessed)	–2.359 *	0.546 *	–	–2.494		–0.844 *	–	2.02	–0.06	0.746
	(–3.18)	(3.96)		(–1.09)		(–2.84)				
European Community	–0.565	0.670 *	–	–2.314 *	0.396	–1.04 d	–	2.24 c	–0.70	0.819
	(–1.03)	(4.55)		(–2.76)	(1.34)	(–1.55)				
South Korea and Taiwan	–1.234 *	0.647 *	–0.389 *	–	–	–	–0.458*b	1.78	0.50	0.806
	(–3.19)	(6.36)	(–2.29)				(–3.64)			
United States	–7.491 *	–	–	9.041 *	–	–2.188 f	–	2.16	–	0.548
	(–11.42)			(–4.52)		(–2.06)				
ASEAN	–4.423 *	0.207 *	–	–	0.033*g	–1.330*f	–	1.94	0.19	0.955
	(–9.18)	(3.28)			(5.16)					

Figures in parentheses are t statistics for estimated coefficients; * denotes significance at the 5 per cent level.
a Time period t. b Dummy variable = 1 for 1977 and 1978, 0 other years. c In inconclusive range. d Wage ratio times D, where D = 0 until 1977-78 and 1 thereafter. e Dummy variable D as footnote d. f Wage in country i_{t-1}, not ratio. g (South Korean and Taiwanese wage)$_{t-1}$.

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