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# China's Wool Import Demand: Implications for Australia

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## Abstract

China is the largest importer of Australian wool. China's demand for wool has significant implications for wool producers in Australia. In this paper, an AIDS model is used to analyse the responsiveness of China's demand for wool imports and preferred sources of imports of wool. The results indicate that, in general, China's demand for wool imports is not very responsive to changes in prices and expenditures. When demand for wool imports increases, China has a tendency to initially obtain imports from countries other than Australia. In the foreseeable future, it is unlikely that China's demand for wool imports will experience significant increase. The wool trade between China and Australia may change, depending on global demand for woollen products, demand for woollen apparel by Chinese consumers, and changes in China's regulations to protect the environment.

**Key words:** wool production, wool trade, import demand, China, Australia

## 1. Introduction

Since the mid-1990s, wool processing capacity has gradually transferred from Western Europe and other traditional processors to China, attracted by relatively low-cost labour and easy entry to the wool processing industry. Subsequently, China has become the largest wool processing centre in the world. The current annual wool processing capacity in China exceeds 400 kt (kilo tonnes, clean equivalent). However, China is not able to produce enough wool to meet the demand of the processors, resulting in increasing imports. In 2009, total wool imports into China reached 327 kt, accounting for 33% of world output (GACPRC 2010, p. 231). Wool is the largest imported animal product in China.

Wool imports into China are likely to remain high. Although China's wool production has grown steadily in the past three decades, most of the wool produced in China is not suitable for the production of high-end woollen apparel. Compared to Australia's wool, China's has a broader micron and a shorter staple. As such, wool produced in China is chiefly used for producing woollen products such as carpets, blankets, and rugs. It is unlikely that China will be able to increase its fine wool production in the near future for the following reasons: (i) fine wool produced in China barely commands any price premium because it is not segregated when farm production is assembled, offering no incentives for growers although they are capable of producing fine wool; and (ii) low wool prices relative to prices of sheep meat have encouraged producers to focus on producing sheep for meat rather than wool. Further, government assistance is given to boost sheep meat production but support for wool production has been minimal (Waldron *et al.* 2007). Hence, China's wool imports will continue to be high in the foreseeable future. It would be prudent though, for major wool exporters, Australia in particular, to continue to pay attention to China's demand for wool imports. This paper adds to the understanding of the current wool import demand of China.

Since the 1980s, import demand models have been widely applied to analyse imports and exports. Depending on the ultimate purpose of imports and exports, i.e., for final consumer goods or for intermediate inputs, two different theoretical frameworks have been used in previous studies. One is the import demand model deduced from demand theory and the other is one from production theory. It is hard to obtain wool import data of individual firms; hence models based on production theory cannot be used in this paper. Instead, import data of all firms are used to estimate wool import demand in China. The AIDS (Almost Ideal Demand System) model is a commonly used analytical method. Many researchers, for example Deaton and Muellbauer (1980), Yang and Koo (1994), Lee *et al.* (1994), Gao and Tian (2007), Yang and Nie (2008) and Peng (2008), have employed the AIDS model to study import demand of different goods, including meats, wheat, cotton, food, and dairy products. This paper also makes use of the AIDS model to estimate the demand for wool imports by China from Australia, New Zealand, South Africa, Uruguay, and other countries.

## 2. China's Wool Imports

### 2.1 Total Imports

China's wool imports have steadily increased since 1980 (Table 1). Low-level domestic fine wool output coupled with the expansion of fine wool processing capacity drove China's demand for wool imports to increase (Zhao 2006; Tian 2007; Marinakim *et al.* 2008;

Yu 2009; Song 2010). Table 1 shows that China's total wool production is high and total wool output has more than doubled compared to that of 1980. However, its fine wool output did not increase very fast and has largely stagnated at around 120 kt; hence, domestic production has been unable to meet the increasing demand for fine wool by the wool processing industry. Table 1 indicates that fine wool, semi-fine wool and coarse wool each accounted for about 1/3 of the total output. It must be noted, however, China's 'fine' wool is not as fine as Australia's 'fine' wool. Most of China's fine wool is between 20 and 23 microns in fibre diameter. In Australia, only wool with a fibre diameter of 19 microns or under is regarded as fine wool. China's output of 'fine' wool would be much lower if Australia's standard was followed (Longworth *et al.* 2004).

Table 1. China's Wool Output and Import (1980-2009) (kt)

| Year | Output | | | | Import |
|---|---|---|---|---|---|
| | Total | Fine wool | Semi-fine wool | Coarse wool | |
| 1980 | 176 | 69 | 35 | 72 | 58 |
| 1985 | 178 | 86 | 32 | 60 | 115 |
| 1986 | 185 | 90 | 32 | 63 | 119 |
| 1987 | 209 | 100 | 37 | 72 | 119 |
| 1988 | 222 | 111 | 41 | 70 | 112 |
| 1989 | 237 | 120 | 43 | 75 | 80 |
| 1990 | 239 | 119 | 44 | 76 | 38 |
| 1991 | 240 | 109 | 56 | 75 | 120 |
| 1992 | 238 | 106 | 52 | 80 | 152 |
| 1993 | 240 | 110 | 54 | 77 | 198 |
| 1994 | 255 | 113 | 58 | 83 | 251 |
| 1995 | 277 | 112 | 73 | 93 | 211 |
| 1996 | 298 | 121 | 74 | 103 | 183 |
| 1997 | 255 | 116 | 56 | 83 | 164 |
| 1998 | 278 | 116 | 69 | 93 | 138 |
| 1999 | 283 | 114 | 74 | 95 | 183 |
| 2000 | 293 | 117 | 85 | 90 | 245 |
| 2001 | 298 | 115 | 88 | 96 | 246 |
| 2002 | 308 | 112 | 102 | 93 | 183 |
| 2003 | 338 | 120 | 110 | 108 | 138 |
| 2004 | 374 | 130 | 120 | 124 | 205 |
| 2005 | 393 | 128 | 123 | 142 | 234 |
| 2006 | 389 | 132 | 116 | 141 | 256 |
| 2007 | 363 | 124 | 107 | 133 | 275 |
| 2008 | 368 | 124 | 105 | 139 | 235 |
| 2009 | 364 | 127 | 113 | 124 | 327 |

Sources: Output from National Bureau of Statistics of China, 1981-2010 (NBS, 1981-2010); import from General Administration of Customs of the People's Republic of China, 1981-2010 (GACPRC, 1981-2010).

Whether China's future wool imports will further increase depends on at least three factors:

(i) Competition from alternative fibres. Demand for woollen products will be largely affected by the supply of alternative fibres. As an important portion of China's processed wool products are re-exported, changes in global demand for woollen products will have an impact on China's need to import fine wool.
(ii) Changes in environment protection rules. Currently, part of the greasy wool imported into China is semi-processed, sometimes only involving scouring (washing), combing, or sorting, and then the products are re-exported. This uses up much water – becoming increasingly precious to China – and places heavy pollution pressure on the environment. If such simple processing is prohibited by the government because of environmental considerations, China's raw wool imports may decline. Between 1992 and 2009, the annual exports of semi-processed wool and wool tops were equivalent to raw wool in the range of 40-116 kt, with the annual average being about 80 kt (Table 2). Should China ban semi-processing for re-exports, the decline in China's raw wool import demand could be 15-30% of recent total imports.
(iii) Chinese consumers' demand for fine wool products. Domestic demand in China for fine wool products is likely to increase as a result of increased consumer disposable income. Based on projections by the World Bank, China's middle income population will increase from around 56 million in 2000 to 361 million by 2030 (World Bank 2006). Generally, Chinese people regard woollen products highly and fine wool apparel adds to a person's status.

### *2.2 Major Sources of Wool Imports*

In recent years, Australia, New Zealand, Uruguay and South Africa have been the major raw wool suppliers to China. According to FAO, the output of raw wool in the above countries was 265 kt, 218 kt, 45 kt and 45 kt in 2008, respectively. In terms of the share of total world output, these are 21.1%, 9.9%, 2.1% and 2.1%, respectively (FAO 2008a). These four countries are also the main wool exporters; together they exported 459 kt of wool in 2008, accounting for 68.1% of world's wool exports. The value of these exports was US$2.3 billion and accounted for 84.5% of the total world export value of wool (in 2008 US dollars) (FAO 2008b).

The volume and value shares of China's wool imports from these four countries are given in Table 3. The majority of China's wool imports is from Australia. Volume wise, Australia's exports contributed between 66-80% of China's total imports between 2001 and 2009. In terms of value, the share was between 77% and 89%. Wool imports from New Zealand, Uruguay and South Africa make up 11%, 3.4% and 6.2% in volume, and 6.8%, 2.3% and 7% in value terms, respectively, in 2009. For Australia and South Africa, their share of total value is greater than the volume share, because they export wool of higher quality, thus attracting a price premium (Table 3).

Table 2. Value and Volume of Scoured Wool and Wool Top Exports by China (1992-2009)

| Year | Degreased shorn wool | | | Wool top | | | Total raw wool equivalent (kt) |
|---|---|---|---|---|---|---|---|
| | Value (US$, million) | Volume (kt) | Raw wool equivalent (kt) | Value (US$, million) | Volume (kt) | Raw wool equivalent (kt) | |
| 1992 | 0.05 | 0.03 | 0.05 | 220.58 | 47.44 | 87.85 | 87.90 |
| 1993 | 0.30 | 0.18 | 0.30 | 169.80 | 44.97 | 83.28 | 83.58 |
| 1994 | 0.24 | 0.20 | 0.33 | 199.82 | 54.90 | 101.67 | 102.00 |
| 1995 | 1.85 | 0.96 | 1.60 | 280.16 | 50.49 | 93.50 | 95.10 |
| 1996 | 5.15 | 2.08 | 3.47 | 242.02 | 44.95 | 83.24 | 86.71 |
| 1997 | 10.58 | 3.79 | 6.32 | 272.08 | 46.62 | 86.33 | 92.65 |
| 1998 | 4.25 | 2.66 | 4.43 | 176.67 | 31.68 | 58.67 | 63.10 |
| 1999 | 5.42 | 4.58 | 7.63 | 193.81 | 43.59 | 80.72 | 88.36 |
| 2000 | 3.39 | 3.12 | 5.20 | 288.07 | 60.35 | 111.76 | 116.96 |
| 2001 | 2.16 | 2.00 | 3.33 | 254.75 | 58.37 | 108.09 | 111.43 |
| 2002 | 2.93 | 2.44 | 4.07 | 220.33 | 44.51 | 82.43 | 86.49 |
| 2003 | 13.38 | 11.56 | 19.27 | 158.19 | 27.67 | 51.24 | 70.51 |
| 2004 | 23.74 | 20.33 | 33.88 | 125.20 | 23.90 | 44.26 | 78.14 |
| 2005 | 32.38 | 23.40 | 39.00 | 103.39 | 21.46 | 39.74 | 78.74 |
| 2006 | 27.10 | 20.57 | 34.28 | 96.28 | 21.4 | 39.63 | 73.91 |
| 2007 | 22.76 | 16.18 | 26.97 | 110.54 | 20.80 | 38.52 | 65.49 |
| 2008 | 11.49 | 6.78 | 11.30 | 102.85 | 19.34 | 35.81 | 47.11 |
| 2009 | 6.18 | 3.46 | 5.77 | 74.38 | 18.58 | 34.41 | 40.17 |

Note: In Australia, the ratio of clean wool to greasy is that clean weight is about 55-65% of greasy weight, depending on the different parts of Australia with differing climatic conditions in which the wool is grown. An average yield would be about 60% (i.e., 1kg greasy wool = 600 grams of scoured wool) and an average combing yield of 90% (i.e., 1kg scoured wool = 900 grams of wool top). Because the majority of China's wool imports are from Australia, in this table, we have used these ratios to convert the scoured wool and wool tops back to raw wool equivalent. We thank Wes Brown, the Manager of Grenabri Pastoral and also the Principal of Grazing Management Analysis in NSW Central West for helping with these conversion ratios.

Source: UN Comtrade database (1992-2009).

### *2.3 Wool Imports from Australia*

Australia's dominant position in China's wool imports is because of superior wool quality. In addition, Australia has in the past decades provided assistance to China's wool production and to the development of the woollen textile industry, helping the acceptance of Australian wool in China. Australian wool attracts a higher price in China than wool from competitors and domestically produced wool. According to the statistics of the Chinese Nanjing Wool Market, average auction prices of Australian wool in China are 10 thousand yuan per tonne higher than domestically produced wool, and also higher than the prices of wool imported from any other countries (Nanjing Wool Market 2006).

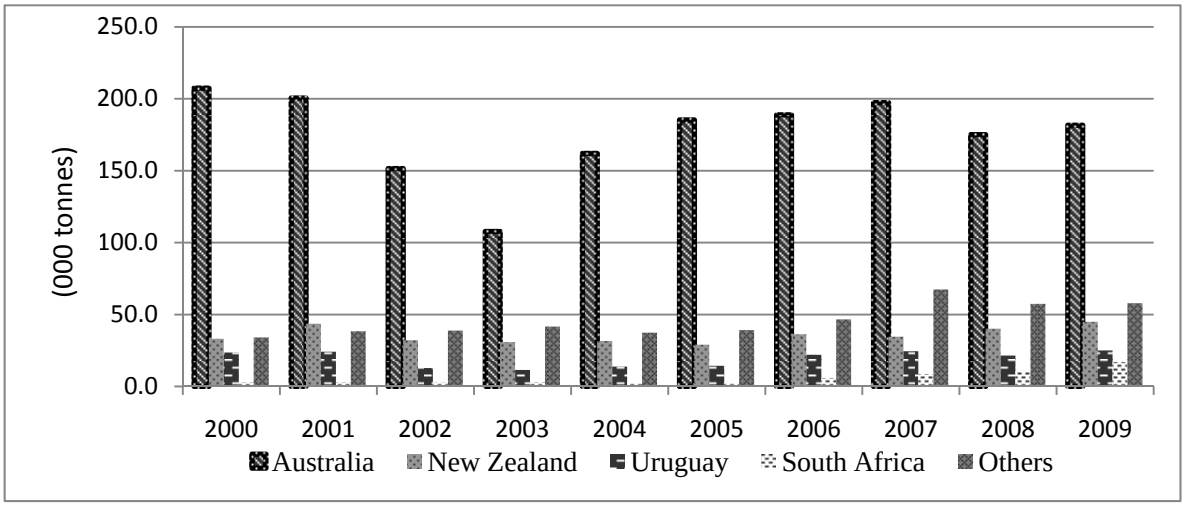
China's wool imports from Australia fluctuate, as shown in Figure 1. The volatility of Australia's wool output partially explains the fluctuating quantities. As well, some Chinese wool companies turn to imports from other suppliers when facing high prices of Australian wool. In Figure 1 it is shown that imports from South Africa have been increasing during the latter part of the decade. Imports from Uruguay have also risen since 2003.

Table 3. Share of China's Wool Imports from Four Major Suppliers (2001-2009

| Year | Australia | | New Zealand | | Uruguay | | South Africa | |
|---|---|---|---|---|---|---|---|---|
| | Volume (%) | Value (%) | Volume (%) | Value (%) | Volume (%) | Value (%) | Volume (%) | Value (%) |
| 2001 | 79.1 | 85.1 | 14.9 | 11.1 | 1.9 | 1.5 | - | - |
| 2002 | 80.4 | 88.9 | 14.8 | 8.9 | - | - | - | - |
| 2003 | 72.8 | 85.5 | 17.3 | 9.8 | - | - | - | - |
| 2004 | 79.2 | 87.9 | 12.7 | 7.7 | 1.1 | 0.8 | - | - |
| 2005 | 79.7 | 87.3 | 11.5 | 7.7 | 1.7 | 1.2 | - | - |
| 2006 | 74.3 | 83.5 | 10.6 | 7.0 | 4.4 | 2.8 | 2.0 | 2.1 |
| 2007 | 71.6 | 84.0 | 8.4 | 4.6 | 4.2 | 2.3 | 3.3 | 3.0 |
| 2008 | 71.6 | 83.0 | 11.2 | 6.0 | 2.9 | 1.8 | 4.2 | 4.3 |
| 2009 | 66.3 | 77.0 | 11.0 | 6.8 | 3.4 | 2.3 | 6.2 | 7.0 |

Denotes no number or negligible
Source: GACPRC, various issues

Figure 1. Major Sources of China's Wool Imports (2000-2009)

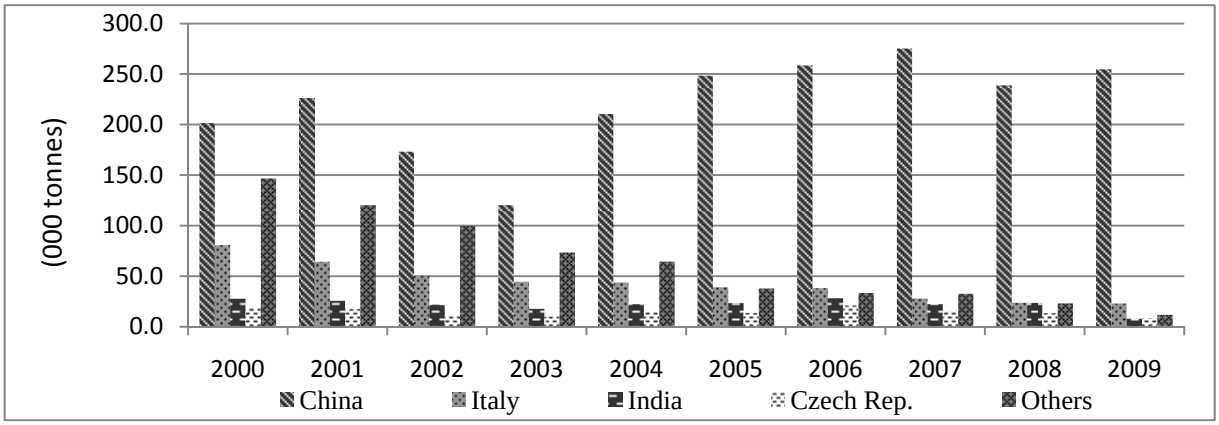



Source: GACPRC, various issues.

In Figure 2 it is shown that the relative importance of different destinations for wool exports from Australia has changed markedly. Relocation of wool processing capacity from relatively high cost regions, such as Western Europe, to lower cost countries has led to a significant reduction of Australia's wool exports to traditional markets such as the European Union, Japan and the

Republic of Korea. Correspondingly, in the past few years, China's intake of the Australian wool exports has been far greater than any other major importing countries, e.g., Italy, India and Czech Republic. Note that there is a difference between the wool imports by China from Australia and the wool exports from Australia to China in Figures 1 and 2 and Table 4. This is the result of having to rely on different sources of data. This import-export difference, however, should not cause major concern for conclusions in this paper as these data are used to show the relative importance of the Chinese market to Australia.

Figure 2. Main Destinations of Australia's Wool Exports (2000-2009)




Source: UN Comtrade database, 2000-2009.

According to Figure 2, Australia's total wool exports have been declining as sheep numbers have declined to their lowest level for 100 years. However, exports to China have been on the increase. In 2000, wool exports by Australia to China were 201.5 kt from a total export volume of 475.2 kt, or 42%. By 2009, over 80% of its wool exports went to China (254.7kt, from total exports of 305.6 kt).

Australian wool production is likely to continue to dominate wool exports to China, especially fine wool. Table 4 shows that, from 2000 to 2009, wool with a fibre diameter less than or equal to 19 microns that was exported to China from Australia rose rapidly, both in volume (from 16.9 kt to 56.4 kt) and share (from 10% to 34%). While the changes in volume and share of wool exports with larger microns (≧24um) are less significant, exports of wool with a fibre diameter between 20 to 23 microns declined significantly; from 122 kt in 2000 to 83 kt in 2009 in volume terms and from 74% to 50% in market share terms. Australia is a major supplier of fine and super fine wool and there are few substitutes for this quality of wool. Undoubtedly, Australia's dominant position in wool exports to China will remain for some years to come.

Table 4. Australia's Wool Exports to China by Fibre Diameter (2000-2009)

| Year | China's fine wool | | Wool imports from Australia | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total fine wool output (kt) | Fine wool as % of total wool output | Total imports from Australia (kt) | ≦19um | | 20-23um | | ≧24um | |
| | | | | Volume (kt) | % out of total | Volume (kt) | % out of total | Volume (kt) | % out of total |
| 2000 | 117 | 40 | 165.2 | 16.9 | 10 | 122.4 | 74 | 25.9 | 16 |
| 2001 | 115 | 38 | 170.2 | 20.5 | 12 | 122.6 | 72 | 27.1 | 16 |
| 2002 | 112 | 36 | 137.3 | 29.5 | 22 | 91.4 | 67 | 16.4 | 12 |
| 2003 | 120 | 36 | 92.5 | 28.0 | 30 | 52.7 | 57 | 11.9 | 13 |
| 2004 | 130 | 35 | 149.0 | 47.4 | 32 | 81.1 | 54 | 20.5 | 14 |
| 2005 | 128 | 33 | 171.7 | 55.9 | 33 | 93.7 | 55 | 22.0 | 13 |
| 2006 | 132 | 34 | 177.4 | 53.4 | 30 | 100.8 | 57 | 23.1 | 13 |
| 2007 | 124 | 34 | 138.2 | 51.1 | 37 | 67.3 | 49 | 19.7 | 14 |
| 2008 | 124 | 34 | 158.9 | 57.4 | 36 | 75.7 | 48 | 26.7 | 16 |
| 2009 | 127 | 35 | 166.2 | 56.4 | 34 | 82.8 | 50 | 27.0 | 16 |

Note: clean equivalent.

Sources: GACPRC (2010, p. 241); Australian Wool Innovation Limited (2010).

## 3. Existing Projections of China's Wool Import Demand

Global wool consumption has declined from a peak of nearly two million tonnes in the late 1980s to around one million tonnes in 2006 (Marinakim *et al.* 2008, p. 7). The demand for wool has been affected by structural factors such as changing consumer demand for woollen products and increased competition from other fibres such as man-made fibres and cotton. Wool consumption has fallen in many major markets such as Eastern Europe and the former Soviet Union, Western Europe and Japan in the past two decades. In contrast, China's wool consumption has increased from an average of 208 kt in the 1980s to 259 kt in the 2000s (Woolmark Company 2006).

Marinakim *et al.*, a research team at ABARE, projected China's wool production, imports and use, using ABARE's Global Trade and Environment Model, based on the assumption that there are no changes to economic policies which could potentially affect world wool demand and supply (Table 5). In their study, trade policies such as tariff rate quotas in China and other restrictive measures in other parts of the world, were assumed to be non-binding.

Table 5. Projection of China's Wool Production, Imports and Use (1990-2025)

| Year | Production | Imports | Use |
|---|---|---|---|
| | (kt) | (kt) | (kt) |
| 1990 | 103 | 31 | 134 |
| 1995 | 122 | 186 | 308 |
| 2000 | 128 | 234 | 362 |
| 2005 | 175 | 239 | 415 |
| 2010 | 189 | 303 | 492 |
| 2015 | 198 | 365 | 564 |
| 2020 | 204 | 411 | 615 |
| 2025 | 208 | 427 | 635 |

Note: In China, wool production is generally expressed in greasy wool. One kilogram clean wool is equivalent to about three kilograms of greasy wool in China (Zhao 2006). In the projections by ABARE, China's greasy wool has been converted to clean wool equivalent.

Source: Marinakim *et al.* (2008).

While China's total wool production is expected to increase, the proportion of fine wool in the Chinese total clip is projected to decline. Wool-producers in China are expected to continue to move resources toward sheep meat production. The projected increase in domestic production of coarse and semi-fine wool will mainly be used to manufacture carpets, blankets and other interior products. As strong income growth continues in China, domestic consumption of these products is projected to increase, together with a rising demand for higher quality woollen textiles and clothing.

China's exports of woollen textiles and clothing have been growing strongly. China is now the world's largest exporter of wool yarn and the world's second largest exporter of wool fabric. The country is also the largest exporter of woollen clothing, accounting for around half of global exports (Marinakim *et al.* 2008).

The relocation of global woollen textile manufacturing to China will continue to forge the transformation of China's textile and clothing industry. China is expected to produce more higher quality woollen products as the country shifts from producing large quantity of low-value products to products with higher value added. Consequently, the demand for fine wool by Chinese processors is expected to continue to be strong. With limited growth of domestic fine wool production, a large portion of fine wool demand by China in the future will still have to be met through imports.

## 4. Responsiveness of China's Wool Import Demand

Existing studies clearly indicate that, in the foreseeable future, China will continue to import a large quantity of fine wool. However, few have attempted to estimate how responsive China's wool imports are to price and income changes and whether there is clear preference in China's selection of import sources.

*The model*

The AIDS model is used in the analysis of China's wool import demand responsiveness. The assumptions are that (1) the decision to import is subject to objectives of maximising utility, (2) domestic and imported products are weakly separable, and (3) products from different sources are not of the same quality.

The AIDS model in general is given as (Deaton and Muellbauer 1980):

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left(X / P\right) + u_i \quad (1)$$

where $w_i$ is the share of total expenditure allocated to a product for country $i$; $p_j$ is the price of the product for country $j$; $X$ is total import expenditure on the product; $\alpha_i$,$\beta_i$ and $\gamma_{ij}$ are parameters to be estimated ; $P$ is the price index and defined as:

$$\ln P = a_0 + \sum_{j=1}^{n} a_j \ln p_j + \frac{1}{2} \sum_j \sum_i \gamma_{ij} \ln P_i \ln P_j \quad (2)$$

The AIDS model is based on the premise of weak division of preference and permits sub-stage estimation on budget expenditure. When a time variable is introduced, Equations (1) and (2) can be rewritten as:

$$w_{it} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_{jt} + \beta_i \ln\left(X_t / P_t\right) \quad (3)$$

and,

$$\ln P_t = a_0 + \sum_{j=1}^{n} a_j \ln p_{jt} + \frac{1}{2} \sum_j \sum_i \gamma_{ij} \beta_i \ln P_{it} \ln P_{jt} \quad (4)$$

where t denotes different time, t=1, 2… T.

The properties from neoclassical demand theory can be imposed on Equation (1) by restricting its parameters using the general properties of demand.

The adding-up restriction is imposed as:

$$\sum_i a_i = 1; \sum_i^n \gamma_{ij} = 0; \sum_i \beta_i = 0$$

Homogeneity is imposed as:

$$\sum_j^n \gamma_{ij} = 0$$

Slutsky symmetry is given by: $\gamma_{ij} = \gamma_{ji}$

The AIDS model is a nonlinear equation after substituting equation (4) into (3). In order to more easily solve the estimation, Deaton and Muellbouer (1980) proposed substituting $P_t$ with Stone's price index $P^*$:

$$\ln P^* = \sum_k w_k \ln P_k \tag{5}$$

Thus Equation (3) is changed into:

$$w_{it} = a_i^* + \sum_{j=1}^n \gamma_{ij} \ln p_{jt} + \beta_i \ln(X_t / P_t^*) \tag{6}$$

Equation (6) is known as the Linear Approximate Almost Ideal Demand System (LAAIDS). The demand expenditure elasticity and demand price elasticities can be deduced from the results (Green and Alston 1990).

**Demand expenditure elasticity**: if it is assumed that the price and total expenditure X are independent each other, then the elasticity of demand ($\varepsilon_i$) from source *i* to total expenditure is defined as:

$$\varepsilon_i = \frac{d \log q_i}{d \log X} = \frac{d \log w_i X / p_i}{d \log X} = \frac{d \log w_i}{d \log X} + 1 = \frac{\beta_i}{w_i} + 1 \tag{7}$$

where $\varepsilon_i$ denotes the change in the volume of demand resulting from a change in expenditure on imports in a given period. If it is above zero, then both have the same direction of change. The greater the value of $\varepsilon_i$, the more wool imported from source *i* when China's total import expenditure of raw wool increases.

**Demand price elasticity**: both the own-price elasticity and the cross-price elasticity can be estimated with the AIDS model. The formula for elasticity is defined as:

$$\eta_{ij} = -\delta_{ij} + \frac{\gamma_{ij} - \beta_i w_j}{w_i} \quad (8)$$

Both own-price elasticity and cross-price elasticity can be derived from Equation (8). $\eta_{ij}$ is the own-price elasticity when $i$ is equal to $j$, and $\delta_{ij}$, the Kronecker delta, is equal to 1. A negative sign is expected, suggesting import share and import price move in the opposite direction. $\eta_{ij}$ is the cross-price elasticity when $i$ is not equal to $j$, and $\delta_{ij}$ is equal to 0. Its sign can be either positive or negative, depending on whether wool from different countries is a substitute or a complement.

Domestic output and import tariffs may have impacts on wool imports. An extended model is defined as:

$$w_{it} = a_i^* + \sum_{j=1}^{n} \gamma_{ij} \ln p_{jt} + \beta_{1i} \ln(X_t / P_t^*) + \beta_{2i} \ln(Q_{it}) + \beta_{3i} TR_{it} \quad (9)$$

where $Q_{it}$ is domestic output of wool and $TR_{it}$ is wool import tariffs. The meaning of the other parameters is the same as above.

*Data*

The data used for this study are yearly data of China's wool imports from 1992 to 2009. It is hard to obtain monthly data of domestic wool output, and the output of domestic wool is a very important factor in analysing China's demand for imports of wool.

According to the China Customs Statistics Yearbook and Harmonized Commodity Description and Coding System (HS1992), wool included for analysis in this research is raw wool (510111). In addition, although China's raw wool imports from South Africa exceeded Uruguay in 2008, and now South Africa has become the third raw wool supplier to China, the raw wool trade between China and South Africa only started in 2001. Until 2005 wool imports from South Africa were negligible. Therefore only four sources of China's raw wool imports are included in the model: namely, Australia, New Zealand, Uruguay and all other countries combined.

While imported wool can be used for processing immediately, for domestically produced wool, it takes about half a year for the wool to be ready for processing because of delays through the marketing system. As such, the value of domestic wool output is replaced by a two-stage moving average, taking into consideration the lag of the impacts of domestic raw wool. In addition, the majority of woollen textiles use fine wool as inputs, so the value of output of domestic raw wool is substituted by that of fine wool in the model. Eighty percent of China's

imported raw wool comes from Australia, and the appreciation of the Australian dollar increases the wool price in US dollars. This offsets the gains of the low cost of raw wool imports from the appreciation of the Chinese yuan against the US dollar. For these reasons, exchange rate changes are not taken into account in the model.

Yearly data used include: volume data of China's raw wool imports from Australia, New Zealand, Uruguay and other countries from 1992 to 2009; price data of China's raw wool imported from Australia, New Zealand, Uruguay and other countries; share of import value of China from Australia, New Zealand, Uruguay and other countries in total import value; output of domestic fine wool; China's import tariff of raw wool. These data are obtained from China Customs Statistics Yearbook, China Animal Husbandry Yearbook and China Customs Tariff. The limitations of using yearly data are that the shorter series restricts the number of variables that can be included in the model and lowers the significance of the results.

### *Empirical Results*

The analytical tool Eviews 5.1 was used for the econometric analysis. Estimation results are presented in Table 6. Data for 'other countries' are calculated from the adding-up restriction, so there is no t value for coefficients of 'other countries'. The price coefficients on the diagonal line are own-price coefficients; the others are cross-price coefficients. Most of the coefficients for the Australia and New Zealand variables are significant at the 1% or 10% level (Table 6). All the coefficients of explanatory variables of Uruguay are insignificant and the value of $R^2$ is lower than for Australia and New Zealand. This may be because of the low share of wool from Uruguay in total wool imports by China.

None of the own-price parameters are statistically significant. This seems to suggest that China's wool imports are not price sensitive. Nonetheless, negative signs on the own-price parameters estimates for New Zealand and other countries suggest that China has a tendency to increase wool imports from them if their wool prices decrease. In the case of Australia and Uruguay, other factors, such as quality of wool, may have a significant effect on China's decision to import wool from them.

The estimates of cross-price parameters suggest that wool exports from Australia to China and wool exports from New Zealand, Uruguay, and other countries to China are complementary, although only the Australia-Uruguay relationship is statistically significant. The superior quality of Australian wool and the size of its export volume means there are few substitutes to Australia's wool exports to China. The majority of wool exported from New Zealand to China is coarse wool. Uruguay exports semi-fine wool to China. Other countries such as South Africa export fine wool to China, but in low volumes. Few wool suppliers compete directly with Australia. However, New Zealand and Uruguay are competitors.

Table 6. Parameter Estimates of Import Demand Model of China's Raw Wool (510111)

| Sources | Price parameter ($\gamma_{ij}$) | | | | Expenditure parameter ($\beta_{1i}$) | Domestic output parameter ($\beta_{2i}$) | Import tariff parameter ($\beta_{3i}$) |
|---|---|---|---|---|---|---|---|
| | Australia | New Zealand | Uruguay | Other countries | | | |
| Australia | 0.0376 | -0.0427 | -0.0449*** | -0.0467 | -0.3292*** | 0.3772* | -1.0393*** |
| $R^2$=0.8068 | (0.8276) | (-1.1310) | (-3.5500) | - | (-3.1887) | (1.7986) | (-4.4287) |
| New Zealand | - | -0.0060 | 0.0395*** | 0.0088 | -0.0641 | -0.2407* | 0.4561*** |
| $R^2$=0.8428 | - | （-0.1435） | (2.9392) | - | (-1.0344) | (-1.8816) | (2.8709) |
| Uruguay | - | - | 0.0043 | 0.0008 | 0.0301 | 0.0482 | -0.0430 |
| $R^2$=0.3854 | - | - | (0.4785) | - | (1.2976) | (0.9943) | (-0.7526) |
| Other countries | - | - | - | -0.0586 | 0.3628 | -0.1849 | 0.6257 |

Note: *** and * denote statistical significance at the 1% and 10% level.

Source: Authors' own calculation.

Estimates of expenditure parameters reflect China's preferences for wool imports from different sources. None of the estimated coefficients are statistically significant except for Australia. The expenditure parameters for Uruguay and other countries are above zero, while those for Australia and New Zealand are below zero. These results imply that China's wool processing enterprises have a stronger preference to import wool from Uruguay and other countries. That is, the share of wool imports from Uruguay and other countries would tend to increase with the growth of China's wool import expenditure. On the other hand, the preference to import from Australia is the lowest, and the share of wool imports from Australia would decrease with the growth of China's wool import expenditure.

Domestic output parameters are used to capture how wool imports from different sources would change when domestic fine wool output increases. If the estimate is negative for a particular country, then wool imports from this country would decrease when China's fine wool output increases; and vice versa. The estimates of wool import coefficients are positive for Australia and Uruguay and negative for New Zealand and other countries. Only the coefficients for wool imports for Australia and New Zealand are statistically significant at the 10% level. If China produced more fine wool and did so at a competitive price, without an increase in demand, it would be expected that imports of fine wool would reduce. However, the results suggest that when China's domestically produced fine wool have increased, the imports from Australia have also increased. This could be because China's demand for fine wool has been increasing, and the increase in domestic fine wool production is far less than the increased demand for extra fine wool by the processing industry.

Import tariff parameters are used to reveal how wool imports from different sources may change if the tariff changes. There were some changes in wool import tariffs during the time period the data cover (1992-2009). Prior to 1999, the wool import tariff for preferential trading partners was 15%. As part of China's effort to enter the WTO, in 1999, a wool TRQ (tariff-rate quota) was introduced. Within quota tariff was 1% and above-quota tariff was 38%. As part of the commitment to get into the WTO, China promised to increase the quota and reduce the above-quota tariff. Since the joining of the WTO in late 2001, the TRQ has been increased. The reduction in above-quota tariff is still under negotiation. In Table 7 is shown the wool TRQ, the TRQ increase in recent years, the actual wool imports, and the usage of the TRQ. According to Table 7, 2007 was the only year in which the TRQ was exceeded. Nonetheless, the above-quota tariff was not activated. As such, data used in this analysis covers the time period when the tariff was 15% (prior to 1999) and the time period when the effective tariff was 1% (since 1999). The coefficient estimates have the expected sign for Australia and Uruguay but not for New Zealand and other countries. It would have expected that the exports to China would increase with reduced tariff. Nonetheless, the results for Australia and Uruguay suggest that wool exports to China by these two countries benefited from the reduction in the tariff, and, Australia benefited far more than any other exporters. Given that within-quote tariff is only 1%, wool exporters will continue to benefit from this low tariff.

Drawing on the price parameters in Table 6, and using the elasticity formulae (7) and (8), expenditure, own-price and cross-price elasticity estimates can be derived. These are shown in Table 8. Estimates of price elasticities for wool from Uruguay were not calculated as most of the estimated coefficients were not significant. Also, the share of Uruguay's wool exports to China account for a small share (3.4% in volume term and 2.3% in value terms).

Table 7. China's Raw Wool Import TRQ Usage (2002-2010)

| Year | TRQ | Actual imports | TRQ usage (%) |
|---|---|---|---|
| 2002 | 264.5 | 231.0 | 87.33 |
| 2003 | 275.8 | 188.0 | 68.17 |
| 2004 | 287.0 | 221.0 | 77.00 |
| 2005 | 287.0 | 253.0 | 88.15 |
| 2006 | 287.0 | 277.0 | 96.52 |
| 2007 | 287.0 | 311.7 | 108.61 |
| 2008 | 287.0 | 285.6 | 99.51 |
| 2009 | 287.0 | 261.6 | 91.15 |
| 2010 | 287.0 | 265.1 | 92.37 |

Sources: Wool import TRQ from "Rules for the Implementation of Tariff Rate Quota Administration of the Imported Wool and Wool Tops", 2002-2010, by the Ministry of Commerce of the People's Republic of China; actual imports from China Customs Statistics Yearbook (2003-2011).

Table 8. Expenditure Elasticity, Own-price Elasticity and Cross-price Elasticity

| Source of imports | Expenditure elasticity ($\varepsilon_i$) | Own-price elasticity ($\eta_{ij}$) ($i=j$) | Cross-price elasticity ($\eta_{ij}$) ($i \neq j$) | | | |
|---|---|---|---|---|---|---|
| | | | Australia | New Zealand | | Other countries |
| Australia | 0.597 | -0.625 | - | -0.016 | | -0.030 |
| New Zealand | 0.288 | -1.003 | 0.107 | - | | -1.122 |
| Other countries | 5.657 | -2.136 | -4.441 | -0.301 | | - |

Source: Authors' own calculation.

All expenditure elasticities have positive signs, as expected. Expenditure elasticity of wool imports from other countries is greater than 1, suggesting that when China's wool import expenditure increases, more wool is likely to be imported from these 'other countries' such as South Africa. Expenditure elasticities of wool imports from Australia and New Zealand are 0.597 and 0.288, respectively, indicating inelastic responses when China's wool expenditure changes.

Negative signs of all own-price elasticity show that import value and import price of wool change in opposite directions. The estimates suggest that if the import price of wool increases, China's wool imports from other countries will reduce the most, followed by imports from New Zealand. Imports from Australia are the least responsive to price changes.

Cross-price elasticity reflects the competitive relationship between wool exports from different sources to China. Most of the estimates indicate a complementary relationship. However, only two of them are elastic, i.e., between New Zealand other countries (-1.122) and between other countries and Australia (-4.441). The cross-price elasticity estimates imply that price changes in

Australian wool exports to China have little impact on the quantity of wool exported to China from New Zealand and other countries. Similar results hold between (a) price changes in New Zealand wool exports to China and the quantity exported from Australia to China; and (b) price changes of exports of wool by other countries to China and the quantity exported from New Zealand to China. However, when there are price changes in wool exports from New Zealand and other countries to China, there will be elastic responses in the quantity exported to China from other countries and Australia, respectively.

It has to be noted that the above estimates should be interpreted with caution. Some estimates in Table 6 are not statistically significant, especially price coefficients – only two cross-price parameter estimates are statistically significant (Australia-Uruguay and New Zealand-Uruguay). Some coefficients even had a wrong sign. A relative short time series (1992-2009) is likely to be responsible for such results. In 1992, China switched to use HS1992. This has unfortunately caused incompatibility of data before and after 1992. Only data starting from 1992 could be used. Nevertheless, though indicative only, the results shed some light on China's wool import responsiveness and the likely preference for sources of imports.

## 5. Conclusions and Implications

In this paper, China's wool import demand has been examined, with a particular focus on China's wool imports from Australia. An AIDS model was used to evaluate how responsive China's wool imports are to price and income changes and whether there is clear preference in China's selection of import sources. The analysis indicates that China's demand for wool imports is not highly responsive to changes of wool prices in general, and to changes of Australian wool prices in particular. This is attributed to the fact that China has to import a large amount of fine wool to meet the needs of wool processors because of the low domestic fine wool output, and that Australia is a major supplier of wool with few substitutes. Thus, Australia enjoys an absolute dominant position in exporting wool to China.

Though Australian woolgrowers are preferred suppliers, the results also show that Chinese importers of wool are alert to resorting to suppliers other than Australia if opportunities arise. As such, Australian exporters need to remain vigilant about China's preferences in sources for wool imports and wool production developments (particularly, fine wool production) in countries that are potential alternative suppliers of wool to the Chinese market.

The amount of wool China imports from Australia can have significant ramifications for the prices received by Australian wool growers. The state of the key determinants of China's demand for wool imports warrants close observation. In the short term, how China's environment policy changes will affect its wool imports deserves close attention. As shown in this paper, China's raw wool import demand would be significantly reduced should China ban the semi-processing of wool for re-export. If this happens, import from Australia would likely be reduced. In the longer term, trends in global demand for fine wool apparel in general and in China's demand for fine wool apparel in particular, should remain subjects of keen interest to Australian fine wool producers and exporters.

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