

UNDERSTANDING THE WORLD WOOL MARKET: TRADE, PRODUCTIVITY AND GROWER INCOMES

PART I: INTRODUCTION*

by

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ABSTRACT

The core objective of this thesis is summarised by its title: “*Understanding the World Wool Market: Trade, Productivity and Grower Incomes*”. Thus, we wish to aid understanding of the economic mechanisms by which the world wool market operates. In doing so, we analyse two issues – trade and productivity – and their effect on, *inter alia*, grower incomes. To achieve the objective, we develop a novel analytical framework, or model. The model combines two long and rich modelling traditions: the partial-equilibrium commodity-specific approach and the computable-general-equilibrium approach. The result is a model that represents the world wool market in detail, tracking the production of greasy wool through five off-farm production stages ending in the production of wool garments. Capturing the multistage nature of the wool production system is a key pillar in this part of the model. At the same time, the rest of the economy, or nonwool economy, is represented through six representative agents: nonwool producers, capital creators, households, exporters, governments and importers.

The model is first applied to analysing the relationship between productivity changes and grower incomes. Here, we examine the relationship between grower incomes and on- and off-farm productivity changes. The analysis indicates that the nature of the assumed supply shift from research is crucial in estimating returns to wool growers from productivity improvements. Assuming a degree of research leakage to foreign producers, a pivotal supply shift (whereby each supply price decreases equiproportionately) will reduce quasi-rents to Australian wool producers for both on- and off-farm research, in both the short and long run; the losses are largest from on-farm research. Again assuming a degree of research leakage to foreign producers, a parallel supply shift (an equal absolute decrease

in each supply price) will increase quasi-rents to Australian wool producers for both on- and off-farm research, in both the short and long run; the gains are largest from on-farm research.

The model is then applied to analysing the economic effects of wool tariff changes. Changes in recent wool tariffs (i.e., between 1997 and 2005) are found to cause positive welfare effects for most regions. Nevertheless, sensitivity analysis shows that the estimated welfare gains are robust only for three regions: Italy, the United Kingdom and China. The welfare gains for Italy and China, 0.09% for both regions, are significant given the small relative size of the wool industries in these regions. The results indicate that Italy and China are the biggest winners from changes in recent wool tariffs.

For the removal of current (2005) wool tariffs, China and the United Kingdom are estimated to be the only winners; but the welfare gain is robust only for China. The estimated welfare gain for China is 0.1% of real income; this is a significant welfare gain. For three losing regions – Italy, Germany and Japan – the results are robust and we can be highly confident that these regions are the largest losers from the complete removal of 2005 wool tariffs. In both wool tariff liberalisation scenarios, regions whose exports are skewed towards wool textiles and garments gain the most as it is these wool products that have the highest initial tariff rates.

The overall finding of this work is that a sophisticated analytical framework is necessary for analysing productivity and trade issues in the world wool market. Only a model of this kind can appropriately handle the degree of complexity of interactions between members (domestic and foreign) of the multistage wool production system. Further, including the nonwool economy in the analytical framework allows us to capture the indirect effects of changes in the world wool market and also the effects on the nonwool economy itself.

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CHAPTER 1

INTRODUCTION

1.1 Preamble

The core objective of this thesis is to aid understanding of the economic mechanisms by which the world wool market operates. We do this by constructing an analytical framework, or model, that encompasses the most important characteristics of the world wool market: the extreme multistage nature of the wool production system, the highly heterogeneous nature of wool products, and the significant trade in wool products. These characteristics are introduced in Section 1.2; this section also provides a description of the general profile of the Australian wool industry. We then explore the nature of the wool production system and demonstrate the significant ‘economic distance’ between members of the wool production system (Section 1.3). Besides capturing wool-specific aspects of the world wool market in the model, it is also desirable to allow for feedback effects from the wool economy to the nonwool economy and back to the wool economy. Therefore, we model the wool economy as a fully integrated part of the wider economy by applying the computable-general-equilibrium (CGE) approach. Section 1.4 discusses the two modelling approaches – commodity-specific and CGE – that are synthesised to create the model; it also discusses recent wool models and compares them to the model constructed here. We then provide a preview of the thesis (Section 1.5) and discuss the contributions and limitations of the thesis (Section 1.6).

1.2 Background

1.2.1 The world wool market

Wool, cotton and man-made fibres account for around 98% of world fibre use.¹ Amongst these three fibres, man-made fibres hold the dominant position accounting for around 60% of world fibre use; cotton accounts for around 36% and wool around 2% (TWC 2004). Wool's small share of world fibre use belies the concentration of wool production, exporting, importing and processing, amongst a few but different countries/regions.

In terms of primary production, Australia is the world's largest wool producer accounting for one-quarter of world wool output; China and New Zealand are the next most important producers at 16% and 11% each (TWC 2004). In terms of apparel wool, Australia's importance is even greater with it supplying around half of such wool (AWIL 2006). Similarly, nearly two-thirds of wool exports are supplied by three countries alone: Australia, 40%; New Zealand, 19%; the United Kingdom (UK), 5% (TWC 2004). Wool imports are somewhat less concentrated: China is the dominant importer (27%),² followed by Italy (10%), India and the UK (8% each), and France and Germany (5% each).

At the spinning (or yarn) and weaving (or fabric) production stages, the use of wool is concentrated in the Far East (mainly China) at 30%, Western Europe (mainly Italy and the UK) at 21%, and the Indian subcontinent (mainly India and Pakistan) at 14%. At the garment-manufacturing stage, the regional concentration is similar but Western Europe is less important (16%) and the Indian subcontinent more important (15%). The consumption of wool at the retail stage (in the form of apparel, carpets, etc.) is distributed differently again. Here, Western Europe (mainly UK, Italy and Germany) and the Far East (mainly

¹ All data discussed in this subsection refers to quantities and either 2003 or 2004.

² This includes Hong Kong and Macau.

China and Japan) are equally important at 26% each, and North America (mainly the United States) less important at 13% (TWC 2004).

The above discussion has hinted at four broad stages of production through which apparel wool passes; the left-hand side of figure 1.1 summarises this structure. This structure, though highly simplified, captures the multistage nature of the wool production system. But the outputs of each of the four production stages can be further disaggregated to provide a more realistic structure of the wool production system that underlies the world wool market. Raw wool produced at stage 1 can be disaggregated into greasy, scoured, carbonised, carded and combed wool. Wool yarn produced at stage 2 can be divided into worsted and woollen yarn, and similarly for wool fabrics produced at stage 3 and wool garments produced at stage 4. Table 1.1 provides a short description of each of these outputs.

The wool production system begins with the production of greasy wool, which is removed from the sheep's back by shearing. Greasy wool is then washed (scoured) to remove extraneous matter, giving scoured wool. Some scoured wools are then carbonised to remove vegetable matter and then carded; other scoured wools bypass the carbonising process and are carded directly and then combed (the carding and combing processes prepare wool for the spinning process). At this point, wools now enter the spinning process where yarns are produced. In general, two types of yarns can be distinguished: worsted and woollen. Worsted yarns are produced from combed wools; woollen yarns are produced from carded wools. The distinction between worsted and woollen yarns is maintained through the weaving process where fabrics are produced and the manufacturing process where garments are produced.

Figure 1.1 A simple representation of apparel wool production stages

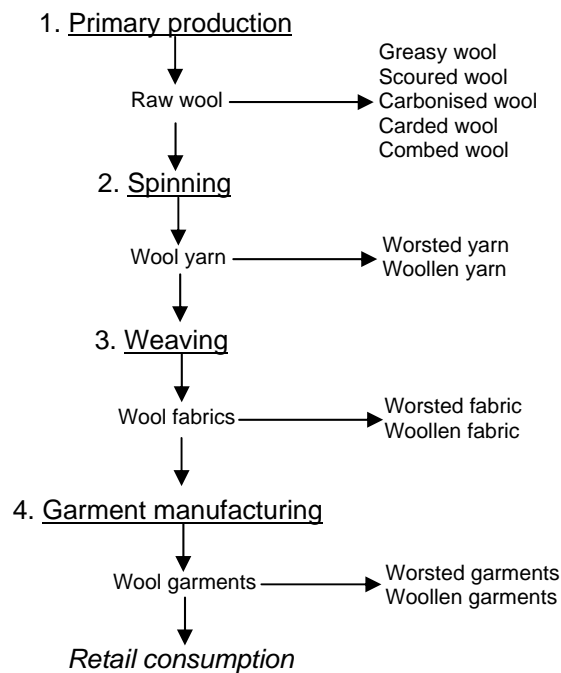


Table 1.1 Description of wool outputs in figure 1.1

<u>Wool output</u>	<u>Description</u>
<i>Raw wool</i>	
Greasy wool	Raw wool straight from the sheep’s back and containing 20-60% extraneous matter, e.g., dirt, natural grease, dried perspiration and vegetable matter.
Scoured wool	Wool that has been cleaned by scouring process, which removes all extraneous matter from greasy wool except for vegetable matter.
Carbonised wool	Wool that has been treated with sulphuric acid to remove vegetable matter from scoured wool.
Carded wool	Wool that has subjected to carding, whereby fibres are opened out and separated to give a web of fibres, crossed and recrossed.
Combed wool	Wool that has subjected to combing, whereby fibres are made to lie parallel to one another in a rope or combed top.
<i>Wool yarn</i>	
Worsted yarn	Yarn in which the fibres are reasonably parallel and that is spun from combed wool.
Woollen yarn	Yarn that has been carded, condensed and spun on woollen machinery from carded wool.
<i>Wool fabric</i>	
Worsted fabric	Fabric manufactured from worsted yarn.
Woollen fabric	Fabric manufactured from woollen yarn.
<i>Wool garments</i>	
Worsted garments	Garments manufactured from worsted yarns and fabrics.
Woollen garments	Garments manufactured from woollen yarns and fabrics.

Source: Bell (1970).

Thus, there exist two sub-production systems within the broader apparel wool production system: the worsted system and the woollen system. From the perspective of consumers of wool garments, worsted fabrics are made with longer (yarn) fibres that produce a surface that is smooth to touch whereas woollen fabrics are made with shorter fibres that stand up from the surface and give the fabric a hairy touch (AWIL 2006). Examples of wool garments produced from worsted fabrics include wool suits and skirts; examples of wool garments produced from woollen fabrics include woollen jumpers.

The worsted and woollen sub-production systems give a flavour of the heterogeneous nature of the wool production system. The degree of heterogeneity can be further expanded. Raw wool (greasy, scoured, etc.) is commonly distinguished by hauteur (or length) and diameter. Hauteur is quoted in millimetres (mm); diameter is quoted in microns, or millionths of a metre, (μm). The properties, or qualities, of hauteur and diameter determine the type of processing and the range of products that can be made from a given batch of wool. Consequently, the qualities determine the relative price of different wools by reflecting the relative value of the end-use products that they enter. In general, finer wools fetch higher prices. Finer wool ($<20 \mu\text{m}$) is used for producing lightweight fabrics and garments. Broader wool is processed into nonapparel, e.g., blankets, upholstery and carpets. Longer fibres ($>56 \text{ mm}$) enter the worsted system and are used for making suiting and lightweight knitwear. Shorter fibres ($<56 \text{ mm}$) enter the woollen system and are used for making bulky fabrics such as tweeds, felts, flannels and knitwear (Kopke et al. 2004). Table 1.2 summarises the wool sub-qualities as they apply to wool products identified in figure 1.1. In this work, these sub-qualities are used to represent a highly detailed wool production system.

Table 1.2 Wool products and their sub-qualities

<u>Wool product</u>	<u>Sub-qualities</u>
<i>Raw wool</i>	
Greasy wool	Diameter; hauteur (length)
Scoured wool	Diameter; hauteur (length)
Carbonised wool	Diameter; hauteur (length)
Carded wool	Diameter; hauteur (length)
Combed wool	Diameter; hauteur (length)
<i>Wool yarn</i>	
Worsted yarn	Blended; pure; lightweight; heavyweight
Woollen yarn	Blended; pure
<i>Wool fabric</i>	
Worsted fabric	Blended; pure; lightweight; heavyweight; woven; knitted
Woollen fabric	Blended; pure; woven
<i>Wool garments</i>	
Worsted garments	Men's; women's; blended; pure; woven; knitted
Woollen garments	Men's; women's; blended; pure; woven; knitted

1.2.2 The Australian wool industry

It has already been noted that Australia is the world's largest producer of wool producing 25% of world output; in terms of apparel wool, Australia supplies around 50% of world output.³ Such an important player in the world wool market deserves some extra attention and this is provided below.

The wool industry has historically been an important agricultural export earner for Australia; at the end of the 19th century, wool earned around 54% of *total* merchandise exports (Boehm 1979).⁴ But the relative importance of wool exports has been on a secular downward trend since that time; in 2004-05 wool accounted for only 2.5% of Australia's total commodity (agricultural and mining) exports, and only 8.3% of Australia's agricultural exports, ranking fourth behind beef, wheat and wine. In dollar terms, wool exports were valued at \$2.5 billion in 2004-05 (AWIL 2006).

The declining relative importance of wool export earnings, over the last 100 years or so, reflects the huge growth in other commodity exports (particularly mining), but also,

³ Although Australia is the world's largest producer of wool, China has the largest sheep population (AWIL 2006).

⁴ This is an average for the period 1881-90.

more recently, declining sheep numbers and wool production; in 1989, the sheep flock was around 170 million whereas in 2004-05 it had fallen to around 107 million (AWIL 2006; CIE 2002). The decline in sheep numbers over this period reflects lower wool prices that, in turn, reflect lower wool demand. At the same time, incomes for wool-producing farms have fallen in concert with wool prices. This has encouraged wool producers to diversify their production by producing less wool and more crops and livestock. Consequently, in 2002 only about one-third of the 45 000 sheep- and wool-producing farms in Australia derived a significant proportion of their income from sheep and wool, whereas the remainder were mixed livestock-crops and sheep-beef producers (CIE 2002).

In 2003, the Australian flock was mainly composed of Merino sheep (85%); Merino sheep are bred primarily for their wool. In the same year, 73% of the total wool produced in Australia was produced by less than 40% of wool-producing farms. This reflects a degree of concentration in Australian wool production. It is expected that the amount of wool produced in 2005-06 will fall by 1.7% reflecting low wool prices relative to lamb and alternative farm uses. Since 1993-94 there has been a significant increase in the $\leq 19 \mu\text{m}$ profile of the Australian clip, from 9% to 32% (AWIL 2006). This has contributed to Australia's reputation as the world's leading producer of quality fine apparel wool (DAWA 1999).

Over the second half of the 20th century, the Australian wool industry has oscillated from almost zero government intervention in the 1960s to a number of failed price support schemes in the 1970s and 1980s, and (again) back to almost zero government intervention at the end of the 20th century. The most well-known of the failed price support schemes commenced in 1974 and was eventually known as the 'Reserve Price Scheme' (RPS). The RPS established a firm floor price and was backed by a compulsory levy of 5% of the gross proceeds from the sale of shorn wool. The scheme appeared to stabilise Australian dollar

prices over the period 1974–87. Up to 1987 the (nominal) floor price was increased annually by 5-7%, but during the two-year period 1987–1988 it was increased by 70%. This was followed by a 19% increase in production in 1989-90 to record levels. The RPS eventually collapsed and was abandoned in 1991. By this time, 4.75 million bales of wool (about one average wool clip) had been amassed under the scheme due to the failure to reduce the reserve price after 1988. Nine years after the scheme was abandoned, a million bales of wool remained in the stockpile. One legacy of the RPS is the return, at the beginning of the 21st century, to the minimal (government) intervention environment of the 1950s (Richardson 2001).

1.3 The nature of the wool production system

Applying some of the wool sub-qualities to the wool production system presented in figure 1.1, we can develop a more realistic representation of the wool production system; this is presented in figure 1.2 with arrows indicating the flows of outputs and inputs at each production stage. Six production stages are distinguished: primary production (producing greasy wool), scouring (producing scoured wool), carding/combing (producing carbonised wool, worsted tops, and noils), spinning (producing yarns), weaving (producing fabrics), and manufacturing (producing garments). Figure 1.2 also includes the use of nonwool inputs, such as synthetic textiles (used to produce blended wool yarns), and factors of production.

$$pind_j = SPRIM_j pprim_j + SINT_j pint_j; \quad (1.1)$$

where $pprim_j$ and $pint_j$ are the percentage changes in prices of primary factors and intermediate inputs by the j -th industry, and $SPRIM_j$ and $SINT_j$ are the shares of primary factors and intermediate inputs in industry costs. We assign $pprim_j$ as exogenous, whereas $pint_j$ is defined as

$$pint_j = \sum_{i=1}^I SINT_{ij} pcom_i; \quad (1.2)$$

where $pcom_i$ is the percentage change in the price of commodity i . For $i =$ other goods, synthetic textiles, $pcom_i$ is exogenous as these goods are produced outside the wool production system. For all other goods, $pcom_i$ is defined as

$$pcom_i = pind_j, \quad i = j. \quad (1.3)$$

We calibrate the model by using the data presented in table 1.3, which is an aggregated form of the data used in this study (see Chapter 4). The data show a number of interesting trends as wool moves through the production system. First, the importance of primary factors (row 1) is low and intermediate inputs (row 2) high in the production costs of early-stage processing industries (scoured wool, column 2; carbonised wool, column 3; worsted top, column 4). As wool moves to late-stage processing industries (yarn, column 5; fabric, column 6; garments, column 7) primary factors become more important and intermediate inputs less important. Second, the importance of other goods (row 11) is low and wool inputs (rows 3–9) high in the intermediate input costs of early-stage processing industries. But the importance of other goods as an intermediate input is much greater in late-stage processing industries, so much so that it is more important than wool inputs in garment production. Third, the input-output table (table 1.3) shows a recursive pattern.

That is, if a_{ij} represents the input-output coefficient for the use of input i by industry j , then

$a_{ij} = 0$ for $i = j$ but, in general, $a_{ij} > 0$ for $j > i$.

Table 1.3 Data used to calibrate input-output price model

<u>INPUTS</u>	<u>INDUSTRIES</u>						
	Sheep (1)	Scoured wool (2)	Carbonised wool (3)	Worsted top (4)	Wool yarn (5)	Wool fabric (6)	Wool garments (7)
	<u>Broad cost shares</u>						
1. Primary factors	0.450	0.077	0.118	0.168	0.239	0.278	0.330
2. Intermediates	0.550	0.923	0.882	0.832	0.761	0.722	0.670
<i>Total costs</i>	<i>1.000</i>	<i>1.000</i>	<i>1.000</i>	<i>1.000</i>	<i>1.000</i>	<i>1.000</i>	<i>1.000</i>
	<u>Intermediate input shares</u>						
3. Greasy wool	0	0.976	0	0	0	0	0
4. Scoured wool	0	0	0.951	0.902	0	0	0
5. Carbon wool	0	0	0	0	0.352	0	0
6. Worsted tops/noils	0	0	0	0	0.359	0	0
7. Wool yarn	0	0	0	0	0	0.613	0.038
8. Wool fabric	0	0	0	0	0	0	0.310
9. Wool garments	0	0	0	0	0	0	0
10. Synthetics	0	0	0	0	0.033	0	0
11. Other goods	1.000	0.024	0.049	0.098	0.256	0.387	0.652
<i>Intermed costs</i>	<i>1.000</i>	<i>1.000</i>	<i>1.000</i>	<i>1.000</i>	<i>1.000</i>	<i>1.000</i>	<i>1.000</i>

Source: Chapter 4.

We explore the properties of the wool production system by applying shocks to each production stage and observing the flow-on effects to the prices of downstream industries. We apply a 5% reduction in the price of primary factors used by each industry, which can be thought of as a 5% improvement in the total factor productivity (TFP) of the industry in question. The effects on industry prices are presented in table 1.4. These effects show a lower triangular, or recursive, structure that is implied by the recursive structure of the input-output coefficients (table 1.3). The pattern is an indication of the linear or unidirectional hierarchy in the wool production system (see Dorfman et al. 1987, p.205).

Table 1.4 Effects on industry prices of a 5% reduction in primary factor costs at each production stage

<u>Effect on price of:</u>	<u>5% reduction in primary factor costs of:</u>					
	Sheep	Scoured wool	Carbon wool/ worsted top	Wool yarn	Wool fabric	Wool garments
Sheep	-2.25	0	0	0	0	0
Scoured wool	-2.03	-0.38	0	0	0	0
Carbon wool	-1.70	-0.32	-0.59	0	0	0
Worsted top	-1.52	-0.29	-0.84	0	0	0
Wool yarn	-0.87	-0.17	-0.39	-1.19	0	0
Wool fabric	-0.39	-0.07	-0.17	-0.53	-1.39	0
Wool garments	-0.10	-0.02	-0.05	-0.14	-0.29	-1.65

The input-output price model confirms that there is a significant ‘economic distance’ between the first and last stages of the wool production system. For instance, a 5% reduction in the primary factor costs of the sheep industry leads to only a 0.1% reduction in the price of wool garments. This reflects the decreasing importance of wool inputs at each successive production stage as wool moves from on-farm production to early-stage wool processing to late-stage processing. In contrast, there is less economic distance between the sheep industry and the early-stage processing industries, e.g., a 5% TFP improvement in the sheep industry leads to a 2% fall in the price of scoured wool, a 1.7% fall in the price of carbonised wool and a 1.5% fall in the price of worsted top industry. Further, the links between the late-stage processing industries are also weak. Thus, a 5% reduction in the primary factor costs of the wool fabric industry leads to only a 0.3% reduction in the price of wool garments. This reflects the minority share of total costs that wool inputs (yarns and fabrics) comprise in garment production (35%).

The model demonstrates the general weakness of the economic links between early- and late-stage members of the wool production system. If substitution between inputs were allowed in the model, then the links would be stronger; industries could then exploit lower input prices by substituting cheaper inputs for more expensive inputs. Regardless, allowing substitution would not change the general result unless the degree of substitution was

infinite. The general result serves to illustrate an important property of the wool production system that surfaces prominently in the productivity experiments performed in Chapter 5.

1.4 Methodology

The model developed here represents the synthesis of two modelling traditions: (i) the partial-equilibrium commodity-specific approach, and (ii) the computable-general-equilibrium (CGE) approach.

1.4.1 The partial-equilibrium commodity-specific modelling approach

Commodity-specific models have a long and rich history that began in the 1960s. They do not constitute a unique research stream but consist of an amalgam of work from agricultural economics, energy economics, mineral economics, marine economics, commodity futures and financial economics. These models feature varied methodologies, consisting of econometrics, mathematical programming, input-output analysis, and systems simulation theory and methods (Güvener et al. 1991).

In the aggregate, models of agricultural commodities vary widely but they all contain a number of common characteristics; inelastic demand, slow growth in total demand, competitive market structure, significant technological change, and the tendency of resources to become specific to the agricultural sector. For individual agricultural commodities the aggregate modelling approach is modified to account for additional characteristics that are unique to the commodity in question (Güvener et al. 1991). The work presented here contains characteristics common to all agricultural models (inelastic demand, competitive market structure, sector-specific resources) and additional characteristics that are unique to wool (the multistage nature of the wool production system, heterogeneous treatment of wool products). There are many commodity-specific models

of wool. Recent examples include Mullen et al. (1989), Connolly (1992), Tulpule et al. (1992), Layman (1999) and Verikios (2004).

Mullen et al. (1989) construct an equilibrium displacement model of the world wool top industry, which uses wool and nonwool inputs to produce wool top. Wool inputs are distinguished between Australian and foreign supply. Connolly (1992) constructs an econometrically-estimated partial-equilibrium model of the world wool market and distinguishes between apparel and carpet wool. There are seven demand regions and five supply regions. The wool production system is depicted via three stages: raw wool production, textile production, and end-use products. Wool products from different regions are treated as differentiated products. The model by Tulpule et al. (1992) is also econometrically estimated and partial equilibrium. It represents the wool production system via four production stages: wool top, yarn, fabric, and garments. Wool inputs to top production are distinguished between Australian and foreign supply. At each production stage, wool products are assumed to be differentiated on the basis of four categories of wool content: pure wool, wool rich, wool poor, and nonwool; but there is no geographic differentiation of these products.

Layman (1999) represents a significant advance on the models already discussed. Similar to Mullen et al. (1989), it is an equilibrium displacement model, albeit a very large one. It depicts seven production stages: a sheep industry, scouring industries, carding/combing industries, yarn industries, fabric industries, wholesale garment industries and retail garment industries. It differentiates wool products by both quality (diameter, hauteur, worsted, woollen, woven, knitted, pure, blended, etc.) and place of production. Thus, 10 regions of the world are distinguished and international trade occurs in all wool products except retail garments. The degree of industry and commodity detail in Layman (1999) is unprecedented. Verikios (2004) uses the database of Layman (1999) to construct

a model of the world wool market with an almost identical degree of industry and commodity detail. It departs from Layman (1999) by adjusting the benchmark data for discrepancies, using more flexible functional forms to represent demand and supply for all inputs and outputs, and updating all parameter values using a literature search and wool experts' advice.

1.4.2 The computable-general-equilibrium modelling approach

The defining characteristic of CGE models is a comprehensive representation of the economy, i.e., as a complete system of interdependent components – industries, households, investors, governments, importers and exporters (Dixon et al. 1992). These can be single region models, e.g., Dixon et al. (1982), or multi-region models, e.g., Hertel (1997). It is not unheard of to incorporate the characteristics of commodity-specific models within a CGE framework, but it is uncommon. The most prominent examples of such a synthesis are the linking of input-output models of the energy sector with macroeconomic models (e.g., Hudson and Jorgenson 1974). Synthesised energy-market models allow for feedback effects, from the energy sector to the rest of the economy and back to the energy sector, to inform the analysis of energy-specific issues. A more recent example of such a synthesis is Trela and Whalley (1990), who construct a CGE model of textile and apparel markets with 14 specific textile and apparel categories and one composite other good, and 37 regions trading regions. In terms of wool, the only example of a wool CGE model (that we are aware of) is CIE (2002), where GTAP, a multi-region CGE model (Hertel 1997), is disaggregated to distinguish raw wool, wool textile and wool garments sectors. The main drawback of such a model is the homogeneous representation of wool products.

In developing a synthesised wool model, we take a similar approach to Trela and Whalley (1990). Thus, we distinguish 54 individual wool products and two nonwool

products (synthetic textiles and one composite other good). But our approach goes further, by distinguishing 42 individual wool products industries and a separate composite other industries sector.⁵ The wool products industries in each region are linked with the other industries sector through domestic factor markets, domestic and international markets for intermediate inputs, and domestic and international markets for household goods. This completes and complements the commodity-specific aspects of the model. This also constrains the behaviour of the wool economy in individual regions to assumptions about macroeconomic behaviour, such as a balance of trade constraint, and household and government consumption constraints. All of this is done at minimum computational cost, by representing nonwool industries and commodities as a single composite industry and commodity. This model builds on the work of Verikios (2004).

1.5 A preview of the thesis

The thesis consists of six chapters. Chapter 2 presents a number of ‘tools’ that are applied in constructing the model. The tools consist of functional forms used to develop the theoretical structure of the model. The linearised versions of the functional forms are derived from their nonlinear forms. In doing so, many of the assumptions underlying the functional forms, and their properties, are identified. Chapter 3 applies the linearised versions of the functional forms to develop the theoretical structure of the model. This is done by documenting the equations, variables and coefficients of the model. We also develop two alternative model closures: a short-run and long-run closure. Chapter 4 is concerned with the model database and parameter values. As such, it does three things: (i) it describes the sources and methods used to construct the model database; (ii) it summarises the resulting database to aid in the interpretation of simulation results; (iii) it

⁵ See Chapter 4 for a complete listing of model industries and commodities.

describes the sources and rationale underlying the parameters used to calibrate the behavioural equations of the model.

Chapters 5 and 6 apply the model to issues of interest to scholars, wool industry analysts and policy makers. The model is first applied to analysing the relationship between on- and off-farm productivity changes and grower incomes (Chapter 5). The analysis is conducted under short- and long-run assumptions, and under alternative assumptions regarding the degree of productivity spill-over to foreign competitors. Our results show that the estimated research gains for Australian wool producers depend crucially on the nature of the assumed research-induced supply shift, i.e., pivotal or parallel. Pivotal supply shifts lead to losses for on- and off-farm research, in both short- and long-run environments. Parallel supply shifts lead to gains for on- and off-farm research, in both short- and long-run environments. Extensive sensitivity analysis confirms that the assumed nature of the supply shift is the important determinant of the sign of the welfare effects from research.

Following the argument made by Rose (1980) in favour of using a parallel supply shift as the best approximation, we focus on the estimates generated from parallel supply shifts. We find that on-farm research is to be preferred to all other forms of research; on-farm research gives the largest welfare gain to Australian wool producers and off-farm research ranks second. Our results indicate that, in general, off-farm research that is ‘close’ to the wool producer provides larger benefits than off-farm research that is ‘distant’. Extensive sensitivity analysis indicates that certain assumptions do affect the estimated welfare gains from research. None of these assumptions are found to alter the ranking of benefits from on- and off-farm research.

The model is then applied to analysing the economic effects of global wool tariff changes (Chapter 6). We analyse the effects of recent (i.e., between 1997 and 2005) and

current (2005) tariffs on wool products. Sensitivity analysis is undertaken to test the robustness of the results with respect to variations in parameter values.

The results provide an indication of the degree of discrimination imposed by wool tariffs. Recent (1997–2005) wool tariffs lead to positive welfare effects for most regions. Nevertheless, sensitivity analysis shows that the estimated welfare gains are robust only for three regions: Italy, the UK and China. The welfare gains for Italy and China are significant given the small relative size of the wool industries in these regions. Tariff barriers on wool textiles and garments fall significantly over 1997–2005 and the pattern of both China's and Italy's exports are more skewed towards these goods than in other regions.

For the removal of 2005 wool tariffs, China and the UK are estimated to be the only winners; but the welfare gain is only robust for China. The reason for China's gain from 2005 wool tariffs is similar to the reason for its gain from 1997–2005 tariff changes; its exports are skewed towards wool products that have the highest tariff rates in 2005 (i.e., wool fabrics and garments) and their removal benefits China more than any other region. The result is an allocative efficiency improvement and increase in the use of capital due to a rise in the demand for primary factors that reduces the relative price of capital.

Underlying the welfare effects of recent and current wool tariffs are the effects on individual industries in each region. The results indicate that the nature of both recent and current wool tariffs severely distort the size of wool industries in different regions. For recent wool tariffs, the changes in the output of wool commodities are extreme reflecting the discriminatory nature of the tariffs. The results indicate a relocation of wool garments production away from France, Germany and Italy, largely to China and the ROW region. For 2005 wool tariffs, production effects on wool processing follow a general pattern: large reductions in most regions and large expansions in China. There is also a major relocation

of wool garments industries away from France, Germany and Italy to the UK, China and the ROW region.

1.6 Contributions and limitations

Any piece of large-scale research is expected to make some contribution to existing knowledge while at the same having some limitations. This thesis is no different.

1.6.1 Contributions

The main contribution of this research is the development of a sophisticated and novel analytical framework for analysing the world wool market. This framework combines the advantages of commodity-specific and CGE modelling. The model is rich enough in commodity and industry detail to realistically represent all of the special characteristics of the world wool market and its submarkets (i.e., the multistage nature of the production system, the heterogeneous nature of wool products); it is also rich enough in nonwool economy detail to represent each region as complete system of interdependent components (i.e., distinguishing nonwool industries, households, investors, governments, importers and exporters). Within such a setting, it is possible to analyse both wool-specific and economy-wide issues and to capture the direct and indirect effects of such issues. The development of such a model represents a significant advance on previous models in this area.

The applications of the model in this thesis also represent a contribution to knowledge. The relationship between on- and off-farm productivity changes and wool growers' welfare has been thoroughly examined by previous studies using a variety of models (see Freebairn et al. 1982; Alston and Scobie 1983; Holloway 1989; Mullen et al. 1989). Studies addressing this issues have suffered from two limitations: failure to

represent the extreme multistage nature of the wool production system, and treating wool products as homogeneous. These limitations are addressed by the application of the model developed here.

Analysis of the economic effects of global wool tariffs is unprecedented in the literature. Here we apply our model to analysing the effects of recent (i.e., between 1997 and 2005) and current (2005) tariffs on wool products. The estimates represent a first pass at establishing which industries and regions gain or lose from recent and current wool tariffs.

1.6.2 Limitations

The main limitation of the work is the age of the benchmark data (1997). The wool economy has not stood still 1997 and, as such, to the extent that changes have occurred, the database deviates from the present nature of the wool economy. Nevertheless, we have minimised the influence of this limitation by addressing issues that we have judged not to be unduly affected by the changes that have occurred in the wool economy since 1997. Any future applications of the model would need to keep in mind this limitation and how it might influence the results.

Another, but less important, limitation is the comparative-static nature of the model, i.e., the model tells us the difference between the initial and new equilibrium and there is no information on how the economy changes over time. Where information on the economy's trajectory through time is of interest, an intertemporal framework would be required. A major advantage of an intertemporal framework is the explicit consideration of expectations, especially firms' investment responses to a policy shock, such as tariff liberalisation. Such responses will vary depending on whether it is assumed that changes in tariffs are announced or unannounced (Dixon et al. 1992). Thus, as the model is

comparative-static it ignores the issue of announcement effects that could be important in the analysis of wool tariff changes in Chapter 6.

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