NSW DEPARTMENT OF PRIMARY INDUSTRIES

An Equilibrium Displacement Model of the Australian Sheep and Wool Industries

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Abstract
This report documents the specification of an equilibrium displacement model (EDM) of the Australian sheep and wool industries. The model is capable of estimating and comparing the potential benefits from R&D and generic promotion investments, and other policy changes, in the different sectors and markets of the Australian sheep and wool industries. Inclusive in the model are the multiple components of the Australian sheep and wool industries to account for cross-product interactions not considered in most previous studies. A high degree of industry disaggregation within the model enables estimation of the distribution of the potential benefits among the various industry sectors and across different regional environments. A number of hypothetical R&D and promotion investment scenarios were modelled as 1 per cent exogenous parallel shifts in the relevant market demand or supply curves, although only two scenarios are reported here. Changes in economic surplus were calculated as measures of welfare changes in each of the various industry sectors. In summary, the results from the simulations suggest sheep and wool producers' gain more from on-farm research than off-farm research; export promotion than domestic promotion; and export promotion than most other R&D scenarios. Domestic consumers gain more from lamb R&D than from promotion, while they gain very little from promotion of wool in the export market. Although needing numerous prices and quantities as inputs, the model is not overtaxing on data requirements, as are econometric models. It can be updated with relative ease, as most of the necessary price and quantity data are readily available from government departments and industry organisations. The model is useful in both *ex ante* evaluations, as a means of assisting decisions of priority setting and resource allocations, and in *ex post* evaluations of actual investments or policy impacts. The inclusion of the multiple sheep and wool industry components enhances the accuracy of economic analysis, making the model a valuable tool to assist in industry policy and decision-making.

Keywords: wool; sheep meat; research and development; economic; evaluation; Australia

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ACRONYMS AND ABBREVIATIONS USED IN THE REPORT

ABARE	Australian Bureau of Agricultural and Resource Economics
ACWEP	Australian Council of Wool Exporters and Processors
AWI	Australian Wool Innovation
AWTA	Australian Wool Testing Authority
BSE	Bovine spongiform encephalitis
EDM	Equilibrium displacement model
FMD	Foot and mouth disease
MLA	Meat and Livestock Australia
MRT	Marginal rate of transformation
R&D	Research and development
VIC DPI	Department of Primary Industries Victoria
VM	Vegetable matter

EXECUTIVE SUMMARY

Challenging issues confronting the Australian sheep and wool industries in recent years include a weakened demand for wool, widespread drought, animal welfare concerns and a steady decline in Australian sheep producers' terms of trade. Less secure market environments, increased competition and lower levels of profitability highlight the importance of the efficient investment of Australian sheep and wool industry R&D and promotion funds.

This report documents the specification of an equilibrium displacement model (EDM) of the Australian sheep and wool industries developed by Mounter (2007) in PhD research at the University of New England. The model is capable of estimating and comparing the potential benefits from R&D and generic promotion investments, and other policy changes, in the different sectors and markets of the Australian sheep and wool industries. Inclusive in the model are the multiple components of the Australian sheep and wool industries to account for cross-product interactions not considered in most previous studies. A high degree of industry disaggregation within the model enables estimation of the distribution of the potential benefits among the various industry sectors.

A number of hypothetical R&D and promotion investment scenarios were modelled as 1 per cent exogenous parallel shifts in the relevant market demand or supply curves, although only two are reported here. Changes in economic surplus were calculated as measures of welfare changes in each of the various industry sectors.

The first scenario examined was a 1 per cent reduction in the cost of producing lamb. Although domestic consumers are the main beneficiaries from this scenario (31 per cent), the proportion of total benefits collected by overseas consumers is also significant (also 31 per cent). Due to the joint nature of wool and lamb production, the supply of wool increases in conjunction with increased lamb production, leading to an expansion in the supply of wool exports. Purchasers of Australian greasy and processed wool are the recipients of 67.0 per cent of the additional surplus gained by overseas consumers, highlighting the importance of accounting for joint-product relationships in the analyses. Sheep and wool producers receive a little less than one quarter of the total benefits in this scenario (24 per cent). Taking into consideration that the dry sheep enterprises experience negative surplus changes in response to the lamb industry research investment, lamb-producing enterprises actually receive 28 per cent of the total returns. The fact that it is possible for some enterprises to experience a loss of surplus in response to alternative investments reinforces the argument for the inclusion of the multiple components of the sheep and wool industries in the analyses. Other industry sectors to benefit are the domestic sheepmeat processing and retail sectors, each obtaining moderate gains, while the benefit shares received by the wool warehouse/brokerage, domestic wool processing, wool export and sheepmeat export sectors are all negligible.

The second scenario relates to a hypothetical wool promotion investment on the export market. The majority of the returns accrue to overseas consumers (54 per cent), as the bulk of Australian wool is exported. Domestic consumers receive a much smaller share of the total benefits (7.5 per cent) than those gained in the lamb-specific investment scenario, mostly as a result of lower retail prices from an increase in the supply of lamb.

Sheep and wool producers gain one third of the total returns (33 per cent) while gains to each of the other industry sectors are minimal.

Although needing numerous prices and quantities as inputs, the model is not overtaxing on data requirements, as are econometric models. It can be updated with relative ease, as most of the necessary price and quantity data are readily available from government departments and industry organisations. The model is applicable for use in *ex ante* evaluations, as a means of assisting decisions of priority setting and resource allocations, and in *ex post* evaluations of actual investments or policy impacts. The inclusion of the multiple sheep and wool industry components enhances the accuracy of economic analysis, making the model a valuable tool to assist in industry policy and decision-making.

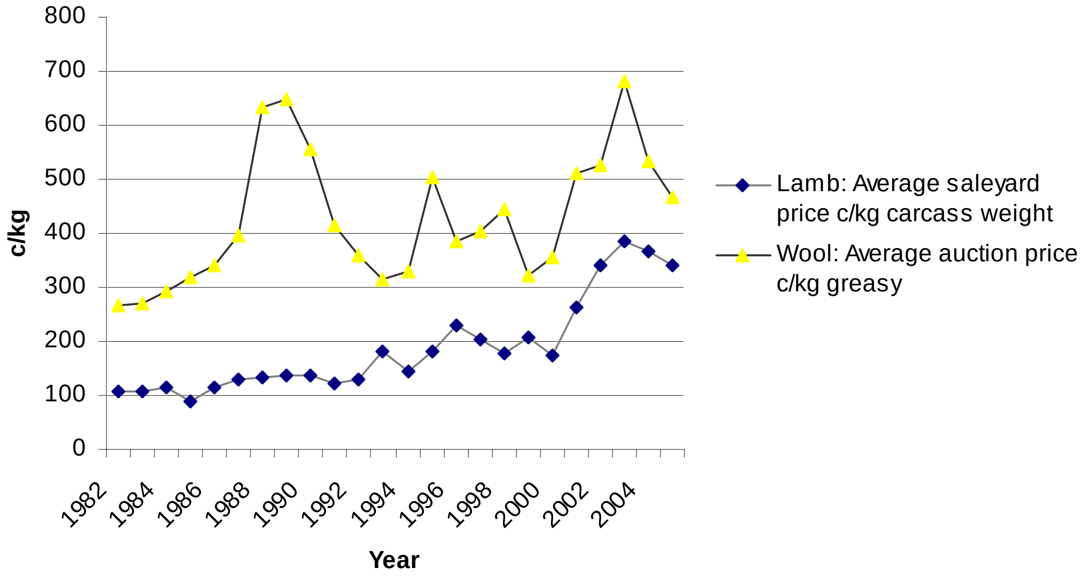
1 Introduction

1.1 Background and Motivation

A number of challenging issues have confronted the Australian sheep and wool industries in recent years. The global demand for wool has declined in the face of strong competition from substitute fibres in wool's traditional apparel markets (AWI 2002). The weakened demand and prices, coupled with widespread drought throughout much of Eastern Australia, has contributed to a large reduction in Australian flock numbers. There has also been a sharp decline in Australia's wool-processing industry, primarily arising from global over-capacity and the emergence of China and other low-labour-cost regions in the wool-processing sector. Welfare concerns over live sheep exports and mulesing to prevent fly strike have plagued the industries, featuring prominently in media headlines amid animal rights campaigns for boycotts on the purchase of Australian sheep and wool products.

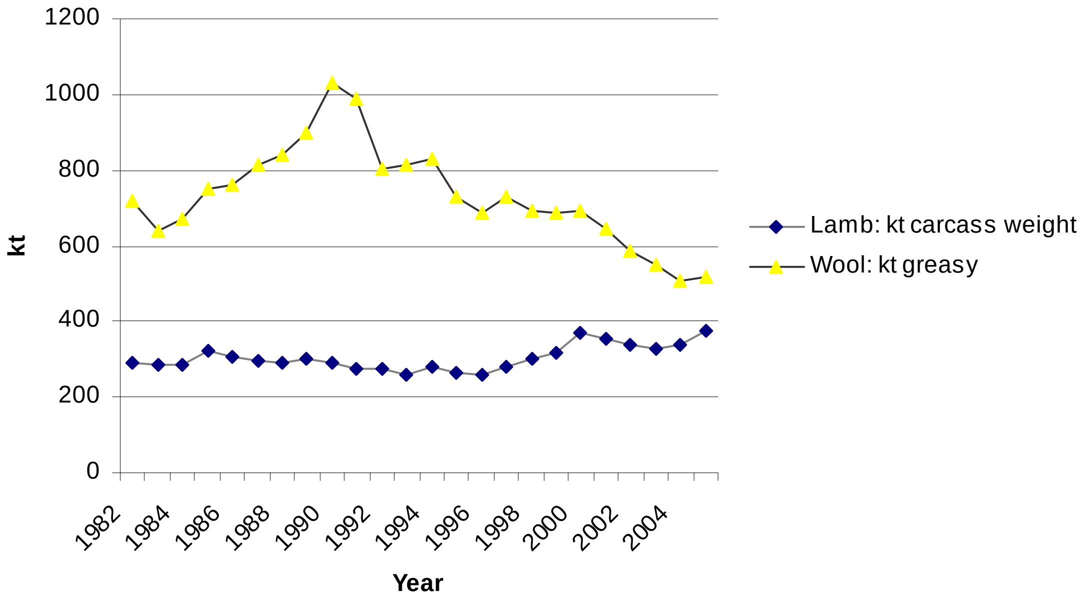
A shift in focus towards lamb production has also seen a significant change in the composition of the national flock. The number of specialist lamb producers has increased (MLA 2004), driven, in part, by higher lamb and sheepmeat prices and growth in key export markets. The strong growth in lamb prices post 2000 (Figure 1(a)) coincides with the sharp increase in Australian lamb production, as shown in Figure 1(b). Conversely, Australian greasy wool production has fallen markedly since the demise of the reserve price scheme in the early 1990s (Figure 1(b)).[1]

Figure1(a): Wool and Lamb Prices



[1] The Reserve Price Scheme for wool was established in 1970 with the introduction of a floor price aimed at improving price stability. Subsequent increases in the floor price led to a large stockpile of wool and the abandonment of the scheme in 1991.

Figure 1(b): Wool and Lamb Production



Source: ABARE (2006)

But despite the higher prices for lamb and mutton over the past few years, Australian sheep producers' terms of trade have been in steady decline. According to Martin *et al.* (2004), over the period 1977-78 to 2001-02 sheep producers' terms of trade fell, on average, by 2.1 per cent a year.

Declining terms of trade and reductions in farm income can be offset by productivity growth resulting from new technologies, reaping scale and scope economies, and more efficient farming practices. The development and widespread adoption of new technologies from R&D investments lead to gains in productivity so that either more output can be produced with the same amount of inputs or the same output can be produced with fewer inputs (Alston *et al*. 1995). These R&D investments in the sheep and wool industries may be directed into on-farm research or off-farm sectors along the processing and marketing chain. Increased industry returns may also be achieved through domestic or export promotions that successfully increase demand.

Australian sheep and wool producers make significant contributions in the form of compulsory levies on gross wool and livestock sales to R&D investments and generic promotions undertaken by industry research providers and organisations.[2] The current levy rates are 2 per cent on the sale price of greasy shorn wool (AWI 2007) and 2 per cent on sheep and lamb sales. Where there is a defined sale price of $5.00 or more, producers pay 2 per cent of the sale price up to a maximum of $0.20 for sheep and up to a maximum of $1.50 for lambs. If there is no defined sale price the rates are $0.20 and $0.80 for sheep

[2] According to their respective financial reports, AWI has a total budget of around $60m pa and MLA has a budget for sheep-meat of around $30m pa.

and lambs, respectively. No levies apply to sales of less than $5.00 (MLA 2006). Australian taxpayers also make contributions through government funding. The less secure market environments, increased competition and lower levels of profitability highlight the importance of efficient investment of Australian sheep and wool industry R&D and promotion funds.

Knowing the potential size and distribution of returns from alternative research and promotion investments across different sectors of an industry enable more informed strategic-level decisions to be made about how to allocate limited resources among a number of investment options. Information of this nature is helpful to policy makers in decisions of priority setting and resource allocations. The provision of this type of information can assist in answering questions such as, which types of R&D and promotion investments are preferred to others, which sectors of the industries benefit, and from which industry sectors should the investment funds be collected?

1.2 Aims of the Study

The main aim of the report is to describe the development of an economic model of the Australian sheep and wool industries that accounts for the interrelationships among the major enterprises in these industries; for the domestic and export markets for the products of these industries; and for the different market levels and degrees of processing in the different industries. In particular, the objectives are:

- to provide a modelling framework to be able to consistently estimate and compare the potential benefits from new technologies, generic promotion and other policy changes in the different sectors and markets; and

- to estimate the distribution of the potential benefits among the various industry sectors.

The study provides a comparison of the potential benefits from 1 per cent reductions in per unit costs of production resulting from new technologies in various industry sectors or 1 per cent increases in consumers' willingness-to-pay from generic promotion in domestic or export markets. In terms of monetary gains, which investment scenario is preferred over another depends on the costs required to bring about the 1 per cent changes. Because investment costs are not considered in this study, comparison of the monetary returns from the different scenarios can only be made under the assumption of equal investment costs in each sector. However, the distributions of total benefits among industry sectors from alternative scenarios are directly comparable, even in the absence of cost information.

The complementary contributions of this study are two-fold. Firstly, cross-commodity relationships are a key feature of the Australian sheep and wool industries and these are formally accounted for. Examples include joint production of wool and lamb, and substitution in domestic consumption of lamb and mutton. Therefore, any exogenous changes, such as a research-induced innovation or successful promotion in one industry, will have spillover and feedback effects to and from the other industries. For example, research may deliver a new technology which reduces the per kilogram cost of producing prime lamb. This change in profitability will encourage an increase in lamb production relative to wool production because the number of ewes joined to terminal and other meat-breed rams will increase relative to the number of ewes joined to Merino rams. A further shift in resources to lamb will occur as consumers switch from other meat products to cheaper lamb products. In using a single-industry modelling approach to evaluate the industry returns from a cost reduction in lamb production, the benefits to lamb producers would be estimated, but the indirect benefits and costs to producers through impacts on the wool, mutton and live sheep export enterprises would be ignored. Similarly, in estimating consumer impacts the changes in lamb consumption would be valued, but changes in the consumption of the other products would be ignored. The economic framework developed in this study accounts for the multi-product nature of the Australian sheep and wool industries. It is expected that the more realistic representation of industry structure, through the inclusion of inter-industry relationships, will improve the accuracy of economic analysis.

Secondly, the high degree of industry disaggregation in the model allows for the evaluation of individual investments specific to an agricultural zone or commodity. This has particular relevance to evaluation of R&D investments where new technologies may not be applicable, nor adopted, Australia wide.

1.3 Method of the Study

Evaluation of the returns from new technology adoption or generic promotion at an industry level requires a structural model representative of the industry or market under consideration. Econometric models and partial equilibrium models are the two most often used methods in agricultural industry analysis of R&D and promotion investments. Econometric models use time-series data on the variables included in the model to estimate parameter values. The estimated equations of the model can be used to predict prices and quantities enabling economic surplus changes to be calculated. Favourable aspects of econometric estimation are that dynamic relationships such as seasonality and time effects can be captured within the simulation. In sheep production, seasonal conditions influence breeding decisions and biological constraints may result in time lags between breeding and product sales (Vere *et al*. 2005). Time lags also exist between initial research investment and maximum adoption of a new technology. Econometric studies specific to the sheep industry have been undertaken, but most have maintained a single industry focus (e.g. Griffith *et al*. 1995; Templeton *et al*. 2004). Vere *et al*. (2000) developed a quarterly structural econometric model of the Australian grazing industries incorporating the wool, lamb and mutton sectors of the sheep industry. Although relevant in the context of this study, the data-intensive nature of the model is prohibitive to its use. As data continues to be collected and reported less, the maintenance of econometric models that rely on lengthy historical data becomes increasingly difficult.

For this reason, the use of a comparative static approach, more commonly known as 'Equilibrium Displacement Modelling' (EDM) (Piggott 1992), to evaluate R&D and promotion investments has increased in popularity. Rather than needing historical data spanning decades, EDMs require base equilibrium price and quantity data and Marshallian elasticity values. A limitation of EDM is the inability to satisfactorily account for dynamic responses within the modelling framework. However, repeated applications for different lengths of run can overcome this deficiency to some extent

(Piggott 1992). A number of EDMs have been developed in relation to the Australian sheep and wool industries but they are single industry approaches that largely ignore the cross-product interactions (Mullen *et al*. 1989; Mullen and Alston 1994; Hill *et al*. 1996).

There is a software package available called DREAM (Dynamic Research Evaluation for Management) (IFPRI 2001) which is based on the EDM methodology. Appealing features of DREAM are its generic applicability to a diverse range of industries and the capability to incorporate multi-regional evaluations in the analysis, but the model does have some restrictions. Analysis is limited to a single homogeneous commodity and any cross-commodity relationships such as evident in the Australian sheep industry are not included in the simulation. In addition, the DREAM framework does not allow for vertical market disaggregation. Processors, retailers and consumers are combined as a single entity and as such, information on the distribution of potential returns from R&D and promotion investments among different industry groups and sectors cannot be determined. Limitations of this type can be overcome through the development of industry-specific EDMs such as the one described in this report.

The partial equilibrium framework of the EDM involves linear approximation of changes in prices and quantities of inputs and outputs arising from new technology or promotion. In using this method the industries are represented by a system of demand and supply relationships with base prices and quantities used to define an initial equilibrium. The impact of any exogenous change to the system, such as a new technology or promotion campaign, is modelled as a shift in demand or supply from that initial equilibrium. From the resulting changes in all market prices and quantities, the changes in producer and consumer surpluses can be calculated as a measure of the changes in welfare accruing to the various industry sectors.

The structure of the Australian sheep and wool industries is specified in considerable detail within the EDM framework. Horizontally, the industries are disaggregated into different regions, products and markets, and vertically into the various sectors of the production chain. The main inputs are base equilibrium values for all prices and quantities in the model to specify an initial equilibrium before any exogenous changes occur. Market elasticities are also needed to quantify the responsiveness of producers and consumers to changes in market prices.

The issue of economic surplus measurement in multi-market analyses has received considerable attention in the literature, especially when there are multiple sources of equilibrium feedback in the model (for example, Thurman 1991a). Zhao *et al*. (2005) demonstrated that significant errors are possible if the partial equilibrium effects are not measured in a sequential manner, as has been the case in some previous studies. The measurement of economic surplus in this analysis follows the derivation by Zhao *et al*. (2005).

1.4 Outline of the Report

The EDM of the Australian sheep and wool industries, comprising 295 endogenous variables and 61 exogenous variables, is specified in Section 2. A diagrammatic representation of the industries accompanies a discussion of the horizontal and vertical industry disaggregation. The 295 equations of the model are listed in general functional form and conditions of integrability are considered.

In Section 3, the base equilibrium prices and quantities for all the variables in the EDM are specified. The initial values, taken over a three-year period, represent an average equilibrium in the sheep and wool industries for 2002-03 to 2004-05. Existing elasticity estimates are reviewed and values for each parameter in the model are selected. The chosen market parameters correspond to a medium-run time frame. Two hypothetical exogenous change scenarios are also presented in Section 3.

The potential annual benefits and their distribution among the various industry sectors for two selected scenario are listed in Section 4. The scenarios are compared, permitting policy-related inferences to be drawn from the results.

A summary of the study and conclusions from the research are given in Section 5. Some of the limitations relating to the study are discussed and future areas of research are identified.

2 An EDM of the Australian Sheep and Wool Industries

2.1 Introduction

This Section outlines the Australian sheep and wool industry structure and details its specification in terms of the equilibrium displacement model. The conceptual structure of the model is depicted diagrammatically in Section 2.2 and a brief discussion of the horizontal and vertical market segments is given. In Section 2.3 the production, cost and revenue functions for the various industry sectors are specified in general functional forms. From the decision-making functions, generalised derivations of the input demand, output supply, exogenous supply and exogenous demand schedules are presented.[3] The general functional form equations of the model are specified in Section 2.4. Derivation of the model in displacement form, integrability conditions and their importance, and the imposition of integrability conditions on the displacement model are each considered in turn. The model in equilibrium displacement form and with integrability conditions imposed at the initial equilibrium points is specified in Equations (A1.1)-(A1.295) and (A1.1)'-(A1.295)', respectively in Appendix 1.

2.2 Model Structure

2.2.1 Conceptual Structure

The Australian sheep and wool industries consist of numerous market segments. Accurate analysis of the returns from research, promotion or government policies undertaken in different industry sectors or markets require a model properly representative of the industry structure. Horizontal and vertical industry disaggregation allows for the distribution of total industry returns among the various regions and sectors to be estimated.

The structure of the EDM of the Australian sheep and wool industries is depicted in Figure 2. Each rectangle represents a production function with the supply and demand for each product portrayed as an arrowed line. The non-arrowed end gives the supply for the product and the arrowed end indicates the demand for the product. Supply and demand schedules incorporating the exogenous shifters are drawn as ovals in the diagrams. The structure of the Australian sheep and wool industries represented in Figure 2 consists of four connecting diagrams. The logic of the block structure of diagrams is as follows. Figure 2(a) shows the disaggregation of the national flock and associated production of wool, lamb, mutton and live sheep. Figure 2(b) traces the supplies of wool from the farm to the warehouse where it is sold at auction and either exported or purchased for use in domestic processing. Following on from Figure 2(b), the different stages of the domestic wool processing sector and exports of semi-processed wool products are depicted in Figure 2(c). Connecting directly back to Figure 2(a), the various stages of the sheepmeat supply chain and markets for lamb, mutton and live sheep are presented in Figure 2(d).

[3] Sub-sections 2.3.1-2.3.5 and 2.4.3-2.4.4 draw on Zhao *et al*. (2000, pp.10-12, 15-17 and 27-33).

Figure 2(a): Model structure

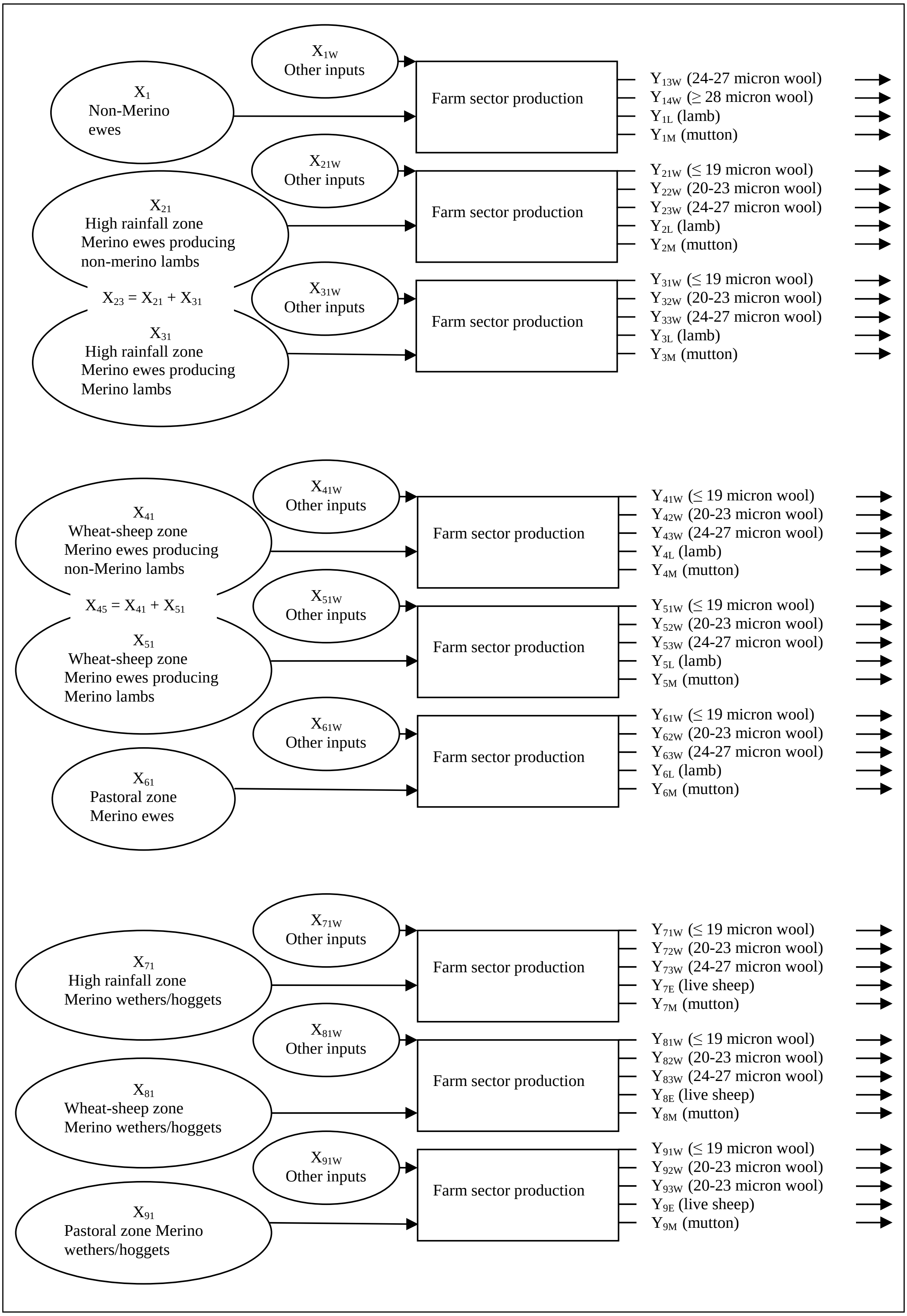


Figure 2(b): Model structure

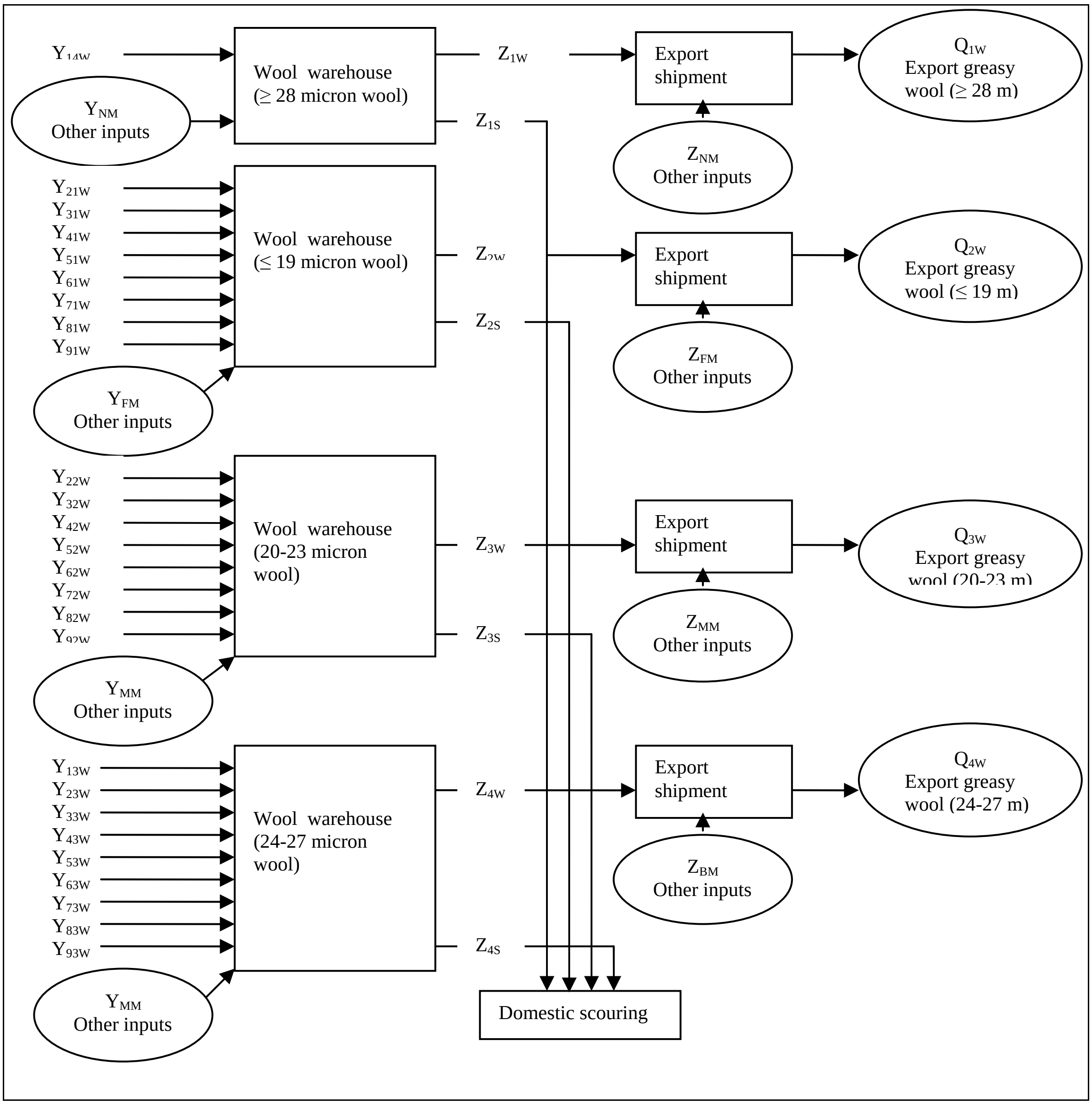


Figure 2(c): Model structure

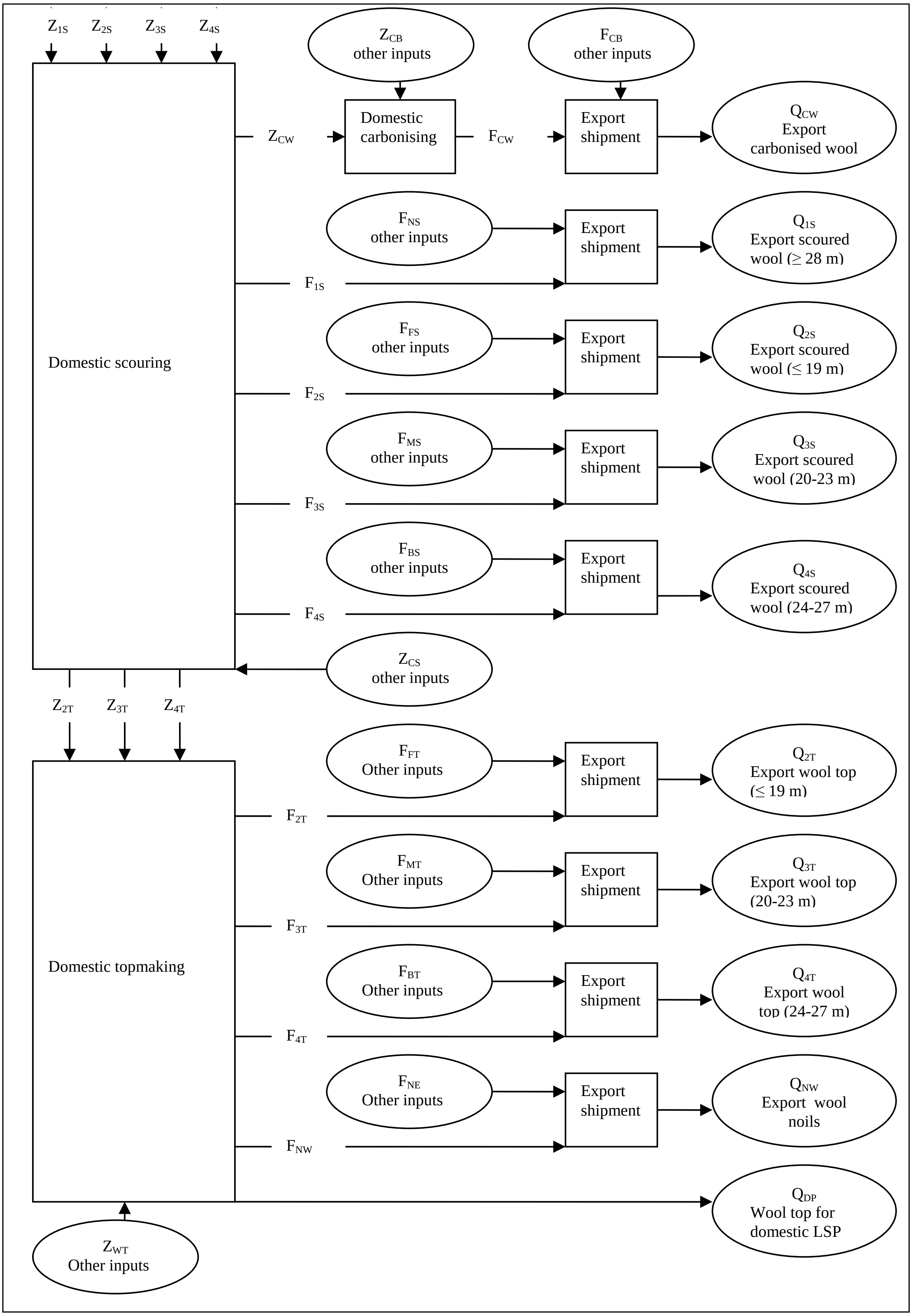
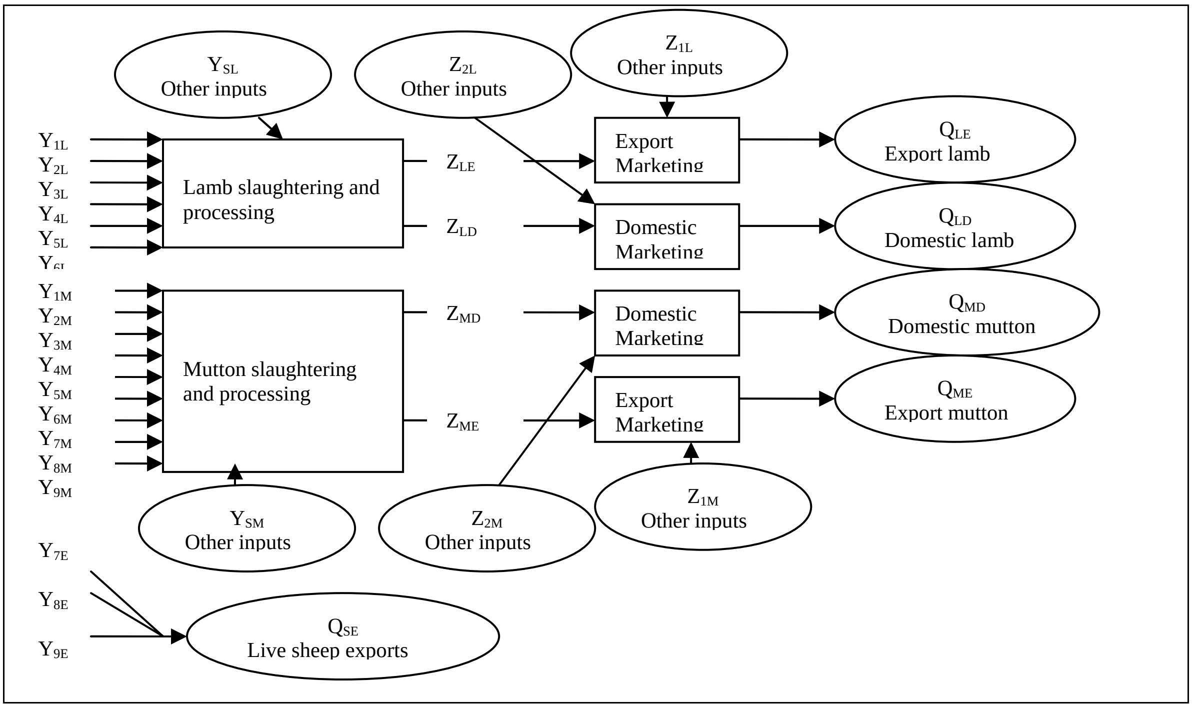


Figure 2(d): Model structure



2.2.2 Horizontal and Vertical Market Segments

In Figure 2(a) the industries are horizontally disaggregated into Merino sheep and non-Merino sheep. Merino sheep are further disaggregated by production enterprise in each of the three agricultural zones; high rainfall, wheat-sheep and pastoral. Breeding intention separates Merino ewes in the high rainfall and wheat-sheep zones into Merino lamb and non-Merino lamb producing enterprises. Merino sheep not used for breeding purposes are classified as dry sheep and are grouped together. As such, Merino wethers and Merino hoggets within each zone are combined as a single enterprise or sector.

Australian wool production is divided into four main diameter categories corresponding to Australian Bureau of Statistics wool export categories of 19 µm and finer, 20-23 µm, 24-27 µm and 28 µm or broader. Wool of the same diameter classification within each zone is assumed homogeneous in quality. For example, wool 19 µm and finer produced from ewes in the high rainfall zone is assumed to exhibit the same characteristics as wool 19 µm and finer produced from wethers and hoggets in the same zone, with no difference in price. However, separate price variables are included in the model should data on observable price differentials between the products become available in the future.

Vertical disaggregation of the wool industry includes the warehousing, export and Australian early-stage processing sectors. Around 85 per cent of wool is sold through the auction system while the rest is sold 'privately' on-farm or to local wool handling facilities. For simplification in this analysis it is assumed that 100 per cent of wool is sold through the auction system.[4] The warehouse sector (Figure 2b) is assumed to include wool handling, storage, testing and associated selling costs. The majority of Australian wool production is exported in its raw greasy form with the remainder undergoing some

[4] This assumption implies that gross revenue in the warehousing sector within the EDM is over-estimated.

degree of early-stage processing before being exported as scoured wool, carbonised wool or wool tops. Limited quantities of wool tops are used as inputs in domestic later-stage processing such as spinning and weaving. Early-stage processing of wool in Australia is separated into scouring, carbonising and topmaking sectors (Figure 2c). Post-sale costs such as transport, dumping and shipment preparation for greasy wool are included in the export sector.

Other production comprises live sheep exports and lamb and mutton destined for the export and domestic markets. Live sheep exports from all three zones are assumed homogeneous in quality with a single price. Supplies of lamb and mutton across all three zones are also assumed homogeneous in quality though, for reasons stated above, separate price variables are specified for each individual supply within the model. Individual price variables also enable product quality differentiation between export and domestic supplies of lamb and mutton.

Vertical disaggregation of the sheepmeat supply chain (Figure 2d) beyond the farm gate consists of processing and marketing sectors. The processing sector undertakes all slaughtering and processing activities necessary to produce lamb and mutton for the export market and carcasses of lamb and mutton for sale to domestic retailers. The domestic marketing or retail sector processes the carcasses and packages the products for sale to final consumers. This sector comprises supermarkets, butchers and integrated abattoir or independent boning rooms that undertake the same process.

2.3 Model Specification

2.3.1 Production Functions[5]

As shown in Figure 2, all the farm, wool warehouse, wool scouring, topmaking and lamb and mutton processing sectors are characterised by multi-output production functions. The wool carbonising, export shipment sectors for wool and marketing sectors for lamb and mutton have single production technologies. All the production functions are deemed to exhibit constant returns to scale with multi-output production functions separable in inputs and outputs.[6] The objective of profit maximisation is an implicit behavioural assumption of each industry sector within the model.

Written in general form, the multi-output production function is (Zhao *et al*. 2000, p.11):

(2.3.1) $F(x, y) = 0$

where, using the non-Merino farm sector from the model as an example, $x = (X_1, X_{1W})$ are the inputs used to produce the $y = (Y_{13W}, Y_{14W}, Y_{1L}, Y_{1M})$ outputs. All

[5] Interested readers are referred to the relevant pages in Chambers (1998) and Varian (1992) for a more comprehensive treatment of the derivations in Sections 2.3.1 to 2.3.5.

[6] These are standard assumptions also used in general equilibrium modelling. The assumption of separability implies aggregation of inputs and aggregation of outputs. The implications of input-output separability are discussed in Chambers and Fare (1993).

variable and parameter symbols in the model are defined in Table 1 at the end of this Section.[7]

If $F(x, y) = 0$ is twice-continuously differentiable, with no derivatives vanishing, output separability in the form $F(x, Y_1(y)) = 0$, implies that Equation (2.3.1) can also be written as (Chambers 1988, p.286)

$$(2.3.2) \qquad Y_1(y) = X_N(x)$$

where $Y_1 = Y_1(y)$ is the scalar output index and $X_N = X_X(x)$ is the corresponding scalar input index under the assumption of input separability. As in Equation (2.3.2), the production functions for the industry sectors specified in the model can be written as

Farm sectors

(2.3.3) $Y_1(Y_{13W}, Y_{14W}, Y_{1L}, Y_{1M}) = X_N(X_1, X_{1W})$

(2.3.4) $Y_2(Y_{21W}, Y_{22W}, Y_{23W}, Y_{2L}, Y_{2M}) = X_2(X_{21}, X_{21W})$

(2.3.5) $Y_3(Y_{31W}, Y_{32W}, Y_{33W}, Y_{3L}, Y_{3M}) = X_3(X_{31}, X_{31W})$

(2.3.6) $Y_4(Y_{41W}, Y_{42W}, Y_{43W}, Y_{4L}, Y_{4M}) = X_4(X_{41}, X_{41W})$

(2.3.7) $Y_5(Y_{51W}, Y_{52W}, Y_{53W}, Y_{5L}, Y_{5M}) = X_5(X_{51}, X_{51W})$

(2.3.8) $Y_6(Y_{61W}, Y_{62W}, Y_{63W}, Y_{6L}, Y_{6M}) = X_6(X_{61}, X_{61W})$

(2.3.9) $Y_7(Y_{71W}, Y_{72W}, Y_{73W}, Y_{7E}, Y_{7M}) = X_7(X_{71}, X_{71W})$

(2.3.10) $Y_8(Y_{81W}, Y_{82W}, Y_{83W}, Y_{8E}, Y_{8M}) = X_8(X_{81}, X_{81W})$

(2.3.11) $Y_9(Y_{91W}, Y_{92W}, Y_{93W}, Y_{9E}, Y_{9M}) = X_9(X_{91}, X_{91W})$

Wool warehouse sectors

(2.3.12) $Z_1(Z_{1W}, Z_{1S}) = Y_N(Y_{14W}, Y_{NM})$

(2.3.13) $Z_2(Z_{2W}, Z_{2S}) = Y_F(Y_{21W}, Y_{31W}, Y_{41W}, Y_{51W}, Y_{61W}, Y_{71W}, Y_{81W}, Y_{91W}, Y_{FM})$

(2.3.14) $Z_3(Z_{3W}, Z_{3S}) = Y_C(Y_{22W}, Y_{32W}, Y_{42W}, Y_{52W}, Y_{62W}, Y_{72W}, Y_{82W}, Y_{92W}, Y_{MM})$

(2.3.15) $Z_4(Z_{4W}, Z_{4S}) = Y_B(Y_{13W}, Y_{23W}, Y_{33W}, Y_{43W}, Y_{53W}, Y_{63W}, Y_{73W}, Y_{83W}, Y_{93W}, Y_{BM})$

Greasy wool export shipment sectors

(2.3.16) $Q_{1W} = Z_N(Z_{1W}, Z_{NM})$

(2.3.17) $Q_{2W} = Z_F(Z_{2W}, Z_{FM})$

(2.3.18) $Q_{3W} = Z_G(Z_{3W}, Z_{MM})$

(2.3.19) $Q_{4W} = Z_B(Z_{4W}, Z_{BM})$

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[7] The meanings of the subscripts attached to each variable can be traced in Figure 2. For example, Y_{13W} refers to 24 micron to 27 micron wool produced from non-Merino sheep.

Wool scouring sector

(2.3.20) $Z_S(F_{1S}, F_{2S}, F_{3S}, F_{4S}, Z_{2T}, Z_{3T}, Z_{4T}, Z_{CW}) = Z_C(Z_{1S}, Z_{2S}, Z_{3S}, Z_{4S}, Z_{CS})$

Wool carbonising sector

(2.3.21) $F_{CW} = Z_P(Z_{CW}, Z_{CB})$

Wool topmaking sector

(2.3.22) $F_T(F_{2T}, F_{3T}, F_{4T}, F_{NW}, Q_{DP}) = Z_T(Z_{2T}, Z_{3T}, Z_{4T}, Z_{WT})$

Semi-processed wool export shipment sectors

(2.3.23) $Q_{CW} = F_C(F_{CW}, F_{CB})$

(2.3.24) $Q_{1S} = F_1(F_{1S}, F_{NS})$

(2.3.25) $Q_{2S} = F_2(F_{2S}, F_{FS})$

(2.3.26) $Q_{3S} = F_3(F_{3S}, F_{MS})$

(2.3.27) $Q_{4S} = F_4(F_{4S}, F_{BS})$

(2.3.28) $Q_{2T} = F_F(F_{2T}, F_{FT})$

(2.3.29) $Q_{3T} = F_M(F_{3T}, F_{MT})$

(2.3.30) $Q_{4T} = F_B(F_{4T}, F_{BT})$

(2.3.31) $Q_{NW} = F_W(F_{NW}, F_{NE})$

Lamb and mutton processing sectors

(2.3.32) $Z_L(Z_{LE}, Z_{LD}) = Y_L(Y_{1L}, Y_{2L}, Y_{3L}, Y_{4L}, Y_{5L}, Y_{6L}, Y_{SL})$

(2.3.33) $Z_M(Z_{ME}, Z_{MD}) = Y_M(Y_{1M}, Y_{2M}, Y_{3M}, Y_{4M}, Y_{5M}, Y_{6M}, Y_{7M}, Y_{8M}, Y_{9M}, Y_{SM})$

Lamb and mutton marketing sectors

(2.3.34) $Q_{LE} = Z_1(Z_{LE}, Z_{1L})$

(2.3.35) $Q_{LD} = Z_2(Z_{LD}, Z_{2L})$

(2.3.36) $Q_{ME} = Z_1(Z_{ME}, Z_{1M})$

(2.3.37) $Q_{MD} = Z_2(Z_{ME}, Z_{2M})$

The variables on the left hand side of each equation denote the outputs for each sector and those on the right hand side are the inputs for each sector.

2.3.2 Cost Functions and Derived Demand Schedules

The cost function can be specified as (Zhao *et al*. 2000, p.11):

(2.3.38) $C_{Y1}(w, y) = \min\{w'x : y\}$

where $w = (w_1, w_{1W})'$ are the prices for inputs (X_1, X_{1W}).

The assumption of output separability allows Equation (2.3.38) to be expressed in terms of a single output cost function (Chambers 1988, p.286; Zhao *et al*. 2000, p.11)

(2.3.39) $$C_{Y1}(w, y) = \min_x \{w'x : y\} = \min_x \{w'x : Y_1 = Y_1(y)\} = C_{Y1}(w, Y_1)$$

where $C_{Y1}(w, Y_1)$ is the cost function for the single output technology $Y_1 = X_N(x)$.

The existence of constant returns to scale implies that $X_N(\alpha x) = \alpha Y_1$ and $Y_1(\alpha y) = \alpha X_N$ for all $\alpha > 0$. Therefore, the cost function can be written as (Zhao *et al*. 2000, p.11):

(2.3.40) $$C_{Y1}(w, Y_1) = \min_x \{w'x : X_N(x) = Y_1\}$$

$$= \min_x \{w'x : X_N(\alpha x) = \alpha Y_1\}$$

$$= \min_x \{w'x : X_N(x / Y_1) = 1\} \qquad \text{use } (\alpha = 1/Y_1)$$

$$= Y_1 \min_x \{w'(x / Y_1) : X_N(x / Y_1) = 1\} = Y_1 C_{Y1}(w,1) = Y_1 c_{Y1}(w)$$

where $c_{Y1}(w)$ is the unit cost function associated with the minimum cost of producing one unit of Y_1.

From the cost function above, if $c_{Y1}(w)$ is differentiable with respect to *w*, the output constrained input demand functions can be found through application of Shephard's Lemma (Cornes 1992, p.106)

(2.3.41) $$\partial C_{Y1}(w, Y_1) / \partial w_i = Y_1 c_{Y1}'_i(w) \qquad (i = 1,2,..., k)$$

where $c_{Y1}'_i(w), (i = 1,2,...., k)$ are the partial derivatives of the unit cost function $c_Y(w)$

In this example for the non-Merino farm sector, the output constrained input demand functions derived from the unit cost function $c_{Y1}(w) = c_{Y1}(w_1, w_{1w})$ are

(2.3.42) $$X_1 = \partial C_{Y1}(w, Y_1) / \partial w_1 = Y_1 c_{Y1,}'_{X1}(w_1, w_{1w}) \text{ and,}$$

(2.3.43) $$X_{1w} = \partial C_{Y1}(w, Y_1) / \partial w_{1W} = Y_1 c_{Y1,}'_{X1W}(w_1, w_{1W})$$

where $c_{Y1,}{'}_{X1}(w_1, w_{1w})$ and $c_{Y1,}{'}_{X1W}(w_1, w_{1w})$ are partial derivatives of the unit cost function $c_{Y1}(w_1, w_{1w})$.

Following the specification of the total cost function in Equation (2.3.40), the total cost functions associated with the production functions for each of the industry sectors are

Farm enterprises

(2.3.44) $C_{Y1} = Y_1 * c_{Y1}(w_1, w_{1W})$

(2.3.45) $C_{Y2} = Y_2 * c_{Y2}(w_{23}, w_{21W})$

(2.3.46) $C_{Y3} = Y_3 * c_{Y3}(w_{23}, w_{31W})$

(2.3.47) $C_{Y4} = Y_4 * c_{Y4}(w_{45}, w_{41W})$

(2.3.48) $C_{Y5} = Y_5 * c_{Y5}(w_{45}, w_{51W})$

(2.3.49) $C_{Y6} = Y_6 * c_{Y6}(w_{61}, w_{61W})$

(2.3.50) $C_{Y7} = Y_7 * c_{Y7}(w_{71}, w_{71W})$

(2.3.51) $C_{Y8} = Y_8 * c_{Y8}(w_{81}, w_{81W})$

(2.3.52) $C_{Y9} = Y_9 * c_{Y9}(w_{91}, w_{91W})$

Wool warehouse sectors

(2.3.53) $C_{Z1} = Z_1 * c_{Z1}(v_{14W}, v_{NM})$

(2.3.54) $C_{Z2} = Z_2 * c_{Z2}(v_{21W}, v_{31W}, v_{41W}, v_{51W}, v_{61W}, v_{71W}, v_{81W}, v_{91W}, v_{FM})$

(2.3.55) $C_{Z3} = Z_3 * c_{Z3}(v_{22W}, v_{32W}, v_{42W}, v_{52W}, v_{62W}, v_{72W}, v_{82W}, v_{92W}, v_{MM})$

(2.3.56) $C_{Z4} = Z_4 * c_{Z4}(v_{13W}, v_{23W}, v_{33W}, v_{43W}, v_{53W}, v_{63W}, v_{73W}, v_{83W}, v_{93W}, v_{BM})$

Greasy wool export shipment sectors

(2.3.57) $C_{Q1W} = Q_{1W} * c_{Q1W}(u_{1W}, u_{NM})$

(2.3.58) $C_{Q2W} = Q_{2W} * c_{Q2W}(u_{2W}, u_{FM})$

(2.3.59) $C_{Q3W} = Q_{3W} * c_{Q3W}(u_{3W}, u_{MM})$

(2.3.60) $C_{Q4W} = Q_{4W} * c_{Q4W}(u_{4W}, u_{BM})$

Wool scouring sector

(2.3.61) $C_{ZS} = Z_S * c_{ZS}(u_{1S}, u_{2S}, u_{3S}, u_{4S}, u_{CS})$

Wool carbonising sector

(2.3.62) $C_{FCW} = F_{CW} * c_{FCW}(u_{CW}, u_{CB})$

Wool topmaking sector

(2.3.63) $C_{FT} = F_T * c_{FT}(u_{2T}, u_{3T}, u_{4T}, u_{WT})$

Semi-processed wool export shipment sectors

(2.3.64) $C_{QCW} = Q_{CW}*c_{QCW}(s_{CW}, s_{CB})$

(2.3.65) $C_{Q1S} = Q_{1S}*c_{Q1S}(s_{1S}, s_{NS})$

(2.3.66) $C_{Q2S} = Q_{2S}*c_{Q2S}(s_{2S}, s_{FS})$

(2.3.67) $C_{Q3S} = Q_{3S}*c_{Q3S}(s_{3S}, s_{MS})$

(2.3.68) $C_{Q4S} = Q_{4S}*c_{Q4S}(s_{4S}, s_{BS})$

(2.3.69) $C_{Q2T} = Q_{2T}*c_{Q2T}(s_{2T}, s_{FT})$

(2.3.70) $C_{Q3T} = Q_{3T}*c_{Q3T}(s_{3T}, s_{MT})$

(2.3.71) $C_{Q4T} = Q_{4T}*c_{Q4T}(s_{4T}, s_{BT})$

(2.3.72) $C_{QNW} = Q_{NW}*c_{QNW}(s_{NW}, s_{NE})$

Lamb and mutton processing sectors

(2.3.73) $C_{ZL} = Z_L*c_{ZL}(v_{1L}, v_{2L}, v_{3L}, v_{4L}, v_{5L}, v_{6L}, v_{SL})$

(2.3.74) $C_{ZM} = Z_M*c_{ZM}(v_{1M}, v_{2M}, v_{3M}, v_{4M}, v_{5M}, v_{6M}, v_{7M}, v_{8M}, v_{9M}, v_{SM})$

Lamb and mutton marketing sectors

(2.3.75) $C_{QLE} = Q_{LE}*c_{QLE}(u_{LE}, u_{1L})$

(2.3.76) $C_{QLD} = Q_{LD}*c_{QLD}(u_{LD}, u_{2L})$

(2.3.77) $C_{QME} = Q_{ME}*c_{QME}(u_{ME}, u_{1M})$

(2.3.78) $C_{QMD} = Q_{MD}*c_{QMD}(u_{MD}, u_{2M})$

The total cost of producing the level of output index q is represented by Cq and $c_{q(.)}$ represents the unit cost function where q = $Y_1,\ldots,Y_9$, $Z_1,\ldots,Z_4$, $Q_{1W},\ldots,Q_{4W}$, Z_S, F_{CW}, F_T, Q_{CW}, $Q_{1S},\ldots,Q_{4S}$, $Q_{2T},\ldots,Q_{4T}$, Q_{NW}, Z_L, Z_M, Q_{LE}, Q_{LD}, Q_{ME}, Q_{MD}. The demand functions for the endogenous input variables in the model can be derived from the corresponding cost functions using Shephard's Lemma as in Equation (2.3.41).

2.3.3 Revenue Functions and Derived Supply Schedules

Input separability is an analogous concept to output separability. The revenue function can be written as (Zhao *et al*. 2000, p.12)

(2.3.79) $R_{XN}(v,x) = \max_y \{v' y : x\}$ where $v = (v_{13W}, v_{14W}, v_{1L}, v_{1M})$ are the output prices for $(Y_{13W}, Y_{14W}, Y_{1L}, Y_{1M})$.

The assumption of input separability allows Equation (2.3.79) to be expressed in terms of a single input revenue function as (Zhao *et al*. 2000, p.12):

(2.3.80) $R_{XN}(v,x) = \max_y \{v' y : x\} = \max_y \{v' y : X_N = X_N(x)\} = R_{XN}(v, X_N)$

where $R_{XN}(v, X_N)$ is the revenue function for the single input technology $X_N = Y_1(y)$.

Constant returns to scale imply that the revenue function can be written as (Zhao *et al*. 2000, p.12):

(2.3.81) $$R_{XN}(v, X_N) = \max_y \{v' y : Y_1(y) = X_N\}$$

$$= \max_y \{v' y : Y_1(\alpha y) = \alpha X_N\}$$

$$= \max_y \{v' y : Y_1(y / X_N) = 1\} \qquad \text{use } (\alpha = 1/X_N)$$

$$= X_N \max_y \{v'(y / X_N) : Y_1(y / X_N) = 1\} = X_N R_{XN}(v,1) = X_N r_{XN}(v)$$

where $r_{XN}(v)$ is the unit revenue function associated with the maximum revenue from one unit of input index X_N

From the revenue function above, if $r_{XN}(v)$ is differentiable with respect to all output prices, then using the Samuelson-McFadden Lemma (Chambers 1988, p.264):

(2.3.82) $$\partial R_{XN}(v, X_N) / \partial v_j = X_N r_{XN}{}'_j(v) \qquad (j = 1,2,...,n)$$

where $r_{XN}{}'_j(v), (j = 1,2,....,n)$ are the partial derivatives of the unit revenue function $r_{XN}(v)$.

The input constrained output supply functions derived from the unit revenue function $r_{XN}(v) = r_{XN}(v_{13W}, v_{14W}, v_{1L}, v_{1M})$ are

(2.3.83) $$Y_{13W} = \partial R_{XN}(v, X_N) / \partial v_{13W} = X_N r_{XN,}{}'_{13W}(v_{13W}, v_{14W}, v_{1L}, v_{1M})$$

(2.3.84) $$Y_{14W} = \partial R_{XN}(v, X_N) / \partial v_{14W} = X_N r_{XN,}{}'_{14W}(v_{13W}, v_{14W}, v_{1L}, v_{1M})$$

(2.3.85) $$Y_{1L} = \partial R_{XN}(v, X_N) / \partial v_{1L} = X_N r_{XN,}{}'_{1L}(v_{13W}, v_{14W}, v_{1L}, v_{1M})$$

(2.3.86) $$Y_{1M} = \partial R_{XN}(v, X_N) / \partial v_{1M} = X_N r_{XN,}{}'_{1M}(v_{13W}, v_{14W}, v_{1L}, v_{1M})$$

where
$r_{XN,}{}'_{13W}(v_{13W}, v_{14W}, v_{1L}, v_{1M})$, $r_{XN,}{}'_{14W}(v_{13W}, v_{14W}, v_{1L}, v_{1M})$, $r_{XN,}{}'_{1L}(v_{13W}, v_{14W}, v_{1L}, v_{1M})$ and

$r_{XN,\,'1M}(v_{13W}, v_{14W}, v_{1L}, v_{1M})$ are partial derivatives of the unit revenue function $r_{XN}(v_{13W}, v_{14W}, v_{1L}, v_{1M})$.

Based on equation (2.3.81), the revenue functions for the industry sectors are

Farm enterprises

(2.3.87) $R_{XN} = X_N*r_{XN}(v_{13W}, v_{14W}, v_{1L}, v_{1M})$

(2.3.88) $R_{X2} = X_2*r_{X2}(v_{21W}, v_{22W}, v_{23W}, v_{2L}, v_{2M})$

(2.3.89) $R_{X3} = X_3*r_{X3}(v_{31W}, v_{32W}, v_{33W}, v_{3L}, v_{3M})$

(2.3.90) $R_{X4} = X_4*r_{X4}(v_{41W}, v_{42W}, v_{43W}, v_{4L}, v_{4M})$

(2.3.91) $R_{X5} = X_5*r_{X5}(v_{51W}, v_{52W}, v_{53W}, v_{5L}, v_{5M})$

(2.3.92) $R_{X6} = X_6*r_{X6}(v_{61W}, v_{62W}, v_{63W}, v_{6L}, v_{6M})$

(2.3.93) $R_{X7} = X_7*r_{X7}(v_{71W}, v_{72W}, v_{73W}, p_{SE}, v_{7M})$

(2.3.94) $R_{X8} = X_8*r_{X8}(v_{81W}, v_{82W}, v_{83W}, p_{SE}, v_{8M})$

(2.3.95) $R_{X9} = X_9*r_{X9}(v_{91W}, v_{92W}, v_{93W}, p_{SE}, v_{9M})$

Wool warehouse sectors

(2.3.96) $R_{YN} = Y_N*r_{YN}(u_{1W}, u_{1S})$

(2.3.97) $R_{YF} = Y_F*r_{YF}(u_{2W}, u_{2S})$

(2.3.98) $R_{YC} = Y_C*r_{YC}(u_{3W}, u_{3S})$

(2.3.99) $R_{YB} = Y_B*r_{YB}(u_{4W}, u_{4S})$

Greasy wool export shipment sectors

(2.3.100) $R_{ZN} = Z_N*r_{ZN}(p_{1W})$

(2.3.101) $R_{ZF} = Z_F*r_{ZF}(p_{2W})$

(2.3.102) $R_{ZG}= Z_G*r_{ZG}(p_{3W})$

(2.3.103) $R_{ZB} = Z_B*r_{ZB}(p_{4W})$

Wool scouring sector

(2.3.104) $R_{ZC} = Z_C*r_{ZC}(s_{1S}, s_{2S}, s_{3S}, s_{4S}, u_{2T}, u_{3T}, u_{4T}, u_{CW})$

Wool carbonising sector

(2.3.105) $R_{ZP} = Z_P*r_{ZP}(s_{CW})$

Wool topmaking sector

(2.3.106) $R_{ZT} = Z_T*r_{ZT}(s_{2T}, s_{3T}, s_{4T}, s_{NW}, p_{DP})$

Semi-processed wool export shipment sectors

(2.3.107) $R_{FC} = F_C * r_{FC}(p_{CW})$

(2.3.108) $R_{F1} = F_1 * r_{F1}(p_{1S})$

(2.3.109) $R_{F2} = F_2 * r_{F2}(p_{2S})$

(2.3.110) $R_{F3} = F_3 * r_{F3}(p_{3S})$

(2.3.111) $R_{F4} = F_4 * r_{F4}(p_{4S})$

(2.3.112) $R_{FF} = F_F * r_{FF}(p_{2T})$

(2.3.113) $R_{FM} = F_M * r_{FM}(p_{3T})$

(2.3.114) $R_{FB} = F_B * r_{FB}(p_{4T})$

(2.3.115) $R_{FW} = F_W * r_{FW}(p_{NW})$

Lamb and mutton processing sectors

(2.3.116) $R_{YL} = Y_L * r_{YL}(u_{LE}, u_{LD})$

(2.3.117) $R_{YM} = Y_M * r_{YM}(u_{ME}, u_{MD})$

Lamb and mutton marketing sectors

(2.3.118) $R_{Z1} = Z_1 * r_{Z1}(p_{LE})$

(2.3.119) $R_{Z2} = Z_2 * r_{Z2}(p_{LD})$

(2.3.120) $R_{Z3} = Z_3 * r_{Z3}(p_{ME})$

(2.3.121) $R_{Z4} = Z_4 * r_{Z4}(p_{MD})$

The total revenue produced from input index level x is represented by Rx and $r_{x(.)}$ represents the unit revenue function where $x = X_N, X_2, \ldots, X_9, Y_N, Y_F, Y_C, Y_B, Z_N, Z_F, Z_G, Z_B, Z_C, Z_P, Z_T, F_C, F_1, \ldots, F_4, F_F, F_M, F_B, F_W, Y_L, Y_M, Z_1, \ldots, Z_4$. The supply functions for the endogenous input variables in the model can be derived from the corresponding revenue functions through application of the Samuelson-McFadden Lemma as in Equation (2.3.82).

2.3.4 Profit Functions and Exogenous Supply

The supplies of inputs $X_1, X_{21}, \ldots, X_{91}, X_{1W}, X_{21W}, \ldots, X_{91W}, Y_{NM}, Y_{FM}, Y_{MM}, Y_{BM}, Z_{NM}, Z_{FM}, Z_{MM}, Z_{BM}, Z_{CS}, Z_{CB}, Z_{WT}, F_{CB}, F_{NS}, F_{FS}, F_{MS}, F_{BS}, F_{FT}, F_{MT}, F_{BT}, F_{NE}, Y_{SL}, Y_{SM}, Z_{1L}, Z_{2L}, Z_{1M}, Z_{2M}$ are exogenous to the model. The supplies of these factors cannot be entirely specified within the model, as not all decision variables pertaining to their supplies are included in the model.

Assume x is any one of the exogenous inputs into the model and the production function for the producer of x is (Zhao *et al*. 2000, p.16):

$$F(x, O) = 0$$

where O is the vector of all other inputs and outputs of the production function. The profit function can be specified as (Zhao *et al*. 2000, p.16):

$$(2.3.122) \quad \pi = \max_{x,O}\{w_x x + W'O : F(x,O) = 0\} = \pi(w_x, W)$$

where w_x is the price of x and W denotes the price vector for O. Each element in O is set negative or positive depending on whether it is an input or an output, respectively (Varian 1992, p.25). Using Hotelling's Lemma the supply of x can be derived as

$$(2.3.123) \quad x = \frac{\partial}{\partial w_x}\pi(w_x, W) = \pi_{wx}{}'(w_x, W) = x(w_x, W)$$

where $\pi_{wx}{}'(.)$ is the partial derivative of $\pi(w_x, W)$ with respect to w_x.

2.3.5 Utility Functions and Exogenous Demand

Also exogenous to the model are the demands for the final sheep, meat and wool products $Q_{1W},\ldots,Q_{4W}$, Q_{CW}, $Q_{1S},\ldots,Q_{4S}$, $Q_{2T},\ldots,Q_{4T}$, Q_{NW}, Q_{DP}, Q_{LE}, Q_{LD}, Q_{ME}, Q_{MD}, Q_{SE}. Consider that an indirect utility function for the consumer of Q_{LE} (export lamb) with an income level m can be specified as (Varian 1992, p.99; Zhao *et al*. 2000, p.16):

$$(2.3.124) \quad v(p_{LE}, P, m) = \max_{QLE,Q}\{u(Q_{LE}, Q) : p_{LE}Q_{LE} + P'Q = m\}$$

where p_{LE} is the price of Q_{LE}, Q is the vector of all the other commodities consumed, P represents the price vector of Q and u(.) is the consumer's utility function. Using Roy's identity (Varian 1992, p.106) the Marshallian demand equations can be derived as

$$(2.3.125) \quad Q_{LD}(p_{LD}, P, m) = -\frac{\dfrac{\partial v(p_{LD}, P, m)}{\partial p_{LD}}}{\dfrac{\partial v(p_{LD}, P, m)}{\partial m}}$$

All the demand equations for the sheep, meat and wool products within the model can be derived accordingly with the exception of lamb and mutton sales in the domestic retail market. In this case the two commodities are substitutes in consumption with the demand for each product responsive to its own price and the price of the other commodity.[8] Assume the indirect utility function for domestic consumers of lamb and mutton with a given income level m is (Varian 1992, p.99; Zhao *et al*. 2000, p.16):

[8] The prices of lamb and mutton are also responsive to the prices of other meat commodities not included in the model such as beef, pork and chicken. . Similarly, wool prices are responsive to the prices of substitute fibres not included in the model such as cotton and synthetics.

(2.3.126) $$v(p_{LD}, p_{MD}, P, m) = \max_{Q_{LD}, Q_{MD}, Q} \{u(Q_{LD}, Q_{MD}, Q) : p_{LD}Q_{LD} + p_{MD}Q_{MD} + P'Q = m\}$$

where p_{LD} and p_{MD} are the respective prices for Q_{LD} (domestic lamb) and Q_{MD} (domestic mutton). Again *P* and *Q* represent the price and quantity vectors of all other commodities consumed and *u*(.) is the consumer's utility function. The Marshallian demand equations derived using Roy's identity are

(2.3.127) $$Q_{LD}(p_{LD}, p_{MD}, P, m) = -\frac{\dfrac{\partial v(p_{LD}, p_{MD}, P, m)}{\partial p_{LD}}}{\dfrac{\partial v(p_{LD}, p_{MD}, P, m)}{\partial m}}$$

(2.3.128) $$Q_{MD}(p_{LD}, p_{MD}, P, m) = -\frac{\dfrac{\partial v(p_{LD}, p_{MD}, P, m)}{\partial p_{MD}}}{\dfrac{\partial v(p_{LD}, p_{MD}, P, m)}{\partial m}}$$

2.4 The Equilibrium Displacement Model

2.4.1 Structural Model

The general functional form system of Equations (2.4.1)-(2.4.295) representing equilibrium in the Australian sheep and wool industries can be derived from Equations (2.3.44)-(2.3.78), (2.3.87)-(2.3.121), (2.3.122), (2.3.124) and (2.3.126). The impacts of promotions and new technologies are modelled as parallel shifts in the relevant demand or supply curves through the inclusion of exogenous shifters in the demand and supply functions. Any variables not included in the partial equilibrium framework are assumed impervious to any shifts and thus remain constant. All endogenous and exogenous variables in the structural model are defined in Table 1.

<u>*Input supply to farm enterprises*</u>

(2.4.1) $X_1 = X_1(w_1, T_{X1})$

(2.4.2) $X_{1W} = X_{1W}(w_{1W}, T_{X1W})$

(2.4.3) $X_{23} = X_{23}(w_{23}, T_{X23})$

(2.4.4) $X_{21W} = X_{21W}(w_{21W}, T_{X21W})$

(2.4.5) $X_{31W} = X_{31W}(w_{31W}, T_{X31W})$

(2.4.6) $X_{23} = X_{21} + X_{31}$

(2.4.7) $X_{45} = X_{45}(w_{45}, T_{X45})$

(2.4.8) $X_{41W} = X_{41W}(w_{41W}, T_{X41W})$

(2.4.9) $X_{51W} = X_{51W}(w_{51W}, T_{X51W})$

(2.4.10) $X_{45} = X_{41} + X_{51}$

(2.4.11) $X_{61} = X_{61}(w_{61}, T_{X61})$

(2.4.12) $X_{61W} = X_{61W}(w_{61W}, T_{X61W})$

(2.4.13) $X_{71} = X_{71}(w_{71}, T_{X71})$

(2.4.14) $X_{71W} = X_{71W}(w_{71W}, T_{X71W})$

(2.4.15) $X_{81} = X_{81}(w_{81}, T_{X81})$

(2.4.16) $X_{81W} = X_{81W}(w_{81W}, T_{X81W})$

(2.4.17) $X_{91} = X_{91}(w_{91}, T_{X91})$

(2.4.18) $X_{91W} = X_{91W}(w_{91W}, T_{X91W})$

With the exception of Equations (2.4.6) and (2.4.10), the supplies of each type of sheep and the supplies of other inputs to the farm enterprises within the model are represented by Equations (2.4.1)-(2.4.18). Based on Equation (2.3.123), the supply functions are derived from the respective profit functions as in Equation (2.3.122). All other prices specified as *W* in Equation (2.3.123) are excluded from the supply equations as they are exogenous to the model and deemed constant.

The two types of Merino ewe enterprises in the high rainfall zone (X_{21} and X_{31}) are homogeneous with a single price and share the same supply schedule given by Equations (2.4.3) and (2.4.6). Similarly, Equations (2.4.7) and (2.4.10) specify the supply of Merino ewes in the wheat-sheep zone (X_{41} and X_{51}). In all equations the exogenous supply shifters T_{Xi} represent technologies that reduce the costs of production.

<u>Output constrained input demands of farm enterprises</u>

(2.4.19) $X_1 = Y_1c'_{Y1,1}(w_1, w_{1W})$

(2.4.20) $X_{1W} = Y_1c'_{Y1,1W}(w_1, w_{1W})$

(2.4.21) $X_{21} = Y_2c'_{Y2,23}(w_{23}, w_{21W})$

(2.4.22) $X_{21W} = Y_2c'_{Y2,21W}(w_{23}, w_{21W})$

(2.4.23) $X_{31} = Y_3c'_{Y3,23}(w_{23}, w_{31W})$

(2.4.24) $X_{31W} = Y_3c'_{Y3,31W}(w_{23}, w_{31W})$

(2.4.25) $X_{41} = Y_4c'_{Y4,45}(w_{45}, w_{41W})$

(2.4.26) $X_{41W} = Y_4c'_{Y4,41W}(w_{45}, w_{41W})$

(2.4.27) $X_{51} = Y_5c'_{Y5,45}(w_{45}, w_{51W})$

(2.4.28) $X_{51W} = Y_5c'_{Y5,51W}(w_{45}, w_{51W})$

(2.4.29) $X_{61} = Y_6c'_{Y6,61}(w_{61}, w_{61W})$

(2.4.30) $X_{61W} = Y_6c'_{Y6,61W}(w_{61}, w_{61W})$

(2.4.31) $X_{71} = Y_7c'_{Y7,71}(w_{71}, w_{71W})$

(2.4.32) $X_{71W} = Y_7c'_{Y7,71W}(w_{71}, w_{71W})$

(2.4.33) $X_{81} = Y_8c'_{Y8,81}(w_{81}, w_{81W})$

(2.4.34) $X_{81W} = Y_8c'_{Y8,81W}(w_{81}, w_{81W})$

(2.4.35) $X_{91} = Y_9c'_{Y9,91}(w_{91}, w_{91W})$

(2.4.36) $X_{91W} = Y_9c'_{Y9,91W}(w_{91}, w_{91W})$

Following Equation (2.3.41), Equations (2.4.19)-(2.4.36) are derived from the cost functions in Equations (2.3.44)-(2.3.52) using Shephard's Lemma.

Farm enterprise equilibriums

(2.4.37) $X_N(X_1, X_{1W}) = Y_1(Y_{13W}, Y_{14W}, Y_{1L}, Y_{1M})$

(2.4.38) $c_{Y1}(w_1, w_{1W}) = r_{XN}(v_{13W}, v_{14W}, v_{1L}, v_{1M})$

(2.4.39) $X_2(X_{21}, X_{21W}) = Y_2(Y_{21W}, Y_{22W}, Y_{23W}, Y_{2L}, Y_{2M})$

(2.4.40) $c_{Y2}(w_{23}, w_{21W}) = r_{X2}(v_{21W}, v_{22W}, v_{23W}, v_{2L}, v_{2M})$

(2.4.41) $X_3(X_{31}, X_{31W}) = Y_3(Y_{31W}, Y_{32W}, Y_{33W}, Y_{3L}, Y_{3M})$

(2.4.42) $c_{Y3}(w_{23}, w_{31W}) = r_{X3}(v_{31W}, v_{32W}, v_{33W}, v_{3L}, v_{3M})$

(2.4.43) $X_4(X_{41}, X_{41W}) = Y_4(Y_{41W}, Y_{42W}, Y_{43W}, Y_{4L}, Y_{4M})$

(2.4.44) $c_{Y4}(w_{45}, w_{41W}) = r_{X4}(v_{41W}, v_{42W}, v_{43W}, v_{4L}, v_{4M})$

(2.4.45) $X_5(X_{51}, X_{51W}) = Y_5(Y_{51W}, Y_{52W}, Y_{53W}, Y_{5L}, Y_{5M})$

(2.4.46) $c_{Y5}(w_{45}, w_{51W}) = r_{X5}(v_{51W}, v_{52W}, v_{53W}, v_{5L}, v_{5M})$

(2.4.47) $X_6(X_{61}, X_{61W}) = Y_6(Y_{61W}, Y_{62W}, Y_{63W}, Y_{6L}, Y_{6M})$

(2.4.48) $c_{Y6}(w_{61}, w_{61W}) = r_{X6}(v_{61W}, v_{62W}, v_{63W}, v_{6L}, v_{6M})$

(2.4.49) $X_7(X_{71}, X_{71W}) = Y_7(Y_{71W}, Y_{72W}, Y_{73W}, Y_{7E}, Y_{7M})$

(2.4.50) $c_{Y7}(w_{71}, w_{71W}) = r_{X7}(v_{71W}, v_{72W}, v_{73W}, p_{SE}, v_{7M})$

(2.4.51) $X_8(X_{81}, X_{81W}) = Y_8(Y_{81W}, Y_{82W}, Y_{83W}, Y_{8E}, Y_{8M})$

(2.4.52) $c_{Y8}(w_{81}, w_{81W}) = r_{X8}(v_{81W}, v_{82W}, v_{83W}, p_{SE}, v_{8M})$

(2.4.53) $X_9(X_{91}, X_{91W}) = Y_9(Y_{91W}, Y_{92W}, Y_{93W}, Y_{9E}, Y_{9M})$

(2.4.54) $c_{Y9}(w_{91}, w_{91W}) = r_{X9}(v_{91W}, v_{92W}, v_{93W}, p_{SE}, v_{9M})$

Equations (2.4.37)-(2.4.54) are the equilibrium conditions for the nine farm enterprise sectors. Equilibrium conditions are imposed through two equations for each sector. For example, Equation (2.4.37) is the multi-output product transformation function for the non-Merino farm sector ensuring that aggregated input quantities are equal to aggregated output quantities. Equation (2.4.38) sets the unit costs (c_{Y1}) incurred per unit of aggregated output (Y_1) equal to the unit revenue (r_{XN}) earned per unit of aggregated input (X_N).

Input constrained output supply of farm enterprises

(2.4.55) $Y_{13W} = X_N r'_{XN,13W}(v_{13W}, v_{14W}, v_{1L}, v_{1M})$

(2.4.56) $Y_{14W} = X_N r'_{XN,14W}(v_{13W}, v_{14W}, v_{1L}, v_{1M})$

(2.4.57) $Y_{1L} = X_N r'_{XN,1L}(v_{13W}, v_{14W}, v_{1L}, v_{1M})$

(2.4.58) $Y_{1M} = X_N r'_{XN,1M}(v_{13W}, v_{14W}, v_{1L}, v_{1M})$

(2.4.59) $Y_{21W} = X_2 r'_{X2,21W}(v_{21W}, v_{22W}, v_{23W}, v_{2L}, v_{2M})$

(2.4.60) $Y_{22W} = X_2 r'_{X2,22W}(v_{21W}, v_{22W}, v_{23W}, v_{2L}, v_{2M})$

(2.4.61) $Y_{23W} = X_2 r'_{X2,23W}(v_{21W}, v_{22W}, v_{23W}, v_{2L}, v_{2M})$

(2.4.62) $Y_{2L} = X_2 r'_{X2,2L}(v_{21W}, v_{22W}, v_{23W}, v_{2L}, v_{2M})$

(2.4.63) $Y_{2M} = X_2 r'_{X2,2M}(v_{21W}, v_{22W}, v_{23W}, v_{2L}, v_{2M})$

(2.4.64) $Y_{31W} = X_3 r'_{X3,31W}(v_{31W}, v_{32W}, v_{33W}, v_{3L}, v_{3M})$

(2.4.65) $Y_{32W} = X_3 r'_{X3,32W}(v_{31W}, v_{32W}, v_{33W}, v_{3L}, v_{3M})$

(2.4.66) $Y_{33W} = X_3 r'_{X3,33W}(v_{31W}, v_{32W}, v_{33W}, v_{3L}, v_{3M})$

(2.4.67) $Y_{3L} = X_3 r'_{X3,3L}(v_{31W}, v_{32W}, v_{33W}, v_{3L}, v_{3M})$

(2.4.68) $Y_{3M} = X_3 r'_{X3,3M}(v_{31W}, v_{32W}, v_{33W}, v_{3L}, v_{3M})$

(2.4.69) $Y_{41W} = X_4 r'_{X4,41W}(v_{41W}, v_{42W}, v_{43W}, v_{4L}, v_{4M})$

(2.4.70) $Y_{42W} = X_4 r'_{X4,42W}(v_{41W}, v_{42W}, v_{43W}, v_{4L}, v_{4M})$

(2.4.71) $Y_{43W} = X_4 r'_{X4,43W}(v_{41W}, v_{42W}, v_{43W}, v_{4L}, v_{4M})$

(2.4.72) $Y_{4L} = X_4 r'_{X4,4L}(v_{41W}, v_{42W}, v_{43W}, v_{4L}, v_{4M})$

(2.4.73) $Y_{4M} = X_4 r'_{X4,4M}(v_{41W}, v_{42W}, v_{43W}, v_{4L}, v_{4M})$

(2.4.74) $Y_{51W} = X_5 r'_{X5,51W}(v_{51W}, v_{52W}, v_{53W}, v_{5L}, v_{5M})$

(2.4.75) $Y_{52W} = X_5 r'_{X5,52W}(v_{51W}, v_{52W}, v_{53W}, v_{5L}, v_{5M})$

(2.4.76) $Y_{53W} = X_5 r'_{X5,53W}(v_{51W}, v_{52W}, v_{53W}, v_{5L}, v_{5M})$

(2.4.77) $Y_{5L} = X_5 r'_{X5,5L}(v_{51W}, v_{52W}, v_{53W}, v_{5L}, v_{5M})$

(2.4.78) $Y_{5M} = X_5 r'_{X5,5M}(v_{51W}, v_{52W}, v_{53W}, v_{5L}, v_{5M})$

(2.4.79) $Y_{61W} = X_6 r'_{X6,61W}(v_{61W}, v_{62W}, v_{63W}, v_{6L}, v_{6M})$

(2.4.80) $Y_{62W} = X_6 r'_{X6,62W}(v_{61W}, v_{62W}, v_{63W}, v_{6L}, v_{6M})$

(2.4.81) $Y_{63W} = X_6 r'_{X6,63W}(v_{61W}, v_{62W}, v_{63W}, v_{6L}, v_{6M})$

(2.4.82) $Y_{6L} = X_6 r'_{X6,6L}(v_{61W}, v_{62W}, v_{63W}, v_{6L}, v_{6M})$

(2.4.83) $Y_{6M} = X_6 r'_{X6,6M}(v_{61W}, v_{62W}, v_{63W}, v_{6L}, v_{6M})$

(2.4.84) $Y_{71W} = X_7 r'_{X7,71W}(v_{71W}, v_{72W}, v_{73W}, p_{SE}, v_{7M})$

(2.4.85) $Y_{72W} = X_7 r'_{X7,72W}(v_{71W}, v_{72W}, v_{73W}, p_{SE}, v_{7M})$

(2.4.86) $Y_{73W} = X_7 r'_{X7,73W}(v_{71W}, v_{72W}, v_{73W}, p_{SE}, v_{7M})$

(2.4.87) $Y_{7E} = X_7 r'_{X7,7E}(v_{71W}, v_{72W}, v_{73W}, p_{SE}, v_{7M})$

(2.4.88) $Y_{7M} = X_7 r'_{X7,7M}(v_{71W}, v_{72W}, v_{73W}, p_{SE}, v_{7M})$

(2.4.89) $Y_{81W} = X_8 r'_{X8,81W}(v_{81W}, v_{82W}, v_{83W}, p_{SE}, v_{8M})$

(2.4.90) $Y_{82W} = X_8 r'_{X8,82W}(v_{81W}, v_{82W}, v_{83W}, p_{SE}, v_{8M})$

(2.4.91) $Y_{83W} = X_8 r'_{X8,83W}(v_{81W}, v_{82W}, v_{83W}, p_{SE}, v_{8M})$

(2.4.92) $Y_{8E} = X_8 r'_{X8,8E}(v_{81W}, v_{82W}, v_{83W}, p_{SE}, v_{8M})$

(2.4.93) $Y_{8M} = X_8 r'_{X8,8M}(v_{81W}, v_{82W}, v_{83W}, p_{SE}, v_{8M})$

(2.4.94) $Y_{91W} = X_9 r'_{X9,91W}(v_{91W}, v_{92W}, v_{93W}, p_{SE}, v_{9M})$

(2.4.95) $Y_{92W} = X_9 r'_{X9,92W}(v_{91W}, v_{92W}, v_{93W}, p_{SE}, v_{9M})$

(2.4.96) $Y_{93W} = X_9 r'_{X9,93W}(v_{91W}, v_{92W}, v_{93W}, p_{SE}, v_{9M})$

(2.4.97) $Y_{9E} = X_9 r'_{X9,9E}(v_{91W}, v_{92W}, v_{93W}, p_{SE}, v_{9M})$

(2.4.98) $Y_{9M} = X_9 r'_{X9,9M}(v_{91W}, v_{92W}, v_{93W}, p_{SE}, v_{9M})$

Following Equation (2.3.82), Equations (2.4.55)-(2.4.98) are derived from the revenue functions in Equations (2.3.87)-(2.3.95) using the Samuelson-McFadden Lemma.

<u>Other input supply to wool warehouse sectors</u>

(2.4.99) $Y_{NM} = Y_{NM}(v_{NM}, T_{YNM})$

(2.4.100) $Y_{BM} = Y_{BM}(v_{BM}, T_{YBM})$

(2.4.101) $Y_{MM} = Y_{MM}(v_{MM}, T_{YMM})$

(2.4.102) $Y_{FM} = Y_{FM}(v_{FM}, T_{YFM})$

As derived in Equation (2.3.123), Equations (2.4.99)-(2.4.102) are the supplies of other inputs to the wool warehouse sectors. The exogenous supply shifters T_{Yi} represent technologies that reduce the costs of production.

<u>Other input supply to lamb and mutton slaughtering/processing sectors</u>

(2.4.103) $Y_{SL} = Y_{SL}(v_{SL}, T_{YSL})$

(2.4.104) $Y_{SM} = Y_{SM}(v_{SM}, T_{YSM})$

As derived in Equation (2.3.123), Equations (2.4.103) and (2.4.104) are the supplies of other inputs to the lamb and mutton processing sectors. The exogenous supply shifters T_{Yi} represent technologies that reduce the costs of production.

<u>Output constrained input demand of wool warehouse sectors</u>

(2.4.105) $Y_{14W} = Z_1 c'_{Z1,14W}(v_{14W}, v_{NM})$

(2.4.106) $Y_{NM} = Z_1 c'_{Z1,NM}(v_{1W}, v_{WN})$

(2.4.107) $Y_{21W} = Z_2 c'_{Z2,21W}(v_{21W}, v_{31W}, v_{41W}, v_{51W}, v_{61W}, v_{71W}, v_{81W}, v_{91W}, v_{FM})$

(2.4.108) $Y_{31W} = Z_2 c'_{Z2,31W}(v_{21W}, v_{31W}, v_{41W}, v_{51W}, v_{61W}, v_{71W}, v_{81W}, v_{91W}, v_{FM})$

(2.4.109) $Y_{41W} = Z_2 c'_{Z2,41W}(v_{21W}, v_{31W}, v_{41W}, v_{51W}, v_{61W}, v_{71W}, v_{81W}, v_{91W}, v_{FM})$

(2.4.110) $Y_{51W} = Z_2 c'_{Z2,51W}(v_{21W}, v_{31W}, v_{41W}, v_{51W}, v_{61W}, v_{71W}, v_{81W}, v_{91W}, v_{FM})$

(2.4.111) $Y_{61W} = Z_2 c'_{Z2,61W}(v_{21W}, v_{31W}, v_{41W}, v_{51W}, v_{61W}, v_{71W}, v_{81W}, v_{91W}, v_{FM})$

(2.4.112) $Y_{71W} = Z_2 c'_{Z2,71W}(v_{21W}, v_{31W}, v_{41W}, v_{51W}, v_{61W}, v_{71W}, v_{81W}, v_{91W}, v_{FM})$

(2.4.113) $Y_{81W} = Z_2 c'_{Z2,81W}(v_{21W}, v_{31W}, v_{41W}, v_{51W}, v_{61W}, v_{71W}, v_{81W}, v_{91W}, v_{FM})$

(2.4.114) $Y_{91W} = Z_2 c'_{Z2,91W}(v_{21W}, v_{31W}, v_{41W}, v_{51W}, v_{61W}, v_{71W}, v_{81W}, v_{91W}, v_{FM})$

(2.4.115) $Y_{FM} = Z_2 c'_{Z2,FM}(v_{21W}, v_{31W}, v_{41W}, v_{51W}, v_{61W}, v_{71W}, v_{81W}, v_{91W}, v_{FM})$

(2.4.116) $Y_{22W} = Z_3c'_{Z3,22W}(v_{22W}, v_{32W}, v_{42W}, v_{52W}, v_{62W}, v_{72W}, v_{82W}, v_{92W}, v_{MM})$

(2.4.117) $Y_{32W} = Z_3c'_{Z3,32W}(v_{22W}, v_{32W}, v_{42W}, v_{52W}, v_{62W}, v_{72W}, v_{82W}, v_{92W}, v_{MM})$

(2.4.118) $Y_{42W} = Z_3c'_{Z3,42W}(v_{22W}, v_{32W}, v_{42W}, v_{52W}, v_{62W}, v_{72W}, v_{82W}, v_{92W}, v_{MM})$

(2.4.119) $Y_{52W} = Z_3c'_{Z3,52W}(v_{22W}, v_{32W}, v_{42W}, v_{52W}, v_{62W}, v_{72W}, v_{82W}, v_{92W}, v_{MM})$

(2.4.120) $Y_{62W} = Z_3c'_{Z3,62W}(v_{22W}, v_{32W}, v_{42W}, v_{52W}, v_{62W}, v_{72W}, v_{82W}, v_{92W}, v_{MM})$

(2.4.121) $Y_{72W} = Z_3c'_{Z3,72W}(v_{22W}, v_{32W}, v_{42W}, v_{52W}, v_{62W}, v_{72W}, v_{82W}, v_{92W}, v_{MM})$

(2.4.122) $Y_{82W} = Z_3c'_{Z3,82W}(v_{22W}, v_{32W}, v_{42W}, v_{52W}, v_{62W}, v_{72W}, v_{82W}, v_{92W}, v_{MM})$

(2.4.123) $Y_{92W} = Z_3c'_{Z3,92W}(v_{22W}, v_{32W}, v_{42W}, v_{52W}, v_{62W}, v_{72W}, v_{82W}, v_{92W}, v_{MM})$

(2.4.124) $Y_{MM} = Z_3c'_{Z3,MM}(v_{22W}, v_{32W}, v_{42W}, v_{52W}, v_{62W}, v_{72W}, v_{82W}, v_{92W}, v_{MM})$

(2.4.125) $Y_{13W} = Z_4c'_{Z4,13W}(v_{13W}, v_{23W}, v_{33W}, v_{43W}, v_{53W}, v_{63W}, v_{73W}, v_{83W}, v_{93W}, v_{BM})$

(2.4.126) $Y_{23W} = Z_4c'_{Z4,23W}(v_{13W}, v_{23W}, v_{33W}, v_{43W}, v_{53W}, v_{63W}, v_{73W}, v_{83W}, v_{93W}, v_{BM})$

(2.4.127) $Y_{33W} = Z_4c'_{Z4,33W}(v_{13W}, v_{23W}, v_{33W}, v_{43W}, v_{53W}, v_{63W}, v_{73W}, v_{83W}, v_{93W}, v_{BM})$

(2.4.128) $Y_{43W} = Z_4c'_{Z4,43W}(v_{13W}, v_{23W}, v_{33W}, v_{43W}, v_{53W}, v_{63W}, v_{73W}, v_{83W}, v_{93W}, v_{BM})$

(2.4.129) $Y_{53W} = Z_4c'_{Z4,53W}(v_{13W}, v_{23W}, v_{33W}, v_{43W}, v_{53W}, v_{63W}, v_{73W}, v_{83W}, v_{93W}, v_{BM})$

(2.4.130) $Y_{63W} = Z_4c'_{Z4,63W}(v_{13W}, v_{23W}, v_{33W}, v_{43W}, v_{53W}, v_{63W}, v_{73W}, v_{83W}, v_{93W}, v_{BM})$

(2.4.131) $Y_{73W} = Z_4c'_{Z4,73W}(v_{13W}, v_{23W}, v_{33W}, v_{43W}, v_{53W}, v_{63W}, v_{73W}, v_{83W}, v_{93W}, v_{BM})$

(2.4.132) $Y_{83W} = Z_4c'_{Z4,83W}(v_{13W}, v_{23W}, v_{33W}, v_{43W}, v_{53W}, v_{63W}, v_{73W}, v_{83W}, v_{93W}, v_{BM})$

(2.4.133) $Y_{93W} = Z_4c'_{Z4,93W}(v_{13W}, v_{23W}, v_{33W}, v_{43W}, v_{53W}, v_{63W}, v_{73W}, v_{83W}, v_{93W}, v_{BM})$

(2.4.134) $Y_{BM} = Z_4c'_{Z4,1BM}(v_{13W}, v_{23W}, v_{33W}, v_{43W}, v_{53W}, v_{63W}, v_{73W}, v_{83W}, v_{93W}, v_{BM})$

Following Equation (2.3.41), Equations (2.4.105)-(2.4.134) are derived from the cost functions in Equations (2.3.53)-(2.3.56) using Shephard's Lemma.

Output constrained input demand of lamb and mutton slaughtering/processing sectors

(2.4.135) $Y_{1L} = Z_Lc'_{ZL,1L}(v_{1L}, v_{2L}, v_{3L}, v_{4L}, v_{5L}, v_{6L}, v_{SL})$

(2.4.136) $Y_{2L} = Z_Lc'_{ZL,2L}(v_{1L}, v_{2L}, v_{3L}, v_{4L}, v_{5L}, v_{6L}, v_{SL})$

(2.4.137) $Y_{3L} = Z_Lc'_{ZL,3L}(v_{1L}, v_{2L}, v_{3L}, v_{4L}, v_{5L}, v_{6L}, v_{SL})$

(2.4.138) $Y_{4L} = Z_Lc'_{ZL,4L}(v_{1L}, v_{2L}, v_{3L}, v_{4L}, v_{5L}, v_{6L}, v_{SL})$

(2.4.139) $Y_{5L} = Z_Lc'_{ZL,5L}(v_{1L}, v_{2L}, v_{3L}, v_{4L}, v_{5L}, v_{6L}, v_{SL})$

(2.4.140) $Y_{6L} = Z_Lc'_{ZL,6L}(v_{1L}, v_{2L}, v_{3L}, v_{4L}, v_{5L}, v_{6L}, v_{SL})$

(2.4.141) $Y_{SL} = Z_Lc'_{ZL,SL}(v_{1L}, v_{2L}, v_{3L}, v_{4L}, v_{5L}, v_{6L}, v_{SL})$

(2.4.142) $Y_{1M} = Z_Mc'_{ZM,1M}(v_{1M}, v_{2M}, v_{3M}, v_{4M}, v_{5M}, v_{6M}, v_{7M}, v_{8M}, v_{9M}, v_{SM})$

(2.4.143) $Y_{2M} = Z_Mc'_{ZM,2M}(v_{1M}, v_{2M}, v_{3M}, v_{4M}, v_{5M}, v_{6M}, v_{7M}, v_{8M}, v_{9M}, v_{SM})$

(2.4.144) $Y_{3M} = Z_Mc'_{ZM,3M}(v_{1M}, v_{2M}, v_{3M}, v_{4M}, v_{5M}, v_{6M}, v_{7M}, v_{8M}, v_{9M}, v_{SM})$

(2.4.145) $Y_{4M} = Z_Mc'_{ZM,4M}(v_{1M}, v_{2M}, v_{3M}, v_{4M}, v_{5M}, v_{6M}, v_{7M}, v_{8M}, v_{9M}, v_{SM})$

(2.4.146) $Y_{5M} = Z_Mc'_{ZM,5M}(v_{1M}, v_{2M}, v_{3M}, v_{4M}, v_{5M}, v_{6M}, v_{7M}, v_{8M}, v_{9M}, v_{SM})$

(2.4.147) $Y_{6M} = Z_M c'_{ZM,6M}(v_{1M}, v_{2M}, v_{3M}, v_{4M}, v_{5M}, v_{6M}, v_{7M}, v_{8M}, v_{9M}, v_{SM})$

(2.4.148) $Y_{7M} = Z_M c'_{ZM,7M}(v_{1M}, v_{2M}, v_{3M}, v_{4M}, v_{5M}, v_{6M}, v_{7M}, v_{8M}, v_{9M}, v_{SM})$

(2.4.149) $Y_{8M} = Z_M c'_{ZM,8M}(v_{1M}, v_{2M}, v_{3M}, v_{4M}, v_{5M}, v_{6M}, v_{7M}, v_{8M}, v_{9M}, v_{SM})$

(2.4.150) $Y_{9M} = Z_M c'_{ZM,9M}(v_{1M}, v_{2M}, v_{3M}, v_{4M}, v_{5M}, v_{6M}, v_{7M}, v_{8M}, v_{9M}, v_{SM})$

(2.4.151) $Y_{SM} = Z_M c'_{ZM,SM}(v_{1M}, v_{2M}, v_{3M}, v_{4M}, v_{5M}, v_{6M}, v_{7M}, v_{8M}, v_{9M}, v_{SM})$

Following Equation (2.3.41), Equations (2.4.135)-(2.4.151) are derived from the cost functions in Equations (2.3.73)-(2.3.74) using Shephard's Lemma.

Wool warehouse sectors equilibrium

(2.4.152) $Y_N(Y_{14W}, Y_{NM}) = Z_1(Z_{1W}, Z_{1S})$

(2.4.153) $c_{Z1}(v_{14W}, v_{NM}) = r_{YN}(u_{1W}, u_{1S})$

(2.4.154) $Y_F(Y_{21W}, Y_{31W}, Y_{41W}, Y_{51W}, Y_{61W}, Y_{71W}, Y_{81W}, Y_{91W}, Y_{FM}) = Z_2(Z_{2W}, Z_{2S})$

(2.4.155) $c_{Z2}(v_{21W}, v_{31W}, v_{41W}, v_{51W}, v_{61W}, v_{71W}, v_{81W}, v_{91W}, v_{FM}) = r_{YF}(u_{2W}, u_{2S})$

(2.4.156) $Y_C(Y_{22W}, Y_{32W}, Y_{42W}, Y_{52W}, Y_{62W}, Y_{72W}, Y_{82W}, Y_{92W}, Y_{MM}) = Z_3(Z_{3W}, Z_{3S})$

(2.4.157) $c_{Z3}(v_{22W}, v_{32W}, v_{42W}, v_{52W}, v_{62W}, v_{72W}, v_{82W}, v_{92W}, v_{MM}) = r_{YC}(u_{2W}, u_{2S})$

(2.4.158) $Y_B(Y_{13W}, Y_{23W}, Y_{33W}, Y_{43W}, Y_{53W}, Y_{63W}, Y_{73W}, Y_{83W}, Y_{93W}, Y_{BM}) = Z_4(Z_{4W}, Z_{4S})$

(2.4.159) $c_{Z4}(v_{13W}, v_{23W}, v_{33W}, v_{43W}, v_{53W}, v_{63W}, v_{73W}, v_{83W}, v_{93W}, v_{BM}) = r_{YB}(u_{3W}, u_{3S})$

Equations (2.4.152)-(2.4.159) are the quantity and value equilibrium conditions for the wool warehouse sectors as explained for the farm sector equilibrium in Equations (2.4.37)-(2.4.54).

Lamb and mutton slaughtering/processing sectors equilibrium

(2.4.160) $Y_L(Y_{1L}, Y_{2L}, Y_{3L}, Y_{4L}, Y_{5L}, Y_{6L}, Y_{SL},) = Z_L(Z_{LE}, Z_{LD})$

(2.4.161) $c_{ZL}(v_{1L}, v_{2L}, v_{3L}, v_{4L}, v_{5L}, v_{6L}, v_{SL},) = r_{YL}(u_{LE}, u_{LD})$

(2.4.162) $Y_M(Y_{1M}, Y_{2M}, Y_{3M}, Y_{4M}, Y_{5M}, Y_{6M}, Y_{7M}, Y_{8M}, Y_{9M}, Y_{SM},) = Z_M(Z_{ME}, Z_{MD})$

(2.4.163) $c_{ZM}(v_{1M}, v_{2M}, v_{3M}, v_{4M}, v_{5M}, v_{6M}, v_{7M}, v_{8M}, v_{9M}, v_{SM},) = r_{YM}(u_{ME}, u_{MD})$

Equations (2.4.160)-(2.4.163) are the quantity and value equilibrium conditions for the lamb and mutton processing sectors as explained for the farm sector equilibrium in Equations (2.4.37)-(2.4.54).

Input constrained output supply of wool warehouse sectors

(2.4.164) $Z_{1W} = Y_N r'_{YN,1W}(u_{1W}, u_{1S})$

(2.4.165) $Z_{1S} = Y_N r'_{YN,1S}(u_{1W}, u_{1S})$

(2.4.166) $Z_{2W} = Y_F r'_{YF,2W}(u_{2W}, u_{2S})$

(2.4.167) $Z_{2S} = Y_F r'_{YF,2S}(u_{2W}, u_{2S})$

(2.4.168) $Z_{3W} = Y_C r'_{YC,3W}(u_{3W}, u_{3S})$

(2.4.169) $Z_{3S} = Y_C r'_{YC,3S}(u_{3W}, u_{3S})$

(2.4.170) $Z_{4W} = Y_B r'_{YB,4W}(u_{4W}, u_{4S})$

(2.4.171) $Z_{4S} = Y_B r'_{YB,4S}(u_{4W}, u_{4S})$

Following Equation (2.3.82), Equations (2.4.164)-(2.4.171) are derived from the revenue functions in Equations (2.3.96)-(2.3.99) using the Samuelson-McFadden Lemma.

Input constrained output supply of lamb and mutton slaughtering/processing sectors

(2.4.172) $Z_{LE} = Y_L r'_{YL,LE}(u_{LE}, u_{LD})$

(2.4.173) $Z_{LD} = Y_L r'_{YL,LD}(u_{LE}, u_{LD})$

(2.4.174) $Z_{ME} = Y_M r'_{YM,ME}(u_{ME}, u_{MD})$

(2.4.175) $Z_{MD} = Y_M r'_{YM,MD}(u_{ME}, u_{MD})$

Following Equation (2.3.82), Equations (2.4.172)-(2.4.175) are derived from the revenue functions in Equations (2.3.116)-(2.3.117) using the Samuelson-McFadden Lemma.

Other input supply to wool scouring sector

(2.4.176) $Z_{CS} = Z_{CS}(u_{CS}, T_{ZCS})$

As derived in Equation (2.3.123), Equation (2.4.176) is the supply of other inputs to the wool scouring sector. The exogenous supply shifter T_{ZCS} represents technologies that reduce the costs of production.

Output constrained input demand of wool scouring sector

(2.4.177) $Z_{1S} = Z_S c'_{ZS,1S}(u_{1S}, u_{2S}, u_{3S}, u_{4S}, u_{CS})$

(2.4.178) $Z_{2S} = Z_S c'_{ZS,2S}(u_{1S}, u_{2S}, u_{3S}, u_{4S}, u_{CS})$

(2.4.179) $Z_{3S} = Z_S c'_{ZS,3S}(u_{1S}, u_{2S}, u_{3S}, u_{4S}, u_{CS})$

(2.4.180) $Z_{4S} = Z_S c'_{ZS,4S}(u_{1S}, u_{2S}, u_{3S}, u_{4S}, u_{CS})$

(2.4.181) $Z_{CS} = Z_S c'_{ZS,CS}(u_{1S}, u_{2S}, u_{3S}, u_{4S}, u_{CS})$

Following Equation (2.3.41), Equations (2.4.177)-(2.4.181) are derived from the cost function in Equations (2.3.61) using Shephard’s Lemma.

Wool scouring sector equilibrium

(2.4.182) $Z_C(Z_{1S}, Z_{2S}, Z_{3S}, Z_{4S}, Z_{CS}) = Z_S(Z_{CW}, F_{1S}, F_{2S}, F_{3S}, F_{4S}, Z_{2T}, Z_{3T}, Z_{4T})$

(2.4.183) $c_{ZS}(u_{1S}, u_{2S}, u_{3S}, u_{4S}, u_{CS}) = r_{ZC}(u_{CW}, s_{1S}, s_{2S}, s_{3S}, s_{4S}, u_{2T}, u_{3T}, u_{4T})$

Equations (2.4.182) and (2.4.183) are the quantity and value equilibrium conditions for the wool scouring sector as explained for the farm sector equilibrium in Equations (2.4.37)-(2.4.54).

Input constrained output supply of wool scouring sector

(2.4.184) $F_{1S} = Z_C r'_{ZC,1S}(u_{CW}, s_{1S}, s_{2S}, s_{3S}, s_{4S}, u_{2T}, u_{3T}, u_{4T})$

(2.4.185) $F_{2S} = Z_C r'_{ZC,2S}(u_{CW}, s_{1S}, s_{2S}, s_{3S}, s_{4S}, u_{2T}, u_{3T}, u_{4T})$

(2.4.186) $F_{3S} = Z_C r'_{ZC,3S}(u_{CW}, s_{1S}, s_{2S}, s_{3S}, s_{4S}, u_{2T}, u_{3T}, u_{4T})$

(2.4.187) $F_{4S} = Z_C r'_{ZC,4S}(u_{CW}, s_{1S}, s_{2S}, s_{3S}, s_{4S}, u_{2T}, u_{3T}, u_{4T})$

(2.4.188) $Z_{2T} = Z_C r'_{ZC,2T}(u_{CW}, s_{1S}, s_{2S}, s_{3S}, s_{4S}, u_{2T}, u_{3T}, u_{4T})$

(2.4.189) $Z_{3T} = Z_C r'_{ZC,3T}(u_{CW}, s_{1S}, s_{2S}, s_{3S}, s_{4S}, u_{2T}, u_{3T}, u_{4T})$

(2.4.190) $Z_{4T} = Z_C r'_{ZC,4T}(u_{CW}, s_{1S}, s_{2S}, s_{3S}, s_{4S}, u_{2T}, u_{3T}, u_{4T})$

(2.4.191) $Z_{CW} = Z_C r'_{ZC,CW}(u_{CW}, s_{1S}, s_{2S}, s_{3S}, s_{4S}, u_{2T}, u_{3T}, u_{4T})$

Following Equation (2.3.82), Equations (2.4.184)-(2.4.191) are derived from the revenue function in Equation (2.3.104) using the Samuelson-McFadden Lemma.

Other input supply to wool carbonising sector

(2.4.192) $Z_{CB} = Z_{CB}(u_{CB}, T_{ZCB})$

As derived in Equation (2.3.123), Equation (2.4.192) is the supply of other inputs to the wool carbonising sector. The exogenous supply shifter T_{ZCB} represents technologies that reduce the costs of production.

Output constrained input demand of wool carbonising sector

(2.4.193) $Z_{CW} = F_{CW} c'_{FCW,CW}(u_{CW}, u_{CB})$

(2.4.194) $Z_{CB} = F_{CW} c'_{FCW,CB}(u_{CW}, u_{CB})$

Following Equation (2.3.41), Equations (2.4.193) and (2.4.194) are derived from the cost function in Equations (2.3.62) using Shephard's Lemma.

Wool carbonising sector equilibrium

(2.4.195) $s_{CW} = c_{FCW}(u_{CW}, u_{CB})$

Equation (2.4.195) is the market clearing value equilibrium condition for the wool carbonising sector specifying that unit prices for output equal the unit costs of production at the margin.

Other input supply to wool topmaking sector

(2.4.196) $Z_{WT} = Z_{WT}(u_{WT}, T_{ZWT})$

As derived in Equation (5.3.123), Equation (5.4.196) is the supply of other inputs to the wool topmaking sector. The exogenous supply shifter T_{ZWT} represents technologies that reduce the costs of production.

Output constrained input demand of wool topmaking sector

(2.4.197) $Z_{2T} = F_T c'_{FT,2T}(u_{2T}, u_{3T}, u_{4T}, u_{WT})$

(2.4.198) $Z_{3T} = F_T c'_{FT,3T}(u_{2T}, u_{3T}, u_{4T}, u_{WT})$

(2.4.199) $Z_{4T} = F_T c'_{FT,4T}(u_{2T}, u_{3T}, u_{4T}, u_{WT})$

(2.4.200) $Z_{WT} = F_T c'_{FT,WT}(u_{2T}, u_{3T}, u_{4T}, u_{WT})$

Following Equation (2.3.41), Equations (2.4.197) and (2.4.200) are derived from the cost function in Equations (2.3.63) using Shephard's Lemma.

Wool topmaking sector equilibrium

(2.4.201) $Z_T(Z_{2T}, Z_{3T}, Z_{4T}, Z_{WT}) = F_T(F_{2T}, F_{3T}, F_{4T}, F_{NW}, Q_{DP})$

(2.4.202) $c_{FT}(u_{2T}, u_{3T}, u_{4T}, u_{WT}) = r_{ZT}(s_{2T}, s_{3T}, s_{4T}, s_{NW}, p_{DP})$

Equations (2.4.201) and (2.4.202) are the quantity and value equilibrium conditions for the wool topmaking sector as explained for the farm sector equilibrium in Equations (2.4.37)-(2.4.54).

Input constrained output supply of wool topmaking sector

(2.4.203) $F_{2T} = Z_T r'_{ZT,2T}(s_{2T}, s_{3T}, s_{4T}, s_{NW}, p_{DP})$

(2.4.204) $F_{3T} = Z_T r'_{ZT,3T}(s_{2T}, s_{3T}, s_{4T}, s_{NW}, p_{DP})$

(2.4.205) $F_{4T} = Z_T r'_{ZT,4T}(s_{2T}, s_{3T}, s_{4T}, s_{NW}, p_{DP})$

(2.4.206) $F_{NW} = Z_T r'_{ZT,NW}(s_{2T}, s_{3T}, s_{4T}, s_{NW}, p_{DP})$

(2.4.207) $Q_{DP} = Z_T r'_{ZT,DP}(s_{2T}, s_{3T}, s_{4T}, s_{NW}, p_{DP})$

Following Equation (2.3.82), Equations (2.4.203)-(2.4.207) are derived from the revenue function in Equation (2.3.106) using the Samuelson-McFadden Lemma.

Other input supply to export greasy wool shipment sectors

(2.4.208) $Z_{NM} = Z_{NM}(u_{NM}, T_{ZNM})$

(2.4.209) $Z_{FM} = Z_{FM}(u_{FM}, T_{ZFM})$

(2.4.210) $Z_{MM} = Z_{MM}(u_{MM}, T_{ZMM})$

(2.4.211) $Z_{BM} = Z_{BM}(u_{BM}, T_{ZBM})$

As derived in Equation (2.3.123), Equations (2.4.208)-(2.4.211) are the supplies of other inputs to the export greasy wool shipment sectors. The exogenous supply shifters T_{Zi} represent technologies that reduce the costs of production.

Other input supply to export carbonised wool shipment sector

(2.4.212) $F_{CB} = F_{CB}(s_{CB}, T_{FCB})$

As derived in Equation (2.3.123), Equation (2.4.212) is the supply of other inputs to the export carbonised wool shipment sector. The exogenous supply shifter T_{FCB} represents technologies that reduce the costs of production.

Other input supply to export scoured wool shipment sectors

(2.4.213) $F_{NS} = F_{NS}(s_{NS}, T_{FNS})$

(2.4.214) $F_{FS} = F_{FS}(s_{FS}, T_{FFS})$

(2.4.215) $F_{MS} = F_{MS}(s_{MS}, T_{FMS})$

(2.4.216) $F_{BS} = F_{BS}(s_{BS}, T_{FBS})$

As derived in Equation (2.3.123), Equations (2.4.213)-(2.4.216) are the supplies of other inputs to the export scoured wool shipment sectors. The exogenous supply shifters T_{Fi} represent technologies that reduce the costs of production.

Other input supply to export wool tops shipment sectors

(2.4.217) $F_{FT} = F_{FT}(s_{FT}, T_{FFT})$

(2.4.218) $F_{MT} = F_{MT}(s_{MT}, T_{FMT})$

(2.4.219) $F_{BT} = F_{BT}(s_{BT}, T_{FBT})$

(2.4.220) $F_{NE} = F_{NE}(s_{NE}, T_{FNE})$

As derived in Equation (2.3.123), Equations (2.4.217)-(2.4.220) are the supplies of other inputs to the export wool tops shipment sectors. The exogenous supply shifters T_{Fi} represent technologies that reduce the costs of production.

Output constrained input demand of export greasy wool shipment sectors

(2.4.221) $Z_{1W} = Q_{1W}c'_{Q1W,1W}(u_{1W}, u_{NM})$

(2.4.222) $Z_{NM} = Q_{1W}c'_{Q1W,NM}(u_{1W}, u_{NM})$

(2.4.223) $Z_{2W} = Q_{2W}c'_{Q2W,2W}(u_{2W}, u_{FM})$

(2.4.224) $Z_{FM} = Q_{2W}c'_{Q2W,FM}(u_{2W}, u_{FM})$

(2.4.225) $Z_{3W} = Q_{3W}c'_{Q3W,3W}(u_{3W}, u_{MM})$

(2.4.226) $Z_{MM} = Q_{3W}c'_{Q3W,FM}(u_{3W}, u_{FM})$

(2.4.227) $Z_{4W} = Q_{4W}c'_{Q4W,4W}(u_{4W}, u_{BM})$

(2.4.228) $Z_{BM} = Q_{4W}c'_{Q4W,BM}(u_{4W}, u_{BM})$

Following Equation (2.3.41), Equations (2.4.221)-(2.4.228) are derived from the cost functions in Equations (2.3.57)-(2.3.60) using Shephard’s Lemma.

Output constrained input demand of export carbonised wool shipment sector

(2.4.229) $F_{CW} = Q_{CW}c'_{QCW,CW}(s_{CW}, s_{CB})$

(2.4.230) $F_{CB} = Q_{CW}c'_{QCW,CB}(s_{CW}, s_{CB})$

Following Equation (2.3.41), Equations (2.4.229)-(2.4.230) are derived from the cost functions in Equation (2.3.64) using Shephard's Lemma.

Output constrained input demand of export scoured wool shipment sectors

(2.4.231) $F_{1S} = Q_{1S}c'_{Q1S,1S}(s_{1S}, s_{NS})$

(2.4.232) $F_{NS} = Q_{1S}c'_{Q1S,NS}(s_{1S}, s_{NS})$

(2.4.233) $F_{2S} = Q_{2S}c'_{Q2S,2S}(s_{2S}, s_{FS})$

(2.4.234) $F_{FS} = Q_{2S}c'_{Q2S,FS}(s_{1S}, s_{FS})$

(2.4.235) $F_{3S} = Q_{3S}c'_{Q3S,3S}(s_{3S}, s_{MS})$

(2.4.236) $F_{MS} = Q_{3S}c'_{Q3S,MS}(s_{3S}, s_{MS})$

(2.4.237) $F_{4S} = Q_{4S}c'_{Q4S,4S}(s_{4S}, s_{BS})$

(2.4.238) $F_{BS} = Q_{4S}c'_{Q4S,BS}(s_{4S}, s_{BS})$

Following Equation (2.3.41), Equations (2.4.231)-(2.4.238) are derived from the cost functions in Equations (2.3.65)-(2.3.68) using Shephard's Lemma.

Output constrained input demand of export wool tops shipment sectors

(2.4.239) $F_{2T} = Q_{2T}c'_{Q2T,2T}(s_{2T}, s_{FT})$

(2.4.240) $F_{FT} = Q_{2T}c'_{Q2T,FT}(s_{2T}, s_{FT})$

(2.4.241) $F_{3T} = Q_{3T}c'_{Q3T,3T}(s_{3T}, s_{FMT})$

(2.4.242) $F_{MT} = Q_{3T}c'_{Q3T,MT}(s_{3T}, s_{MT})$

(2.4.243) $F_{4T} = Q_{4T}c'_{Q4T,4T}(s_{4T}, s_{BT})$

(2.4.244) $F_{BT} = Q_{4T}c'_{Q4T,BT}(s_{4T}, s_{BT})$

(2.4.245) $F_{NW} = Q_{NW}c'_{QNW,NW}(s_{NW}, s_{NE})$

(2.4.246) $F_{NE} = Q_{NW}c'_{QNW,NE}(s_{NW}, s_{NE})$

Following Equation (2.3.41), Equations (2.4.239)-(2.4.246) are derived from the cost functions in Equations (2.3.69)-(2.3.72) using Shephard's Lemma.

Export greasy wool shipment sector equilibrium

(2.4.247) $p_{1W} = c_{Q1W}(u_{1W}, u_{NM})$

(2.4.248) $p_{2W} = c_{Q2W}(u_{2W}, u_{FM})$

(2.4.249) $p_{3W} = c_{Q3W}(u_{3W}, u_{MM})$

(2.4.250) $p_{4W} = c_{Q4W}(u_{4W}, u_{BM})$

Equations (2.4.247)-(2.4.250) are the market clearing value equilibrium conditions for the export greasy wool shipment sectors specifying that unit prices of output equal the unit costs of production at the margin.

Export carbonised wool shipment sector equilibrium

(2.4.251) $p_{CW} = c_{QCW}(s_{CW}, s_{CB})$

Equation (2.4.251) is the market clearing value equilibrium condition for the export carbonised wool shipment sector specifying that unit prices of output equal the unit costs of production at the margin.

Export scoured wool shipment sector equilibrium

(2.4.252) $p_{1S} = c_{Q1S}(s_{1S}, s_{NS})$

(2.4.253) $p_{2S} = c_{Q2S}(s_{2S}, s_{FS})$

(2.4.254) $p_{3S} = c_{Q3S}(s_{3S}, s_{MS})$

(2.4.251) $p_{4S} = c_{Q4S}(s_{4S}, s_{BS})$

Equations (2.4.252)-(2.4.255) are the market clearing value equilibrium conditions for the export scoured wool shipment sectors specifying that unit prices of output equal the unit costs of production at the margin.

Export wool tops shipment sector equilibrium

(2.4.256) $p_{2T} = c_{Q2T}(s_{2T}, s_{FT})$

(2.4.257) $p_{3T} = c_{Q2T}(s_{3T}, s_{MT})$

(2.4.258) $p_{4T} = c_{Q4T}(s_{4T}, s_{BT})$

(2.4.259) $p_{NW} = c_{QNW}(s_{NW}, s_{NW})$

Equations (2.4.256)-(2.4.259) are the market clearing value equilibrium conditions for the export wool tops shipment sectors specifying that unit prices of output equal the unit costs of production at the margin.

Other input supply to lamb and mutton marketing sectors

(2.4.260) $Z_{1L} = Z_{1L}(u_{1L}, T_{Z1L})$

(2.4.261) $Z_{2L} = Z_{2L}(u_{2L}, T_{Z2L})$

(2.4.262) $Z_{1M} = Z_{1M}(u_{1M}, T_{Z1M})$

(2.4.263) $Z_{2M} = Z_{2M}(u_{2M}, T_{Z2M})$

As derived in Equation (2.3.123), Equations (2.4.260)-(2.4.263) are the supplies of other inputs to the lamb and mutton marketing sectors. The exogenous supply shifters T_{Zi} represent technologies that reduce the costs of production.

Output constrained input demand of lamb and mutton marketing sectors

(2.4.264) $Z_{LE} = Q_{LE}c'_{QLE,LE}(u_{LE}, u_{1L})$

(2.4.265) $Z_{1L} = Q_{LE}c'_{QLE,1L}(u_{LE}, u_{1L})$

(2.4.266) $Z_{LD} = Q_{LD}c'_{QLD,LD}(u_{LD}, u_{2L})$

(2.4.267) $Z_{2L} = Q_{LD}c'_{QLD,2L}(u_{LD}, u_{2L})$

(2.4.268) $Z_{MD} = Q_{MD}c'_{QMD,MD}(u_{MD}, u_{2M})$

(2.4.269) $Z_{2M} = Q_{MD}c'_{QMD,2M}(u_{MD}, u_{2M})$

(2.4.270) $Z_{ME} = Q_{ME}c'_{QME,ME}(u_{ME}, u_{1M})$

(5.4.271) $Z_{1M} = Q_{ME}c'_{QME,1M}(u_{ME}, u_{1M})$

Following Equation (2.3.41), Equations (2.4.264)-(2.4.271) are derived from the cost functions in Equations (2.3.75)-(2.3.78) using Shephard's Lemma.

Lamb and mutton marketing sectors equilibrium

(2.4.272) $p_{LE} = c_{QLE}(u_{LE}, u_{1L})$

(2.4.273) $p_{LD} = c_{QLD}(u_{LD}, u_{2L})$

(2.4.274) $p_{MD} = c_{QMD}(u_{MD}, u_{2M})$

(2.4.275) $p_{ME} = c_{QME}(u_{ME}, u_{1M})$

Equations (2.4.272)-(2.4.275) are the market clearing value equilibrium conditions for the lamb and mutton marketing sectors specifying that unit prices of output equal the unit costs of production at the margin.

Origin of live sheep exports

(2.4.276) $Q_{SE} = Y_{7E} + Y_{8E} + Y_{9E}$

Live sheep exports are homogeneous with a single price. Equation (2.4.276) ensures the total quantity of live sheep exports equals the sum of live sheep exports originating from the three agricultural zones.

Export demand for Australian greasy wool

(2.4.277) $Q_{1W} = Q_{1W}(p_{1W}, N_{Q1W})$

(2.4.278) $Q_{2W} = Q_{2W}(p_{2W}, N_{Q2W})$

(2.4.279) $Q_{3W} = Q_{3W}(p_{3W}, N_{Q3W})$

(2.4.280) $Q_{4W} = Q_{4W}(p_{4W}, N_{Q4W})$

Equations (2.4.277)-(2.4.280) are the own-price-dependent export demand functions for Australian greasy wool as derived in Equation (2.3.125). Income is assumed constant and prices for other classes of greasy wool and other competitive fibres in overseas markets are not included explicitly. The N_{Qi} terms are exogenous demand shifters representing changes in demand for Australian greasy wool in overseas markets due to promotion or changes in taste.

Export demand for Australian carbonised wool

(2.4.281) $Q_{CW} = Q_{CW}(p_{CW}, N_{QCW})$

Equation (2.4.281) is the own-price-dependent export demand function for Australian carbonised wool as derived in Equation (2.3.125). Income is assumed constant and prices for carbonised wool and other competitive fibres in overseas markets are not included explicitly. The N_{QCW} term is an exogenous demand shifter representing changes in demand for Australian carbonised wool in overseas markets due to promotion or changes in taste.

Export demand for Australian scoured wool

(2.4.282) $Q_{1S} = Q_{1S}(p_{1S}, N_{Q1S})$

(2.4.283) $Q_{2S} = Q_{2S}(p_{2S}, N_{Q2S})$

(2.4.284) $Q_{3S} = Q_{3S}(p_{3S}, N_{Q3S})$

(2.4.285) $Q_{4S} = Q_{4S}(p_{4S}, N_{Q4S})$

Equations (2.4.282)-(2.4.285) are the own-price-dependent export demand functions for Australian scoured wool as derived in Equation (2.3.125). Income is assumed constant and prices for scoured wool and other competitive fibres in overseas markets are not included explicitly. The N_{Qi} terms are exogenous demand shifters representing changes in demand for Australian scoured wool in overseas markets due to promotion or changes in taste.

Export demand for Australian wool tops

(2.4.286) $Q_{2T} = Q_{2T}(p_{2T}, N_{Q2T})$

(2.4.287) $Q_{3T} = Q_{3T}(p_{3T}, N_{Q3T})$

(2.4.288) $Q_{4T} = Q_{4T}(p_{4T}, N_{Q4T})$

Equations (2.4.286)-(2.4.288) are the own-price-dependent export demand functions for Australian wool tops as derived in Equation (2.3.125). Income is assumed constant and prices for wool tops and other competitive fibres in overseas markets are not included explicitly. The N_{Qi} terms are exogenous demand shifters representing changes in demand for Australian wool tops in overseas markets due to promotion or changes in taste.

Export demand for Australian noils/other wool

(2.4.289) $Q_{NW} = Q_{NW}(p_{NW}, N_{QNW})$

Equation (2.4.289) is the own-price-dependent export demand function for Australian wool noil as derived in Equation (2.3.125). Income is assumed constant and prices for wool noil and other competitive fibres in overseas markets are not included explicitly.

The N_{QNW} term is an exogenous demand shifter representing changes in demand for Australian wool noil in overseas markets due to promotion or changes in taste.

Domestic demand for LSP wool

(2.4.290) $Q_{DP} = Q_{DP}(p_{DP}, N_{QDP})$

Equation (2.4.290) is the own-price-dependent domestic demand function for Australian wool top as derived in Equation (2.3.125). Income is assumed constant and excluded from the equation. The N_{QDP} term is a demand shifter representing changes in demand for Australian wool top in the domestic market due to promotion or changes in taste.

Export demand for Australian lamb and mutton

(2.4.291) $Q_{LE} = Q_{LE}(p_{LE}, N_{QLE})$

(2.4.292) $Q_{ME} = Q_{ME}(p_{ME}, N_{QME})$

Equations (2.4.291) and (2.4.292) are the own-price-dependent export demand functions for Australian lamb and mutton as derived in Equation (2.3.125). Income is assumed constant and prices of other meat in overseas markets are not included explicitly. The N_{Qi} terms are exogenous demand shifters representing changes in demand for Australian lamb and mutton in overseas markets due to promotion or changes in taste.

Export demand for Australian live sheep

(2.4.293) $Q_{SE} = Q_{SE}(p_{SE}, N_{QSE})$

Equation (2.4.293) is the own-price-dependent export demand function for Australian live sheep as derived in Equation (2.3.125). Income is assumed constant and prices for other meat in overseas markets are not included explicitly. The N_{QSE} term is an exogenous demand shifter representing changes in demand for Australian live sheep in overseas markets due to promotion or changes in taste.

Domestic retail demand for Australian lamb and mutton

(2.4.294) $Q_{LD} = Q_{LD}(p_{LD}, p_{MD}\ N_{QLD}, N_{QMD})$

(2.4.295) $Q_{MD} = Q_{MD}(p_{LD}, p_{MD}\ N_{QLD}, N_{QMD})$

Equations (2.4.294)-(2.4.295) are the demand functions for domestic lamb and mutton as derived in Equations (2.3.127) and (2.3.128). Income and prices for other meats are assumed constant and excluded from the equations. The N_{Qi} terms are demand shifters representing changes in demand for Australian lamb and mutton in the domestic markets due to promotion or changes in taste.

The structural model of the Australian sheep and wool industries represented in general functional form by Equations (2.4.1)-(2.4.295) defines equilibrium in all markets. There are 261 price and quantity variables plus 34 aggregated input and output index variables for the 17 multi-output sectors. Hence, the model is a system of 295 equations with 295 endogenous variables. The 42 supply shift variables representing the impacts of new technologies in various industry sectors and the 19 demand shift variables representing successful promotions, or changes in taste, are exogenous to the model.

2.4.2 Equilibrium Displacement Form of the Model

Exogenous changes representing impacts such as new technologies or promotions are modelled as parallel shifts in the relevant market demand or supply curves. The exogenous shifts displace the equilibrium, initiating changes in market prices and quantities. The resulting market price and quantity changes allow changes in producer and consumer surplus to be estimated for the various industry sectors.

The model in displacement form is found by totally differentiating the system of equations at the initial equilibrium points. Implicit in this approach is the use of local linear approximation when estimating the finite changes in the endogenous variables. Zhao, Mullen and Griffith (1997) demonstrated that when small parallel exogenous shifts are implemented in EDM, the price, quantity and economic surplus change estimates are exact if the percentage change in variable (.) is defined as $E(.) = \Delta(.)/(.)$. The displacement version of the model with market elasticities as parameters is outlined in Equations (A1.1)-(A1.295) of Appendix 1. Parameter definitions are given in Table 1.

2.4.3 Integrability Conditions

Once values for the market parameters have been specified, the changes in economic surplus resulting from an exogenous shift in supply or demand can be estimated from the changes in all market prices and quantities within the model. These equilibrium welfare effects can be calculated using two separate approaches (Just, Hueth and Schmitz 1982, p.469). The first involves measuring completely the total welfare effects off the general equilibrium demand and supply curves in the market where the intervention takes place. Although this single market approach captures all the welfare effects including horizontally and vertically related markets, it is not possible to acquire the distribution of the total welfare changes among industry participants. Estimation of the welfare changes accruing to various industry sectors is possible using the second approach whereby welfare effects are measured off the partial equilibrium demand and supply curves in all markets. The sum of the partial welfare measures from the second approach will be the same as the total welfare effects measured off the general equilibrium curves in a particular market only if integrability conditions are met (Alston, Norton and Pardey 1995, p.232). That is, certain mathematical and economic relationships must be satisfied to ensure demand and supply equations in the model are not specified in an arbitrary manner and market parameters are not inconsistent in their estimation. More specifically, for mathematical integrability it must be possible to recover the set of underlying decision-making preference functions in Equations (2.3.44)-(2.3.78), (2.3.87)-(2.3.121), (2.3.122), (2.3.124) and (2.3.126) from the demand and supply functions in Equations (A1.1)-(A1.295) listed in Appendix 1, whereas economic integrability requires that the preference functions satisfy the regularity conditions to be genuine cost, revenue, profit and utility functions (Zhao *et al*. 2000, pp.27-28). For each of the industry sectors depicted in the model, input demand and output supply functions must be integrable with the underlying cost and revenue functions of relevance. The requirements guaranteeing integrability are briefly discussed below. A more complete discussion and mathematical derivation of integrability conditions can be found in Zhao *et al*. (2000).

Under the assumptions that (1) all sectors maximise profits, (2) multi-output production functions are separable in inputs and outputs and (3) all production functions exhibit constant returns to scale, the integrability conditions relating input demand functions to their respective cost functions are homogeneity, symmetry and concavity (Zhao *et al*. 2000, p.28). The homogeneity and symmetry conditions, respectively, require the input demand function to be homogeneous of degree zero in input prices and the Hessian matrix of Allen-Uzawa input substitution elasticities to be symmetric, while the concavity condition means the Hessian matrix is negative semi-definite (Zhao *et al*. 2000, p.29). The symmetry condition is necessary and sufficient for mathematical integrability while negative semi-definiteness (positive semi-definiteness) for demand (supply) functions is sufficient for economic integrability (Takayama 1994, p.632).

Under the same three assumptions listed above, similar constraints apply for integrability of output supply functions with relevant revenue functions. Homogeneity and symmetry conditions require the output supply function to be homogeneous of degree zero in output prices and the symmetry condition implies symmetry of the Allen-Uzawa product transformation elasticities. The convexity condition means the Hessian matrix is positive semi-definite (Zhao *et al*. 2000, pp.30-31).

In the case of exogenous input supply, each input is the sole decision variable from the model contained in each relevant profit function. Consequently, integrability with the relevant profit function only requires that the own-price elasticity of supply for that exogenous input is positive (Zhao *et al*. 2000, p.31).

As each export market within the model is assumed to be commodity specific for a particular group of consumers, a negative own-price elasticity of demand is sufficient to ensure the recovery of a ‘proper’ utility function from each relevant export demand function. Conversely, as lamb and mutton are substitutes in domestic consumption the demands for each commodity relate integrably with each other (Zhao *et al*. 2000, p.32). Under the assumption of constant marginal utility of income, as implied through the use of Marshallian economic surplus measurement, the symmetry condition is given by (Zhao *et al*. 2000, p.32):

$$\eta_{ij} = \left(\lambda_j / \lambda_i\right)\eta_{ji}$$

where λ_j / λ_i is the relative budget share of the two commodities. Homogeneity and concavity conditions will be satisfied when

$$\eta_{ii} \leq 0, \ \ \eta_{ij} \geq 0 \text{ and } |\eta_{ii}| > |\eta_{ij}|$$

That is, the conditions will always hold as long as the own price elasticity of demand is less than or equal to zero, the cross price elasticity of demand is greater than or equal to zero and in terms of absolute values, the own price elasticity of demand will be larger than the cross price elasticity of demand.

2.4.4 Imposition of Integrability Conditions on the Displacement Model

One of the main concerns with using linear demand and supply curves, as in the EDM approach, is that global integrability is not satisfied because the homogeneity condition does not hold. However, as pointed out by Zhao *et al*. (2000, p.32), the displacement form equations such as those in Equations (A1.1)-(A1.295) are only local linear approximations of the true demand and supply functions specified in Equations (5.4.1)-(5.4.295) "which are not necessarily of a linear functional form and which *can* satisfy the integrability conditions locally or even globally." As an example they assert that the normalised linear input demands derived from a normalised quadratic cost function that is globally homogenous of degree one, will be globally homogeneous of degree zero. Thus, integrability conditions imposed at single point imply global integrability.

The imposition of integrability conditions in the model occurs at the initial equilibrium points. LaFrance (1991) highlighted the importance of integrability and demonstrated that significant errors were associated with linear approaches if the focus of measurement was on the triangular 'deadweight loss'. Based on the findings of LaFrance (1991) and considering that the trapezoid welfare change is the focus of this study, any errors in the welfare measures resulting from a small parallel exogenous shift will be minimal.

The displacement model with elasticities of input substitution (σ_{ij}) and elasticities of product transformation (τ_{ij}) included is detailed in Equations (A1.1)'-(A1.295)' of Appendix 1. Homogeneity and symmetry restrictions have been imposed whilst concavity and convexity conditions will be satisfied when appropriate values for the market parameters are specified.

Table 1: Definition of variables and parameters in the model

Endogenous Variables	
X_1	Quantity of non-Merino ewes
X_{21}	Quantity of Merino ewes for non-Merino lamb production (HRZ)
X_{31}	Quantity of Merino ewes for Merino lamb production (HRZ)
X_{23}	Total quantity of Merino ewes, $X_{23} = X_{21}+X_{31}$ (HRZ)
X_{41}	Quantity of Merino ewes for non-Merino lamb production (WSZ)
X_{51}	Quantity of Merino ewes for Merino lamb production (WSZ)
X_{45}	Total quantity of wheat-sheep zone Merino ewes, $X_{45} = X_{41}+X_{51}$ (WSZ)
X_{61}	Quantity of pastoral zone Merino ewes (PZ)
X_{71}	Quantity of Merino wethers and hoggets (HRZ)
X_{81}	Quantity of Merino wethers and hoggets (WSZ)
X_{91}	Quantity of Merino wethers and hoggets (PZ)
w_1, w_{23}, w_{45}, w_{61}, w_{71}, w_{81}, w_{91}	Prices of X_1, X_{23}, X_{45}, X_{61}, X_{71}, X_{81}, X_{91}
X_{1W}	Quantity of other inputs to the non-Merino farm sector
X_{21W}	Quantity of other inputs to the Merino ewe, non-Merino lamb farm sector (HRZ)
X_{31W}	Quantity of other inputs to the Merino ewe, Merino lamb farm sector (HRZ)

X_{41W}	Quantity of other inputs to the Merino ewe, non-Merino lamb farm sector (WSZ)
X_{51W}	Quantity of other inputs to the Merino ewe, Merino lamb farm sector (WSZ)
X_{61W}	Quantity of other inputs to the Merino ewe farm sector (PZ)
X_{71W}	Quantity of other inputs to the Merino wether and hogget farm sector (HRZ)
X_{81W}	Quantity of other inputs to the Merino wether and hogget farm sector (WSZ)
X_{91W}	Quantity of other inputs to the Merino wether and hogget farm sector (PZ)
$w_{1W}, w_{21W},\ldots,w_{91W}$	Prices of $X_{1W}, X_{21W},\ldots,X_{91W}$
$X_N, X_2,\ldots X_9$	Aggregated input indices for the nine farm sector sheep enterprises
$Y_1,\ldots,Y_9$	Aggregated output indices for the nine farm sector sheep enterprises
Y_{13W}, Y_{14W}	Quantities of 24-27 and ≥28 micron wool, respectively (non-Merino farm sector)
v_{13W}, v_{14W}	Prices of Y_{13W}, Y_{14W}
$Y_{21W}, Y_{22W}, Y_{23W}$	Quantities of ≤19, 20-23 and 24-27 micron wool, respectively (HRZ-Merino ewe, non-Merino lamb farm sector)
$v_{21W}, v_{22W}, v_{23W}$	Prices of $Y_{21W}, Y_{22W}, Y_{23W}$
$Y_{31W}, Y_{32W}, Y_{33W}$	Quantities of ≤19, 20-23 and 24-27 micron wool, respectively (HRZ-Merino ewe, Merino lamb farm sector)
$v_{31W}, v_{32W}, v_{33W}$	Prices of $Y_{31W}, Y_{32W}, Y_{33W}$
$Y_{41W}, Y_{42W}, Y_{43W}$	Quantities of ≤19, 20-23 and 24-27 micron wool, respectively (WSZ-Merino ewe, non-Merino lamb farm sector)
$v_{41W}, v_{42W}, v_{43W}$	Prices of $Y_{41W}, Y_{42W}, Y_{43W}$
$Y_{51W}, Y_{52W}, Y_{53W}$	Quantities of ≤19, 20-23 and 24-27 micron wool, respectively (WSZ-Merino ewe, Merino lamb farm sector)
$v_{51W}, v_{52W}, v_{53W}$	Prices of $Y_{51W}, Y_{52W}, Y_{53W}$
$Y_{61W}, Y_{62W}, Y_{63W}$	Quantities of ≤19, 20-23 and 24-27 micron wool, respectively (PZ-Merino ewe, farm sector)
$v_{61W}, v_{62W}, v_{63W}$	Prices of $Y_{61W}, Y_{62W}, Y_{63W}$
$Y_{71W}, Y_{72W}, Y_{73W}$	Quantities of ≤19, 20-23 and 24-27 micron wool, respectively (HRZ-Merino wether and hogget farm sector)
$v_{71W}, v_{72W}, v_{73W}$	Prices of $Y_{71W}, Y_{72W}, Y_{73W}$
$Y_{81W}, Y_{82W}, Y_{83W}$	Quantities of ≤19, 20-23 and 24-27 micron wool, respectively (WSZ-Merino wether and hogget farm sector)
$v_{81W}, v_{82W}, v_{83W}$	Prices of $Y_{81W}, Y_{82W}, Y_{83W}$
$Y_{91W}, Y_{92W}, Y_{93W}$	Quantities of ≤19, 20-23 and 24-27 micron wool, respectively (PZ-Merino wether and hogget farm sector)
$v_{91W}, v_{92W}, v_{93W}$	Prices of $Y_{91W}, Y_{92W}, Y_{93W}$
Y_{1L}, Y_{1M}	Quantities of lamb and mutton, respectively (non-Merino farm sector)
v_{1L}, v_{1M}	Prices of Y_{1L}, Y_{1M}
Y_{2L}, Y_{2M}	Quantities of lamb and mutton, respectively (HRZ-Merino ewe, non-Merino lamb farm sector)
v_{2L}, v_{2M}	Prices of Y_{2L}, Y_{2M}

Y_{3L}, Y_{3M}	Quantities of lamb and mutton, respectively (HRZ-Merino ewe, Merino lamb farm sector)
v_{3L}, v_{3M}	Prices of Y_{3L}, Y_{3M}
Y_{4L}, Y_{4M}	Quantities of lamb and mutton, respectively (WSZ-Merino ewe, non-Merino lamb farm sector)
v_{4L}, v_{4M}	Prices of Y_{4L}, Y_{4M}
Y_{5L}, Y_{5M}	Quantities of lamb and mutton, respectively (HRZ-Merino ewe, Merino lamb farm sector)
v_{5L}, v_{5M}	Prices of Y_{5L}, Y_{5M}
Y_{6L}, Y_{6M}	Quantities of lamb and mutton, respectively (PZ-Merino ewe, farm sector)
v_{6L}, v_{6M}	Prices of Y_{6L}, Y_{6M}
Y_{7E}, Y_{7M}	Quantities of live sheep exports and mutton, respectively (HRZ-Merino wether and hogget farm sector)
Y_{8E}, Y_{8M}	Quantities of live sheep exports and mutton, respectively (WSZ-Merino wether and hogget farm sector)
Y_{9E}, Y_{9M}	Quantities of live sheep exports and mutton, respectively (PZ-Merino wether and hogget farm sector)
v_{7M}, v_{8M}, v_{9M}	Prices of Y_{7M}, Y_{8M}, Y_{9M}
Y_{NM}, Y_{FM}, Y_{MM}, Y_{BM}	Quantities of other inputs to ≥28, ≤19, 20-23, and 24-27 micron wool warehouse sectors, respectively
v_{NM}, v_{FM}, v_{MM}, v_{BM}	Prices of other inputs to ≥28, ≤19, 20-23, and 24-27 micron wool warehouse sectors, respectively
Y_N, Y_F, Y_C, Y_B	Aggregated input indices of ≥28, ≤19, 20-23, and 24-27 micron wool warehouse sectors, respectively
Z_1, Z_2, Z_3, Z_4	Aggregated output indices of ≥28, ≤19, 20-23, and 24-27 micron wool warehouse sectors, respectively
Z_{1W}, Z_{2W}, Z_{3W}, Z_{4W}	Quantities of ≥28, ≤19, 20-23, and 24-27 micron greasy wool to export shipment sectors, respectively
u_{1W}, u_{2W}, u_{3W}, u_{4W}	Prices of Z_{1W}, Z_{2W}, Z_{3W}, Z_{4W}
Z_{1S}, Z_{2S}, Z_{3S}, Z_{4S}	Quantities of ≥28, ≤19, 20-23, and 24-27 micron greasy wool to domestic scouring sector
u_{1S}, u_{2S}, u_{3S}, u_{4S}	Prices of Z_{1S}, Z_{2S}, Z_{3S}, Z_{4S}
Z_{NM}, Z_{FM}, Z_{MM}, Z_{BM}	Quantities of other inputs to ≥28, ≤19, 20-23, and 24-27 micron greasy wool export shipment sectors, respectively
u_{NM}, u_{FM}, u_{MM}, u_{BM}	Prices of Z_{NM}, Z_{FM}, Z_{MM}, Z_{BM}
Z_{CS}, Z_{CB}, Z_{WT}	Quantities of other inputs to wool scouring, carbonising and topmaking sectors, respectively
u_{CS}, u_{CB}, u_{WT}	Prices of Z_{CS}, Z_{CB}, Z_{WT}
Z_{2T}, Z_{3T}, Z_{4T}	Quantities of ≤19, 20-23, and 24-27 micron wool to domestic topmaking sector
u_{2T}, u_{3T}, u_{4T}	Prices of Z_{2T}, Z_{3T}, Z_{4T}

Z_{CW}, F_{CW}	Quantities of wool to domestic carbonising and export shipment sectors, respectively
u_{CW}, s_{CW}	Prices of Z_{CW}, F_{CW}
F_{1S}, F_{2S}, F_{3S}, F_{4S}	Quantities of ≥28, ≤19, 20-23, and 24-27 micron scoured wool to export shipment sectors, respectively
s_{1S}, s_{2S}, s_{3S}, s_{4S}	Prices of F_{1S}, F_{2S}, F_{3S}, F_{4S}
Z_C, Z_T	Aggregated input indices for domestic scouring and topmaking sectors, respectively
Z_S, F_T	Aggregated output indices for domestic scouring and topmaking sectors, respectively
F_{CB}, F_{NS}, F_{FS}, F_{MS}, F_{BS}	Quantities of other inputs to carbonising, ≥28, ≤19, 20-23, and 24-27 micron scoured wool export shipment sectors, respectively
s_{CB}, s_{NS}, s_{FS}, s_{MS}, s_{BS}	Prices of F_{CB}, F_{NS}, F_{FS}, F_{MS}, F_{BS}
F_{2T}, F_{3T}, F_{34T}, F_{NW}	Quantities of ≤19, 20-23, 24-27 micron wool top and noils of wool to export shipment sectors, respectively
s_{2T}, s_{3T}, s_{4T}, s_{NW}	Prices of F_{2T}, F_{3T}, F_{4T}, F_{NW}
F_{FT}, F_{MT}, F_{BT}, F_{NE}	Quantities of other inputs to ≤19, 20-23, and 24-27 micron wool top and noils export shipment sectors, respectively
s_{FT}, s_{MT}, s_{BT}, s_{NE}	Prices of F_{FT}, F_{MT}, F_{BT}, F_{NE}
Y_{SL}, Y_{SM}	Quantities of other inputs to lamb and mutton processing sectors, respectively
v_{SL}, v_{SM}	Prices of Y_{SL}, Y_{SM}
Z_{LE}, Z_{LD}	Quantities of lamb for the export and domestic marketing sectors, respectively
u_{LE}, u_{LD}	Prices of Z_{LE}, Z_{LD}
Z_{ME}, Z_{MD}	Quantities of mutton for the export and domestic marketing sectors, respectively
u_{ME}, u_{MD}	Prices of Z_{ME}, Z_{MD}
Y_L, Y_M	Aggregated input indices for the lamb and mutton processing sectors, respectively
Z_L, Z_M	Aggregated output indices for the lamb and mutton processing sectors, respectively
Z_{1L}, Z_{2L}	Quantities of other inputs to the export and domestic lamb marketing sectors, respectively
u_{1L}, u_{2L}	Prices of Z_{1L}, Z_{2L}
Z_{1M}, Z_{2M}	Quantities of other inputs to the export and domestic mutton marketing sectors, respectively
u_{1M}, u_{2M}	Prices of Z_{1M}, Z_{2M}
Q_{1W}, Q_{2W}, Q_{3W}, Q_{4W}	Quantities of ≥28, ≤19, 20-23, and 24-27 micron export greasy wool, respectively
p_{1W}, p_{2W}, p_{3W}, p_{4W}	Prices of Q_{1W}, Q_{2W}, Q_{3W}, Q_{4W}
Q_{1S}, Q_{2S}, Q_{3S}, Q_{4S}	Quantities of ≥28, ≤19, 20-23, and 24-27 micron export scoured wool, respectively
p_{1S}, p_{2S}, p_{3S}, p_{4S}	Prices of Q_{1S}, Q_{2S}, Q_{3S}, Q_{4S}
Q_{2T}, Q_{3T}, Q_{4T}	Quantities of ≤19, 20-23, and 24-27 micron export wool tops, respectively

p_{2T}, p_{3T}, p_{4T}	Prices of Q_{2T}, Q_{3T}, Q_{4T}
Q_{CW}, Q_{NW}, Q_{DP}	Quantities of export carbonised wool, noils of wool and wool top for domestic later-stage processing, respectively
p_{CW}, p_{NW}, p_{DP}	Prices of Q_{CW}, Q_{NW}, Q_{DP}
Q_{LE}, Q_{LD}	Quantities of export and domestic lamb, respectively
p_{LE}, p_{LD}	Prices of Q_{LE}, Q_{LD}
Q_{ME}, Q_{MD}	Quantities of export and domestic mutton, respectively
p_{ME}, p_{MD}	Prices of Q_{ME}, Q_{MD}
Q_{SE}	Quantity of live sheep exports
p_{SE}	Price of Q_{SE}
<u>Exogenous Variables</u>	
T_X	Supply shifter shifting the supply curve of x down vertically due to a cost reduction in the production of $_X$ ($_X$ = X_1, X_{23}, X_{45}, X_{61},…,X_{91}, X_{1W}, X_{21W},…,X_{91W}, Y_{NM}, Y_{BM}, Y_{MM}, Y_{FM}, Y_{SL}, Y_{SM}, Z_{CS}, Z_{CB}, Z_{WT}, Z_{NM}, Z_{FM}, Z_{MM}, Z_{BM}, Z_{1L}, Z_{2L}, Z_{1M}, Z_{2M}, F_{CB}, F_{NS}, F_{FS}, F_{MS}, F_{BS}, F_{FT}, F_{MT}, F_{BT}, F_{NE})
t_X	Amount of shift T_X as a percentage of the price of $_X$ ($_X$ = X_1, X_{23}, X_{45}, X_{61},…,X_{91}, X_{1W}, X_{21W},…,X_{91W}, Y_{NM}, Y_{BM}, Y_{MM}, Y_{FM}, Y_{SL}, Y_{SM}, Z_{CS}, Z_{CB}, Z_{WT}, Z_{NM}, Z_{FM}, Z_{MM}, Z_{BM}, Z_{1L}, Z_{2L}, Z_{1M}, Z_{2M}, F_{CB}, F_{NS}, F_{FS}, F_{MS}, F_{BS}, F_{FT}, F_{MT}, F_{BT}, F_{NE})
N_X	Demand shifter shifting the demand curve of x up vertically due to promotion or changes in taste ($_X$ = Q_{1W},…,Q_{4W}, Q_{CW}, Q_{1S},…,Q_{4S}, Q_{2T},…,Q_{4T}, Q_{NW}, Q_{DP}, Q_{LE}, Q_{ME}, Q_{SE}, Q_{LD}, Q_{MD}, Z_{CB}, Z_{WT}, Z_{NM}, Z_{FM}, Z_{MM}, Z_{BM}, Z_{1L}, Z_{2L}, Z_{1M}, Z_{2M}, F_{CB}, F_{NS}, F_{FS}, F_{MS}, F_{BS}, F_{FT}, F_{MT}, F_{BT}, F_{NE})
n_X	Amount of shift N_X as a percentage of the price of taste ($_X$ = Q_{1W},…,Q_{4W}, Q_{CW}, Q_{1S},…,Q_{4S}, Q_{2T},…,Q_{4T}, Q_{NW}, Q_{DP}, Q_{LE}, Q_{ME}, Q_{SE}, Q_{LD}, Q_{MD}, Z_{CB}, Z_{WT}, Z_{NM}, Z_{FM}, Z_{MM}, Z_{BM}, Z_{1L}, Z_{2L}, Z_{1M}, Z_{2M}, F_{CB}, F_{NS}, F_{FS}, F_{MS}, F_{BS}, F_{FT}, F_{MT}, F_{BT}, F_{NE})
<u>Parameters</u>	
$\eta_{(x,y)}$	Demand elasticity of variable x with respect a change in the price of y
$\varepsilon_{(x,y)}$	Supply elasticity of variable x with respect to a change in the price of y
$\tilde{\eta}_{(x,y)}$	Constant-output input demand elasticity of input x with respect to a change in input price y
$\tilde{\varepsilon}_{(x,y)}$	Constant-input output supply elasticity of output x with respect to a change in output price y
$\sigma_{(x,y)}$	Allen's elasticity of input substitution between input x and input y
$\tau_{(x,y)}$	Allen's elasticity of product transformation between output x and output y
k_x	Cost share of input x (x = X_1, X_{1W}, X_{21},…,X_{91}, X_{21W},…,X_{91W}, Y_{21W},…,Y_{91W}, Y_{22W},…,Y_{92W}, Y_{13W},…,Y_{93W}, Y_{NM}, Y_{BM}, Y_{MM}, Y_{FM}, Y_{1L},…,Y_{6L}, Y_{SL}, Y_{1M},…,Y_{9M}, Y_{SM}, Z_{1W},…,Z_{4W}, Z_{1S},…,Z_{4S}, Z_{CS}, Z_{CB}, Z_{CW}, Z_{WT}, Z_{NM}, Z_{FM}, Z_{MM}, Z_{BM}, Z_{2T},…,Z_{4T}, Z_{1L}, Z_{2L}, Z_{LE}, Z_{LD}, Z_{1M}, Z_{2M}, Z_{ME}, Z_{MD}, F_{1S},…,F_{4S}, F_{CW}, F_{CB}, F_{NS}, F_{FS}, F_{MS}, F_{BS},

	$F_{2T},\ldots,F_{4T}$, F_{NW}, F_{FT}, F_{MT}, F_{BT}, F_{NE}) where $\sum_{i=1,1W} k_{xi}=1$, $\sum_{i=21,21W} k_{xi}=1$, $\sum_{i=31,31W} k_{xi}=1$, $\sum_{i=41,41W} k_{xi}=1$, $\sum_{i=51,51W} k_{xi}=1$, $\sum_{i=61,61W} k_{xi}=1$, $\sum_{i=71,71W} k_{xi}=1$, $\sum_{i=81,81W} k_{xi}=1$, $\sum_{i=91,91W} k_{xi}=1$, $\sum_{i=NM,14W} k_{yi}=1$, $\sum_{i=FM,21W,\ldots,91W} k_{yi}=1$, $\sum_{i=MM,22W,\ldots,92W} k_{yi}=1$, $\sum_{i=BM,13W,\ldots,93W} k_{yi}=1$, $\sum_{i=SL,1L,\ldots,6L} k_{yi}=1$, $\sum_{i=SM,1M,\ldots,9M} k_{yi}=1$, $\sum_{i=NM,1W} k_{Zi}=1$, $\sum_{i=FM,2W} k_{Zi}=1$, $\sum_{i=MM,3W} k_{Zi}=1$, $\sum_{i=BM,4W} k_{Zi}=1$, $\sum_{i=CS,1S,\ldots,4S} k_{Zi}=1$, $\sum_{i=CB,CW} k_{Zi}=1$, $\sum_{i=WT,2T,\ldots,4T} k_{Zi}=1$, $\sum_{i=LE,1L} k_{Zi}=1$, $\sum_{i=LD,2L} k_{Zi}=1$, $\sum_{i=ME,1M} k_{Zi}=1$, $\sum_{i=MD,2M} k_{Zi}=1$, $\sum_{i=CB,CW} k_{Fi}=1$, $\sum_{i=NS,1S} k_{Fi}=1$, $\sum_{i=FS,2S} k_{Fi}=1$, $\sum_{i=MS,3S} k_{Fi}=1$, $\sum_{i=BS,4S} k_{Fi}=1$, $\sum_{i=FT,2T} k_{Fi}=1$, $\sum_{i=MT,3T} k_{Fi}=1$, $\sum_{i=BT,4T} k_{Fi}=1$, $\sum_{i=NE,NW} k_{Fi}=1$
γ_Y	Revenue share of output y (y = $Y_{21W},\ldots,Y_{91W}$, $Y_{22W},\ldots,Y_{92W}$, $Y_{13W},\ldots,Y_{93W}$, $Y_{1L},\ldots,Y_{6L}$, $Y_{1M},\ldots,Y_{9M}$, $Y_{7E},\ldots,Y_{9E}$, $Z_{1W},\ldots,Z_{4W}$, $Z_{1S},\ldots,Z_{4S}$, Z_{CW}, $Z_{2T},\ldots,Z_{4T}$, Z_{LE}, Z_{LD}, Z_{ME}, Z_{MD}, $F_{1S},\ldots,F_{4S}$, $F_{2T},\ldots,F_{4T}$, F_{NW}, Q_{DP}) where $\sum_{i=13W,14W,1L,1M} \gamma_{Yi}=1$, $\sum_{i=21W,22W,23W,1L,1M} \gamma_{Yi}=1$, $\sum_{i=31W,32W,33W,3L,3M} \gamma_{Yi}=1$, $\sum_{i=41W,42W,43W,4L,4M} \gamma_{Yi}=1$, $\sum_{i=51W,52W,53W,5L,5M} \gamma_{Yi}=1$, $\sum_{i=61W,62W,63W,6L,6M} \gamma_{Yi}=1$, $\sum_{i=71W,72W,73W,7E,7M} \gamma_{Yi}=1$, $\sum_{i=81W,82W,83W,8E,8M} \gamma_{Yi}=1$, $\sum_{i=91W,92W,93W,9E,9M} \gamma_{Yi}=1$, $\sum_{i=1W,1S} \gamma_{Zi}=1$, $\sum_{i=2W,2S} \gamma_{Zi}=1$, $\sum_{i=3W,3S} \gamma_{Zi}=1$, $\sum_{i=4W,4S} \gamma_{Zi}=1$, $\sum_{i=CW,2T,\ldots,4T,F1S,\ldots,F4S} \gamma_{Zi}=1$, $\sum_{i=LE,LD} \gamma_{Zi}=1$, $\sum_{i=ME,MD} \gamma_{Zi}=1$, $\sum_{i=2T,\ldots,4T,NW,QDP} \gamma_{Fi}=1$
βx	Quantity shares (x = X_{21}, X_{31}, X_{41}, X_{51}, Y_{7E}, Y_{8E}, Y_{9E}) where $\beta_{x21}=X_{21}/(X_{21}+X_{31})$, $\beta_{x31}=X_{31}/(X_{21}+X_{31})$, $\beta_{x41}=X_{41}/(X_{41}+X_{51})$, $\beta_{x51}=X_{51}/(X_{41}+X_{51})$, $\beta_{Y7E}=Y_{7E}/(Y_{7E}+Y_{8E}+Y_{9E})$, $\beta_{Y8E}=Y_{8E}/(Y_{7E}+Y_{8E}+Y_{9E})$, $\beta_{Y9E}=Y_{9E}/(Y_{7E}+Y_{8E}+Y_{9E})$

3 Input Data and Exogenous Shifts

3.1 Introduction

Estimates of market parameters and base price and quantity values representing equilibrium in all sectors are required to solve the model outlined in Section 2. Typically in EDM analysis, average values taken over a five-year period are used to represent the base equilibrium situation to dampen the impact of seasonal effects or other anomalies that occur in any particular year. In 2002, Australian woolgrowers began operating in a free market for the first time in almost thirty years after the last of the 4.7 million-bale wool stockpile was sold in 2001. Consequently, the base equilibrium values and associated cost shares used in the model were taken as an average of prices and quantities for the three-year period 2002-03 to 2004-05 to abstract from any influence that the accumulated wool stockpile sales may have had on the market prior to 2002.

Wool production refers to shorn wool only and does not include dead and fellmongered wool or wool on skins. Other by-products such as wool wax, offal and fat are also excluded from the model for reasons of additional complexity and data collection difficulties. Non-consideration of by-products may underestimate total revenues and costs in some industry sectors but in monetary terms these values are likely to be small.[9]

Section 3.2 provides a brief discussion of the base model equilibrium prices and quantities for all sheep, sheepmeat and wool products. All meat quantities are expressed in carcass weight or carcass weight equivalent kilo tonnes and all wool quantities are in greasy or greasy equivalent kilo tonnes. Sheepmeat prices are in c/kg carcass weight and all wool prices are in c/kg greasy or greasy equivalent.

Section 3.3 provides a discussion of the Marshallian demand and factor supply elasticities, and the elasticities of input substitution and product transformation used in the model. The market parameter values, listed in Table 65, were chosen on the basis of published empirical estimates combined with theoretical and subjective judgements. The estimated parameters correspond to a medium-run time frame. A transition period of approximately three to five years is assumed as the time taken for the industry to obtain a new equilibrium after an exogenous shock to the initial equilibrium.

Solving the displacement model produces price and quantity changes that are used to estimate the welfare changes to individual industry groups for various investment scenarios. The exogenous shift variables and relevant hypothetical exogenous change scenarios are described in Section 3.4. The economic surplus change formulas used in the displacement model are listed in Table 8 and Table 9.[10]

[9] By-product revenues in the meat industry are only a few per cent of individual sector total revenues (Griffith, Green and Duff 1991).

[10] Zhao *et al*. (2000) and Zhao *et al*. (2005) provide detailed derivations of the economic surplus changes and formulas.

3.2 Prices and Quantities

Average annual prices and quantities for the three-year period 2002-03 to 2004-05 are needed as inputs into the EDM. These were sourced from industry and government agencies. Because of the high degree of industry disaggregation in the model, some data were unavailable. Details on the composition of the Australian sheep flock, the methods used and the assumptions made in calculating the disaggregated base quantity and price data in the EDM are given in Mounter *et al*. (2007a). The average base equilibrium prices and quantities used in the EDM are listed in Table 2, as are the cost and revenue shares for all sectors. For definitions of the variables, refer back to Table 1.

Table 2: Base equilibrium prices, quantities, cost shares and revenue shares

Prices and Quantities	Total Value	Cost Shares	Revenue Shares
Sheep			
$X_1 = 150.47$, $w_1 = 0.30$	$TV_{X1} = 45.14$		
$X_{21} = 65.67$, $w_{23} = 0.48$	$TV_{X21} = 31.52$		
$X_{31} = 202.36$, $w_{23} = 0.48$	$TV_{X31} = 97.13$		
$X_{41} = 163.03$, $w_{45} = 0.30$	$TV_{X41} = 48.91$		
$X_{51} = 440.77$, $w_{45} = 0.30$	$TV_{X51} = 132.23$		
$X_{61} = 168.65$, $w_{61} = 0.35$	$TV_{X61} = 59.03$		
$X_{71} = 276.93$, $w_{71} = 0.68$	$TV_{X71} = 188.31$		
$X_{81} = 404.06$, $w_{81} = 0.80$	$TV_{X81} = 323.25$		
$X_{91} = 112.21$, $w_{91} = 0.90$	$TV_{X91} = 100.99$		
Farm Sector			
$Y_{13W} = 6.20$, $v_{13W} = 4.39$	$TV_{Y1} = 550.57$	$k_{X1} = 0.08$, $k_{X1W} = 0.92$	$\gamma_{Y13W} = 0.05$, $\gamma_{Y14W} = 0.14$
$Y_{14W} = 22.81$, $v_{14W} = 3.37$			$\gamma_{Y1L} = 0.76$, $\gamma_{Y1M} = 0.05$
$Y_{1L} = 120.60$, $v_{1L} = 3.58$			
$Y_{1M} = 8.42$, $v_{1M} = 1.75$			
$Y_{21W} = 9.99$, $v_{21W} = 6.63$	$TV_{Y2} = 292.65$	$k_{X21} = 0.11$, $k_{X21W} = 0.89$	$\gamma_{Y21W} = 0.23$, $\gamma_{Y22W} = 0.15$
$Y_{22W} = 8.03$, $v_{22W} = 5.62$			$\gamma_{Y23W} = 0.02$, $\gamma_{Y2L} = 0.54$
$Y_{23W} = 1.06$, $v_{23W} = 4.51$			$\gamma_{Y2M} = 0.06$
$Y_{2L} = 43.95$, $v_{2L} = 3.58$			
$Y_{2M} = 9.56$, $v_{2M} = 1.75$			
$Y_{31W} = 30.77$, $v_{31W} = 6.63$	$TV_{Y3} = 472.45$	$k_{X31} = 0.21$, $k_{X31W} = 0.79$	$\gamma_{Y31W} = 0.43$, $\gamma_{Y32W} = 0.30$
$Y_{32W} = 24.75$, $v_{32W} = 5.62$			$\gamma_{Y33W} = 0.05$, $\gamma_{Y3L} = 0.09$
$Y_{33W} = 4.93$, $v_{33W} = 4.51$			$\gamma_{Y3M} = 0.13$
$Y_{3L} = 17.84$, $v_{3L} = 2.47$			
$Y_{3M} = 36.03$, $v_{3M} = 1.75$			

$Y_{41W} = 11.31$, $v_{41W} = 5.52$	$TV_{Y4} = 547.03$	$k_{X41} = 0.09$, $k_{X41W} = 0.91$	$\gamma_{Y41W} = 0.11$, $\gamma_{Y42W} = 0.23$
$Y_{42W} = 25.73$, $v_{42W} = 4.93$			$\gamma_{Y43W} = 0.02$, $\gamma_{Y4L} = 0.61$
$Y_{43W} = 1.91$, $v_{43W} = 4.39$			$\gamma_{Y4M} = 0.03$
$Y_{4L} = 93.40$, $v_{4L} = 3.58$			
$Y_{4M} = 8.57$, $v_{4M} = 1.75$			
$Y_{51W} = 30.57$, $v_{51W} = 5.52$	$TV_{Y5} = 719.73$	$k_{X51} = 0.18$, $k_{X51W} = 0.82$	$\gamma_{Y51W} = 0.23$, $\gamma_{Y52W} = 0.48$
$Y_{52W} = 69.58$, $v_{52W} = 4.93$			$\gamma_{Y53W} = 0.03$, $\gamma_{Y5L} = 0.18$
$Y_{53W} = 5.16$, $v_{53W} = 4.39$			$\gamma_{Y5M} = 0.08$
$Y_{5L} = 52.18$, $v_{5L} = 2.47$			
$Y_{5M} = 33.24$, $v_{5M} = 1.75$			
$Y_{61W} = 4.65$, $v_{61W} = 5.19$	$TV_{Y6} = 229.63$	$k_{X61} = 0.26$, $k_{X61W} = 0.74$	$\gamma_{Y61W} = 0.11$, $\gamma_{Y62W} = 0.37$
$Y_{62W} = 19.04$, $v_{62W} = 4.48$			$\gamma_{Y63W} = 0.04$, $\gamma_{Y6L} = 0.15$
$Y_{63W} = 2.40$, $v_{63W} = 4.20$			$\gamma_{Y6M} = 0.33$
$Y_{6L} = 13.74$, $v_{6L} = 2.47$			
$Y_{6M} = 43.53$, $v_{6M} = 1.75$			
$Y_{71W} = 42.25$, $v_{71W} = 6.63$	$TV_{Y7} = 655.99$	$k_{X71} = 0.29$, $k_{X71W} = 0.71$	$\gamma_{Y71W} = 0.43$, $\gamma_{Y72W} = 0.32$
$Y_{72W} = 37.51$, $v_{72W} = 5.62$			$\gamma_{Y73W} = 0.05$, $\gamma_{Y7E} = 0.11$
$Y_{73W} = 6.58$, $v_{73W} = 4.51$			$\gamma_{Y7M} = 0.09$
$Y_{7E} = 23.55$, $p_{SE} = 3.19$			
$Y_{7M} = 34.44$, $v_{7M} = 1.75$			
$Y_{81W} = 26.74$, $v_{81W} = 5.52$	$TV_{Y8} = 781.27$	$k_{X81} = 0.42$, $k_{X81W} = 0.58$	$\gamma_{Y81W} = 0.19$, $\gamma_{Y82W} = 0.43$
$Y_{82W} = 68.51$, $v_{82W} = 4.93$			$\gamma_{Y83W} = 0.03$, $\gamma_{Y8E} = 0.27$
$Y_{83W} = 4.46$, $v_{83W} = 4.39$			$\gamma_{Y8M} = 0.08$
$Y_{8E} = 66.73$, $p_{SE} = 3.19$			
$Y_{8M} = 35.90$, $v_{8M} = 1.75$			
$Y_{91W} = 3.06$, $v_{91W} = 5.19$	$TV_{Y9} = 144.93$	$k_{X91} = 0.70$, $k_{X91W} = 0.30$	$\gamma_{Y91W} = 0.11$, $\gamma_{Y92W} = 0.43$
$Y_{92W} = 13.38$, $v_{92W} = 4.48$			$\gamma_{Y93W} = 0.05$, $\gamma_{Y9E} = 0.03$
$Y_{93W} = 1.55$, $v_{93W} = 4.20$			$\gamma_{Y9M} = 0.38$
$Y_{9E} = 1.52$, $p_{SE} = 3.19$			
$Y_{9M} = 31.72$, $v_{9M} = 1.75$			
Wool Warehouse Sector			
$Z_{1W} = 20.72$, $u_{1W} = 3.73$	$TV_{Z1} = 82.26$	$k_{Y14W} = 0.93$, $k_{YNM} = 0.07$	$\gamma_{Z1W} = 0.94$, $\gamma_{Z1S} = 0.06$
$Z_{1S} = 2.09$, $u_{1S} = 2.38$			

$Z_{2W} = 124.67$, $u_{2W} = 6.63$	$TV_{Z2} = 1007.54$	$k_{Y21W} = 0.06$, $k_{Y31W} = 0.20$	$\gamma_{Z2W} = 0.82$, $\gamma_{Z2S} = 0.18$
$Z_{2S} = 34.67$, $u_{2S} = 5.52$		$k_{Y41W} = 0.06$, $k_{Y51W} = 0.17$	
		$k_{Y61W} = 0.02$, $k_{Y71W} = 0.28$	
		$k_{Y81W} = 0.15$, $k_{Y91W} = 0.02$	
		$k_{YFM} = 0.04$	
$Z_{3W} = 189.46$, $u_{3W} = 5.65$	$TV_{Z3} = 1414.09$	$k_{Y22W} = 0.03$, $k_{Y32W} = 0.10$	$\gamma_{Z3W} = 0.76$, $\gamma_{Z3S} = 0.24$
$Z_{3S} = 77.57$, $u_{3S} = 4.43$		$k_{Y42W} = 0.09$, $k_{Y52W} = 0.24$	
		$k_{Y62W} = 0.06$, $k_{Y72W} = 0.15$	
		$k_{Y82W} = 0.24$, $k_{Y92W} = 0.04$	
		$k_{YMM} = 0.05$	
$Z_{4W} = 26.60$, $u_{4W} = 4.63$	$TV_{Z4} = 161.65$	$k_{Y13W} = 0.17$, $k_{Y23W} = 0.05$	$\gamma_{Z4W} = 0.76$, $\gamma_{Z4S} = 0.24$
$Z_{2S} = 8.19$, $u_{4S} = 4.70$		$k_{Y33W} = 0.14$, $k_{Y43W} = 0.05$	
		$k_{Y53W} = 0.14$, $k_{Y63W} = 0.06$	
		$k_{Y73W} = 0.18$, $k_{Y83W} = 0.12$	
		$k_{Y93W} = 0.04$, $k_{YBM} = 0.05$	
Scouring Sector			
$Z_{CW} = 29.55$, $u_{CW} = 3.68$	$TV_{CS} = 609.35$	$k_{Z1S} = 0.01$, $k_{Z2S} = 0.30$	$\gamma_{ZCW} = 0.18$, $\gamma_{F1S} = 0.01$
$F_{1S} = 1.38$, $s_{1S} = 2.68$		$k_{Z3S} = 0.56$, $k_{Z4S} = 0.06$	$\gamma_{F2S} = 0.14$, $\gamma_{F3S} = 0.29$
$F_{2S} = 15.14$, $s_{2S} = 5.78$		$k_{ZCS} = 0.07$	$\gamma_{F4S} = 0.02$, $\gamma_{Z2T} = 0.15$
$F_{3S} = 33.71$, $s_{3S} = 5.30$			$\gamma_{Z3T} = 0.17$, $\gamma_{Z4T} = 0.04$
$F_{4S} = 2.98$, $s_{4S} = 5.09$			
$Z_{2T} = 15.84$, $u_{2T} = 5.67$			
$Z_{3T} = 20.16$, $u_{3T} = 5.16$			
$Z_{4T} = 3.76$, $u_{4T} = 5.78$			
Carbonising Sector			
$F_{CW} = 29.55$, $s_{CW} = 4.36$	$TV_{FCW} = 128.84$	$k_{ZCW} = 0.84$, $k_{ZCB} = 0.16$	
Topmaking Sector			
$F_{2T} = 14.67$, $s_{2T} = 6.67$	$TV_{FT} = 241.16$	$k_{Z2T} = 0.37$, $k_{Z3T} = 0.43$	$\gamma_{F2T} = 0.41$, $\gamma_{F3T} = 0.45$
$F_{3T} = 15.70$, $s_{3T} = 6.93$		$k_{Z4T} = 0.09$, $k_{ZWT} = 0.11$	$\gamma_{F4T} = 0.10$, $\gamma_{FNW} = 0.04$
$F_{4T} = 3.17$, $s_{4T} = 7.44$			
$F_{NW} = 6.21$, $s_{NW} = 1.76$			
Wool Export Sector			
$Q_{1W} = 20.72$, $p_{1W} = 4.03$	$TV_{Q1W} = 83.50$	$k_{Z1W} = 0.93$, $k_{ZNM} = 0.07$	
$Q_{2W} = 124.67$, $p_{2W} = 6.93$	$TV_{Q2W} = 863.96$	$k_{Z2W} = 0.96$, $k_{ZFM} = 0.04$	

$Q_{3W} = 189.46$, $p_{3W} = 5.95$	$TV_{Q3W} = 1127.29$	$k_{Z3W} = 0.95$, $k_{ZMM} = 0.05$	
$Q_{4W} = 26.60$, $p_{4W} = 4.93$	$TV_{Q4W} = 131.14$	$k_{Z4W} = 0.94$, $k_{ZBM} = 0.06$	
$Q_{CW} = 29.55$, $p_{CW} = 4.66$	$TV_{QCW} = 137.70$	$k_{FCW} = 0.94$, $k_{FCB} = 0.06$	
$Q_{1S} = 1.38$, $p_{1S} = 2.98$	$TV_{Q1S} = 4.11$	$k_{F1S} = 0.90$, $k_{FNS} = 0.10$	
$Q_{2S} = 15.54$, $p_{2S} = 6.08$	$TV_{Q2S} = 92.05$	$k_{F2S} = 0.95$, $k_{FFS} = 0.05$	
$Q_{3S} = 33.71$, $p_{3S} = 5.60$	$TV_{Q3S} = 188.78$	$k_{F3S} = 0.95$, $k_{FMS} = 0.05$	
$Q_{4S} = 2.98$, $p_{4S} = 5.39$	$TV_{Q4S} = 16.06$	$k_{F4S} = 0.95$, $k_{FBS} = 0.05$	
$Q_{2T} = 14.67$, $p_{2T} = 6.97$	$TV_{Q2T} = 102.25$	$k_{F2T} = 0.96$, $k_{FFT} = 0.04$	
$Q_{3T} = 15.70$, $p_{3T} = 7.23$	$TV_{Q3T} = 113.51$	$k_{F3T} = 0.96$, $k_{FMT} = 0.04$	
$Q_{4T} = 3.17$, $p_{4T} = 7.74$	$TV_{Q4T} = 24.54$	$k_{F4T} = 0.96$, $k_{FBT} = 0.04$	
$Q_{NW} = 6.21$, $p_{NW} = 2.06$	$TV_{QNW} = 12.79$	$k_{FNW} = 0.85$, $k_{FNE} = 0.15$	
Sheepmeat Processing Sector			
$Z_{LE} = 130.57$, $u_{LE} = 4.76$	$TV_{ZL} = 1626.49$	$k_{Y1L} = 0.27$, $k_{Y2L} = 0.10$	$\gamma_{ZLE} = 0.38$, $\gamma_{ZLD} = 0.62$
$Z_{LD} = 211.14$, $u_{LD} = 4.76$		$k_{Y3L} = 0.03$, $k_{Y4L} = 0.20$	
		$k_{Y5L} = 0.08$, $k_{Y6L} = 0.02$	
		$k_{YSL} = 0.30$	
$Z_{ME} = 176.70$, $u_{ME} = 2.39$	$TV_{ZM} = 437.50$	$k_{Y1M} = 0.05$, $k_{Y2M} = 0.03$	$\gamma_{ZME} = 0.73$, $\gamma_{ZMD} = 0.27$
$Z_{MD} = 64.70$, $u_{MD} = 2.39$		$k_{Y3M} = 0.11$, $k_{Y4M} = 0.02$	
		$k_{Y5M} = 0.09$, $k_{Y6M} = 0.13$	
		$k_{Y7M} = 0.10$, $k_{Y8M} = 0.10$	
		$k_{Y9M} = 0.10$, $k_{YSM} = 0.27$	
Sheepmeat Marketing Sectors			
$Q_{LE} = 130.57$, $p_{LE} = 4.83$	$TV_{QLE} = 630.65$	$k_{ZLE} = 0.98$, $k_{Z1L} = 0.02$	
$Q_{LD} = 143.57$, $p_{LD} = 10.15$	$TV_{QLD} = 1457.22$	$k_{ZLD} = 0.69$, $k_{Z2L} = 0.31$	
$Q_{ME} = 176.70$, $p_{ME} = 2.45$	$TV_{QME} = 432.92$	$k_{ZME} = 0.98$, $k_{Z1M} = 0.02$	
$Q_{MD} = 44.00$, $p_{MD} = 5.22$	$TV_{QMD} = 229.66$	$k_{ZMD} = 0.67$, $k_{Z2M} = 0.33$	
Live Sheep Exports			
$Q_{SE} = 92.00$, $p_{SE} = 3.19$	$TV_{QSE} = 293.49$		

3.3 Market Parameters

Few, if any, empirical estimates are available for many of the elasticities used in the model. Due to the level of industry disaggregation, numerous parameters had to be specified using subjective judgement. In this section, each of the market parameters in the model is discussed and the values chosen for each parameter are listed in Table 6.

3.3.1 Sheep Supply Elasticities

The supplies of wool, lamb, mutton and live sheep exports are determined by joint-product relationships. Price elasticities of supply are needed for each of the joint products to estimate joint-product elasticities of supply of sheep in each zone. Estimates by zone are preferred due to differences in numerous factors such as climate, topography and production mix. A comprehensive review of supply response in Australian broadacre agriculture can be found in Griffith *et al*. (2001a) but caution is needed with the interpretation of sheepmeat and wool supply estimates for several reasons. Firstly, differences in datasets make comparisons difficult and estimates can differ markedly depending on the methodology implemented or functional form chosen when using econometric estimation. Possibly more problematic is the fact that almost all published elasticities were estimated in an era of wool market price stabilisation. As pointed out by Griffith *et al*. (2001a), it is possible that price elasticities of supply may be higher in an unregulated than in a regulated market. Although medium-run elasticity values are used in the model, the following brief discussions highlight the range of published estimates over differing time frames for sheepmeat and wool indicating the lack of agreement on supply response values.

Published estimates of the own-price elasticity of the supply of wool in Australia vary considerably (Table 3). For example, medium-term estimates range in value from 0.36 (Wicks and Dillon 1978) to 2.02 (Hall and Menz 1985.) Significant variations in magnitude are also evident in the short-and long-run estimates. Numerous studies have estimated the supply response of wool according to agricultural zone of origin (e.g. Wicks and Dillon 1978; Vincent *et al*. 1980; Wall and Fisher 1987; Johnson *et al*. 1990; Kokic *et al*. 1993; Agbola 1999) with short-run and medium-run estimates ranging in value from 0.06 to 0.57.[11] Mullen, Alston and Wohlgenant (1989), in a model of the wool top industry, assumed a medium-to long-run supply elasticity of 1.00 while Sinden *et al*. (2004) and Vere *et al*. (2005) both used medium-term values of 0.90. Similarly, a value of 0.90 is used to represent the supply response of wool in each of the three zones.

Table 3: Elasticities of the supply of wool in Australia

Length of Run	Source	Wool	Area/Zone
S	Easter and Paris (1983)	0.21	Australia
	Wicks and Dillon (1978)	0.35	Australia
	McKay *et al*. (1983)	0.72	Australia
	Low and Hinchy (1990)	0.94	Australia
	Adams (1987)	0.95	Australia
L	Simmons and Ridley (1987)	1.35	Australia
	Hall *et al*. (1988)	2.50	Australia
M	Wicks and Dillon (1978)	0.36	Australia
	Hall and Menz (1985)	2.02	Australia
	Hall *et al*. (1988)	0.60	Australia

[11] A more comprehensive review can be found in Griffith *et al*. (2001a).

Estimates of the individual supply responses of lamb and mutton are scarce. Most own-price elasticity of supply estimates relate to sheepmeat that presumably includes lamb and mutton. Elasticities of the supply of sheepmeat in Australia are presented in Table 4. Of the more recent studies that have focused on a medium-run time frame, values estimated by Kokic *et al*. (1993) and Piggott *et al*. (1995) have been price elastic. Sinden *et al*. (2004) and Vere *et al*. (2005) both used a value of 1.38 for the medium-term supply response of mutton and lamb in Australia. Based on the above review, a value of 1.30 is considered to be a reasonable estimate for the medium-term sheepmeat supply elasticity.

Table 4: Elasticities of the supply of sheepmeat in Australia

Length of Run	Source	Sheepmeat	Area/Zone
S	Vincent *et al*. (1980)	0.11	High rainfall
		0.23	Wheat-sheep
	Johnson *et al*. (1990)	0.31	High rainfall
		0.37	Wheat-sheep
		0.29	Pastoral
L	Wall and Fisher (1987)	0.28 – 0.49	High Rainfall
		0.22 – 0.49	Wheat-sheep
		0.39 – 0.46	Pastoral
	Dewbre *et al*. (1985)	0.60	Australia
	Hall *et al*. (1988)	1.50	Australia
	Mullen and Alston (1991)	1.50	Australia
M	Dewbre *et al*. (1985)	0.47	Australia
	Hall *et al*. (1990)	0.30	Australia
	Kokic *et al*. (1993)	2.17	High Rainfall
		2.02	Wheat-sheep
		1.37	Pastoral
	Piggott *et al*. (1995)	1.40 (lamb)	Australia

In such instances where joint products are obtained in approximately fixed proportions from a basic commodity, Houck (1964) demonstrated the demand price elasticity of the basic commodity is a weighted harmonic average of the price elasticities of the joint products.[12] The price elasticity of the basic commodity can be computed as follows (Tomek and Robinson 1995, p.45):

$$\varepsilon_X = \frac{P_1 w_1 + P_2 w_2}{\frac{1}{\varepsilon_1}(P_1 w_1) + \frac{1}{\varepsilon_2}(P_2 w_2)}$$

[12] As long as elasticities are calculated at the same market level.

where X is the basic commodity, ε_1 and ε_2 are the price elasticities of the joint products, P_1 and P_2 are the price per unit of the joint products and $w_1=(X_1/X)$ and $w_2=(X_2/X)$ are the fixed yields per unit of the basic commodity.[13] The weights are the proportions of X's average value per unit attributable to the sales of the joint products. Given the price elasticities of the joint products are constants, the price elasticity of the basic commodity will vary as the weights vary. In the extreme if P_1w_1 or P_2w_2 were equal to zero, ε_X would equal ε_2 or ε_1, respectively.

A weighted harmonic average of the supply price elasticities of the joint products wool and sheepmeat were used to obtain supply elasticity estimates of 1.2 for non-Merino sheep and 1.0 for Merino sheep. An example of the sheep supply elasticity calculation is given in Appendix 2.

Compared with the high rainfall and wheat-sheep zones, the pastoral zone supply of sheep should be less elastic because of greater physical limitations on substitution possibilities between enterprise mixes. Conversely, the supply of sheep in the wheat-sheep zone should be more elastic than the other two zones as substitution possibilities in the enterprise mix are greater. As such, the Merino sheep supply elasticity of 1.0 is used to represent the supply of Merino sheep in the high rainfall zone and values of 0.8 and 1.2 are assigned to the supplies of sheep in the pastoral and wheat-sheep zones, respectively.

3.3.2 Lamb and Mutton Retail Demand Elasticities

Published estimates of retail demand elasticities for Australian meat products are reviewed in Griffith *et al*. (2001b). As was the case for the product supply estimates, values differ depending on the data period and estimation method chosen. However, almost all estimates suggest the demand for lamb in Australia over the past 30 years has been elastic with values ranging from -0.99 (Cashin 1991) to -1.89 (Main *et al*. 1976). Vere, Griffith and Bootle (1992) estimated a demand elasticity of -1.50 and this value was used by Mullen and Alston (1994) in an EDM of the Australian lamb industry. More recently Vere *et al*. (2000) estimated per capita demand equations for different meats as part of a quarterly structural econometric model of the Australian livestock industries. Consistent with the majority of earlier estimates they found the retail elasticity of demand for lamb to be elastic with a value of -1.54. A similar value of -1.50 is used in the base model.

Retail demand elasticity estimates for mutton are few. Using different methods, Main *et al*. (1976) estimated values of -1.25 and -1.24 while Dewbre *et al*. (1985) derived an estimate of -2.51. Based on a review of published estimates and subjective industry opinion, a value of -1.40, chosen by Sinden *et al*. (2004), was considered an appropriate estimate.

Lamb and mutton are considered substitutes in demand at the retail level in the domestic market. Cross-price elasticities are required for lamb and mutton though estimates are scarce. In Dewbre *et al*. (1985) the cross-price elasticity of demand for lamb with respect to a change in the price of mutton was estimated as 0.13 and the cross-price elasticity of

[13] In this example two joint products are used to illustrate the relationship among the elasticities. The example can be extended to include *n* joint products (Houck 1964).

demand for mutton with respect to a change in the price of lamb was estimated as 0.71. As would be expected in the case of substitution between the two types of meat, both estimates were positive with the consumption of mutton shown to be more responsive to price changes in lamb than vice-versa. Because lamb and mutton are substitutes in demand, the cross-price elasticities must comply with the symmetry condition[14]

$$\eta_{(QMD,PLD)} = (\lambda_{LD}/\lambda_{MD})\eta_{(QLD,PMD)}$$

where $\lambda_{LD}/\lambda_{MD} = (P_{LD},Q_{LD})/(P_{MD},Q_{MD}) = 6.3$ is the relative budget share of the two commodities.[15] Using the Dewbre *et al*. (1985) estimated cross-price elasticity of demand for lamb with respect to changes in the price of mutton $\eta_{(QLD,PMD)} = 0.13$, and applying the symmetry condition, the cross-price elasticity of demand for mutton with respect to changes in the price of lamb is $\eta_{(QMD,PLD)} = (6.3)(0.13) = 0.82$.[16]

3.3.3 Lamb, Mutton and Live Sheep Export Demand Elasticities

While there have been a few studies on the export demand elasticity for Australian beef, similar studies for lamb and mutton are limited. Ball and Dewbre (1989) estimated short-run and long-run export demand elasticity values for lamb of -0.94 and -2.56, respectively. In an EDM of the Australian beef industry, Zhao *et al*. (2000) specified export demand elasticities of -5 for grassfed beef and -2.5 for grainfed beef. The demand for grainfed beef was expected to be less elastic than grassfed beef demand because of product specificity and Australia's supply dominance in one export market, purchasing around 95 per cent of Australian grainfed beef. Alternatively, Australian grassfed beef is sold to numerous countries, and changes in the quantity exported are unlikely to significantly influence export prices. Although Australia only produces about 7 per cent of the world's lamb and mutton supply, it is the world's largest exporter of mutton and live sheep, and ranks second behind New Zealand in world lamb exports (MLA 2006). Of the top twenty sheepmeat exporting countries in 2004, Australian exports accounted for approximately 30 per cent by volume and 25 per cent by value (FAO 2006). Even so, the range of markets for Australian sheepmeat is extensive and any impact on export prices arising from changes in Australian export quantities is unlikely to be large.

As opposed to Australian mutton, which is assumed homogeneous in quality with mutton from other countries in overseas markets, the perceived distinctiveness of Australian lamb in overseas markets, particularly in the US, implies the export demand for Australian lamb is less price elastic than the export demand for Australian mutton. Consequently, values of -2.5 and -5.0 are given to the export demand elasticities for lamb and mutton, respectively. The export demand for Australian live sheep is also assumed to be less price elastic than the export demand for Australian mutton. Australian live sheep exports are predominantly sold in the Middle Eastern markets and are recognised as being free of serious diseases such as Foot and Mouth Disease (FMD) and Bovine Spongiform Encephalitis (BSE). A value of -2.0 is used for the export demand elasticity for Australian live sheep.

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[14] The symmetry condition is discussed in Section 2.4.3.

[15] Values for P_{LD},Q_{LD}, P_{MD} and Q_{MD} are specified in Table 2.

[16] Dewbre *et al*. (1985) estimated a value 0.71 for the cross-price elasticity of demand for mutton with respect to changes in the price of lamb.

3.3.4 Wool Export Demand Elasticities

Demand elasticity estimates for Australian wool are available from a number of studies, though most are dated with few providing estimates according to wool type. Connolly (1992) estimated demand elasticities for Australian wool exports to selected destinations for varying lengths of time. Medium and long-run estimates for the geographically defined regions ranged in value from -0.75 to -1.58. Beare and Meshios (1990) derived estimates for combing wools of different fibre diameters. Their results showed demand becomes more price elastic as fibre diameter increases. They suggested that, compared with fine yarn production, less restrictive technical specifications in the production of coarser yarns may allow for greater substitutability among coarser wools. The Beare and Meshios estimates are reproduced in Table 5.

Table 5: Own price demand elasticities for combing wools

19 micron	-1.02	23 micron	-1.44
20 micron	-1.23	24 micron	-1.76
21 micron	-1.15	25 micron	-2.00
22 micron	-1.16	26 micron	-1.17[a]

Source: Beare and Meshios (1990)

[a] not significant at the five per cent level

Sinden *et al*. (2004) and Vere *et al*. (2005) used a value of -1.40 as the demand elasticity for Australian wool. This estimate falls within the mid-range values of demand elasticities for the different micron categories estimated by Beare and Meshios. In the current model, wool is separated by fibre diameter into four categories, ≤19 micron, 20-23 micron, 24-27 micron and ≥ 28 micron. The Beare and Meshios estimates in Table 3.4 are used to specify the export demand elasticities for each greasy wool category. The 19 micron estimate of -1.0 is used to represent the ≤19 micron category and the 20-23 micron category estimate of -1.2 is taken as an average value of the 20, 21, 22 and 23 micron wools. The 24-27 micron estimate of -1.9 is derived as an average of the 24 and 25 micron values. The 26 micron demand elasticity in Table 5 was not significant and therefore not taken into consideration. Reasoning that demand becomes more price elastic as fibre diameter increases, a value of -2.0 was used for wool ≥ 28 micron.

Few demand elasticity estimates exist for domestically processed wool exports. Most studies have observed either the demand for raw wool or retail level demand. The same values specified for the greasy wool export categories in the model were used as estimates of export demand elasticities for the corresponding scoured wool export categories.

Mullen, Alston and Wohlgenant (1989a) estimated a short-run elasticity of demand for wool top of -0.45 but evidence was inconclusive for a longer adjustment period. Using a formula for derived demand and reasoning that the demand for wool top could be thought of as being derived from the demand for clothing, Mullen *et al*. (1989) discussed the improbability of the elasticity of demand for wool top exceeding -1.0. The emergence of China as the biggest wool processing country in the world has been the catalyst for a sharp decline in wool processing in Australia. In 2004-05 Australian wool top exports were a little over 16 kt, down from 52 kt in 2000-01 (ABARE 2006). Current changes in Australian wool top export quantities are less likely to exert any influence on export prices than may have been the case in previous years. Medium-run elasticities of demand for each of the three wool top export categories were given a value of -1.5.

Carbonised wools of all fibre diameter categories are combined into a single export quantity in the model. For reasons similar to the discussion above, a value of -1.5 was used to represent the export demand elasticity for carbonised wool. The same parameter value was assigned to the export demand elasticity for noils of wool that also comprise differing fibre diameters.

Although the proportion of annual wool production used in later stage processing of wool in Australia is small, the domestic demand for wool top is included in the model. As per the export wool top elasticities, a value of -1.5 is assigned to the domestic demand elasticity for wool top.

3.3.5 Other Factor Supply Elasticities

In each of the sectors within the model, all other production inputs such as capital and labour are aggregated into one group. Without empirical estimates on elasticities of supply or detailed information on cost structures for individual industry sectors to allow further disaggregation of inputs, most studies have assumed these inputs to be non-specialised and therefore highly elastic in supply (Mullen *et al*. 1989; Zhao *et al*. 2000). One exception is Zhao, Anderson and Wittwer (2003) where inputs into the Australian wine industry, other than grapes, were disaggregated into capital and mobile factors. Capital factor inputs were those with relatively inelastic supplies and specific to wine making such as fixed capital and human capital. These inputs were given values ranging from 0.4 in the short-run to 2.0 in the long-run. The mobile inputs were considered non-specific to the wine industry and hence more elastic in supply. This group was assumed to include factors such as labour and chemicals and were given a value of 5.

Early-stage processing of wool is capital-intensive using highly specialised equipment. Scouring, carbonising and topmaking all require the use of large-scale machinery offering processors little opportunity to diversify (AWI 2002). This implies the elasticity value for aggregate input supply into these sectors would be considerably less than the assumed value for mobile inputs mentioned above. As such, a value of 1.0 is specified for the supply of factor inputs into the scouring, carbonising and topmaking sectors.

Non-wool input supplies necessary to conduct handling, wool testing, warehousing and dumping procedures in the wool warehouse and export shipment sectors are assumed to be more elastic than non-wool factor supplies in the domestic wool processing sectors. An aggregate factor supply elasticity of 2.5 is given to each non-wool input group in the wool warehouse and export shipment sectors.

Other factor inputs used in meat processing and marketing have been assumed relatively elastic in supply (for example, Mullen, Wohlgenant and Farris 1988; Mullen and Alston 1994; Zhao *et al*. 2000). Zhao, Anderson and Wittwer (2003) specified a value of 2.0 for wine marketing inputs. It seems unlikely that the processing and marketing of lamb and mutton would rely substantially on highly specialised inputs. Therefore, values of 2.0 are allocated to the elasticities of aggregated factor supplies into those sectors.

It is also believed that the supplies of ‘other inputs’ into farm production such as capital and labour are not specialised. For example, labour is viewed as being highly mobile across different rural and non-rural industries. Recent Australian labour trends lend credence to this opinion. ABS (2007) reported that Australia’s current unemployment rate of 4.3 per cent was its lowest level for over thirty years. The low unemployment rate, the mining boom in Western Australia and a general population shift away from rural areas over the past decade has seen labour shortages increase in many rural industries and regions. Values of 3.0 are assumed for the elasticities of supplies of ‘other’ sheep and wool farm inputs.

3.3.6 Input Substitution Elasticities

In EDM analysis, it has been common practice to measure the degree of substitutability between inputs using the Allen-Uzawa elasticity of input substitution. A simpler approach is to assume all inputs are used in fixed proportions, implying zero elasticity of substitution. Diewert (1981) pointed out the likely existence of input substitution at the industry level as firms choose to utilise different technologies in response to changes in relative input prices. Alston and Scobie (1983) discussed how a small degree of input substitution could have a significant impact on the distribution of research benefits. Even though the importance of this result is acknowledged in the literature, empirical estimates of input substitution relating to agricultural industries remain few.

Most studies have viewed substitution between farm and non-farm inputs as limited, assigning a small value of 0.1 to the substitution elasticity (Mullen, Wohlgenant and Farris 1998; Mullen, Alston and Wohlgenant 1989; Zhao *et al*. 2000). In the base model a value of 0.1 is given to the elasticity of substitution between sheep and other inputs for each of the sheep enterprises in each agricultural zone.

Mullen, Alston and Wohlgenant (1989) used a value of 0.1 for the elasticity of substitution between wool and other processing inputs. Elasticities of substitution between all wool and non-wool inputs in the wool warehouse, export shipment, and domestic scouring, carbonising and topmaking sectors in the base run were also assigned values of 0.1.

Information was not available on input substitution elasticities of wool produced by zone. After estimating a value of 6.5 in a preliminary study, Mullen, Alston and Wohlgenant (1989) used a value of 5 for the elasticity of substitution between wool from different countries. In the current model, greasy wool within the same micron category produced from different enterprises in the same zone is assumed homogeneous in quality. Although it was not possible from the available data to differentiate wool production by zone according to other characteristics, fibre diameter has been highlighted as the most important physical attribute of wool as it closely governs the strength, texture and spinning capacity of yarns (Quirk 1983). Fibre diameter is recognised as the dominant determinant of wool prices because it is the only currently measured raw wool fibre attribute that has relevance throughout the processing chain to the consumer. Though important in the early-stage processing of wool, other factors such as yield, strength, length and point of break, do not affect the wool product beyond the spinning stage (AWI 2004a). Fibre diameter accounts for around 75 to 80 per cent of the value of wool top (AWI 2006b). A substitution elasticity of 5 is used to represent the homogeneity of greasy wool in the same diameter category produced from different enterprises in the same zone.[17]

Substitution possibilities between greasy wool within the same micron category grown in different zones are expected to be smaller. Differences in climatic conditions and other factors affect not only the physical attributes of wool, but also the amount of impurities such as dust and vegetable matter contained in the wool. The substitution elasticities for the same micron categories of wool produced in different zones are set at 2.

Elasticities are also required for input substitution between different wool types in the domestic scouring and topmaking processes. Different wool types may be blended or mixed to ensure end product consistency. Even so, wool with different characteristics is used to produce different end products and substitution between wool types may be limited for particular products (Alston and Wohlgenant 1990). Beare and Meshios (1990) estimated cross-price elasticities for combing wools of different fibre diameters. Their estimates suggested substitution takes place within a very limited range of fibre diameters, around four microns. The results are consistent with those of Connolly, MacAulay and Piggott (1987) who found direct substitution between broadly defined wool grades was limited. The cross-price elasticities estimated by Beare and Meshios (1990) indicated that the pair-wise substitution between different fibre diameter categories declined rapidly as the difference in fibre diameter increased. Thus, 20 micron wool may be a close substitute for 19 micron wool but 21 micron, 22 micron and 23 micron wools less so. Given the broadly defined fibre diameter categories in the model, input substitution between categories is deemed to be limited. A small value of 0.1 is specified for the input substitution elasticities between greasy wool categories and scoured wool categories for the scouring and topmaking processes, respectively.

There are no empirical estimates of the degree of substitution between lamb and processing inputs in producing lamb for retail consumption. As previously mentioned, a small value of 0.1 has been assumed for input substitution elasticities between farm and non-farm inputs in most agricultural EDM studies. In US beef processing, Mullen, Wohlgenant and Farris (1988) estimated a minimum value of 0.1 for the elasticity of substitution between cattle and processing inputs. Mullen and Alston (1994) assumed an elasticity of substitution between lamb and processing inputs of 0.1. Likewise, input substitution elasticities between lamb and ‘other inputs’ in the processing and marketing sectors are given a value of 0.1. The same value is given to the substitution elasticities between mutton and ‘other inputs’ in the processing and marketing sectors.

In the model, prime lamb production from non-Merino ewes and first-cross lamb production from Merino ewes in the high rainfall and wheat-sheep zones are assumed homogeneous in quality. As with wool, the elasticities of substitution between homogeneous lamb types are set at 5. Elasticities of substitution between Merino lambs

[17] Little difference in the results was found when the substitution elasticity was changed from 5 to 20.

produced in all three zones are also set at 5, as meat quality differences are assumed negligible. Less substitutability is assumed between non-Merino and Merino lamb. In terms of eating quality, Merino lamb is perceived as inferior to other breeds. Carcasses tend to be less muscled and the meat is prone to having low levels of glycogen leading to increased incidence of dark cutting meat (Pethick 2005). A value of 2 is assigned to the substitution elasticities between Merino and non-Merino lamb. The elasticities of substitution between mutton produced from different sheep enterprises and zones are given a value of 5, as the differences in meat quality attributes are assumed to be small.

3.3.7 Product Transformation Elasticities

The elasticity of product transformation is a measure of the responsiveness of the product mix ratio to changes in the marginal rate of transformation (MRT) (Powell and Gruen 1968). Thus, it provides a measure of the possibility of changing the product mix for given inputs. Elasticities of product transformation are needed for all multi-output sectors in the model. Each of the non-Merino and Merino ewe enterprises produce wool, lamb and mutton while the dry sheep enterprises, comprising wethers and hoggets, produce wool, mutton and live sheep exports.[18]

Few empirical estimates of this parameter are available with respect to broadacre agricultural industries. Vincent, Dixon and Powell (1980) estimated product transformation elasticities for broadly defined Australian agricultural products for the three agricultural zones. Values ranged from -0.04 to -2.13. Product transformation elasticities in the ORANI/Monash model (Dixon, Parmenter, Sutton and Vincent 1997) were given values of -2.

Wool quality characteristics are strongly influenced by nutrition and feed supply (AWI 2006a). Therefore, some degree of product transformation with respect to the fibre diameter of wool produced is possible in the short run. However, over a longer time frame selective breeding practices can assist in altering the micron profile of the national flock considerably. For example, in 2000-01 approximately 17.8 per cent of the national wool clip was ≤ 19 microns in fibre diameter. By 2004-05 this figure had risen to 32.4 per cent (AWTA 2007). In the EDM, the extent of transformation is expected to be moderate as the categories of wool are specified over a range of microns. Product transformation elasticities are set at -0.5 between the ≤ 19 micron and 20-23 micron categories, -0.25 between the 20-23 micron and 24-27 micron categories, and -0.25 between the 24-27 micron and ≥ 28-micron categories.

The elasticity of product transformation between wool and lamb is set at -0.2. The effects of pregnancy on wool growth have been well documented (for example, Corbett 1979; Donnelly, Morley and McKinney 1983; Masters, Stewart and Connell 1993) with reduced fleece weight estimates of up to 20 per cent reported in some instances. At an aggregate industry level, alterations in the composition of the national sheep flock over time result in changes in the product output mix. In recent years, decreased wool production and

[18] Mutton can be considered as a by-product in wool and lamb-producing enterprises. Hence, product transformation possibilities between wool and mutton and between lamb and mutton are assumed to be zero.

increased lamb production have arisen from an increased proportion of ewes and decreased proportion of wethers in the national flock (Martin *et al*. 2004).

The product transformation elasticity between mutton and live sheep exports is given a value of -1.8 indicating production can easily be varied according to the relative prices of each.

Once sold at auction, greasy wool is either exported or used in the domestic processing sector. Product transformation elasticities for greasy wool in the same micron categories are set at -2 to reflect the ease of transfer between the export and domestic processing sectors for similar wool types.[19]

The first stage of wool processing is scouring whereby the wool is washed to remove dirt, grease and suint (sweat). Scoured wool that is not exported at this stage undergoes further processing in either the carbonising or topmaking sectors. Carbonising is primarily used for treating wools with high vegetable matter content that are subsequently processed in the woollen system. Combing wools, destined for processing in the worsted system, comprise around 80 per cent of Australia's wool production (AWI 2006b). Wools of this type enter the topmaking process. Under the assumption that the majority of scoured wool exports are also wools of this type, there are limited possibilities of increasing scoured wool destined for carbonising at the expense of either scoured wool exports or scoured wool inputs to topmaking. Product transformation elasticities between scoured wool for carbonising and other scoured wool types are assumed to be zero. It is expected that transformation possibilities between broadly defined grades of scoured wool would be small and hence the transformation elasticities are set at -0.1.

In topmaking, wool is formed into a sliver of parallel fibres through a process of combing to remove any noils. The majority of wool top is exported with a small amount retained domestically for later-stage processing into yarn. Product transformation elasticities between broadly defined grades of export wool top are set at -0.1. Following industry advice, Verikios (2007) set product transformation elasticities for the worsted top industries to zero as the top and noil output mix is considered unresponsive to relative prices. Likewise, product transformation elasticities between wool top and noil in the model are given zero values.

The range of markets for Australian sheepmeat is extensive, with many varying product specifications. In most cases, lambs are sold as domestic trade lambs or export lambs. Regional conditions and factors such as soil type and fertility, season and pasture quantity and quality contribute in determining the production of each type of lamb. Export lambs are leaner and heavier weighing 22 kg plus with fat scores of 2 and 3. Trade lambs typically weigh 17 kg to 22 kg with 2 and 3 fat scores though, due to increased demand for trim lamb, major retailers also buy 'heavy trade' lambs up to 28 kg carcass weight (Department of Primary Industries Victoria 2005). Hence, it is possible to alter the product mix in response to changes in domestic and export lamb prices. Mounter, Griffith and Piggott (2005) specified a product transformation value of -0.5 between export and

[19] There was no change in the distribution of benefits when this value was changed from -2 to -5 and only minor changes were found when set to zero.

domestic pork carcass. The product transformation elasticity between export and domestic lamb carcass for the processing sector is also set at -0.5. Most mutton exports are in frozen carcass or bone-in cut form. Differences in attributes between export and domestic mutton carcass are assumed to be considerably less than differences between export and domestic lamb carcass as much of the mutton in the domestic market constitute an ingredient for small goods manufacturing (Sheepmeat Council of Australia 1998). A value of -1.0 is given to the product transformation elasticity between export and domestic mutton carcass.

Each of the assumed market elasticity values used in the EDM is reported in Table 6. Definitions of the parameters are listed in Table 1.

Table 6: Medium term market elasticity values

Sheep Supply:	ε(X1, W1) = 1.2	ε(X23, W23) = 1	ε(X45, W45) = 1.2	ε(X61, W61) = 0.8
	ε(X71, W71) = 1	ε(X81, W81) = 1.2	ε(X91, W91) = 0.8	
Other Factor Supply: ***Farm Enterprises:***	ε(X1W, W1W) = 3	ε(X21W, W21W) = 3	ε(X31W, W31W) = 3	ε(X41W, W41W) = 3
	ε(X51W, W51W) = 3	ε(X61W, W61W) = 3	ε(X71W, W71W) = 3	ε(X81W, W81W) = 3
	ε(X91W, W91W) = 3			
Wool Warehouse:	ε(YNM, VNM) = 2.5	ε(YBM, VBM) = 2.5	ε(YMM, VMM) = 2.5	ε(YFM, VFM) = 2.5
Wool Scouring:	ε(ZCS, UCS) = 1			
Wool Carbonising:	ε(ZCB, UCB) = 1			
Wool Topmaking:	ε(ZWT, UWT) = 1			
Wool Export:	ε(ZNM, UNM) = 2.5	ε(ZFM, UFM) = 2.5	ε(ZMM, UMM) = 2.5	ε(ZBM, UBM) = 2.5
	ε(FCB, SCB) = 2.5	ε(FNS, SNS) = 2.5	ε(FFS, SFS) = 2.5	ε(FMS, SMS) = 2.5
	ε(FBS, SBS) = 2.5	ε(FFT, SFT) = 2.5	ε(FMT, SMT) = 2.5	ε(FBT, SBT) = 2.5
	ε(FNE, SNE) = 2.5			
Lamb & Mutton Processing:	ε(YSL, VSL) = 2	ε(YSM, VSM) = 2		
Lamb & Mutton Marketing:	ε(Z1L, U1L) = 2	ε(Z2L, U2L) = 2	ε(Z1M, U1M) = 2	ε(Z2M, U2M) = 2
Input Substitution ***Farm Enterprises:***	σ(X1, X1W) = 0.1	σ(X21, X21W) = 0.1	σ(X31, X31W) = 0.1	σ(X41, X41W) = 0.1
	σ(X51, X51W) = 0.1	σ(X61, X61W) = 0.1	σ(X71, X71W) = 0.1	σ(X81, X81W) = 0.1
	σ(X91, X91W) = 0.1			
Wool Warehouse:	σ(Y14W, YNM) = 0.1	σ(Y21W, Y31W) = 5	σ(Y21W, Y41W) = 2	σ(Y21W, Y51W) = 2
	σ(Y21W, Y61W) = 2	σ(Y21W, Y71W) = 5	σ(Y21W, Y81W) = 2	σ(Y21W, Y91W) = 2
	σ(Y21W, YFM) = 0.1	σ(Y31W, Y41W) = 2	σ(Y31W, Y51W) = 2	σ(Y31W, Y61W) = 2
	σ(Y31W, Y71W) = 5	σ(Y31W, Y81W) = 2	σ(Y31W, Y91W) = 2	σ(Y31W, YFM) = 0.1

	σ(Y41W, Y51W) = 5	σ(Y41W, Y61W) = 2	σ(Y41W, Y71W) = 2	σ(Y41W, Y81W) = 5
	σ(Y41W, Y91W) = 2	σ(Y41W, YFM) = 0.1	σ(Y51W, Y61W) = 2	σ(Y51W, Y71W) = 2
	σ(Y51W, Y81W) = 5	σ(Y51W, Y91W) = 2	σ(Y51W, YFM) = 0.1	σ(Y61W, Y71W) = 2
	σ(Y61W, Y81W) = 2	σ(Y61W, Y91W) = 5	σ(Y61W, YFM) = 0.1	σ(Y71W, Y81W) = 2
	σ(Y71W, Y91W) = 2	σ(Y71W, YFM) = 0.1	σ(Y81W, Y91W) = 2	σ(Y81W, YFM) = 0.1
	σ(Y91W, YFM) = 0.1	σ(Y22W, Y32W) = 5	σ(Y22W, Y42W) = 2	σ(Y22W, Y52W) = 2
	σ(Y22W, Y62W) = 2	σ(Y22W, Y72W) = 5	σ(Y22W, Y82W) = 2	σ(Y22W, Y92W) = 2
	σ(Y22W, YMM) = 0.1	σ(Y32W, Y42W) = 2	σ(Y32W, Y52W) = 2	σ(Y32W, Y62W) = 2
	σ(Y32W, Y72W) = 5	σ(Y32W, Y82W) = 2	σ(Y32W, Y92W) = 2	σ(Y32W, YMM) = 0.1
	σ(Y42W, Y52W) = 5	σ(Y42W, Y62W) = 2	σ(Y42W, Y72W) = 2	σ(Y42W, Y82W) = 5
	σ(Y42W, Y92W) = 2	σ(Y42W, YMM) = 0.1	σ(Y52W, Y62W) = 2	σ(Y52W, Y72W) = 2
	σ(Y52W, Y82W) = 5	σ(Y52W, Y92W) = 2	σ(Y52W, YMM) = 0.1	σ(Y62W, Y72W) = 2
	σ(Y62W, Y82W) = 2	σ(Y62W, Y92W) = 5	σ(Y62W, YMM) = 0.1	σ(Y72W, Y82W) = 2
	σ(Y72W, Y92W) = 2	σ(Y72W, YMM) = 0.1	σ(Y82W, Y92W) = 2	σ(Y82W, YMM) = 0.1
	σ(Y92W, YMM) = 0.1	σ(Y13W, Y23W) = 2	σ(Y13W, Y33W) = 2	σ(Y13W, Y43W) = 2
	σ(Y13W, Y53W) = 2	σ(Y13W, Y63W) = 2	σ(Y13W, Y73W) = 2	σ(Y13W, Y83W) = 2
	σ(Y13W, Y93W) = 2	σ(Y13W, YBM) = 2	σ(Y23W, Y33W) = 5	σ(Y13W, Y43W) = 2
	σ(Y23W, Y53W) = 2	σ(Y23W, Y63W) = 2	σ(Y23W, Y73W) = 5	σ(Y23W, Y83W) = 2
	σ(Y23W, Y93W) = 2	σ(Y23W, YBM) = 0.1	σ(Y33W, Y43W) = 2	σ(Y33W, Y53W) = 2
	σ(Y33W, Y63W) = 2	σ(Y33W, Y73W) = 5	σ(Y33W, Y83W) = 2	σ(Y33W, Y93W) = 2
	σ(Y33W, YBM) = 0.1	σ(Y43W, Y53W) = 5	σ(Y43W, Y63W) = 2	σ(Y43W, Y73W) = 2
	σ(Y43W, Y83W) = 5	σ(Y43W, Y93W) = 2	σ(Y43W, YBM) = 0.1	σ(Y53W, Y63W) = 2
	σ(Y53W, Y73W) = 2	σ(Y53W, Y83W) = 5	σ(Y53W, Y93W) = 2	σ(Y53W, YBM) = 0.1
	σ(Y63W, Y73W) = 2	σ(Y63W, Y83W) = 2	σ(Y63W, Y93W) = 5	σ(Y63W, YBM) = 0.1
	σ(Y73W, Y83W) = 2	σ(Y73W, Y93W) = 2	σ(Y73W, YBM) = 0.1	σ(Y83W, Y93W) = 2
	(Y83W, YBM) = 0.1	σ(Y93W, YBM) = 0.1		
Wool Scouring:	σ(Z1S, Z2S) = 0.1	σ(Z1S, Z3S) = 0.1	σ(Z1S, Z4S) = 0.1	σ(Z1S, ZCS) = 0.1
	σ(Z2S, Z3S) = 0.1	σ(Z2S, Z4S) = 0.1	σ(Z2S, ZCS) = 0.1	σ(Z3S, Z4S) = 0.1
	σ(Z3S, ZCS) = 0.1	σ(Z4S, ZCS) = 0.1		
Wool Carbonising:	σ(ZCW, ZCB) = 0.1			
Wool Topmaking:	σ(Z2T, Z3T) = 0.1	σ(Z2T, Z4T) = 0.1	σ(Z2T, ZWT) = 0.1	σ(Z3T, Z4T) = 0.1
	σ(Z3T, ZWT) = 0.1	σ(Z4T, ZWT) = 0.1		
Wool Export:	σ(Z1W, ZNM) = 0.1	σ(Z2W, ZFM) = 0.1	σ(Z3W, ZMM) = 0.1	σ(Z4W, ZBM) = 0.1
	σ(FCW, FCB) = 0.1	σ(F1S, FNS) = 0.1	σ(F2S, FFS) = 0.1	σ(F3S, FMS) = 0.1
	σ(F4S, FBS) = 0.1	σ(F2T, FFT) = 0.1	σ(F3T, FMT) = 0.1	σ(F4T, FBT) = 0.1
	σ(FNW, FNE) = 0.1			
Lamb & Mutton Processing:	σ(Y1L, Y2L) = 5	σ(Y1L, Y3L) = 2	σ(Y1L, Y4L) = 5	σ(Y1L, Y5L) = 2
	σ(Y1L, Y6L) = 2	σ(Y1L, YSL) = 0.1	σ(Y2L, Y3L) = 2	σ(Y2L, Y4L) = 5
	σ(Y2L, Y5L) = 2	σ(Y2L, Y6L) = 2	σ(Y2L, YSL) = 0.1	σ(Y3L, Y4L) = 2
	σ(Y3L, Y5L) = 5	σ(Y3L, Y6L) = 5	σ(Y3L, YSL) = 0.1	σ(Y4L, Y5L) = 5
	σ(Y4L, Y6L) = 2	σ(Y4L, YSL) = 0.1	σ(Y5L, Y6L) = 5	σ(Y5L, YSL) = 0.1
	σ(Y6L, YSL) = 0.1	σ(Y1M, Y2M) = 5	σ(Y1M, Y3M) = 5	σ(Y1M, Y4M) = 5
	σ(Y1M, Y5M) = 5	σ(Y1M, Y6M) = 5	σ(Y1M, Y7M) = 5	σ(Y1M, Y8M) = 5
	σ(Y1M, Y9M) = 5	σ(Y1M, YSM) = 0.1	σ(Y2M, Y3M) = 0.1	σ(Y2M, Y4M) = 5

	σ(Y2M, Y5M) = 5	σ(Y2M, Y6M) = 5	σ(Y2M, Y7M) = 5	σ(Y2M, Y8M) = 5
	σ(Y2M, Y9M) = 5	σ(Y2M, YSM) = 0.1	σ(Y3M, Y4M) = 5	σ(Y3M, Y5M) = 5
	σ(Y3M, Y6M) = 5	σ(Y3M, Y7M) = 5	σ(Y3M, Y8M) = 5	σ(Y3M, Y9M) = 5
	σ(Y3M, YSM) = 0.1	σ(Y4M, Y5M) = 5	σ(Y4M, Y6M) = 5	σ(Y4M, Y7M) = 5
	σ(Y4M, Y8M) = 5	σ(Y4M, Y9M) = 5	σ(Y4M, YSM) = 0.1	σ(Y5M, Y6M) = 5
	σ(Y5M, Y7M) = 5	σ(Y5M, Y8M) = 5	σ(Y5M, Y9M) = 5	σ(Y5M, YSM) = 0.1
	σ(Y6M, Y7M) = 5	σ(Y6M, Y8M) = 5	σ(Y6M, Y9M) = 5	σ(Y6M, YSM) = 0.1
	σ(Y7M, Y8M) = 5	σ(Y7M, Y9M) = 5	σ(Y7M, YSM) = 0	σ(Y8M, Y9M) = 5
	σ(Y8M, YSM) = 0.1	σ(Y9M, YSM) = 0.1		
Lamb & Mutton Marketing:	σ(ZLE, Z1L) = 0.1	σ(ZLD, Z2L) = 0.1	σ(ZME, Z1M) = 0.1	σ(ZMD, Z2M) = 0.1
Product Transformation ***Farm Enterprises:***	τ(Y13W, Y14W)= -0.25	τ(Y13W, Y1L) = - 0.2	τ(Y13W, Y1M) = 0	τ(Y14W, Y1L) = - 0.2
	τ(Y14W, Y1M) = 0	τ(Y1L, Y1M) = 0	τ(Y21W, Y22W) = - 0.5	τ(Y21W, Y23W) = 0
	τ(Y21W, Y2L) = - 0.2	τ(Y21W, Y2M) = 0	τ(Y22W, Y23W)= -0.25	τ(Y22W, Y2L) = - 0.2
	τ(Y22W, Y2M) = 0	τ(Y23W, Y2L) = - 0.2	τ(Y23W, Y2M) = 0	τ(Y2L, Y2M) = 0
	τ(Y31W, Y32W) = - 0.5	τ(Y31W, Y33W) = 0	τ(Y31W, Y3L) = - 0.2	τ(Y31W, Y3M) = 0
	τ(Y32W, Y33W)= -0.25	τ(Y32W, Y3L)= - 0.2	τ(Y32W, Y3M)= 0	τ(Y33W, Y3L)= - 0.2
	τ(Y33W, Y3M) = 0	τ(Y3L, Y3M) = 0	τ(Y41W, Y42W) = - 0.5	τ(Y41W, Y43W) = 0
	τ(Y41W, Y4L) = - 0.2	τ(Y41W, Y4M) = 0	τ(Y42W, Y43W)= -0.25	τ(Y42W, Y4L)= - 0.2
	τ(Y42W, Y4M) = 0	τ(Y43W, Y4L) = - 0.2	τ(Y43W, Y4M) = 0	τ(Y4L, Y4M) = 0
	τ(Y51W, Y52W) = - 0.5	τ(Y51W, Y53W) = 0	τ(Y51W, Y5L) = - 0.2	τ(Y51W, Y5M) = 0
	τ(Y52W, Y53W)= -0.25	τ(Y52W, Y5L)= - 0.2	τ(Y52W, Y5M)= 0	τ(Y53W, Y5L)= - 0.2
	τ(Y53W, Y5M) = 0	τ(Y5L, Y5M) = 0	τ(Y61W, Y62W) = - 0.5	τ(Y61W, Y63W) = 0
	τ(Y61W, Y6L) = - 0.2	τ(Y61W, Y6M) = 0	τ(Y62W, Y63W)= -0.25	τ(Y62W, Y6L)= - 0.2
	τ(Y62W, Y6M) = 0	τ(Y63W, Y6L) = - 0.2	τ(Y63W, Y6M) = 0	τ(Y6L, Y6M) = 0
	τ(Y71W, Y72W)= - 0.5	τ(Y71W, Y73W)= 0	τ(Y71W, Y7E)= 0	τ(Y71W, Y7M)= 0
	τ(Y72W, Y73W)= -0.25	τ(Y72W, Y7E)= 0	τ(Y72W, Y7M)= 0	τ(Y73W, Y7E)= 0
	τ(Y73W, Y7M) = 0	τ(Y7E, Y7M) = - 1.8	τ(Y81W, Y82W) = - 0.5	τ(Y81W, Y83W) = 0
	τ(Y81W, Y8E) = 0	τ(Y81W, Y8M) = 0	τ(Y82W, Y83W)= -0.25	τ(Y82W, Y8E)= 0
	τ(Y82W, Y8M) = 0	τ(Y83W, Y8E) = 0	τ(Y83W, Y8M) = 0	τ(Y8E, Y7M) = - 1.8
	τ(Y91W, Y92W) = - 0.5	τ(Y91W, Y93W) = 0	τ(Y91W, Y9E) = 0	τ(Y91W, Y9M) = 0
	τ(Y92W, Y93W)= -0.25	τ(Y92W, Y9E)= 0	τ(Y92W, Y9M)= 0	τ(Y93W, Y9E)= 0
	τ(Y93W, Y9M) = 0	τ(Y9E, Y9M) = - 1.8		
Wool Warehouse:	τ(Z1W, Z1S) = -2	τ(Z2W, Z2S) = -2	τ(Z3W, Z3S) = -2	τ(Z4W, Z4S) = -2
Wool Scouring:	τ(F1S, F2S) = -0.1	τ(F1S, F3S) = -0.1	τ(F1S, F4S) = -0.1	τ(F1S, ZCW) = 0
	τ(F1S, Z2T) = -0.1	τ(F1S, Z3T) = -0.1	τ(F1S, Z4T) = -0.1	τ(F2S, F3S) = -0.1
	τ(F2S, F4S) = -0.1	τ(F2S, ZCW) = 0	τ(F2S, Z2T) = -2	τ(F2S, Z3T) = -0.1
	τ(F2S, Z4T) = -0.1	τ(F3S, F4S) = -0.1	τ(F3S, ZCW) = 0	τ(F3S, Z2T) = -0.1
	τ(F3S, Z3T) = -2	τ(F3S, Z4T) = -0.1	τ(F4S, ZCW) = -0.1	τ(F4S, Z2T) = -0.1
	τ(F4S, Z3T) = -0.1	τ(F4S, Z4T) = -2	τ(Z2T, ZCW) = 0	τ(Z2T, Z3T) = -0.1
	τ(Z2T, Z4T) = -0.1	τ(Z3T, ZCW) = 0	τ(Z3T, Z4T) = -0.1	τ(Z4T, ZCW) = 0
Wool Topmaking:	τ(F2T, F3T) = -0.1	τ(F2T, F4T) = -0.1	τ(F3T, F4T) = -0.1	τ(F2T, FNW) = 0
	τ(F2T, QDP) = -2	τ(F3T, FNW) = 0	τ(F3T, QDP) = -2	τ(F4T, FNW) = 0
	τ(F4T, QDP) = -2	τ(FNW, QDP) = -0.1		

Lamb & Mutton:	τ(ZLE, ZLD) = -0.5	τ(ZME, ZMD) = -1		
<u>Export Demand</u> ***Wool:***	η(Q1W, P1W) = -2	η(Q2W, P2W) = -1	η(Q3W, P3W) = -1.2	η(Q4W, P4W) = -1.9
	η(QcW, PcW) = -1.5	η(Q1S, P1S) = -2	η(Q2S, P2S) = -1	η(Q3S, P3S) = -1.2
	η(Q4S, P4S) = -1.9	η(Q2T, P2T) = -1.5	η(Q3T, P3T) = -1.5	η(Q4T, P4T) = -1.5
	η(QNW, PNW) = -1.5			
Lamb & Mutton:	η(QLE, PLE) = -2.5	η(QME, PME) = -5	η(QSE, PSE) = -2	
<u>Domestic Demand</u> ***Wool:***	η(QDP, PDP) = -1.5			
Lamb & Mutton:	η(QLD, PLD) = -1.5	η(QMD, PMD) = -1.4	η(QLD, PMD) = 0.13	η(QMD, PLD) = 0.82

3.4 Exogenous Shift Variables and Selected Scenarios

The model contains 42 exogenous supply shift variables and 19 exogenous demand shift variables. The supply shift variables represent the impacts of alternative research scenarios in various industry sectors and the demand shift variables represent successful promotion investment scenarios in different markets. Due to the size of the model, there are a large number of possible alternative investment scenarios. Consequently, the evaluation and comparison of alternative hypothetical investments in the sheepmeat and wool industries are limited to two scenarios. The first scenario examines a 1 per cent reduction in per unit costs of production resulting from a new technology and the second scenario evaluates a 1 per cent increase in consumers' willingness to pay. The costs involved to bring about the same 1 per cent shift in each of the scenarios are not taken into consideration.

Scenario 1 relates to a 1 per cent cost reduction in the production of lamb and is modelled as a vertical, parallel downward shift of the relevant supply curve. In each of the ewe enterprises in the model, lamb and wool are produced jointly by sharing a number of common inputs. Under the assumptions specified in Section 2.3.1, the total cost of inputs for each individual sector is equal to the total revenue of its outputs.[20] The cost of the sheep input was subtracted from the total value of output to derive the production cost of the other inputs group. An average per kg lamb production cost estimate for 2002-03 to 2004-05 of $2.68, obtained from the Holmes Sackett and Associates benchmarking database (D. Lee, Holmes Sackett and Associates per. comm. 2006), was multiplied by the volume of lamb production to obtain the cost of lamb production for each ewe enterprise. The cost of other inputs into wool production for each ewe enterprise was calculated as the difference between the cost of lamb production and the total cost of the other inputs group. The percentage shift in the supply of other inputs corresponding to a 1 per cent cost reduction in producing lamb was estimated as 1 per cent of the cost of lamb production divided by the total cost of the other inputs group. The following example

[20] The assumptions imply that the Australian sheep and wool industries are perfectly competitive. In all sectors, prices are assumed to equal marginal costs.

demonstrates the calculation of the percentage shift required for the non-Merino sheep enterprise in Scenario 1.

Sheep input cost (TV_{X1}) = \$45.14 m

Total output value (TV_{Y1}) = \$550.47 m

Other inputs cost (TV_{X1W}) = $TV_{Y1} - TV_{X1}$ = \$505.43 m

Lamb production cost (TV_{Y1L}) = Y_{1L} * \$2.68 = 120.60 kt * \$2.68 = \$323.21 m

1 per cent reduction in TV_{Y1L} = \$3.23 m

Required percentage shift (t_{X1W}) = TV_{Y1L} / TV_{X1W} = \$3.232 / \$505.43*100 = 0.639 per cent.

Scenario 2 simulates an increase in the ‘willingness to pay’ by export consumers of Australian greasy wool due to promotion or changes in taste in the overseas market. The exogenous change is modelled as a 1 per cent vertical, parallel upward shift of the relevant demand curve.

The two hypothetical scenarios are presented in Table 7. The $t_{(\ )}$ represent the size of the downward vertical shift of supply curve x as a percentage of the price of x. The $n_{(\ )}$ represent the size of the upward vertical shift of demand curve x as a percentage of the price of x.

Table 7: Selected hypothetical scenarios

Scenario 1: Lamb Production Research

t_{X1W} = -0.00639, t_{X21W} = -0.00451, t_{X31W} = -0.00127, t_{X41W} = -0.00503, t_{X51W} = -0.00237, t_{X61W} = -0.00216, rest $t_{(\ )}$ = 0, $n_{(\ )}$ = 0.

Cost reduction in lamb production resulting from any farm technology that reduces the cost of producing lambs. The technology applies to all non-Merino and Merino lambs produced for slaughter in all three agricultural zones.

Scenario 2: Greasy Wool Export Promotion

n_{Q1W} = 0.01, n_{Q2W} = 0.01, n_{Q3W} = 0.01, n_{Q4W} = 0.01, rest $t_{(\ )}$ = 0, $n_{(\ )}$ = 0.

Increase in the ‘willingness to pay’ by export consumers of greasy wool due to promotion or changes in taste in the overseas market.

The EDM approach calculates changes in producer and consumer welfare using economic surplus measures. The economic surplus change formulas used in the displacement model are listed in Table 8 and Table 9.

Table 8: Surplus change formulas for industry groups

<u>Factor Producer Surplus changes</u>

Sheep and Wool Producers

$$\Delta PS_{X1} = w_1^{(1)} X_1^{(1)} (Ew_1 - t_{X1})(1+0.5EX_1)$$
$$\Delta PS_{X1W} = w_{1W}^{(1)} X_{1W}^{(1)} (Ew_{1W} - t_{X1W})(1+0.5EX_{1W})$$
$$\Delta PS_{X23} = w_{23}^{(1)} X_{23}^{(1)} (Ew_{23} - t_{X23})(1+0.5EX_{23})$$
$$\Delta PS_{X21W} = w_{21W}^{(1)} X_{21W}^{(1)} (Ew_{21W} - t_{X21W})(1+0.5EX_{21W})$$
$$\Delta PS_{X31W} = w_{31W}^{(1)} X_{31W}^{(1)} (Ew_{31W} - t_{X31W})(1+0.5EX_{31W})$$
$$\Delta PS_{X45} = w_{45}^{(1)} X_{45}^{(1)} (Ew_{45} - t_{X45})(1+0.5EX_{45})$$
$$\Delta PS_{X41W} = w_{41W}^{(1)} X_{41W}^{(1)} (Ew_{41W} - t_{X41W})(1+0.5EX_{41W})$$
$$\Delta PS_{X51W} = w_{51W}^{(1)} X_{51W}^{(1)} (Ew_{51W} - t_{X51W})(1+0.5EX_{51W})$$
$$\Delta PS_{X61} = w_{61}^{(1)} X_{61}^{(1)} (Ew_{61} - t_{X61})(1+0.5EX_{61})$$
$$\Delta PS_{X61W} = w_{61W}^{(1)} X_{61W}^{(1)} (Ew_{61W} - t_{X61W})(1+0.5EX_{61W})$$
$$\Delta PS_{X71} = w_{71}^{(1)} X_{71}^{(1)} (Ew_{71} - t_{X71})(1+0.5EX_{71})$$
$$\Delta PS_{X71W} = w_{71W}^{(1)} X_{71W}^{(1)} (Ew_{71W} - t_{X71W})(1+0.5EX_{71W})$$
$$\Delta PS_{X81} = w_{81}^{(1)} X_{81}^{(1)} (Ew_{81} - t_{X81})(1+0.5EX_{81})$$
$$\Delta PS_{X81W} = w_{81W}^{(1)} X_{81W}^{(1)} (Ew_{81W} - t_{X81W})(1+0.5EX_{81W})$$
$$\Delta PS_{X91} = w_{91}^{(1)} X_{91}^{(1)} (Ew_{91} - t_{X91})(1+0.5EX_{91})$$
$$\Delta PS_{X91W} = w_{91W}^{(1)} X_{91W}^{(1)} (Ew_{91W} - t_{X91W})(1+0.5EX_{91W})$$

Wool Warehouse Sector

$$\Delta PS_{YNM} = v_{NM}^{(1)} Y_{NM}^{(1)} (Ev_{NM} - t_{YNM})(1+0.5EY_{NM})$$
$$\Delta PS_{YFM} = v_{FM}^{(1)} Y_{FM}^{(1)} (Ev_{FM} - t_{YFM})(1+0.5EY_{FM})$$
$$\Delta PS_{YMM} = v_{MM}^{(1)} Y_{MM}^{(1)} (Ev_{MM} - t_{YMM})(1+0.5EY_{MM})$$
$$\Delta PS_{YBM} = v_{BM}^{(1)} Y_{BM}^{(1)} (Ev_{BM} - t_{YBM})(1+0.5EY_{BM})$$

Domestic Wool Processors

$$\Delta PS_{ZCS} = u_{CS}^{(1)} Z_{CS}^{(1)} (Eu_{CS} - t_{ZCS})(1+0.5EZ_{CS})$$
$$\Delta PS_{ZCB} = u_{CB}^{(1)} Z_{CB}^{(1)} (Eu_{CB} - t_{ZCB})(1+0.5EZ_{CB})$$
$$\Delta PS_{ZWT} = u_{WT}^{(1)} Z_{WT}^{(1)} (Eu_{WT} - t_{ZWT})(1+0.5EZ_{WT})$$

Wool Exporters

$$\Delta PS_{ZNM} = u_{NM}^{(1)} Z_{NM}^{(1)} (Eu_{NM} - t_{ZNM})(1+0.5EZ_{NM})$$
$$\Delta PS_{ZFM} = u_{FM}^{(1)} Z_{FM}^{(1)} (Eu_{FM} - t_{ZFM})(1+0.5EZ_{FM})$$

$$\Delta PS_{ZMM} = u_{MM}{}^{(1)} Z_{MM}{}^{(1)} (Eu_{MM} - t_{ZMM})(1 + 0.5EZ_{MM})$$
$$\Delta PS_{ZBM} = u_{BM}{}^{(1)} Z_{BM}{}^{(1)} (Eu_{BM} - t_{ZBM})(1 + 0.5EZ_{BM})$$
$$\Delta PS_{FCB} = s_{CB}{}^{(1)} F_{CB}{}^{(1)} (Es_{CB} - t_{FCB})(1 + 0.5EF_{CB})$$
$$\Delta PS_{FNS} = s_{NS}{}^{(1)} F_{NS}{}^{(1)} (Es_{NS} - t_{FNS})(1 + 0.5EF_{NS})$$
$$\Delta PS_{FFS} = s_{FS}{}^{(1)} F_{FS}{}^{(1)} (Es_{FS} - t_{FFS})(1 + 0.5EF_{FS})$$
$$\Delta PS_{FMS} = s_{MS}{}^{(1)} F_{MS}{}^{(1)} (Es_{MS} - t_{FMS})(1 + 0.5EF_{MS})$$
$$\Delta PS_{FBS} = s_{BS}{}^{(1)} F_{BS}{}^{(1)} (Es_{BS} - t_{FBS})(1 + 0.5EF_{BS})$$
$$\Delta PS_{FFT} = s_{FT}{}^{(1)} F_{FT}{}^{(1)} (Es_{FT} - t_{FFT})(1 + 0.5EF_{FT})$$
$$\Delta PS_{FMT} = s_{MT}{}^{(1)} F_{MT}{}^{(1)} (Es_{MT} - t_{FMT})(1 + 0.5EF_{MT})$$
$$\Delta PS_{FBT} = s_{BT}{}^{(1)} F_{BT}{}^{(1)} (Es_{BT} - t_{FBT})(1 + 0.5EF_{BT})$$
$$\Delta PS_{FNE} = s_{NE}{}^{(1)} F_{NE}{}^{(1)} (Es_{NE} - t_{FNE})(1 + 0.5EF_{NE})$$

Sheepmeat Processors

$$\Delta PS_{YSL} = v_{SL}{}^{(1)} Y_{SL}{}^{(1)} (Ev_{SL} - t_{YSL})(1 + 0.5EY_{SL})$$
$$\Delta PS_{YSM} = v_{SM}{}^{(1)} Y_{SM}{}^{(1)} (Ev_{SM} - t_{YSM})(1 + 0.5EY_{SM})$$

Sheepmeat Exporters

$$\Delta PS_{Z1L} = u_{1L}{}^{(1)} Z_{1L}{}^{(1)} (Eu_{1L} - t_{Z1L})(1 + 0.5EZ_{1L})$$
$$\Delta PS_{Z1M} = u_{1M}{}^{(1)} Z_{1M}{}^{(1)} (Eu_{1M} - t_{Z1M})(1 + 0.5EZ_{1M})$$

Domestic Sheepmeat Retailers

$$\Delta PS_{Z2L} = u_{2L}{}^{(1)} Z_{2L}{}^{(1)} (Eu_{2L} - t_{Z2L})(1 + 0.5EZ_{2L})$$
$$\Delta PS_{Z2M} = u_{2M}{}^{(1)} Z_{2M}{}^{(1)} (Eu_{2M} - t_{Z2M})(1 + 0.5EZ_{2M})$$

Export Consumer Surplus Changes

Export Greasy Wool Consumers

$$\Delta CS_{Q1W} = p_{1W}{}^{(1)} Q_{1W}{}^{(1)} (n_{Q1W} - Ep_{1W})(1 + 0.5EQ_{1W})$$
$$\Delta CS_{Q2W} = p_{2W}{}^{(1)} Q_{2W}{}^{(1)} (n_{Q2W} - Ep_{2W})(1 + 0.5EQ_{2W})$$
$$\Delta CS_{Q3W} = p_{3W}{}^{(1)} Q_{3W}{}^{(1)} (n_{Q3W} - Ep_{3W})(1 + 0.5EQ_{3W})$$
$$\Delta CS_{Q4W} = p_{4W}{}^{(1)} Q_{4W}{}^{(1)} (n_{Q4W} - Ep_{4W})(1 + 0.5EQ_{4W})$$

Export Semi-processed Wool Consumers

$$\Delta CS_{QCW} = p_{CW}{}^{(1)} Q_{CW}{}^{(1)} (n_{QCW} - Ep_{CW})(1 + 0.5EQ_{CW})$$
$$\Delta CS_{Q1S} = p_{1S}{}^{(1)} Q_{1S}{}^{(1)} (n_{Q1S} - Ep_{1S})(1 + 0.5EQ_{1S})$$

$$\Delta CS_{Q2S} = p_{2S}{}^{(1)} Q_{2S}{}^{(1)} (n_{Q2S} - Ep_{2S})(1 + 0.5EQ_{2S})$$
$$\Delta CS_{Q3S} = p_{3S}{}^{(1)} Q_{3S}{}^{(1)} (n_{Q3S} - Ep_{3S})(1 + 0.5EQ_{3S})$$
$$\Delta CS_{Q4S} = p_{4S}{}^{(1)} Q_{4S}{}^{(1)} (n_{Q4S} - Ep_{4S})(1 + 0.5EQ_{4S})$$
$$\Delta CS_{QNW} = p_{NW}{}^{(1)} Q_{NW}{}^{(1)} (n_{QNW} - Ep_{NW})(1 + 0.5EQ_{NW})$$
$$\Delta CS_{Q2T} = p_{2T}{}^{(1)} Q_{2T}{}^{(1)} (n_{Q2T} - Ep_{2T})(1 + 0.5EQ_{2T})$$
$$\Delta CS_{Q3T} = p_{3T}{}^{(1)} Q_{3T}{}^{(1)} (n_{Q3T} - Ep_{3T})(1 + 0.5EQ_{3T})$$
$$\Delta CS_{Q4T} = p_{4T}{}^{(1)} Q_{4T}{}^{(1)} (n_{Q4T} - Ep_{4T})(1 + 0.5EQ_{4T})$$

Export Sheepmeat Consumers

$$\Delta CS_{QLE} = p_{LE}{}^{(1)} Q_{LE}{}^{(1)} (n_{QLE} - Ep_{LE})(1 + 0.5EQ_{LE})$$
$$\Delta CS_{QME} = p_{ME}{}^{(1)} Q_{ME}{}^{(1)} (n_{QME} - Ep_{ME})(1 + 0.5EQ_{ME})$$
$$\Delta CS_{QSE} = p_{SE}{}^{(1)} Q_{SE}{}^{(1)} (n_{QSE} - Ep_{SE})(1 + 0.5EQ_{SE})$$

<u>Domestic Consumer Surplus Changes</u>

Domestic Sheepmeat Consumers

$$\Delta CS_{QD} = p_{LD}{}^{(1)} Q_{LD}{}^{(1)} (n_{QLD} - Ep_{LD})(1 + 0.5EQ_{LD}) +$$
$$p_{MD}{}^{(1)} Q_{MD}{}^{(1)} (n_{QMD} - Ep_{MD})(1 + 0.5EQ_{MD})$$

Domestic Semi-processed Wool Consumers

$$\Delta CS_{QDP} = p_{DP}{}^{(1)} Q_{DP}{}^{(1)} (n_{QDP} - Ep_{DP})(1 + 0.5EQ_{DP})$$

Table 9: Total surplus change formulas

Scenario 1	$\Delta TS_{X1W} = -w_{1W}^{(1)} X_{1W}^{(1)} t_{X1W}(1+0.5EX_{1W})$ $\Delta TS_{X21W} = -w_{21W}^{(1)} X_{21W}^{(1)} t_{X21W}(1+0.5EX_{21W})$ $\Delta TS_{X31W} = -w_{31W}^{(1)} X_{31W}^{(1)} t_{X31W}(1+0.5EX_{31W})$ $\Delta TS_{X41W} = -w_{41W}^{(1)} X_{41W}^{(1)} t_{X41W}(1+0.5EX_{41W})$ $\Delta TS_{X51W} = -w_{51W}^{(1)} X_{51W}^{(1)} t_{X51W}(1+0.5EX_{51W})$ $\Delta TS_{X61W} = -w_{61W}^{(1)} X_{61W}^{(1)} t_{X61W}(1+0.5EX_{61W})$ $\Delta TS_{X1-6} = \sum_{i=X1W-X61W} \Delta PS_i$
Scenario 2	$\Delta TS_{Q1W} = p_{1W}^{(1)} Q_{1W}^{(1)} n_{Q1W}(1+0.5EQ_{1W})$ $\Delta TS_{Q2W} = p_{2W}^{(1)} Q_{2W}^{(1)} n_{Q2W}(1+0.5EQ_{2W})$ $\Delta TS_{Q3W} = p_{3W}^{(1)} Q_{3W}^{(1)} n_{Q3W}(1+0.5EQ_{3W})$ $\Delta TS_{Q4W} = p_{4W}^{(1)} Q_{4W}^{(1)} n_{Q4W}(1+0.5EQ_{4W})$ $\Delta TS_{Q} = \sum_{i=Q1W-Q4W} \Delta PS_i$

Source: Zhao *et al*. (2000)

4 Results

4.1 Introduction

The economic surplus changes for each of the hypothetical scenarios listed in Table 7 are presented in this chapter. Based on the 2002-03 to 2004-05 data specified in Table 2, and the market parameter values specified in Table 6, each scenario is simulated individually in the equilibrium displacement model. In Scenario 1, the exogenous change representing a 1 per cent reduction in the cost per unit of production from a new technology is modelled as a parallel downward shift in supply. A parallel upward shift in demand in Scenario 2 represents a 1 per cent increase in consumers' willingness to pay. From the resulting price and quantity percentage changes, the total economic surplus changes and their distribution among various industry sectors are estimated for each scenario using the formulas from Tables 8 and 9.

Zhao, Mullen and Griffith (1997, p.1250) demonstrated the conditions under which EDM results are exact. Their results showed that when these conditions are not met in empirical applications, the errors are small for a small parallel initial shift. In EDM analysis when information on actual shift sizes is unknown, 1 per cent shifts are typically simulated in the demand or supply curves in the relevant market. However, shifts in the order of 10 per cent can still be considered small in measuring the displacement effects of finite changes in exogenous variables (Piggott 1992).

An important point to note is that comparative static models, such as EDMs, compare two equilibrium situations, before and after a change. They do not consider the time path of responses to new technologies or promotions before a new equilibrium is reached. Therefore, potential annual returns estimated from the model assume immediate and full adoption of new technologies or promotions, after the markets regain equilibrium.[21]

Analyses and discussion of the two hypothetical scenarios are provided in Section 4.2 to assist in the explanation of output generated from the model and the adjustment to a new equilibrium after the initial displacement from an exogenous shock. The economic surplus changes in millions of dollars and the percentage shares of the total surplus changes accruing to the various industry sectors for the two scenarios are listed in Table 10. In Section 4.3, the two hypothetical scenarios are compared allowing for inferences relevant to policy and decision-making to be drawn from the results. Some general comments and qualifications regarding the results are also provided

4.2 Analysis of Selected Scenarios

Quantities of sheep in each enterprise within the model are specified in kt carcass weight. Therefore, any discussion involving percentage increases or decreases in sheep numbers or quantities refer to percentage increases or decreases in the total kt carcass weight volume of those enterprises. As there are 295 endogenous variables in the model,

[21] Evaluation of investments requires consideration of benefit and cost flows over time. Once known, additional information such as investment costs, investment efficiency and adoption profiles can enable complete benefit-cost analyses to be undertaken.

reporting the individual percentage changes in prices and quantities for each of the scenarios is a tedious task. For this reason, only the directions of the changes are noted in the following discussions and the actual percentage changes are not listed. In response to the 1 per cent exogenous supply or demand curve shifts in the various scenarios, price and quantity changes range in magnitude from 0.01 per cent to 0.84 per cent.

4.2.1 Lamb Production Research: Scenario 1

In this scenario, any new technology that successfully reduces the cost of prime lamb production by 1 per cent is simulated. This corresponds to downward shifts of the supply curves for inputs into lamb production (X_{1W} and X_{21W} – X_{61W}) in each of the lamb-producing enterprises.[22]

As a result of the new technology the supply curves of lambs produced from each enterprise are shifted down. These upward sloping supply curves intersect with downward sloping lamb demand curves to result in new equilibrium positions, increasing the quantities of lamb produced (Y_{1L}-Y_{6L}) and decreasing the sale yard price of lamb. The reduced cost of lamb production also shifts down the supply curves of all lamb products in downstream sectors, decreasing prices and increasing quantities demanded of wholesale lamb carcass (Z_{LD} and Z_{LE}) and domestic and export lamb products (Q_{LD} and Q_{LE}).

The lower domestic retail price of lamb increases the domestic quantity of lamb demanded (Q_{LD}) and decreases the domestic demand for mutton (Q_{MD}). The domestic retail mutton price falls, as does the quantity of mutton supplied in the domestic market. Overall, the domestic retail price of lamb declines and consumption of lamb in the domestic market increases. In the export markets, the supply curves for lamb (Q_{LE}) and mutton (Q_{ME}) are shifted down, decreasing the export lamb and mutton prices and increasing the quantities of lamb and mutton exports demanded.

Increased consumption of lamb shifts up the derived demand curves for live lamb (Y_{1L}-Y_{6L}) and lamb carcasses (Z_{LD} and Z_{LE}) while substitution effects among lambs from different enterprises and zones within the model also shift the demand and supply curves for live lambs (Y_{1L}-Y_{6L}). Results indicate that downward supply shifts dominate with increased quantities of lamb and decreased prices in these markets.

The demand curves for other inputs into the lamb processing and marketing sectors (Y_{SL}, Z_{1L} and Z_{2L}) are shifted up due to the increased consumption of lamb. Conversely, as a consequence of lower lamb and lamb carcass input prices, substitution possibilities between lamb and other inputs decrease the demand for other inputs. However, as small values are assumed for substitution elasticities between lamb and other inputs in the model, the increase in demand from increased consumption outweighs the decrease in demand due to the substitution effects. Hence, the demand for other inputs increases but by less than would be the case under the assumption of fixed input proportions (Zhao 1999, p.146). The quantities of other inputs supplied (Y_{SL}, Z_{1L} and Z_{2L}), and their prices, increase. There are also increases in the derived demands for breeding ewes following the

[22] Not all input supply functions would necessarily have to move downward. An overall 1 per cent cost reduction might also be achieved by downward shifts of selected supply functions by more than 1 per cent.

upward shifts in demand for lambs. The percentage increases in the quantity of non-Merino ewes supplied (X_1) and the quantities supplied of Merino ewes joined to non-Merino rams (X_{21} and X_{41}) are larger than the percentage increases in the quantities supplied of Merino ewes joined to Merino rams (X_{31}, X_{51} and X_{61}). With the increases in ewe numbers there are associated increases in the supply of wool and the supply of mutton from these enterprises.

Due to the substitution possibilities in the model among enterprises and zones, wool and mutton production from the dry sheep enterprises decreases in response to the increased profitability of lamb production, relative to wool production. The quantities of wool and mutton supplied from the dry sheep enterprises fall and there is also a small reduction in the quantity supplied of live sheep exports. The demand curves for wethers and hoggets in each agricultural zone (X_{71}, X_{81} and X_{91}) are also shifted down, as are the demand curves of other inputs into these enterprises. Prices and quantities of other inputs supplied in these markets are reduced.

Given the increases in numbers of ewes there is an overall increase in the quantity of mutton produced. As mentioned above, mutton destined for the export market increases while there is a slight decrease in mutton delivered to the domestic market. Corresponding to the increase in the supply of export mutton is an increase in demand for other inputs into export marketing of mutton, increasing the price and quantity supplied of inputs in that sector. There is a decrease in demand for other inputs in the domestic mutton-marketing sector, decreasing the price and quantity supplied of those inputs.

Shorn wool production in all four micron categories increases, resulting in downward shifts in supply in the greasy wool export markets. Greasy wool export prices fall and the quantities demanded of all greasy wool exports (Q_{2W}, Q_{3W}, Q_{4W} and Q_{1W}) increase.

Small supply increases are also recorded for all four categories of wool used in early-stage domestic processing (Z_{1S}, Z_{2S}, Z_{3S} and Z_{4S}) with reductions in price accompanied by increased quantities demanded. The increases in the supplies of greasy wool increase the demand for other inputs in the export wool shipment sectors and the domestic wool scouring, carbonising and topmaking sectors. Prices and quantities supplied increase in each of these sectors. Corresponding with small downward movements in export prices there are increased quantities demanded of all domestically processed wool (Q_{CW}, Q_{1S}-Q_{4S}, Q_{NW} and Q_{2T}-Q_{4T}).

The changes in economic surplus for Scenario 1 are listed in Table 10. Under the assumption of immediate and full industry-wide adoption of the new technology by lamb producers, the potential total annual economic surplus gains from a 1 per cent reduction in lamb production costs are estimated as $9.23 million. Lamb-producing enterprises gain $2.59 million but, of this amount, $0.40 million is generated at the expense of the dry sheep enterprises where levels of production are reduced. Hence, overall, sheep and wool producers receive around one quarter of the total benefits.

Domestic consumers benefit from a lower retail price for lamb, receiving a little under one third of the total benefits. Overseas consumers gain a similar amount, with approximately two thirds attributed to purchasers of greasy and processed wool and one third accruing to overseas consumers of Australian lamb and mutton. Domestic sheepmeat processors (abattoirs) and retailers (butchers and supermarkets) share 13 per cent of the additional surplus with the remaining 1 per cent distributed throughout the other industry sectors.

4.2.2 Greasy Wool Export Promotion: Scenario 2

Export market promotion of greasy wool is simulated as a 1 per cent parallel upward shift in the export demand curves for greasy wool (Q_{1W}, Q_{2W}, Q_{3W} and Q_{4W}). The increased demands and higher prices increase the derived demands upstream for greasy wool and sheep. In all enterprises, increased quantities of sheep supplied generate higher levels of wool production. The supply curves for greasy wool are shifted down, as are the supply curves for wool in the downstream markets. However, the upward demand curve shifts in the greasy wool export markets are greater than the downward supply curve shifts. Consequently, greasy wool export prices and greasy wool export quantities increase.

Also on the supply side there is a decrease in the supply of greasy wool used in the domestic wool-processing sector in response to the higher greasy wool prices in the export markets. The transformation possibilities in the base model reflect the ease of transferring wool between the two markets. The supply curves for wool in the downstream wool-processing sectors and markets are also shifted up, increasing processed wool export prices and leading to reductions in the quantities of processed wool exports demanded.

Higher prices and increases in the quantities of other inputs supplied into the wool-warehousing sector are associated with upward shifts in the derived demand curves in those markets. Likewise, increases in the derived demands for other inputs into the greasy wool export shipment sectors deliver higher prices and quantities supplied of those inputs. The decrease in the supply of wool to the domestic wool processing sectors leads to downward shifts in the derived demand curves for other inputs in those sectors causing prices and quantities supplied of those inputs to fall.

As a result of higher sheep numbers there are increases in the supply of lamb and mutton. An increase in the supply of export lamb reduces the lamb export price and increases the quantity of lamb exports demanded. The quantity of mutton exports demanded increase following a reduction in the export mutton price from an increase in the supply of mutton. After a new equilibrium is reached in the domestic market, there is fall in price and an increase in the quantity of lamb demanded. The quantity of mutton demanded in the domestic market increases and the domestic retail mutton price falls.

Whereas domestic consumers were the recipients of a substantial share of total returns in the domestic lamb promotion scenario, successful export promotion of greasy wool provides overseas consumers with the largest share of benefits. Sheep and wool producers receive a one-third share of the gains with domestic consumers benefiting little.

Table 10: Economic surplus changes ($ million) and distribution of total surplus changes (%) to various industry sectors

	Scenario 1		Scenario 2	
Producers	**$m**	**%**	**$m**	**%**
ΔPS_{X1}	0.91	9.85	0.22	1.00
ΔPS_{X21}	0.30	3.28	0.27	1.23
ΔPS_{X31}	0.14	1.48	1.05	4.76
ΔPS_{X41}	0.66	7.16	0.40	1.82
ΔPS_{X51}	0.46	4.98	1.45	6.55
ΔPS_{X61}	0.12	1.25	0.35	1.56
ΔPS_{X71}	-0.15	-1.63	1.69	7.64
ΔPS_{X81}	-0.20	-2.17	1.60	7.26
ΔPS_{X91}	-0.05	-0.49	0.31	1.44
Subtotal: ΔPS_{X}	2.19	23.72	7.36	33.28
Wool Warehouse/Brokers ΔPS_{YW}	0.04	0.41	0.21	0.94
Wool Processors				
ΔPS_{ZW}	0.05	0.55	-0.09	-0.43
Wool Exporters				
ΔPS_{ZWF}	0.05	0.51	0.25	1.11
Sheepmeat Processors				
ΔPS_{YS}	0.71	7.64	0.52	2.36
Sheepmeat Exporters				
ΔPS_{Z1}	0.02	0.21	0.03	0.12
Domestic Sheepmeat Retailers ΔPS_{Z2}	0.51	5.51	0.27	1.22
Overseas Consumers				
ΔCS_{QGW}	1.54	16.70	11.23	50.77
ΔCS_{QPW}	0.36	3.92	-0.67	-3.05
ΔCS_{QLE}	0.90	9.70	0.39	1.76
ΔCS_{QME}	0.08	0.91	0.35	1.57
ΔCS_{QSE}	-0.06	-0.60	0.61	2.79
Subtotal: ΔCS_{QE}	2.83	30.63	11.91	53.84
Domestic Consumers				
ΔCS_{QD}	2.85	30.82	1.67	7.56
Total Surplus	**9.23**	**100**	**22.11**	**100**

4.3 Comparison of Economic Surplus Changes

4.3.1 Distribution of Welfare Gains: Scenario 1

In general, as overseas demand for Australian lamb is more elastic than domestic demand, surplus gains for domestic consumers should be considerably larger than those received by overseas consumers. Although domestic consumers are the main beneficiaries in Scenario 1, the proportion of total benefits collected by overseas consumers is also significant. Due to the joint nature of wool and lamb production, the supply of wool increases in conjunction with increased lamb production, leading to an expansion in the supply of wool exports. Purchasers of Australian greasy and processed wool are the recipients of 67.0 per cent of the additional surplus gained by overseas consumers, highlighting the importance of accounting for joint-product relationships in the analyses.

Sheep and wool producers receive a little less than one quarter of the total benefits in Scenario 1. Taking into consideration that the dry sheep enterprises experience negative surplus changes in response to the lamb industry research investment, lamb-producing enterprises actually receive 28.0 per cent of the total returns. The fact that it is possible for some enterprises to experience a loss of surplus in response to alternative investments reinforces the argument for the inclusion of the multiple components of the sheep and wool industries in the analyses.

Other industry sectors to benefit are the domestic sheepmeat processing and retail sectors, each obtaining moderate gains, while the benefit shares received by the wool warehouse/brokerage, domestic wool processing, wool export and sheepmeat export sectors are all negligible.

4.3.2 Distribution of Welfare Gains: Scenario 2

As the majority of Australian wool is exported in greasy or semi-processed form, overseas consumers gain the majority share of the total returns from export promotion of greasy wool in Scenario 2. Buyers of greasy or semi-processed wool acquire upwards of 85 per cent of the benefits going abroad. Domestic consumers receive a much smaller share of the total benefits from the wool-related investment. As the supply of wool increases in response to the promotion investment, the supply of lamb also increases. The additional surplus gains received by domestic consumers are mainly the outcome of lower retail prices for lamb resulting from an increase in the supply of lamb.

Unlike the lamb-specific investment where some of the additional surplus gains accruing to lamb-producing enterprises are transferred from the dry sheep enterprises, the wool-specific investment delivers gains to all sheep enterprises in the model. Approximately one third of the total returns to the industry are captured by sheep and wool producers.

Given the transformation possibilities in the model, domestic wool processors suffer a small loss from successful promotion of greasy wool exports. In each of the other industry sectors the total benefit shares received are less than 3 per cent. Price-elastic supplies of inputs and small value added to products restrict the total benefit shares in these sectors.[23]

4.3.3 General Comments about the Results

A number of qualifications need to be stated. The results are derived from hypothetical 1 per cent exogenous shifts in the relevant sector demand or supply curves. The costs involved in implementing the equal 1 per cent shifts are not taken into consideration. Therefore, the size of the market in which the shift occurs governs the size of the total welfare change.[24] In other words, a 1 per cent shift in a market with high gross revenue will provide larger total returns than a 1 per cent shift in a market with low gross revenue. As such, comparison of the monetary returns from different scenarios can only be made under the assumption that the investment costs required to implement the equal demand or supply curve shifts are the same in each sector. To demonstrate, if the monetary investments in lamb production research and greasy wool promotion were identical (equal $ investment induces equal % shift) sheep and wool producers, as a whole, would prefer greasy wool promotion ($7.36 million) to lamb production research ($2.19 million). For sheep and wool producers to be indifferent as to where the funds are directed, investment in lamb production research would need to be approximately 236 per cent more efficient in generating benefits than investment in greasy wool promotion (7.36/2.19 = 3.36). In other words, the size of the percentage shift necessary to generate the same returns to producers from lamb production research, as from a 1 per cent increase in the demand for export greasy wool, would be 3.36 per cent. Similarly, the size of the percentage shift necessary to generate the same total returns from lamb production research, as from a 1 per cent increase in the 'willingness to pay' by overseas purchasers of Australian greasy wool, would be 2.40 per cent ($22.11m/$9.23m = 2.40).

In terms of monetary gains, which investment scenario should be preferred over another depends on the costs required to shift the demand or supply curves in the relevant market. Hence, as already discussed, the rankings among alternative scenarios are only comparable under the assumption of equal investment efficiency. However, even without knowledge of the investment costs, the distributions of total benefits among industry sectors from alternative scenarios are directly comparable. The same amount of money invested in different industry sectors may result in demand or supply shifts of unequal size but the distribution of total benefits among industry sectors for a particular scenario is independent of the magnitude of the initial shift (Zhao 1999, p160). For example, the producers' share of the total benefits from lamb production research (23.7 per cent in Scenario 1) is the same irrespective of the size of the percentage reduction in the cost of producing lamb. Therefore, a ranking of scenarios based on total benefit shares is valid regardless of information on the costs involved in bringing about the 1 per cent shifts in demand or supply.

A more detailed comparison of these and other sheep industry investment scenarios is given in Mounter *et al*. (2007b).

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[23] With relatively elastic supply the changes in producer surplus are smaller than with inelastic supply as the changes in price are smaller.

[24] Issues of efficiency and the consideration of investment costs have received attention in previous studies including Lemieux and Wohlgenant (1989), Scobie, Mullen and Alston (1991), Mullen and Cox (1995) and Cox, Mullen and Hu (1997).

5 Conclusions, Limitations and Areas for Further Research

5.1 Review and Conclusions of the Study

The Australian sheep and wool industries are characterised by significant cross-commodity relationships. Economic evaluations of research and promotion investments undertaken in the industries should account for any indirect benefits and costs arising from spill-over and feedback effects between the industries. However, industry models to date have largely failed to consider cross-product relationships with related industries. Australian sheep and wool producers make significant contributions to research and promotion via compulsory levies on wool and livestock sales. Ignoring indirect effects may have important policy implications for ways in which investment funds are collected and distributed.

The Australian sheep and wool industries have undergone considerable structural change in recent years, but despite higher prices received for lamb and mutton production, Australian sheep producers' terms of trade have continued to fall. The lower profitability, reflected by the declining terms of trade, can be alleviated by the adoption of new technologies that lead to industry gains in productivity. Domestic or export promotions that successfully increase demand also deliver increased industry returns, but whether levy funds should be directed to R&D or promotion, and to which industry sector or market, has always been a contentious issue. Knowing the potential size and distribution of returns from alternative research and promotion investments across different sectors is a valuable aid in assisting decisions of resource allocations.

An equilibrium displacement model, developed in this Report, is capable of providing such assistance to the Australian sheep and wool industries. Included in the model are the multiple components of the Australian sheep and wool industries, which allows for more realistic representation of the industries' structure, improving the accuracy of economic analysis. The industries are horizontally disaggregated, by agricultural zone, into Merino sheep and non-Merino sheep enterprises producing wool, lamb, mutton and sheep for live export. Vertical disaggregation of the wool industry includes the warehousing, export and Australian early-stage wool processing sectors. Vertical disaggregation of the sheepmeat industry consists of processing and marketing sectors. The extent of industry disaggregation in the model not only enables the distribution of potential benefits among the various industry sectors to be estimated, but it also allows for the evaluation of investments specific to one commodity or agricultural zone. This has particular relevance to R&D investments where adoption of new technologies may be constrained by region.

The model was specified as a system of demand and supply equations in general functional form. Base prices and quantities were used to define an initial equilibrium and the impact of any exogenous changes to the system, such as new technologies or promotion campaigns, were modelled as shifts in demand or supply from that initial equilibrium. The changes in market prices and quantities enabled changes in producer and consumer surpluses to be calculated as measures of welfare changes in each of the various industry sectors. The base equilibrium values used in the model are representative of average annual prices and quantities for the three-year period 2002-03 to 2004-05. The responsiveness of producers and consumers to changes in market prices were simulated using market elasticities. Many of these values had to be specified using subjective judgments as empirical estimates were often scarce or non-existent. The model of the Australian sheep and wool industries consists of 295 endogenous variables and 61 exogenous variables. In the interest of brevity, the number of hypothetical investment simulations was limited to one research and one promotion scenario. In each instance, 1 per cent exogenous parallel shifts in the relevant market demand or supply curves were modelled.

5.2 Comparison of the Investment Scenarios

In terms of absolute monetary gains, the results, summarised in Table 10, indicated that the largest total returns of the two hypothetical scenarios were from greasy wool promotion (Scenario 2). This is because gross revenues in those markets are the largest in the model and, without knowledge of investment costs, the size of the market in which the 1 per cent shift occurs governs the size of the total welfare change. Therefore, the comparison of the monetary returns from the different scenarios can only be made under the assumption of equal investment efficiency. That is, the investment costs required to implement the equal demand or supply curve shifts are the same in each sector.

However, as discussed in Section 4.3.3, even without information on the costs involved in bringing about the 1 per cent shifts in demand or supply, the distributions of total benefits among industry sectors from alternative scenarios are comparable. The main gains from the lamb-specific scenario accrue to domestic consumers (30.8 per cent). However, overseas consumers also receive a substantial share of the total benefits (30.6 per cent). In conjunction with increased lamb production there is an increase in the supply of wool that delivers benefits to overseas purchasers of Australian wool in the form of lower prices. The results emphasise the importance of accounting for joint-product relationships in the analyses. Australian sheep and wool producers receive 23.7 per cent of the returns while domestic sheepmeat processors and retailers also gain significant shares (7.6 per cent and 5.5 per cent, respectively).

Scenario 2 relates to a hypothetical wool promotion investment. The majority of the returns accrue to overseas consumers (53.8 per cent), as the bulk of Australian wool is exported. Domestic consumers receive a much smaller share of the total benefits (7.5 per cent) than those gained in the lamb-specific investment scenario, mostly as a result of lower retail prices from an increase in the supply of lamb. Sheep and wool producers gain one third of the total returns (33.3 per cent) while gains to each of the other industry sectors are minimal.

5.3 Limitations and Further Research

5.3.1 Partial Equilibrium Analysis

The EDM specified in this study only captures the partial equilibrium effects within the Australian sheep and wool industries. The *ceteris paribus* assumption (holding everything else constant) applies to all other market prices and quantities of goods and services not included in the model. Therefore, any feedback or spillover effects to and from other industries are not accounted for in the analysis. In Australia, sheep and wool production competes with other grazing and cropping enterprises. The relative profitability of each determines the enterprise mix on Australian broadacre farms. Sheep and wool products are also substitutes in demand with products from other industries. For example, meats such as beef, pork and chicken are considered substitutes for lamb in consumption, while wool competes with synthetic and other fibre types in apparel markets. New technologies or promotions in the sheep and wool industries will impact on other related industries, and new technologies or promotions in other industries will impact on the sheep and wool industries. In fact, promotions or adoption of new technologies are likely to occur in related industries at the same time, or occur as a response to innovation or promotion in another industry.

A more general equilibrium model of the economy would enable the inclusion of other industries and their interactions with the Australian sheep and wool industries, but the additional data and resources required to develop such a complex model are beyond the scope of this study. As noted by Alston *et al*. (1995, p.80), computable general equilibrium (CGE) models have been developed but the agricultural sectors in such models are usually much more aggregated than is desirable for agricultural research evaluation and priority setting.[25] In addition to the economy-wide impacts, spillover effects to other countries are not considered in the EDM for reasons mentioned above. However, spillover effects among Australia's three agricultural zones can be accommodated in the model.[26]

A more economy-wide EDM poses additional considerations. Additional complications are associated with economic surplus calculations in EDM when more than two sources of equilibrium feedback exist in the analysis. The inclusion of more industries in the model would make the estimation of welfare changes difficult. Analytical approaches for measuring the impacts of technical changes and promotions involving the explicit specification of profit and expenditure functions have been used by Martin and Alston (1994) and Alston, Chalfant and Piggott (1999) to examine the interaction between industries. Zhao's (1999, p.230) suggestion of a two-stage approach using both frameworks, to incorporate the interactions between the sheep and wool industry and other industries into the analyses, might be a logical next step towards a more complete evaluation procedure.

5.3.2 Market Structure Assumptions

Previous studies (for example, Huang and Sexton 1996; Alston, Sexton and Zhang 1996) have indicated that the magnitude and distribution of benefits from imperfectly competitive market structures differ from those derived under perfect competition. The results in this study are based on the assumption that the Australian sheep and wool industries are perfectly competitive. In all sectors, prices are assumed to equal marginal costs.

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[25] One such CGE model of the Australian economy is ORANI. See Dixon *et al*. (1997). An EDM of Australian broadacre agriculture is currently being developed under an ARC Linkage Project by Associate Professor Xueyan Zhao and Professor Keith McLaren of Monash University.

[26] It is possible to estimate international spillover effects using a model such as DREAM but the evaluations are restricted to single commodity analysis. Also, the distributions of welfare changes among industry sectors cannot be estimated using DREAM.

A number of studies have examined market behaviour in the Australian sheep and wool industries. Empirical results by Zhao, Griffith and Mullen (1996) show that the Australian lamb industry exhibited competitive pricing patterns in the domestic market. A further study by Griffith (2000) determined that all Australian domestic meat markets were competitive. In analysing the structure of the wool-buying industry, Hansen and Simmons (1995) found evidence that, rather than displaying the characteristics of a monopoly, the industry structure was more a type of "price leadership with a few dominant firms competing with a number of smaller firms". Simmons and Hansen (2003) added that under-pricing by large firms was unlikely to occur due to the competition from smaller firms. Thus, perfectly competitive behaviour in the Australian sheep and wool industries seems a plausible assumption, though one perhaps less important than initially thought. Wohlgenant and Piggott (2003) examined the relative importance of market power (in the output market) on the distribution of gains from promotion and research on producers. Contrary to earlier studies, they found little difference in the results between market power and perfect competition.

5.3.3 Comparative Static Analysis

The EDM approach used in this study is a comparative static approach in that two equilibriums positions are compared, before and after a change. In reality, time lags exist between the commencement of research, full adoption and eventual disadoption of a technology. Likewise, adjustment periods are associated with promotion investments. Because of its comparative static nature, the EDM approach ignores the path of adjustment from an initial equilibrium position to a new equilibrium position. As such, the shifts in the demand or supply curves representing the impacts of new technologies or promotions are assumed to be instantaneous and the annual flows of benefits are indicative of the returns assuming full adoption and complete market adjustment. In this study, a medium-run time frame is assumed for the industry to adjust to a new equilibrium after an exogenous shock. The estimated welfare gains are the annual benefits generated after the new equilibrium has been obtained.

Typically, the flow of benefits begins once the adoption phase commences and gradually increases over time until full adoption is reached. Conversely, the majority of the investments costs are usually incurred early in the research and development phase. Just, Hueth and Schmitz (1982) demonstrated the correct measurement of welfare changes for the years after the initial exogenous shock and prior to the attainment of a new equilibrium. The benefits during the adjustment period can be simulated in EDM through repeated applications using elasticity values representing different variable lengths of run (Piggott 1992). Although this circumvents the static nature of the model to some degree, the procedure is less than ideal. Incorporating dynamic responses into EDM analyses is an area of further empirical work.

5.3.4 Additional Qualifications

A few other qualifications need to be kept in mind. The focus of the EDM is on the welfare impacts within the Australian sheep and wool industries and the more general equilibrium interactions with other industries are excluded from the analyses. Similarly, any environmental or social impacts are unaccounted for in the welfare measurements.

An additional area of research relates to exogenous factor supplies. In each industry sector in the model, inputs other than the wool or sheepmeat products are classified as an aggregate group. Elasticity estimates for each input group are specified according to the perceived responsiveness of input factors in that group to changes in their own price. The supply of factor inputs in some industry sectors is more elastic than in other sectors, the determination of which is governed by assumptions about the mobility or specialisation of the factors in each industry sector. For example, the wool-processing sector is capital-intensive, requiring highly specialised equipment. Therefore, the own-price elasticity of supply for those inputs is less elastic than the own-price elasticity of supply for inputs in the sheepmeat-processing sector where more labour is utilised. Zhao *et al*. (2003) separated inputs in the winemaking industry into capital and mobile factors. Similar extensions to this model could be made with detailed information on the cost structures of each industry sector.

The potential annual benefits to the Australian sheep and wool industries were estimated for two hypothetical investment scenarios, but monetary comparisons among investments can only be made under assumptions of equal investment efficiency. For complete analysis, information on the costs of alternative investments is also needed. An entire evaluation procedure can be constructed by using other modelling methods in combination with EDM (Alston et *al*. 1995). The amounts of the initial shifts in demand or supply can be estimated using econometric or mathematical programming models (e.g. Griffith *et al*. 1995) while net present values and benefit-cost ratios can be calculated using spreadsheet benefit-cost analysis or software packages such as DREAM (Griffith *et al*. 2007).

5.4 Final Comments

The model developed in this study provides a consistent framework to estimate and compare the potential impacts from new technologies, generic promotions and other industry changes. Due to the extent of industry disaggregation, not present in previous models, it also allows for identification of the potential benefits accruing to the various industry sectors and groups. Although needing numerous prices and quantities as inputs, the model is not overtaxing on data requirements, as are econometric models. It can be updated with relative ease, as most of the necessary price and quantity data are readily available from government departments and industry organisations. The model is applicable for use in *ex ante* evaluations, as a means of assisting decisions of priority setting and resource allocations, and in *ex post* evaluations of actual investments or policy impacts. The inclusion of the multiple sheep and wool industry components enhances the accuracy of economic analysis, making the model a valuable tool to assist in industry policy and decision-making.

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Appendix 1. The Equilibrium Displacement Model

The model in equilibrium displacement form

Input supply to farm enterprises

(A2.1) $EX_1 = \varepsilon_{(X1, W1)}(Ew_1 - t_{X1})$

(A2.2) $EX_{1W} = \varepsilon_{(X1W, W1W)}(Ew_{1W} - t_{X1W})$

(A2.3) $EX_{23} = \varepsilon_{(X23, W23)}(Ew_{23} - t_{X23})$

(A2.4) $EX_{21W} = \varepsilon_{(X21W, W21W)}(Ew_{21W} - t_{X21W})$

(A2.5) $EX_{31W} = \varepsilon_{(X31W, W31W)}(Ew_{31W} - t_{X31W})$

(A2.6) $EX_{23} = \beta_{X21}EX_{21} + \beta_{X31}EX_{31}$

(A2.7) $EX_{45} = \varepsilon_{(X45, W45)}(Ew_{45} - t_{X45})$

(A2.8) $EX_{41W} = \varepsilon_{(X41W, W41W)}(Ew_{41W} - t_{X41W})$

(A2.9) $EX_{51W} = \varepsilon_{(X51W, W51W)}(Ew_{51W} - t_{X51W})$

(A2.10) $EX_{45} = \beta_{X41}EX_{41} + \beta_{X51}EX_{51}$

(A2.11) $EX_{61} = \varepsilon_{(X61, W61)}(Ew_{61} - t_{X61})$

(A2.12) $EX_{61W} = \varepsilon_{(X61W, W61W)}(Ew_{61W} - t_{X61W})$

(A2.13) $EX_{71} = \varepsilon_{(X71, W71)}(Ew_{71} - t_{X71})$

(A2.14) $EX_{71W} = \varepsilon_{(X71W, W71W)}(Ew_{71W} - t_{X71W})$

(A2.15) $EX_{81} = \varepsilon_{(X81, W81)}(Ew_{81} - t_{X81})$

(A2.16) $EX_{81W} = \varepsilon_{(X81W, W81W)}(Ew_{81W} - t_{X81W})$

(A2.17) $EX_{91} = \varepsilon_{(X91, W91)}(Ew_{91} - t_{X91})$

(A2.18) $EX_{91W} = \varepsilon_{(X91W, W91W)}(Ew_{91W} - t_{X91W})$

Output constrained input demands of farm enterprises

(A2.19) $EX_1 = \tilde{\eta}_{(X1, W1)} Ew_1 + \tilde{\eta}_{(X1, W1W)}Ew_{1W} + EY_1$

(A2.20) $EX_{1W} = \tilde{\eta}_{(X1W, W1)}Ew_1 + \tilde{\eta}_{(X1W, W1W)}Ew_{1W} + EY_1$

(A2.21) $EX_{21} = \tilde{\eta}_{(X21, W23)} Ew_{23} + \tilde{\eta}_{(X21, W21W)}Ew_{21W} + EY_2$

(A2.22) $EX_{21W} = \tilde{\eta}_{(X21W, W23)}Ew_{23} + \tilde{\eta}_{(X21W, W21W)}Ew_{21W} + EY_2$

(A2.23) $EX_{31} = \tilde{\eta}_{(X31, W23)} Ew_{23} + \tilde{\eta}_{(X31, W31W)}Ew_{31W} + EY_3$

(A2.24) $EX_{31W} = \tilde{\eta}_{(X31W, W23)}Ew_{23} + \tilde{\eta}_{(X31W, W31W)}Ew_{31W} + EY_3$

(A2.25) $EX_{41} = \tilde{\eta}_{(X41, W45)} Ew_{45} + \tilde{\eta}_{(X41, W41W)}Ew_{41W} + EY_4$

(A2.26) $EX_{41W} = \tilde{\eta}_{(X41W, W45)}Ew_{45} + \tilde{\eta}_{(X41W, W41W)}Ew_{41W} + EY_4$

(A2.27) $EX_{51} = \tilde{\eta}_{(X51, W45)} Ew_{45} + \tilde{\eta}_{(X51, W51W)}Ew_{51W} + EY_5$

(A2.28) $EX_{51W} = \tilde{\eta}_{(X51W, W45)} Ew_{45} + \tilde{\eta}_{(X51W, W51W)} Ew_{51W} + EY_5$

(A2.29) $EX_{61} = \tilde{\eta}_{(X61, W61)} Ew_{61} + \tilde{\eta}_{(X61, W61W)} Ew_{61W} + EY_6$

(A2.30) $EX_{61W} = \tilde{\eta}_{(X61W, W61)} Ew_{61} + \tilde{\eta}_{(X61W, W61W)} Ew_{61W} + EY_6$

(A2.31) $EX_{71} = \tilde{\eta}_{(X71, W71)} Ew_{71} + \tilde{\eta}_{(X71, W71W)} Ew_{71W} + EY_7$

(A2.32) $EX_{71W} = \tilde{\eta}_{(X71W, W71)} Ew_{71} + \tilde{\eta}_{(X71W, W71W)} Ew_{71W} + EY_7$

(A2.33) $EX_{81} = \tilde{\eta}_{(X81, W81)} Ew_{81} + \tilde{\eta}_{(X81, W81W)} Ew_{81W} + EY_8$

(A2.34) $EX_{81W} = \tilde{\eta}_{(X81W, W81)} Ew_{81} + \tilde{\eta}_{(X81W, W81W)} Ew_{81W} + EY_8$

(A2.35) $EX_{91} = \tilde{\eta}_{(X91, W91)} Ew_{91} + \tilde{\eta}_{(X91, W91W)} Ew_{91W} + EY_9$

(A2.36) $EX_{91W} = \tilde{\eta}_{(X91W, W91)} Ew_{91} + \tilde{\eta}_{(X91W, W91W)} Ew_{91W} + EY_9$

Farm enterprise equilibriums

(A2.37) $k_{X1}EX_1 + k_{X1W}EX_{1W} = \gamma_{Y13W}EY_{13W} + \gamma_{Y14W}EY_{14W} + \gamma_{Y1L}EY_{1L} + \gamma_{Y1M}EY_{1M}$

(A2.38) $k_{X1}Ew_1 + k_{X1W}Ew_{1W} = \gamma_{Y13W}Ev_{13W} + \gamma_{Y14W}Ev_{14W} + \gamma_{Y1L}Ev_{1L} + \gamma_{Y1M}Ev_{1M}$

(A2.39) $k_{X21}EX_{21} + k_{X21W}EX_{21W} = \gamma_{Y21W}EY_{21W} + \gamma_{Y22W}EY_{22W} + \gamma_{Y23W}EY_{23W} + \gamma_{Y2L}EY_{2L} + \gamma_{Y2M}EY_{2M}$

(A2.40) $k_{X21}Ew_{23} + k_{X21W}Ew_{21W} = \gamma_{Y21W}Ev_{21W} + \gamma_{Y22W}Ev_{22W} + \gamma_{Y23W}Ev_{23W} + \gamma_{Y2L}Ev_{2L} + \gamma_{Y2M}Ev_{2M}$

(A2.41) $k_{X31}EX_{31} + k_{X31W}EX_{31W} = \gamma_{Y31W}EY_{31W} + \gamma_{Y32W}EY_{32W} + \gamma_{Y33W}EY_{33W} + \gamma_{Y3L}EY_{3L} + \gamma_{Y3M}EY_{3M}$

(A2.42) $k_{X31}Ew_{23} + k_{X31W}Ew_{31W} = \gamma_{Y31W}Ev_{31W} + \gamma_{Y32W}Ev_{32W} + \gamma_{Y33W}Ev_{33W} + \gamma_{Y3L}Ev_{3L} + \gamma_{Y3M}Ev_{3M}$

(A2.43) $k_{X41}EX_{41} + k_{X41W}EX_{41W} = \gamma_{Y41W}EY_{41W} + \gamma_{Y42W}EY_{42W} + \gamma_{Y43W}EY_{43W} + \gamma_{Y4L}EY_{4L} + \gamma_{Y4M}EY_{4M}$

(A2.44) $k_{X41}Ew_{45} + k_{X41W}Ew_{41W} = \gamma_{Y41W}Ev_{41W} + \gamma_{Y42W}Ev_{42W} + \gamma_{Y43W}Ev_{43W} + \gamma_{Y4L}Ev_{4L} + \gamma_{Y4M}Ev_{4M}$

(A2.45) $k_{X51}EX_{51} + k_{X51W}EX_{51W} = \gamma_{Y51W}EY_{51W} + \gamma_{Y52W}EY_{52W} + \gamma_{Y53W}EY_{53W} + \gamma_{Y5L}EY_{5L} + \gamma_{Y5M}EY_{5M}$

(A2.46) $k_{X51}Ew_{45} + k_{X51W}Ew_{51W} = \gamma_{Y51W}Ev_{51W} + \gamma_{Y52W}Ev_{52W} + \gamma_{Y53W}Ev_{53W} + \gamma_{Y5L}Ev_{5L} + \gamma_{Y5M}Ev_{5M}$

(A2.47) $k_{X61}EX_{61} + k_{X61W}EX_{61W} = \gamma_{Y61W}EY_{61W} + \gamma_{Y62W}EY_{62W} + \gamma_{Y63W}EY_{63W} + \gamma_{Y6L}EY_{6L} + \gamma_{Y6M}EY_{6M}$

(A2.48) $k_{X61}Ew_{61} + k_{X61W}Ew_{61W} = \gamma_{Y61W}Ev_{61W} + \gamma_{Y62W}Ev_{62W} + \gamma_{Y63W}Ev_{63W} + \gamma_{Y6L}Ev_{6L} + \gamma_{Y6M}Ev_{6M}$

(A2.49) $k_{X71}EX_{71} + k_{X71W}EX_{71W} = \gamma_{Y71W}EY_{71W} + \gamma_{Y72W}EY_{72W} + \gamma_{Y73W}EY_{73W} + \gamma_{Y7E}EY_{7E} + \gamma_{Y7M}EY_{7M}$

(A2.50) $k_{X71}Ew_{71} + k_{X71W}Ew_{71W} = \gamma_{Y71W}Ev_{71W} + \gamma_{Y72W}Ev_{72W} + \gamma_{Y73W}Ev_{73W} + \gamma_{Y7E}Ep_{SE} + \gamma_{Y7M}Ev_{7M}$

(A2.51) $k_{X81}EX_{81} + k_{X81W}EX_{81W} = \gamma_{Y81W}EY_{81W} + \gamma_{Y82W}EY_{82W} + \gamma_{Y83W}EY_{83W} + \gamma_{Y8E}EY_{8E} + \gamma_{Y8M}EY_{8M}$

(A2.52) $k_{X81}Ew_{81} + k_{X81W}Ew_{81W} = \gamma_{Y81W}Ev_{81W} + \gamma_{Y82W}Ev_{82W} + \gamma_{Y83W}Ev_{83W} + \gamma_{Y8E}Ep_{SE} + \gamma_{Y8M}Ev_{8M}$

(A2.53) $k_{X91}EX_{91} + k_{X91W}EX_{91W} = \gamma_{Y91W}EY_{91W} + \gamma_{Y92W}EY_{92W} + \gamma_{Y93W}EY_{93W} + \gamma_{Y9E}EY_{9E} + \gamma_{Y9M}EY_{9M}$

(A2.54) $k_{X91}Ew_{91} + k_{X91W}Ew_{91W} = \gamma_{Y91W}Ev_{91W} + \gamma_{Y92W}Ev_{92W} + \gamma_{Y93W}Ev_{93W} + \gamma_{Y9E}Ep_{SE} + \gamma_{Y9M}Ev_{9M}$

Input constrained output supply of farm enterprises

(A2.55) $EY_{13W} = \tilde{\varepsilon}_{(Y13W,\ V13W)} Ev_{13W} + \tilde{\varepsilon}_{(Y13W,\ V14W)} Ev_{14W} + \tilde{\varepsilon}_{(Y13W,\ V1L)} Ev_{1L} + \tilde{\varepsilon}_{(Y13W,\ V1M)} Ev_{1M} + EX_N$

(A2.56) $EY_{14W} = \tilde{\varepsilon}_{(Y14W,\ V14W)} Ev_{14W} + \tilde{\varepsilon}_{(Y14W,\ V13W)} Ev_{13W} + \tilde{\varepsilon}_{(Y14W,\ V1L)} Ev_{1L} + \tilde{\varepsilon}_{(Y14W,\ V1M)} Ev_{1M} + EX_N$

(A2.57) $EY_{1L} = \tilde{\varepsilon}_{(Y1L,\ V1L)} Ev_{1L} + \tilde{\varepsilon}_{(Y1L,\ V13W)} Ev_{13W} + \tilde{\varepsilon}_{(Y1L,\ V14W)} Ev_{14W} + \tilde{\varepsilon}_{(Y1L,\ V1M)} Ev_{1M} + EX_N$

(A2.58) $EY_{1M} = \tilde{\varepsilon}_{(Y1M,\ V1M)} Ev_{1M} + \tilde{\varepsilon}_{(Y1M,\ V13W)} Ev_{13W} + \tilde{\varepsilon}_{(Y1M,\ V14W)} Ev_{14W} + \tilde{\varepsilon}_{(Y1M,\ V1L)} Ev_{1L} + EX_N$

(A2.59) $EY_{21W} = \tilde{\varepsilon}_{(Y21W,\ V21W)} Ev_{21W} + \tilde{\varepsilon}_{(Y21W,\ V22W)} Ev_{22W} + \tilde{\varepsilon}_{(Y21W,\ V23W)} Ev_{23W} + \tilde{\varepsilon}_{(Y21W,\ V2L)} Ev_{2L} + \tilde{\varepsilon}_{(Y21W,\ V2M)} Ev_{2M} + EX_2$

(A2.60) $EY_{22W} = \tilde{\varepsilon}_{(Y22W,\ V22W)} Ev_{22W} + \tilde{\varepsilon}_{(Y22W,\ V21W)} Ev_{21W} + \tilde{\varepsilon}_{(Y22W,\ V23W)} Ev_{23W} + \tilde{\varepsilon}_{(Y22W,\ V2L)} Ev_{2L} + \tilde{\varepsilon}_{(Y22W,\ V2M)} Ev_{2M} + EX_2$

(A2.61) $EY_{23W} = \tilde{\varepsilon}_{(Y23W,\ V23W)} Ev_{23W} + \tilde{\varepsilon}_{(Y23W,\ V21W)} Ev_{21W} + \tilde{\varepsilon}_{(Y23W,\ V22W)} Ev_{22W} + \tilde{\varepsilon}_{(Y23W,\ V2L)} Ev_{2L} + \tilde{\varepsilon}_{(Y23W,\ V2M)} Ev_{2M} + EX_2$

(A2.62) $EY_{2L} = \tilde{\varepsilon}_{(Y2L,\ V2L)} Ev_{2L} + \tilde{\varepsilon}_{(Y2L,\ V21W)} Ev_{21W} + \tilde{\varepsilon}_{(Y2L,\ V22W)} Ev_{22W} + \tilde{\varepsilon}_{(Y2L,\ V23W)} Ev_{23W} + \tilde{\varepsilon}_{(Y2L,\ V2M)} Ev_{2M} + EX_2$

(A2.63) $EY_{2M} = \tilde{\varepsilon}_{(Y2M,\ V2M)} Ev_{2M} + \tilde{\varepsilon}_{(Y2M,\ V21W)} Ev_{21W} + \tilde{\varepsilon}_{(Y2M,\ V22W)} Ev_{22W} + \tilde{\varepsilon}_{(Y2M,\ V23W)} Ev_{23W} + \tilde{\varepsilon}_{(Y2M,\ V2L)} Ev_{2L} + EX_2$

(A2.64) $EY_{31W} = \tilde{\varepsilon}_{(Y31W,\ V31W)} Ev_{31W} + \tilde{\varepsilon}_{(Y31W,\ V32W)} Ev_{32W} + \tilde{\varepsilon}_{(Y31W,\ V33W)} Ev_{33W} + \tilde{\varepsilon}_{(Y31W,\ V3L)} Ev_{3L} + \tilde{\varepsilon}_{(Y31W,\ V3M)} Ev_{3M} + EX_3$

(A2.65) $EY_{32W} = \tilde{\varepsilon}_{(Y32W,\ V32W)} Ev_{32W} + \tilde{\varepsilon}_{(Y32W,\ V31W)} Ev_{31W} + \tilde{\varepsilon}_{(Y32W,\ V33W)} Ev_{33W} + \tilde{\varepsilon}_{(Y32W,\ V3L)} Ev_{3L} + \tilde{\varepsilon}_{(Y32W,\ V3M)} Ev_{3M} + EX_3$

(A2.66) $EY_{33W} = \tilde{\varepsilon}_{(Y33W,\ V33W)} Ev_{33W} + \tilde{\varepsilon}_{(Y33W,\ V31W)} Ev_{31W} + \tilde{\varepsilon}_{(Y33W,\ V32W)} Ev_{32W} + \tilde{\varepsilon}_{(Y33W,\ V3L)} Ev_{3L} + \tilde{\varepsilon}_{(Y33W,\ V3M)} Ev_{3M} + EX_3$

(A2.67) $EY_{3L} = \tilde{\varepsilon}_{(Y3L,\ V3L)} Ev_{3L} + \tilde{\varepsilon}_{(Y3L,\ V31W)} Ev_{31W} + \tilde{\varepsilon}_{(Y3L,\ V32W)} Ev_{32W} + \tilde{\varepsilon}_{(Y3L,\ V33W)} Ev_{33W} + \tilde{\varepsilon}_{(Y3L,\ V3M)} Ev_{3M} + EX_3$

(A2.68) $EY_{3M} = \tilde{\varepsilon}_{(Y3M,\ V3M)} Ev_{3M} + \tilde{\varepsilon}_{(Y3M,\ V31W)} Ev_{31W} + \tilde{\varepsilon}_{(Y3M,\ V32W)} Ev_{32W} + \tilde{\varepsilon}_{(Y3M,\ V33W)} Ev_{33W} + \tilde{\varepsilon}_{(Y3M,\ V3L)} Ev_{3L} + EX_3$

(A2.69) $EY_{41W} = \tilde{\varepsilon}_{(Y41W,\ V41W)} Ev_{41W} + \tilde{\varepsilon}_{(Y41W,\ V42W)} Ev_{42W} + \tilde{\varepsilon}_{(Y41W,\ V43W)} Ev_{43W} + \tilde{\varepsilon}_{(Y41W,\ V4L)} Ev_{4L} + \tilde{\varepsilon}_{(Y41W,\ V4M)} Ev_{4M} + EX_4$

(A2.70) $EY_{42W} = \tilde{\varepsilon}_{(Y42W,\ V42W)}\ Ev_{42W} + \tilde{\varepsilon}_{(Y42W,\ V41W)}\ Ev_{41W} + \tilde{\varepsilon}_{(Y42W,\ V43W)}\ Ev_{43W} + \tilde{\varepsilon}_{(Y42W,\ V4L)}\ Ev_{4L} + \tilde{\varepsilon}_{(Y42W,\ V4M)}\ Ev_{4M} + EX_4$

(A2.71) $EY_{43W} = \tilde{\varepsilon}_{(Y43W,\ V43W)}\ Ev_{43W} + \tilde{\varepsilon}_{(Y43W,\ V41W)}\ Ev_{41W} + \tilde{\varepsilon}_{(Y43W,\ V42W)}\ Ev_{42W} + \tilde{\varepsilon}_{(Y43W,\ V4L)}\ Ev_{4L} + \tilde{\varepsilon}_{(Y43W,\ V4M)}\ Ev_{4M} + EX_4$

(A2.72) $EY_{4L} = \tilde{\varepsilon}_{(Y4L,\ V4L)}\ Ev_{4L} + \tilde{\varepsilon}_{(Y4L,\ V41W)}\ Ev_{41W} + \tilde{\varepsilon}_{(Y4L,\ V42W)}\ Ev_{42W} + \tilde{\varepsilon}_{(Y4L,\ V43W)}\ Ev_{43W} + \tilde{\varepsilon}_{(Y4L,\ V4M)}\ Ev_{4M} + EX_4$

(A2.73) $EY_{4M} = \tilde{\varepsilon}_{(Y4M,\ V4M)}\ Ev_{4M} + \tilde{\varepsilon}_{(Y4M,\ V41W)}\ Ev_{41W} + \tilde{\varepsilon}_{(Y4M,\ V42W)}\ Ev_{42W} + \tilde{\varepsilon}_{(Y4M,\ V43W)}\ Ev_{43W} + \tilde{\varepsilon}_{(Y4M,\ V4L)}\ Ev_{4L} + EX_4$

(A2.74) $EY_{51W} = \tilde{\varepsilon}_{(Y51W,\ V51W)}\ Ev_{51W} + \tilde{\varepsilon}_{(Y51W,\ V52W)}\ Ev_{52W} + \tilde{\varepsilon}_{(Y51W,\ V53W)}\ Ev_{53W} + \tilde{\varepsilon}_{(Y51W,\ V5L)}\ Ev_{5L} + \tilde{\varepsilon}_{(Y51W,\ V5M)}\ Ev_{5M} + EX_5$

(A2.75) $EY_{52W} = \tilde{\varepsilon}_{(Y52W,\ V52W)}\ Ev_{52W} + \tilde{\varepsilon}_{(Y52W,\ V51W)}\ Ev_{51W} + \tilde{\varepsilon}_{(Y52W,\ V53W)}\ Ev_{53W} + \tilde{\varepsilon}_{(Y52W,\ V5L)}\ Ev_{5L} + \tilde{\varepsilon}_{(Y52W,\ V5M)}\ Ev_{5M} + EX_5$

(A2.76) $EY_{53W} = \tilde{\varepsilon}_{(Y53W,\ V53W)}\ Ev_{53W} + \tilde{\varepsilon}_{(Y53W,\ V51W)}\ Ev_{51W} + \tilde{\varepsilon}_{(Y53W,\ V52W)}\ Ev_{52W} + \tilde{\varepsilon}_{(Y53W,\ V5L)}\ Ev_{5L} + \tilde{\varepsilon}_{(Y53W,\ V5M)}\ Ev_{5M} + EX_5$

(A2.77) $EY_{5L} = \tilde{\varepsilon}_{(Y5L,\ V5L)}\ Ev_{5L} + \tilde{\varepsilon}_{(Y5L,\ V51W)}\ Ev_{51W} + \tilde{\varepsilon}_{(Y5L,\ V52W)}\ Ev_{52W} + \tilde{\varepsilon}_{(Y5L,\ V53W)}\ Ev_{53W} + \tilde{\varepsilon}_{(Y5L,\ V5M)}\ Ev_{5M} + EX_5$

(A2.78) $EY_{5M} = \tilde{\varepsilon}_{(Y5M,\ V5M)}\ Ev_{5M} + \tilde{\varepsilon}_{(Y5M,\ V51W)}\ Ev_{51W} + \tilde{\varepsilon}_{(Y5M,\ V52W)}\ Ev_{52W} + \tilde{\varepsilon}_{(Y5M,\ V53W)}\ Ev_{53W} + \tilde{\varepsilon}_{(Y5M,\ V5L)}\ Ev_{5L} + EX_5$

(A2.79) $EY_{61W} = \tilde{\varepsilon}_{(Y61W,\ V61W)}\ Ev_{61W} + \tilde{\varepsilon}_{(Y61W,\ V62W)}\ Ev_{62W} + \tilde{\varepsilon}_{(Y61W,\ V63W)}\ Ev_{63W} + \tilde{\varepsilon}_{(Y61W,\ V6L)}\ Ev_{6L} + \tilde{\varepsilon}_{(Y61W,\ V6M)}\ Ev_{6M} + EX_6$

(A2.80) $EY_{62W} = \tilde{\varepsilon}_{(Y62W,\ V62W)}\ Ev_{62W} + \tilde{\varepsilon}_{(Y62W,\ V61W)}\ Ev_{61W} + \tilde{\varepsilon}_{(Y62W,\ V63W)}\ Ev_{63W} + \tilde{\varepsilon}_{(Y62W,\ V6L)}\ Ev_{6L} + \tilde{\varepsilon}_{(Y62W,\ V6M)}\ Ev_{6M} + EX_6$

(A2.81) $EY_{63W} = \tilde{\varepsilon}_{(Y63W,\ V63W)}\ Ev_{63W} + \tilde{\varepsilon}_{(Y63W,\ V61W)}\ Ev_{61W} + \tilde{\varepsilon}_{(Y63W,\ V62W)}\ Ev_{62W} + \tilde{\varepsilon}_{(Y63W,\ V6L)}\ Ev_{6L} + \tilde{\varepsilon}_{(Y63W,\ V6M)}\ Ev_{6M} + EX_6$

(A2.82) $EY_{6L} = \tilde{\varepsilon}_{(Y6L,\ V6L)}\ Ev_{6L} + \tilde{\varepsilon}_{(Y6L,\ V61W)}\ Ev_{61W} + \tilde{\varepsilon}_{(Y6L,\ V62W)}\ Ev_{62W} + \tilde{\varepsilon}_{(Y6L,\ V63W)}\ Ev_{63W} + \tilde{\varepsilon}_{(Y6L,\ V6M)}\ Ev_{6M} + EX_6$

(A2.83) $EY_{6M} = \tilde{\varepsilon}_{(Y6M,\ V6M)}\ Ev_{6M} + \tilde{\varepsilon}_{(Y6M,\ V61W)}\ Ev_{61W} + \tilde{\varepsilon}_{(Y6M,\ V62W)}\ Ev_{62W} + \tilde{\varepsilon}_{(Y6M,\ V63W)}\ Ev_{63W} + \tilde{\varepsilon}_{(Y6M,\ V6L)}\ Ev_{6L} + EX_6$

(A2.84) $EY_{71W} = \tilde{\varepsilon}_{(Y71W,\ V71W)}\ Ev_{71W} + \tilde{\varepsilon}_{(Y71W,\ V72W)}\ Ev_{72W} + \tilde{\varepsilon}_{(Y71W,\ V73W)}\ Ev_{73W} + \tilde{\varepsilon}_{(Y71W,\ PSE)}\ Ep_{SE} + \tilde{\varepsilon}_{(Y71W,\ V7M)}\ Ev_{7M} + EX_7$

(A2.85) $EY_{72W} = \tilde{\varepsilon}_{(Y72W,\ V72W)}\ Ev_{72W} + \tilde{\varepsilon}_{(Y72W,\ V71W)}\ Ev_{71W} + \tilde{\varepsilon}_{(Y72W,\ V73W)}\ Ev_{73W} + \tilde{\varepsilon}_{(Y72W,\ PSE)}\ Ep_{SE} + \tilde{\varepsilon}_{(Y72W,\ V7M)}\ Ev_{7M} + EX_7$

(A2.86) $EY_{73W} = \tilde{\varepsilon}_{(Y73W,\ V73W)}\ Ev_{73W} + \tilde{\varepsilon}_{(Y73W,\ V71W)}\ Ev_{71W} + \tilde{\varepsilon}_{(Y73W,\ V72W)}\ Ev_{72W} + \tilde{\varepsilon}_{(Y73W,\ PSE)}\ Ep_{SE} + \tilde{\varepsilon}_{(Y73W,\ V7M)}\ Ev_{7M} + EX_7$

(A2.87) $EY_{7E} = \tilde{\varepsilon}_{(Y7E,\ PSE)}\ Ep_{SE} + \tilde{\varepsilon}_{(Y7E,\ V71W)}\ Ev_{71W} + \tilde{\varepsilon}_{(Y7E,\ V72W)}\ Ev_{72W} + \tilde{\varepsilon}_{(Y7E,\ V73W)}\ Ev_{73W} + \tilde{\varepsilon}_{(Y7E,\ V7M)}\ Ev_{7M} + EX_7$

(A2.88) $EY_{7M} = \tilde{\varepsilon}_{(Y7M,\ V7M)}\ Ev_{7M} + \tilde{\varepsilon}_{(Y7M,\ V71W)}\ Ev_{71W} + \tilde{\varepsilon}_{(Y7M,\ V72W)}\ Ev_{72W} + \tilde{\varepsilon}_{(Y7M,\ V73W)}\ Ev_{73W} + \tilde{\varepsilon}_{(Y7M,\ PSE)}\ Ep_{SE} + EX_7$

(A2.89) $EY_{81W} = \tilde{\varepsilon}_{(Y81W,\ V81W)}\ Ev_{81W} + \tilde{\varepsilon}_{(Y81W,\ V82W)}\ Ev_{82W} + \tilde{\varepsilon}_{(Y81W,\ V83W)}\ Ev_{83W} + \tilde{\varepsilon}_{(Y81W,\ PSE)}\ Ep_{SE} + \tilde{\varepsilon}_{(Y81W,\ V8M)}\ Ev_{8M} + EX_8$

$$EY_{82W} = \tilde{\varepsilon}_{(Y82W,\ V82W)}\, Ev_{82W} + \tilde{\varepsilon}_{(Y82W,\ V81W)}\, Ev_{81W} + \tilde{\varepsilon}_{(Y82W,\ V83W)}\, Ev_{83W} + \tilde{\varepsilon}_{(Y82W,\ PSE)}\, Ep_{SE} + \tilde{\varepsilon}_{(Y82W,\ V8M)}\, Ev_{8M} + EX_{8} \tag{A2.90}$$

$$EY_{83W} = \tilde{\varepsilon}_{(Y83W,\ V83W)}\, Ev_{83W} + \tilde{\varepsilon}_{(Y83W,\ V81W)}\, Ev_{81W} + \tilde{\varepsilon}_{(Y83W,\ V82W)}\, Ev_{82W} + \tilde{\varepsilon}_{(Y83W,\ PSE)}\, Ep_{SE} + \tilde{\varepsilon}_{(Y83W,\ V8M)}\, Ev_{8M} + EX_{8} \tag{A2.91}$$

$$EY_{8E} = \tilde{\varepsilon}_{(Y8E,\ PSE)}\, Ep_{SE} + \tilde{\varepsilon}_{(Y8E,\ V81W)}\, Ev_{81W} + \tilde{\varepsilon}_{(Y8E,\ V82W)}\, Ev_{82W} + \tilde{\varepsilon}_{(Y8E,\ V83W)}\, Ev_{83W} + \tilde{\varepsilon}_{(Y8E,\ V8M)}\, Ev_{8M} + EX_{8} \tag{A2.92}$$

$$EY_{8M} = \tilde{\varepsilon}_{(Y8M,\ V8M)}\, Ev_{8M} + \tilde{\varepsilon}_{(Y8M,\ V81W)}\, Ev_{81W} + \tilde{\varepsilon}_{(Y8M,\ V82W)}\, Ev_{82W} + \tilde{\varepsilon}_{(Y8M,\ V83W)}\, Ev_{83W} + \tilde{\varepsilon}_{(Y8M,\ PSE)}\, Ep_{SE} + EX_{8} \tag{A2.93}$$

$$EY_{91W} = \tilde{\varepsilon}_{(Y91W,\ V91W)}\, Ev_{91W} + \tilde{\varepsilon}_{(Y91W,\ V92W)}\, Ev_{92W} + \tilde{\varepsilon}_{(Y91W,\ V93W)}\, Ev_{93W} + \tilde{\varepsilon}_{(Y91W,\ PSE)}\, Ep_{SE} + \tilde{\varepsilon}_{(Y91W,\ V9M)}\, Ev_{9M} + EX_{9} \tag{A2.94}$$

$$EY_{92W} = \tilde{\varepsilon}_{(Y92W,\ V92W)}\, Ev_{92W} + \tilde{\varepsilon}_{(Y92W,\ V91W)}\, Ev_{91W} + \tilde{\varepsilon}_{(Y92W,\ V93W)}\, Ev_{93W} + \tilde{\varepsilon}_{(Y92W,\ PSE)}\, Ep_{SE} + \tilde{\varepsilon}_{(Y92W,\ V9M)}\, Ev_{9M} + EX_{9} \tag{A2.95}$$

$$EY_{93W} = \tilde{\varepsilon}_{(Y93W,\ V93W)}\, Ev_{93W} + \tilde{\varepsilon}_{(Y93W,\ V91W)}\, Ev_{91W} + \tilde{\varepsilon}_{(Y93W,\ V92W)}\, Ev_{92W} + \tilde{\varepsilon}_{(Y93W,\ PSE)}\, Ep_{SE} + \tilde{\varepsilon}_{(Y93W,\ V9M)}\, Ev_{9M} + EX_{9} \tag{A2.96}$$

$$EY_{9E} = \tilde{\varepsilon}_{(Y9E,\ PSE)}\, Ep_{SE} + \tilde{\varepsilon}_{(Y9E,\ V91W)}\, Ev_{91W} + \tilde{\varepsilon}_{(Y9E,\ V92W)}\, Ev_{92W} + \tilde{\varepsilon}_{(Y9E,\ V93W)}\, Ev_{93W} + \tilde{\varepsilon}_{(Y9E,\ V9M)}\, Ev_{9M} + EX_{9} \tag{A2.97}$$

$$EY_{9M} = \tilde{\varepsilon}_{(Y9M,\ V9M)}\, Ev_{9M} + \tilde{\varepsilon}_{(Y9M,\ V91W)}\, Ev_{91W} + \tilde{\varepsilon}_{(Y9M,\ V92W)}\, Ev_{92W} + \tilde{\varepsilon}_{(Y9M,\ V93W)}\, Ev_{93W} + \tilde{\varepsilon}_{(Y9M,\ PSE)}\, Ep_{SE} + EX_{9} \tag{A2.98}$$

Other input supply to wool warehouse sectors

$$EY_{NM} = \varepsilon_{(YNM,\ VNM)}(Ev_{NM} - t_{YNM}) \tag{A2.99}$$

$$EY_{BM} = \varepsilon_{(YBM,\ VBM)}(Ev_{BM} - t_{YBM}) \tag{A2.100}$$

$$EY_{MM} = \varepsilon_{(YMM,\ VMM)}(Ev_{MM} - t_{YMM}) \tag{A2.101}$$

$$EY_{FM} = \varepsilon_{(YFM,\ VFM)}(Ev_{FM} - t_{YFM}) \tag{A2.102}$$

Other input supply to lamb and mutton slaughtering/processing sectors

$$EY_{SL} = \varepsilon_{(YSL,\ VSL)}(Ev_{SL} - t_{YSL}) \tag{A2.103}$$

$$EY_{SM} = \varepsilon_{(YSM,\ VSM)}(Ev_{SM} - t_{YSM}) \tag{A2.104}$$

Output constrained input demand of wool warehouse sectors

$$EY_{14W} = \tilde{\eta}_{(Y14W,\ V14W)}\, Ev_{14W} + \tilde{\eta}_{(Y14W,\ VNM)} Ev_{NM} + EZ_{1} \tag{A2.105}$$

$$EY_{NM} = \tilde{\eta}_{(YNM,\ V14W)} Ev_{14W} + \tilde{\eta}_{(YNM,\ VNM)} Ev_{NM} + EZ_{1} \tag{A2.106}$$

$$EY_{21W} = \tilde{\eta}_{(Y21W,\ V21W)}\, Ev_{21W} + \tilde{\eta}_{(Y21W,\ V31W)}\, Ev_{31W} + \tilde{\eta}_{(Y21W,\ V41W)}\, Ev_{41W} + \tilde{\eta}_{(Y21W,\ V51W)}\, Ev_{51W} + \tilde{\eta}_{(Y21W,\ V61W)}\, Ev_{61W} + \tilde{\eta}_{(Y21W,\ V71W)}\, Ev_{71W} + \tilde{\eta}_{(Y21W,\ V81W)}\, Ev_{81W} + \tilde{\eta}_{(Y21W,\ V91W)}\, Ev_{91W} + \tilde{\eta}_{(Y21W,\ VFM)} Ev_{FM} + EZ_{2} \tag{A2.107}$$

$$EY_{31W} = \tilde{\eta}_{(Y31W,\ V31W)}\, Ev_{31W} + \tilde{\eta}_{(Y31W,\ V21W)}\, Ev_{21W} + \tilde{\eta}_{(Y31W,\ V41W)}\, Ev_{41W} + \tilde{\eta}_{(Y31W,\ V51W)}\, Ev_{51W} + \tilde{\eta}_{(Y31W,\ V61W)}\, Ev_{61W} + \tilde{\eta}_{(Y31W,\ V71W)}\, Ev_{71W} + \tilde{\eta}_{(Y31W,\ V81W)}\, Ev_{81W} + \tilde{\eta}_{(Y31W,\ V91W)}\, Ev_{91W} + \tilde{\eta}_{(Y31W,\ VFM)} Ev_{FM} + EZ_{2} \tag{A2.108}$$

(A2.109) $EY_{41W} = \tilde{\eta}_{(Y41W,\ V41W)} Ev_{41W} + \tilde{\eta}_{(Y41W,\ V21W)} Ev_{21W} + \tilde{\eta}_{(Y41W,\ V31W)} Ev_{31W} + \tilde{\eta}_{(Y41W,\ V51W)} Ev_{51W} + \tilde{\eta}_{(Y41W,\ V61W)} Ev_{61W} + \tilde{\eta}_{(Y41W,\ V71W)} Ev_{71W} + \tilde{\eta}_{(Y41W,\ V81W)} Ev_{81W} + \tilde{\eta}_{(Y41W,\ V91W)} Ev_{91W} + \tilde{\eta}_{(Y41W,\ VFM)} Ev_{FM} + EZ_2$

(A2.110) $EY_{51W} = \tilde{\eta}_{(Y51W,\ V51W)} Ev_{51W} + \tilde{\eta}_{(Y51W,\ V21W)} Ev_{21W} + \tilde{\eta}_{(Y51W,\ V31W)} Ev_{31W} + \tilde{\eta}_{(Y51W,\ V41W)} Ev_{41W} + \tilde{\eta}_{(Y51W,\ V61W)} Ev_{61W} + \tilde{\eta}_{(Y51W,\ V71W)} Ev_{71W} + \tilde{\eta}_{(Y51W,\ V81W)} Ev_{81W} + \tilde{\eta}_{(Y51W,\ V91W)} Ev_{91W} + \tilde{\eta}_{(Y51W,\ VFM)} Ev_{FM} + EZ_2$

(A2.111) $EY_{61W} = \tilde{\eta}_{(Y61W,\ V61W)} Ev_{61W} + \tilde{\eta}_{(Y61W,\ V21W)} Ev_{21W} + \tilde{\eta}_{(Y61W,\ V31W)} Ev_{31W} + \tilde{\eta}_{(Y61W,\ V41W)} Ev_{41W} + \tilde{\eta}_{(Y61W,\ V51W)} Ev_{51W} + \tilde{\eta}_{(Y61W,\ V71W)} Ev_{71W} + \tilde{\eta}_{(Y61W,\ V81W)} Ev_{81W} + \tilde{\eta}_{(Y61W,\ V91W)} Ev_{91W} + \tilde{\eta}_{(Y61W,\ VFM)} Ev_{FM} + EZ_2$

(A2.112) $EY_{71W} = \tilde{\eta}_{(Y71W,\ V71W)} Ev_{71W} + \tilde{\eta}_{(Y71W,\ V21W)} Ev_{21W} + \tilde{\eta}_{(Y71W,\ V31W)} Ev_{31W} + \tilde{\eta}_{(Y71W,\ V41W)} Ev_{41W} + \tilde{\eta}_{(Y71W,\ V51W)} Ev_{51W} + \tilde{\eta}_{(Y71W,\ V61W)} Ev_{61W} + \tilde{\eta}_{(Y71W,\ V81W)} Ev_{81W} + \tilde{\eta}_{(Y71W,\ V91W)} Ev_{91W} + \tilde{\eta}_{(Y71W,\ VFM)} Ev_{FM} + EZ_2$

(A2.113) $EY_{81W} = \tilde{\eta}_{(Y81W,\ V81W)} Ev_{81W} + \tilde{\eta}_{(Y81W,\ V21W)} Ev_{21W} + \tilde{\eta}_{(Y81W,\ V31W)} Ev_{31W} + \tilde{\eta}_{(Y81W,\ V41W)} Ev_{41W} + \tilde{\eta}_{(Y81W,\ V51W)} Ev_{51W} + \tilde{\eta}_{(Y81W,\ V61W)} Ev_{61W} + \tilde{\eta}_{(Y81W,\ V71W)} Ev_{71W} + \tilde{\eta}_{(Y81W,\ V91W)} Ev_{91W} + \tilde{\eta}_{(Y81W,\ VFM)} Ev_{FM} + EZ_2$

(A2.114) $EY_{91W} = \tilde{\eta}_{(Y91W,\ V91W)} Ev_{91W} + \tilde{\eta}_{(Y91W,\ V21W)} Ev_{21W} + \tilde{\eta}_{(Y91W,\ V31W)} Ev_{31W} + \tilde{\eta}_{(Y91W,\ V41W)} Ev_{41W} + \tilde{\eta}_{(Y91W,\ V51W)} Ev_{51W} + \tilde{\eta}_{(Y91W,\ V61W)} Ev_{61W} + \tilde{\eta}_{(Y91W,\ V71W)} Ev_{71W} + \tilde{\eta}_{(Y91W,\ V81W)} Ev_{81W} + \tilde{\eta}_{(Y91W,\ VFM)} Ev_{FM} + EZ_2$

(A2.115) $EY_{FM} = \tilde{\eta}_{(YFM,\ VFM)} Ev_{FM} + \tilde{\eta}_{(YFM,\ V21W)} Ev_{21W} + \tilde{\eta}_{(YFM,\ V31W)} Ev_{31W} + \tilde{\eta}_{(YFM,\ V41W)} Ev_{41W} + \tilde{\eta}_{(YFM,\ V51W)} Ev_{51W} + \tilde{\eta}_{(YFM,\ V61W)} Ev_{61W} + \tilde{\eta}_{(YFM,\ V71W)} Ev_{71W} + \tilde{\eta}_{(YFM,\ V81W)} Ev_{81W} + \tilde{\eta}_{(YFM,\ V91W)} Ev_{91W} + EZ_2$

(A2.116) $EY_{22W} = \tilde{\eta}_{(Y22W,\ V22W)} Ev_{22W} + \tilde{\eta}_{(Y22W,\ V32W)} Ev_{32W} + \tilde{\eta}_{(Y22W,\ V42W)} Ev_{42W} + \tilde{\eta}_{(Y22W,\ V52W)} Ev_{52W} + \tilde{\eta}_{(Y22W,\ V62W)} Ev_{62W} + \tilde{\eta}_{(Y22W,\ V72W)} Ev_{72W} + \tilde{\eta}_{(Y22W,\ V82W)} Ev_{82W} + \tilde{\eta}_{(Y22W,\ V92W)} Ev_{92W} + \tilde{\eta}_{(Y22W,\ VMM)} Ev_{MM} + EZ_3$

(A2.117) $EY_{32W} = \tilde{\eta}_{(Y32W,\ V32W)} Ev_{32W} + \tilde{\eta}_{(Y32W,\ V22W)} Ev_{22W} + \tilde{\eta}_{(Y32W,\ V42W)} Ev_{42W} + \tilde{\eta}_{(Y32W,\ V52W)} Ev_{52W} + \tilde{\eta}_{(Y32W,\ V62W)} Ev_{62W} + \tilde{\eta}_{(Y32W,\ V72W)} Ev_{72W} + \tilde{\eta}_{(Y32W,\ V82W)} Ev_{82W} + \tilde{\eta}_{(Y32W,\ V92W)} Ev_{92W} + \tilde{\eta}_{(Y32W,\ VMM)} Ev_{MM} + EZ_3$

(A2.118) $EY_{42W} = \tilde{\eta}_{(Y42W,\ V42W)} Ev_{42W} + \tilde{\eta}_{(Y42W,\ V22W)} Ev_{22W} + \tilde{\eta}_{(Y42W,\ V32W)} Ev_{32W} + \tilde{\eta}_{(Y42W,\ V52W)} Ev_{52W} + \tilde{\eta}_{(Y42W,\ V62W)} Ev_{62W} + \tilde{\eta}_{(Y42W,\ V72W)} Ev_{72W} + \tilde{\eta}_{(Y42W,\ V82W)} Ev_{82W} + \tilde{\eta}_{(Y42W,\ V92W)} Ev_{92W} + \tilde{\eta}_{(Y42W,\ VMM)} Ev_{MM} + EZ_3$

(A2.119) $EY_{52W} = \tilde{\eta}_{(Y52W,\ V21W)} Ev_{52W} + \tilde{\eta}_{(Y52W,\ V22W)} Ev_{22W} + \tilde{\eta}_{(Y52W,\ V32W)} Ev_{32W} + \tilde{\eta}_{(Y52W,\ V42W)} Ev_{42W} + \tilde{\eta}_{(Y52W,\ V62W)} Ev_{62W} + \tilde{\eta}_{(Y52W,\ V72W)} Ev_{72W} + \tilde{\eta}_{(Y52W,\ V82W)} Ev_{82W} + \tilde{\eta}_{(Y52W,\ V92W)} Ev_{92W} + \tilde{\eta}_{(Y52W,\ VMM)} Ev_{MM} + EZ_3$

(A2.120) $EY_{62W} = \tilde{\eta}_{(Y62W,\ V62W)} Ev_{62W} + \tilde{\eta}_{(Y62W,\ V22W)} Ev_{22W} + \tilde{\eta}_{(Y62W,\ V32W)} Ev_{32W} + \tilde{\eta}_{(Y62W,\ V42W)} Ev_{42W} + \tilde{\eta}_{(Y62W,\ V52W)} Ev_{52W} + \tilde{\eta}_{(Y62W,\ V72W)} Ev_{72W} + \tilde{\eta}_{(Y62W,\ V82W)} Ev_{82W} + \tilde{\eta}_{(Y62W,\ V92W)} Ev_{92W} + \tilde{\eta}_{(Y62W,\ VMM)} Ev_{MM} + EZ_{3W}$

(A2.121) $EY_{72W} = \tilde{\eta}_{(Y72W,\ V72W)} Ev_{72W} + \tilde{\eta}_{(Y72W,\ V22W)} Ev_{22W} + \tilde{\eta}_{(Y72W,\ V32W)} Ev_{32W} + \tilde{\eta}_{(Y72W,\ V42W)} Ev_{42W} + \tilde{\eta}_{(Y72W,\ V52W)} Ev_{52W} + \tilde{\eta}_{(Y72W,\ V62W)} Ev_{62W} + \tilde{\eta}_{(Y72W,\ V82W)} Ev_{82W} + \tilde{\eta}_{(Y72W,\ V92W)} Ev_{92W} + \tilde{\eta}_{(Y72W,\ VMM)} Ev_{MM} + EZ_3$

(A2.122) $EY_{82W} = \tilde{\eta}_{(Y82W,\ V82W)} Ev_{82W} + \tilde{\eta}_{(Y82W,\ V22W)} Ev_{22W} + \tilde{\eta}_{(Y82W,\ V32W)} Ev_{32W} + \tilde{\eta}_{(Y82W,\ V42W)} Ev_{42W} + \tilde{\eta}_{(Y82W,\ V52W)} Ev_{52W} + \tilde{\eta}_{(Y82W,\ V62W)} Ev_{62W} + \tilde{\eta}_{(Y82W,\ V72W)} Ev_{72W} + \tilde{\eta}_{(Y82W,\ V92W)} Ev_{92W} + \tilde{\eta}_{(Y82W,\ VMM)} Ev_{MM} + EZ_3$

(A2.123) $EY_{92W} = \tilde{\eta}_{(Y92W,\ V92W)} Ev_{92W} + \tilde{\eta}_{(Y92W,\ V22W)} Ev_{22W} + \tilde{\eta}_{(Y92W,\ V32W)} Ev_{32W} + \tilde{\eta}_{(Y92W,\ V42W)} Ev_{42W} + \tilde{\eta}_{(Y92W,\ V52W)} Ev_{52W} + \tilde{\eta}_{(Y92W,\ V62W)} Ev_{62W} + \tilde{\eta}_{(Y92W,\ V72W)} Ev_{72W} + \tilde{\eta}_{(Y92W,\ V82W)} Ev_{82W} + \tilde{\eta}_{(Y92W,\ VMM)} Ev_{MM} + EZ_3$

(A2.124) $EY_{MM} = \tilde{\eta}_{(YMM,\ VMM)} Ev_{MM} + \tilde{\eta}_{(YMM,\ V22W)} Ev_{22W} + \tilde{\eta}_{(YMM,\ V32W)} Ev_{32W} + \tilde{\eta}_{(YMM,\ V42W)} Ev_{42W} + \tilde{\eta}_{(YMM,\ V52W)} Ev_{52W} + \tilde{\eta}_{(YMM,\ V62W)} Ev_{62W} + \tilde{\eta}_{(YMM,\ V72W)} Ev_{72W} + \tilde{\eta}_{(YMM,\ V82W)} Ev_{82W} + \tilde{\eta}_{(YMM,\ V92W)} Ev_{92W} + EZ_3$

(A2.125) $EY_{13W} = \tilde{\eta}_{(Y13W,\ V13W)} Ev_{13W} + \tilde{\eta}_{(Y13W,\ V23W)} Ev_{23W} + \tilde{\eta}_{(Y13W,\ V33W)} Ev_{33W} + \tilde{\eta}_{(Y13W,\ V43W)} Ev_{43W} + \tilde{\eta}_{(Y13W,\ V53W)} Ev_{53W} + \tilde{\eta}_{(Y13W,\ V63W)} Ev_{63W} + \tilde{\eta}_{(Y13W,\ V73W)} Ev_{73W} + \tilde{\eta}_{(Y13W,\ V83W)} Ev_{83W} + \tilde{\eta}_{(Y13W,\ V93W)} Ev_{93W} + \tilde{\eta}_{(Y13W,\ VBM)} Ev_{BM} + EZ_4$

(A2.126) $EY_{23W} = \tilde{\eta}_{(Y23W,\ V23W)} Ev_{23W} + \tilde{\eta}_{(Y23W,\ V13W)} Ev_{13W} + \tilde{\eta}_{(Y23W,\ V33W)} Ev_{33W} + \tilde{\eta}_{(Y23W,\ V43W)} Ev_{43W} + \tilde{\eta}_{(Y23W,\ V53W)} Ev_{53W} + \tilde{\eta}_{(Y23W,\ V63W)} Ev_{63W} + \tilde{\eta}_{(Y23W,\ V73W)} Ev_{73W} + \tilde{\eta}_{(Y23W,\ V83W)} Ev_{83W} + \tilde{\eta}_{(Y23W,\ V93W)} Ev_{93W} + \tilde{\eta}_{(Y23W,\ VBM)} Ev_{BM} + EZ_4$

(A2.127) $EY_{33W} = \tilde{\eta}_{(Y33W,\ V33W)} Ev_{33W} + \tilde{\eta}_{(Y33W,\ V13W)} Ev_{13W} + \tilde{\eta}_{(Y33W,\ V32W)} Ev_{32W} + \tilde{\eta}_{(Y33W,\ V43W)} Ev_{43W} + \tilde{\eta}_{(Y33W,\ V53W)} Ev_{53W} + \tilde{\eta}_{(Y33W,\ V63W)} Ev_{63W} + \tilde{\eta}_{(Y33W,\ V73W)} Ev_{73W} + \tilde{\eta}_{(Y33W,\ V83W)} Ev_{83W} + \tilde{\eta}_{(Y33W,\ V93W)} Ev_{93W} + \tilde{\eta}_{(Y33W,\ VBM)} Ev_{BM} + EZ_4$

(A2.128) $EY_{43W} = \tilde{\eta}_{(Y43W,\ V43W)} Ev_{43W} + \tilde{\eta}_{(Y43W,\ V13W)} Ev_{13W} + \tilde{\eta}_{(Y43W,\ V23W)} Ev_{23W} + \tilde{\eta}_{(Y43W,\ V33W)} Ev_{33W} + \tilde{\eta}_{(Y43W,\ V53W)} Ev_{53W} + \tilde{\eta}_{(Y43W,\ V63W)} Ev_{63W} + \tilde{\eta}_{(Y43W,\ V73W)} Ev_{73W} + \tilde{\eta}_{(Y43W,\ V83W)} Ev_{83W} + \tilde{\eta}_{(Y43W,\ V93W)} Ev_{93W} + \tilde{\eta}_{(Y43W,\ VBM)} Ev_{BM} + EZ_4$

(A2.129) $EY_{53W} = \tilde{\eta}_{(Y53W,\ V53W)} Ev_{53W} + \tilde{\eta}_{(Y53W,\ V13W)} Ev_{13W} + \tilde{\eta}_{(Y53W,\ V23W)} Ev_{23W} + \tilde{\eta}_{(Y53W,\ V33W)} Ev_{33W} + \tilde{\eta}_{(Y53W,\ V43W)} Ev_{43W} + \tilde{\eta}_{(Y53W,\ V63W)} Ev_{63W} + \tilde{\eta}_{(Y53W,\ V73W)} Ev_{73W} + \tilde{\eta}_{(Y53W,\ V83W)} Ev_{83W} + \tilde{\eta}_{(Y53W,\ V93W)} Ev_{93W} + \tilde{\eta}_{(Y53W,\ VBM)} Ev_{BM} + EZ_4$

(A2.130) $EY_{63W} = \tilde{\eta}_{(Y63W,\ V63W)} Ev_{63W} + \tilde{\eta}_{(Y63W,\ V13W)} Ev_{13W} + \tilde{\eta}_{(Y63W,\ V23W)} Ev_{23W} + \tilde{\eta}_{(Y63W,\ V33W)} Ev_{33W} + \tilde{\eta}_{(Y63W,\ V43W)} Ev_{43W} + \tilde{\eta}_{(Y63W,\ V53W)} Ev_{53W} + \tilde{\eta}_{(Y63W,\ V73W)} Ev_{73W} + \tilde{\eta}_{(Y63W,\ V83W)} Ev_{83W} + \tilde{\eta}_{(Y63W,\ V93W)} Ev_{93W} + \tilde{\eta}_{(Y63W,\ VBM)} Ev_{BM} + EZ_4$

(A2.131) $EY_{73W} = \tilde{\eta}_{(Y73W,\ V73W)} Ev_{73W} + \tilde{\eta}_{(Y73W,\ V13W)} Ev_{13W} + \tilde{\eta}_{(Y73W,\ V23W)} Ev_{23W} + \tilde{\eta}_{(Y73W,\ V33W)} Ev_{33W} + \tilde{\eta}_{(Y73W,\ V43W)} Ev_{43W} + \tilde{\eta}_{(Y73W,\ V53W)} Ev_{53W} + \tilde{\eta}_{(Y73W,\ V63W)} Ev_{63W} + \tilde{\eta}_{(Y73W,\ V83W)} Ev_{83W} + \tilde{\eta}_{(Y73W,\ V93W)} Ev_{93W} + \tilde{\eta}_{(Y73W,\ VBM)} Ev_{BM} + EZ_4$

(A2.132) $EY_{83W} = \tilde{\eta}_{(Y83W,\ V83W)}\ Ev_{83W} + \tilde{\eta}_{(Y83W,\ V13W)}\ Ev_{13W} + \tilde{\eta}_{(Y83W,\ V23W)}\ Ev_{23W} + \tilde{\eta}_{(Y83W,\ V33W)}\ Ev_{33W} + \tilde{\eta}_{(Y83W,\ V43W)}\ Ev_{43W} + \tilde{\eta}_{(Y83W,\ V53W)}\ Ev_{53W} + \tilde{\eta}_{(Y83W,\ V63W)}\ Ev_{63W} + \tilde{\eta}_{(Y83W,\ V73W)}\ Ev_{73W} + \tilde{\eta}_{(Y83W,\ V93W)}\ Ev_{93W} + \tilde{\eta}_{(Y83W,\ VBM)} Ev_{BM} + EZ_4$

(A2.133) $EY_{93W} = \tilde{\eta}_{(Y93W,\ V93W)}\ Ev_{93W} + \tilde{\eta}_{(Y93W,\ V13W)}\ Ev_{13W} + \tilde{\eta}_{(Y93W,\ V23W)}\ Ev_{23W} + \tilde{\eta}_{(Y93W,\ V33W)}\ Ev_{33W} + \tilde{\eta}_{(Y93W,\ V43W)}\ Ev_{43W} + \tilde{\eta}_{(Y93W,\ V53W)}\ Ev_{53W} + \tilde{\eta}_{(Y93W,\ V63W)}\ Ev_{63W} + \tilde{\eta}_{(Y93W,\ V73W)}\ Ev_{73W} + \tilde{\eta}_{(Y93W,\ V83W)}\ Ev_{83W} + \tilde{\eta}_{(Y93W,\ VBM)} Ev_{BM} + EZ_4$

(A2.134) $EY_{BM} = \tilde{\eta}_{(YBM,\ VBM)}\ Ev_{BM} + \tilde{\eta}_{(YBM,\ V13W)}\ Ev_{13W} + \tilde{\eta}_{(YBM,\ V23W)}\ Ev_{23W} + \tilde{\eta}_{(YBM,\ V33W)}\ Ev_{33W} + \tilde{\eta}_{(YBM,\ V43W)}\ Ev_{43W} + \tilde{\eta}_{(YBM,\ V53W)}\ Ev_{53W} + \tilde{\eta}_{(YBM,\ V63W)}\ Ev_{63W} + \tilde{\eta}_{(YBM,\ V73W)}\ Ev_{73W} + \tilde{\eta}_{(YBM,\ V83W)}\ Ev_{83W} + \tilde{\eta}_{(YBM,\ V93W)} Ev_{93W} + EZ_4$

Output constrained input demand of lamb and mutton slaughtering/processing sectors

(A2.135) $EY_{1L} = \tilde{\eta}_{(Y1L,\ V1L)}\ Ev_{1L} + \tilde{\eta}_{(Y1L,\ V2L)}\ Ev_{2L} + \tilde{\eta}_{(Y1L,\ V3L)}\ Ev_{3L} + \tilde{\eta}_{(Y1L,\ V4L)}\ Ev_{4L} + \tilde{\eta}_{(Y1L,\ V5L)}\ Ev_{5L} + \tilde{\eta}_{(Y1L,\ V6L)}\ Ev_{6L} + \tilde{\eta}_{(Y1L,\ VSL)}\ Ev_{SL} + EZ_L$

(A2.136) $EY_{2L} = \tilde{\eta}_{(Y2L,\ V2L)}\ Ev_{2L} + \tilde{\eta}_{(Y2L,\ V1L)}\ Ev_{1L} + \tilde{\eta}_{(Y2L,\ V3L)}\ Ev_{3L} + \tilde{\eta}_{(Y2L,\ V4L)}\ Ev_{4L} + \tilde{\eta}_{(Y2L,\ V5L)}\ Ev_{5L} + \tilde{\eta}_{(Y2L,\ V6L)}\ Ev_{6L} + \tilde{\eta}_{(Y2L,\ VSL)}\ Ev_{SL} + EZ_L$

(A2.137) $EY_{3L} = \tilde{\eta}_{(Y3L,\ V3L)}\ Ev_{3L} + \tilde{\eta}_{(Y3L,\ V1L)}\ Ev_{1L} + \tilde{\eta}_{(Y3L,\ V2L)}\ Ev_{2L} + \tilde{\eta}_{(Y3L,\ V4L)}\ Ev_{4L} + \tilde{\eta}_{(Y3L,\ V5L)}\ Ev_{5L} + \tilde{\eta}_{(Y3L,\ V6L)}\ Ev_{6L} + \tilde{\eta}_{(Y3L,\ VSL)}\ Ev_{SL} + EZ_L$

(A2.138) $EY_{4L} = \tilde{\eta}_{(Y4L,\ V4L)}\ Ev_{4L} + \tilde{\eta}_{(Y4L,\ V1L)}\ Ev_{1L} + \tilde{\eta}_{(Y4L,\ V2L)}\ Ev_{2L} + \tilde{\eta}_{(Y4L,\ V3L)}\ Ev_{3L} + \tilde{\eta}_{(Y4L,\ V5L)}\ Ev_{5L} + \tilde{\eta}_{(Y4L,\ V6L)}\ Ev_{6L} + \tilde{\eta}_{(Y4L,\ VSL)}\ Ev_{SL} + EZ_L$

(A2.139) $EY_{5L} = \tilde{\eta}_{(Y5L,\ V5L)}\ Ev_{5L} + \tilde{\eta}_{(Y5L,\ V1L)}\ Ev_{1L} + \tilde{\eta}_{(Y5L,\ V2L)}\ Ev_{2L} + \tilde{\eta}_{(Y5L,\ V3L)}\ Ev_{3L} + \tilde{\eta}_{(Y5L,\ V4L)}\ Ev_{4L} + \tilde{\eta}_{(Y5L,\ V6L)}\ Ev_{6L} + \tilde{\eta}_{(Y5L,\ VSL)}\ Ev_{SL} + EZ_L$

(A2.140) $EY_{6L} = \tilde{\eta}_{(Y6L,\ V6L)}\ Ev_{6L} + \tilde{\eta}_{(Y6L,\ V1L)}\ Ev_{1L} + \tilde{\eta}_{(Y6L,\ V2L)}\ Ev_{2L} + \tilde{\eta}_{(Y6L,\ V3L)}\ Ev_{3L} + \tilde{\eta}_{(Y6L,\ V4L)}\ Ev_{4L} + \tilde{\eta}_{(Y6L,\ V5L)}\ Ev_{5L} + \tilde{\eta}_{(Y6L,\ VSL)}\ Ev_{SL} + EZ_L$

(A2.141) $EY_{SL} = \tilde{\eta}_{(YSL,\ VSL)}\ Ev_{SL} + \tilde{\eta}_{(YSL,\ V1L)}\ Ev_{1L} + \tilde{\eta}_{(YSL,\ V2L)}\ Ev_{2L} + \tilde{\eta}_{(YSL,\ V3L)}\ Ev_{3L} + \tilde{\eta}_{(YSL,\ V4L)}\ Ev_{4L} + \tilde{\eta}_{(YSL,\ V5L)}\ Ev_{5L} + \tilde{\eta}_{(YSL,\ V6L)}\ Ev_{6L} + EZ_L$

(A2.142) $EY_{1M} = \tilde{\eta}_{(Y1M,\ V1M)}\ Ev_{1M} + \tilde{\eta}_{(Y1M,\ V2M)}\ Ev_{2M} + \tilde{\eta}_{(Y1M,\ V3M)}\ Ev_{3M} + \tilde{\eta}_{(Y1M,\ V4M)}\ Ev_{4M} + \tilde{\eta}_{(Y1M,\ V5M)}\ Ev_{5M} + \tilde{\eta}_{(Y1M,\ V6M)}\ Ev_{6M} + \tilde{\eta}_{(Y1M,\ V7M)}\ Ev_{7M} + \tilde{\eta}_{(Y8M,\ V8M)}\ Ev_{8M} + \tilde{\eta}_{(Y1M,\ V9M)}\ Ev_{9M} + \tilde{\eta}_{(Y1M,\ VSM)} Ev_{SM} + EZ_M$

(A2.143) $EY_{2M} = \tilde{\eta}_{(Y2M,\ V2M)}\ Ev_{2M} + \tilde{\eta}_{(Y2M,\ V1M)}\ Ev_{1M} + \tilde{\eta}_{(Y2M,\ V3M)}\ Ev_{3M} + \tilde{\eta}_{(Y2M,\ V4M)}\ Ev_{4M} + \tilde{\eta}_{(Y2M,\ V5M)}\ Ev_{5M} + \tilde{\eta}_{(Y2M,\ V6M)}\ Ev_{6M} + \tilde{\eta}_{(Y2M,\ V7M)}\ Ev_{7M} + \tilde{\eta}_{(Y2M,\ V8M)}\ Ev_{8M} + \tilde{\eta}_{(Y2M,\ V9M)}\ Ev_{9M} + \tilde{\eta}_{(Y2M,\ VSM)} Ev_{SM} + EZ_M$

(A2.144) $EY_{3M} = \tilde{\eta}_{(Y3M,\ V3M)}\ Ev_{3M} + \tilde{\eta}_{(Y3M,\ V1M)}\ Ev_{1M} + \tilde{\eta}_{(Y3M,\ V2M)}\ Ev_{2M} + \tilde{\eta}_{(Y3M,\ V4M)}\ Ev_{4M} + \tilde{\eta}_{(Y3M,\ V5M)}\ Ev_{5M} + \tilde{\eta}_{(Y3M,\ V6M)}\ Ev_{6M} + \tilde{\eta}_{(Y3M,\ V7M)}\ Ev_{7M} + \tilde{\eta}_{(Y3M,\ V8M)}\ Ev_{8M} + \tilde{\eta}_{(Y3M,\ V9M)}\ Ev_{9M} + \tilde{\eta}_{(Y3M,\ VSM)} Ev_{SM} + EZ_M$

(A2.145) $EY_{4M} = \tilde{\eta}_{(Y4M, V4M)} Ev_{4M} + \tilde{\eta}_{(Y4M, V1M)} Ev_{1M} + \tilde{\eta}_{(Y4M, V2M)} Ev_{2M} + \tilde{\eta}_{(Y4M, V3M)} Ev_{3M} + \tilde{\eta}_{(Y4M, V5M)} Ev_{5M} + \tilde{\eta}_{(Y4M, V6M)} Ev_{6M} + \tilde{\eta}_{(Y4M, V7M)} Ev_{7M} + \tilde{\eta}_{(Y4M, V8M)} Ev_{8M} + \tilde{\eta}_{(Y4M, V9M)} Ev_{9M} + \tilde{\eta}_{(Y4M, VSM)} Ev_{SM} + EZ_M$

(A2.146) $EY_{5M} = \tilde{\eta}_{(Y5M, V5M)} Ev_{5M} + \tilde{\eta}_{(Y5M, V1M)} Ev_{1M} + \tilde{\eta}_{(Y5M, V2M)} Ev_{2M} + \tilde{\eta}_{(Y5M, V3M)} Ev_{3M} + \tilde{\eta}_{(Y5M, V4M)} Ev_{4M} + \tilde{\eta}_{(Y5M, V6M)} Ev_{6M} + \tilde{\eta}_{(Y5M, V7M)} Ev_{7M} + \tilde{\eta}_{(Y5M, V8M)} Ev_{8M} + \tilde{\eta}_{(Y5M, V9M)} Ev_{9M} + \tilde{\eta}_{(Y5M, VSM)} Ev_{SM} + EZ_M$

(A2.147) $EY_{6M} = \tilde{\eta}_{(Y6M, V6M)} Ev_{6M} + \tilde{\eta}_{(Y6M, V1M)} Ev_{1M} + \tilde{\eta}_{(Y6M, V2M)} Ev_{2M} + \tilde{\eta}_{(Y6M, V3M)} Ev_{3M} + \tilde{\eta}_{(Y6M, V4M)} Ev_{4M} + \tilde{\eta}_{(Y6M, V5M)} Ev_{5M} + \tilde{\eta}_{(Y6M, V7M)} Ev_{7M} + \tilde{\eta}_{(Y6M, V8M)} Ev_{8M} + \tilde{\eta}_{(Y6M, V9M)} Ev_{9M} + \tilde{\eta}_{(Y6M, VSM)} Ev_{SM} + EZ_M$

(A2.148) $EY_{7M} = \tilde{\eta}_{(Y7M, V7M)} Ev_{7M} + \tilde{\eta}_{(Y7M, V1M)} Ev_{1M} + \tilde{\eta}_{(Y7M, V2M)} Ev_{2M} + \tilde{\eta}_{(Y7M, V3M)} Ev_{3M} + \tilde{\eta}_{(Y7M, V4M)} Ev_{4M} + \tilde{\eta}_{(Y7M, V5M)} Ev_{5M} + \tilde{\eta}_{(Y7M, V6M)} Ev_{6M} + \tilde{\eta}_{(Y7M, V8M)} Ev_{8M} + \tilde{\eta}_{(Y7M, V9M)} Ev_{9M} + \tilde{\eta}_{(Y7M, VSM)} Ev_{SM} + EZ_M$

(A2.149) $EY_{8M} = \tilde{\eta}_{(Y8M, V8M)} Ev_{8M} + \tilde{\eta}_{(Y8M, V1M)} Ev_{1M} + \tilde{\eta}_{(Y8M, V2M)} Ev_{2M} + \tilde{\eta}_{(Y8M, V3M)} Ev_{3M} + \tilde{\eta}_{(Y8M, V4M)} Ev_{4M} + \tilde{\eta}_{(Y8M, V5M)} Ev_{5M} + \tilde{\eta}_{(Y8M, V6M)} Ev_{6M} + \tilde{\eta}_{(Y8M, V7M)} Ev_{7M} + \tilde{\eta}_{(Y8M, V9M)} Ev_{9M} + \tilde{\eta}_{(Y8M, VSM)} Ev_{SM} + EZ_M$

(A2.150) $EY_{9M} = \tilde{\eta}_{(Y9M, V9M)} Ev_{9M} + \tilde{\eta}_{(Y9M, V1M)} Ev_{1M} + \tilde{\eta}_{(Y9M, V2M)} Ev_{2M} + \tilde{\eta}_{(Y9M, V3M)} Ev_{3M} + \tilde{\eta}_{(Y9M, V4M)} Ev_{4M} + \tilde{\eta}_{(Y9M, V5M)} Ev_{5M} + \tilde{\eta}_{(Y9M, V6M)} Ev_{6M} + \tilde{\eta}_{(Y9M, V7M)} Ev_{7M} + \tilde{\eta}_{(Y9M, V8M)} Ev_{8M} + \tilde{\eta}_{(Y9M, VSM)} Ev_{SM} + EZ_M$

(A2.151) $EY_{SM} = \tilde{\eta}_{(YSM, VSM)} Ev_{SM} + \tilde{\eta}_{(YSM, V1M)} Ev_{1M} + \tilde{\eta}_{(YSM, V2M)} Ev_{2M} + \tilde{\eta}_{(YSM, V3M)} Ev_{3M} + \tilde{\eta}_{(YSM, V4M)} Ev_{4M} + \tilde{\eta}_{(YSM, V5M)} Ev_{5M} + \tilde{\eta}_{(YSM, V6M)} Ev_{6M} + \tilde{\eta}_{(YSM, V7M)} Ev_{7M} + \tilde{\eta}_{(YSM, V8M)} Ev_{8M} + \tilde{\eta}_{(YSM, V9M)} Ev_{9M} + EZ_M$

<u>*Wool warehouse sectors equilibrium*</u>

(A2.152) $k_{Y14W}EY_{14W} + k_{YNM}EY_{NM} = \gamma_{Z1W}EZ_{1W} + \gamma_{Z1S}EZ_{1S}$

(A2.153) $k_{Y14W}Ev_{14W} + k_{YNM}Ev_{NM} = \gamma_{Z1W}Eu_{1W} + \gamma_{Z1S}Eu_{1S}$

(A2.154) $k_{Y21W}EY_{21W} + k_{Y31W}EY_{31W} + k_{Y41W}EY_{41W} + k_{Y51W}EY_{51W} + k_{Y61W}EY_{61W} + k_{Y71W}EY_{71W} + k_{Y81W}EY_{81W} + k_{Y91W}EY_{91W} + k_{YFM}EY_{FM} = \gamma_{Z2W}EZ_{2W} + \gamma_{Z2S}EZ_{2S}$

(A2.155) $k_{Y21W}Ev_{21W} + k_{Y31W}Ev_{31W} + k_{Y41W}Ev_{41W} + k_{Y51W}Ev_{51W} + k_{Y61W}Ev_{61W} + k_{Y71W}Ev_{71W} + k_{Y81W}Ev_{81W} + k_{Y91W}Ev_{91W} + k_{YFM}Ev_{FM} = \gamma_{Z2W}Eu_{2W} + \gamma_{Z2S}Eu_{2S}$

(A2.156) $k_{Y22W}EY_{22W} + k_{Y32W}EY_{32W} + k_{Y42W}EY_{42W} + k_{Y52W}EY_{52W} + k_{Y62W}EY_{62W} + k_{Y72W}EY_{72W} + k_{Y82W}EY_{82W} + k_{Y92W}EY_{92W} + k_{YMM}EY_{MM} = \gamma_{Z3W}EZ_{3W} + \gamma_{Z3S}EZ_{3S}$

(A2.157) $k_{Y22W}Ev_{22W} + k_{Y32W}Ev_{32W} + k_{Y42W}Ev_{42W} + k_{Y52W}Ev_{52W} + k_{Y62W}Ev_{62W} + k_{Y72W}Ev_{72W} + k_{Y82W}Ev_{82W} + k_{Y92W}Ev_{92W} + k_{YMM}Ev_{MM} = \gamma_{Z3W}Eu_{3W} + \gamma_{Z3S}Eu_{3S}$

(A2.158) $k_{Y13W}EY_{13W} + k_{Y23W}EY_{23W} + k_{Y33W}EY_{33W} + k_{Y43W}EY_{43W} + k_{Y53W}EY_{53W} + k_{Y63W}EY_{63W} + k_{Y73W}EY_{73W} + k_{Y83W}EY_{83W} + k_{Y93W}EY_{93W} + k_{YBM}EY_{BM} = \gamma_{Z4W}EZ_{4W} + \gamma_{Z4S}EZ_{4S}$

(A2.159) $k_{Y13W}Ev_{13W} + k_{Y23W}Ev_{23W} + k_{Y33W}Ev_{33W} + k_{Y43W}Ev_{43W} + k_{Y53W}Ev_{53W} + k_{Y63W}Ev_{63W} + k_{Y73W}Ev_{73W} + k_{Y83W}Ev_{83W} + k_{Y93W}Ev_{93W} + k_{YBM}Ev_{BM} = \gamma_{Z4W}Eu_{4W} + \gamma_{Z4S}Eu_{4S}$

Lamb and mutton slaughtering/processing sectors equilibrium

(A2.160) $k_{Y1L}EY_{1L} + k_{Y2L}EY_{2L} + k_{Y3L}EY_{3L} + k_{Y4L}EY_{4L} + k_{Y5L}EY_{5L} + k_{Y6L}EY_{6L} + k_{YSL}EY_{SL} = \gamma_{ZLE}EZ_{LE} + \gamma_{ZLD}EZ_{LD}$

(A2.161) $k_{Y1L}Ev_{1L} + k_{Y2L}Ev_{2L} + k_{Y3L}Ev_{3L} + k_{Y4L}Ev_{4L} + k_{Y5L}Ev_{5L} + k_{Y6L}Ev_{6L} + k_{YSL}Ev_{SL} = \gamma_{ZLE}Eu_{LE} + \gamma_{ZLD}Eu_{LD}$

(A2.162) $k_{Y1M}EY_{1M} + k_{Y2M}EY_{2M} + k_{Y3M}EY_{3M} + k_{Y4M}EY_{4M} + k_{Y5M}EY_{5M} + k_{Y6M}EY_{6M} + k_{Y7M}EY_{7M} + k_{Y8M}EY_{8M} + k_{Y9M}EY_{9M} + k_{YSM}EY_{SM} = \gamma_{ZME}EZ_{ME} + \gamma_{ZMD}EZ_{MD}$

(A2.163) $k_{Y1M}Ev_{1M} + k_{Y2M}Ev_{2M} + k_{Y3M}Ev_{3M} + k_{Y4M}Ev_{4M} + k_{Y5M}Ev_{5M} + k_{Y6M}Ev_{6M} + k_{Y7M}Ev_{7M} + k_{Y8M}Ev_{8M} + k_{Y9M}Ev_{9M} + k_{YSM}Ev_{SM} = \gamma_{ZME}Eu_{ME} + \gamma_{ZMD}Eu_{MD}$

Input constrained output supply of wool warehouse sectors

(A2.164) $EZ_{1W} = \tilde{\varepsilon}_{(Z1W,\, U1W)}\, Eu_{1W} + \tilde{\varepsilon}_{(Z1W,\, U1S)}\, Eu_{1S} + EY_N$

(A2.165) $EZ_{1S} = \tilde{\varepsilon}_{(Z1S,\, U1W)}\, Eu_{1W} + \tilde{\varepsilon}_{(Z1S,\, U1S)}\, Eu_{1S} + EY_N$

(A2.166) $EZ_{2W} = \tilde{\varepsilon}_{(Z2W,\, U2W)}\, Eu_{2W} + \tilde{\varepsilon}_{(Z2W,\, U2S)}\, Eu_{2S} + EY_F$

(A2.167) $EZ_{2S} = \tilde{\varepsilon}_{(Z2S,\, U2W)}\, Eu_{2W} + \tilde{\varepsilon}_{(Z2S,\, U2S)}\, Eu_{2S} + EY_F$

(A2.168) $EZ_{3W} = \tilde{\varepsilon}_{(Z3W,\, U3W)}\, Eu_{3W} + \tilde{\varepsilon}_{(Z3W,\, U3S)}\, Eu_{3S} + EY_C$

(A2.169) $EZ_{3S} = \tilde{\varepsilon}_{(Z3S,\, U3W)}\, Eu_{3W} + \tilde{\varepsilon}_{(Z3S,\, U3S)}\, Eu_{3S} + EY_C$

(A2.170) $EZ_{4W} = \tilde{\varepsilon}_{(Z4W,\, U4W)}\, Eu_{4W} + \tilde{\varepsilon}_{(Z4W,\, U4S)}\, Eu_{4S} + EY_B$

(A2.171) $EZ_{4S} = \tilde{\varepsilon}_{(Z4S,\, U4W)}\, Eu_{4W} + \tilde{\varepsilon}_{(Z4S,\, U4S)}\, Eu_{4S} + EY_B$

Input constrained output supply of lamb and mutton slaughtering/processing sectors

(A2.172) $EZ_{LE} = \tilde{\varepsilon}_{(ZLE,\, ULE)}\, Eu_{LE} + \tilde{\varepsilon}_{(ZLE,\, ULD)}\, Eu_{LD} + EY_L$

(A2.173) $EZ_{LD} = \tilde{\varepsilon}_{(ZLD,\, ULE)}\, Eu_{LE} + \tilde{\varepsilon}_{(ZLD,\, ULD)}\, Eu_{LD} + EY_L$

(A2.174) $EZ_{ME} = \tilde{\varepsilon}_{(ZME,\, UME)}\, Eu_{ME} + \tilde{\varepsilon}_{(ZME,\, UMD)}\, Eu_{MD} + EY_M$

(A2.175) $EZ_{MD} = \tilde{\varepsilon}_{(ZMD,\, UME)}\, Eu_{ME} + \tilde{\varepsilon}_{(ZLD,\, UMD)}\, Eu_{MD} + EY_M$

Other input supply to wool scouring sector

(A2.176) $EZ_{CS} = \varepsilon_{(ZCS,\, UCS)}(Eu_{CS} - t_{ZCS})$

Output constrained input demand of wool scouring sector

(A2.177) $EZ_{1S} = \tilde{\eta}_{(Z1S,\, U1S)}\, Eu_{1S} + \tilde{\eta}_{(Z1S,\, U2S)}\, Eu_{2S} + \tilde{\eta}_{(Z1S,\, U3S)}\, Eu_{3S} + \tilde{\eta}_{(Z1S,\, U4S)}\, Eu_{4S} + \tilde{\eta}_{(Z1S,\, UCS)}\, Eu_{CS} + EZ_S$

(A2.178) $EZ_{2S} = \tilde{\eta}_{(Z2S,\ U2S)}\ Eu_{2S} + \tilde{\eta}_{(Z2S,\ U1S)}\ Eu_{1S} + \tilde{\eta}_{(Z2S,\ U3S)}\ Eu_{3S} + \tilde{\eta}_{(Z2S,\ U4S)}\ Eu_{4S} + \tilde{\eta}_{(Z2S,\ UCS)}\ Eu_{CS} + EZ_S$

(A2.179) $EZ_{3S} = \tilde{\eta}_{(Z3S,\ U3S)}\ Eu_{3S} + \tilde{\eta}_{(Z3S,\ U1S)}\ Eu_{1S} + \tilde{\eta}_{(Z3S,\ U2S)}\ Eu_{2S} + \tilde{\eta}_{(Z3S,\ U4S)}\ Eu_{4S} + \tilde{\eta}_{(Z3S,\ UCS)}\ Eu_{CS} + EZ_S$

(A2.180) $EZ_{4S} = \tilde{\eta}_{(Z4S,\ U4S)}\ Eu_{4S} + \tilde{\eta}_{(Z4S,\ U1S)}\ Eu_{1S} + \tilde{\eta}_{(Z4S,\ U2S)}\ Eu_{2S} + \tilde{\eta}_{(Z4S,\ U3S)}\ Eu_{3S} + \tilde{\eta}_{(Z4S,\ UCS)}\ Eu_{CS} + EZ_S$

(A2.181) $EZ_{CS} = \tilde{\eta}_{(ZCS,\ UCS)}\ Eu_{CS} + \tilde{\eta}_{(ZCS,\ U1S)}\ Eu_{1S} + \tilde{\eta}_{(ZCS,\ U2S)}\ Eu_{2S} + \tilde{\eta}_{(ZCS,\ U3S)}\ Eu_{3S} + \tilde{\eta}_{(ZCS,\ U4S)}\ Eu_{4S} + EZ_S$

<u>*Wool scouring sector equilibrium*</u>

(A2.182) $k_{ZIS}EZ_{1S} + k_{Z2S}EZ_{2S} + k_{Z3S}EZ_{3S} + k_{Z4S}EZ_{4S} + k_{ZCS}EZ_{CS} = \gamma_{ZCW}EZ_{CW} + \gamma_{F1S}EF_{1S} + \gamma_{F2S}EF_{2S} + \gamma_{F3S}EF_{3S} + \gamma_{F4S}EF_{4S} + \gamma_{Z2T}EZ_{2T} + \gamma_{Z3T}EZ_{3T} + \gamma_{Z4T}EZ_{4T}$

(A2.183) $k_{ZIS}Eu_{1S} + k_{Z2S}Eu_{2S} + k_{Z3S}Eu_{3S} + k_{Z4S}Eu_{4S} + k_{ZCS}Eu_{CS} = \gamma_{ZCW}Eu_{CW} + \gamma_{F1S}Es_{1S} + \gamma_{F2S}Es_{2S} + \gamma_{F3S}Es_{3S} + \gamma_{F4S}Es_{4S} + \gamma_{Z2T}Eu_{2T} + \gamma_{Z3T}Eu_{3T} + \gamma_{Z4T}Eu_{4T}$

<u>*Input constrained output supply of wool scouring sector*</u>

(A2.184) $EF_{1S} = \tilde{\varepsilon}_{(F1S,\ S1S)}\ Es_{1S} + \tilde{\varepsilon}_{(F1S,\ S2S)}\ Es_{2S} + \tilde{\varepsilon}_{(F1S,\ S3S)}\ Es_{3S} + \tilde{\varepsilon}_{(FIS,\ S4S)}\ Es_{4S} + \tilde{\varepsilon}_{(F1S,\ UCW)}\ Eu_{CW} + \tilde{\varepsilon}_{(F1S,\ U2T)}\ Eu_{2T} + \tilde{\varepsilon}_{(FIS,\ U3T)}\ Eu_{3T} + \tilde{\varepsilon}_{(F1S,\ U4T)}\ Eu_{4T} + EZ_C$

(A2.185) $EF_{2S} = \tilde{\varepsilon}_{(F2S,\ S1S)}\ Es_{1S} + \tilde{\varepsilon}_{(F2S,\ S2S)}\ Es_{2S} + \tilde{\varepsilon}_{(F2S,\ S3S)}\ Es_{3S} + \tilde{\varepsilon}_{(F2S,\ S4S)}\ Es_{4S} + \tilde{\varepsilon}_{(F2S,\ UCW)}\ Eu_{CW} + \tilde{\varepsilon}_{(F2S,\ U2T)}\ Eu_{2T} + \tilde{\varepsilon}_{(F2S,\ U3T)}\ Eu_{3T} + \tilde{\varepsilon}_{(F2S,\ U4T)}\ Eu_{4T} + EZ_C$

(A2.186) $EF_{3S} = \tilde{\varepsilon}_{(F3S,\ S1S)}\ Es_{1S} + \tilde{\varepsilon}_{(F3S,\ S2S)}\ Es_{2S} + \tilde{\varepsilon}_{(F3S,\ S3S)}\ Es_{3S} + \tilde{\varepsilon}_{(F3S,\ S4S)}\ Es_{4S} + \tilde{\varepsilon}_{(F3S,\ UCW)}\ Eu_{CW} + \tilde{\varepsilon}_{(F3S,\ U2T)}\ Eu_{2T} + \tilde{\varepsilon}_{(F3S,\ U3T)}\ Eu_{3T} + \tilde{\varepsilon}_{(F3S,\ U4T)}\ Eu_{4T} + EZ_C$

(A2.187) $EF_{4S} = \tilde{\varepsilon}_{(F4S,\ S1S)}\ Es_{1S} + \tilde{\varepsilon}_{(F4S,\ S2S)}\ Es_{2S} + \tilde{\varepsilon}_{(F4S,\ S3S)}\ Es_{3S} + \tilde{\varepsilon}_{(F4S,\ S4S)}\ Es_{4S} + \tilde{\varepsilon}_{(F4S,\ UCW)}\ Eu_{CW} + \tilde{\varepsilon}_{(F4S,\ U2T)}\ Eu_{2T} + \tilde{\varepsilon}_{(F4S,\ U3T)}\ Eu_{3T} + \tilde{\varepsilon}_{(F4S,\ U4T)}\ Eu_{4T} + EZ_C$

(A2.188) $EZ_{CW} = \tilde{\varepsilon}_{(ZCW,\ S1S)}\ Es_{1S} + \tilde{\varepsilon}_{(ZCW,\ S2S)}\ Es_{2S} + \tilde{\varepsilon}_{(ZCW,\ S3S)}\ Es_{3S} + \tilde{\varepsilon}_{(ZCW,\ S4S)}\ Es_{4S} + \tilde{\varepsilon}_{(ZCW,\ UCW)}\ Eu_{CW} + \tilde{\varepsilon}_{(ZCW,\ U2T)}\ Eu_{2T} + \tilde{\varepsilon}_{(ZCW,\ U3T)}\ Eu_{3T} + \tilde{\varepsilon}_{(ZCW,\ U4T)}\ Eu_{4T} + EZ_C$

(A2.189) $EZ_{2T} = \tilde{\varepsilon}_{(Z2T,\ S1S)}\ Es_{1S} + \tilde{\varepsilon}_{(Z2T,\ S2S)}\ Es_{2S} + \tilde{\varepsilon}_{(Z2T,\ S3S)}\ Es_{3S} + \tilde{\varepsilon}_{(Z2T,\ S4S)}\ Es_{4S} + \tilde{\varepsilon}_{(Z2T,\ UCW)}\ Eu_{CW} + \tilde{\varepsilon}_{(Z2T,\ U2T)}\ Eu_{2T} + \tilde{\varepsilon}_{(Z2T,\ U3T)}\ Eu_{3T} + \tilde{\varepsilon}_{(Z2T,\ U4T)}\ Eu_{4T} + EZ_C$

(A2.190) $EZ_{3T} = \tilde{\varepsilon}_{(Z3T,\ S1S)}\ Es_{1S} + \tilde{\varepsilon}_{(Z3T,\ S2S)}\ Es_{2S} + \tilde{\varepsilon}_{(Z3T,\ S3S)}\ Es_{3S} + \tilde{\varepsilon}_{(Z3T,\ S4S)}\ Es_{4S} + \tilde{\varepsilon}_{(Z3T,\ UCW)}\ Eu_{CW} + \tilde{\varepsilon}_{(Z3T,\ U2T)}\ Eu_{2T} + \tilde{\varepsilon}_{(Z3T,\ U3T)}\ Eu_{3T} + \tilde{\varepsilon}_{(Z3T,\ U4T)}\ Eu_{4T} + EZ_C$

(A2.191) $EZ_{4T} = \tilde{\varepsilon}_{(Z4T,\ S1S)}\ Es_{1S} + \tilde{\varepsilon}_{(Z4T,\ S2S)}\ Es_{2S} + \tilde{\varepsilon}_{(Z4T,\ S3S)}\ Es_{3S} + \tilde{\varepsilon}_{(Z4T,\ S4S)}\ Es_{4S} + \tilde{\varepsilon}_{(Z4T,\ UCW)}\ Eu_{CW} + \tilde{\varepsilon}_{(Z4T,\ U2T)}\ Eu_{2T} + \tilde{\varepsilon}_{(Z4T,\ U3T)}\ Eu_{3T} + \tilde{\varepsilon}_{(Z4T,\ U4T)}\ Eu_{4T} + EZ_C$

<u>*Other input supply to wool carbonising sector*</u>

(A2.192) $EZ_{CB} = \varepsilon_{(ZCB,\ UCB)}(Eu_{CB} - t_{ZCB})$

Output constrained input demand of wool carbonising sector

(A2.193) $EZ_{CW} = \tilde{\eta}_{(ZCW, UCW)} Eu_{CW} + \tilde{\eta}_{(ZCW, UCB)} Eu_{CB} + EF_{CW}$

(A2.194) $EZ_{CB} = \tilde{\eta}_{(ZCB, UCW)} Eu_{CW} + \tilde{\eta}_{(ZCB, UCB)} Eu_{CB} + EF_{CW}$

Wool carbonising sector equilibrium

(A2.195) $Es_{CW} = k_{ZCW}Eu_{CW} + k_{ZCB}Eu_{CB}$

Other input supply to wool topmaking sector

(A2.196) $EZ_{WT} = \varepsilon_{(ZWT, UWT)}(Eu_{WT} - t_{ZWT})$

Output constrained input demand of wool topmaking sector

(A2.197) $EZ_{2T} = \tilde{\eta}_{(Z2T, U2T)} Eu_{2T} + \tilde{\eta}_{(Z2T, U3T)} Eu_{3T} + \tilde{\eta}_{(Z2T, U4T)} Eu_{4T} + \tilde{\eta}_{(Z2T, UWT)} Eu_{WT} + EF_{T}$

(A2.198) $EZ_{3T} = \tilde{\eta}_{(Z3T, U2T)} Eu_{2T} + \tilde{\eta}_{(Z3T, U3T)} Eu_{3T} + \tilde{\eta}_{(Z3T, U4T)} Eu_{4T} + \tilde{\eta}_{(Z3T, UWT)} Eu_{WT} + EF_{T}$

(A2.199) $EZ_{4T} = \tilde{\eta}_{(Z4T, U2T)} Eu_{4T} + \tilde{\eta}_{(Z4T, U3T)} Eu_{3T} + \tilde{\eta}_{(Z4T, U4T)} Eu_{4T} + \tilde{\eta}_{(Z4T, UWT)} Eu_{WT} + EF_{T}$

(A2.200) $EZ_{WT} = \tilde{\eta}_{(ZWT, U2T)} Eu_{2T} + \tilde{\eta}_{(ZWT, U3T)} Eu_{3T} + \tilde{\eta}_{(ZWT, U4T)} Eu_{4T} + \tilde{\eta}_{(ZWT, UWT)} Eu_{WT} + EF_{T}$

Wool topmaking sector equilibrium

(A2.201) $k_{Z2T}EZ_{2T} + k_{Z3T}EZ_{3T} + k_{Z4T}EZ_{4T} + k_{ZWT}EZ_{WT} = \gamma_{F2T}EF_{2T} + \gamma_{F3T}EF_{3T} + \gamma_{F4T}EF_{4T} + \gamma_{FNW}EF_{NW} + \gamma_{QDP}EQ_{DP}$

(A2.202) $k_{Z2T}Eu_{2T} + k_{Z3T}Eu_{3T} + k_{Z4T}Eu_{4T} + k_{ZWT}Eu_{WT} = \gamma_{F2T}Es_{2T} + \gamma_{F3T}Es_{3T} + \gamma_{F4T}Es_{4T} + \gamma_{FNW}Es_{NW} + \gamma_{QDP}Ep_{DP}$

Input constrained output supply of wool topmaking sector

(A2.203) $EF_{2T} = \tilde{\varepsilon}_{(F2T, S2T)} Es_{2T} + \tilde{\varepsilon}_{(F2T, S3T)} Es_{3T} + \tilde{\varepsilon}_{(F2T, S4T)} Es_{4T} + \tilde{\varepsilon}_{(F2T, SNW)} Es_{NW} + \tilde{\varepsilon}_{(F2T, PDP)} Ep_{DP} + EZ_{T}$

(A2.204) $EF_{3T} = \tilde{\varepsilon}_{(F3T, S3T)} Es_{3T} + \tilde{\varepsilon}_{(F3T, S2T)} Es_{2T} + \tilde{\varepsilon}_{(F3T, S4T)} Es_{4T} + \tilde{\varepsilon}_{(F3T, SNW)} Es_{NW} + \tilde{\varepsilon}_{(F3T, PDP)} Ep_{DP} + EZ_{T}$

(A2.205) $EF_{4T} = \tilde{\varepsilon}_{(F4T, S4T)} Es_{4T} + \tilde{\varepsilon}_{(F4T, S2T)} Es_{2T} + \tilde{\varepsilon}_{(F4T, S3T)} Es_{3T} + \tilde{\varepsilon}_{(F4T, SNW)} Es_{NW} + \tilde{\varepsilon}_{(F4T, PDP)} Ep_{DP} + EZ_{T}$

(A2.206) $EF_{NW} = \tilde{\varepsilon}_{(FNW, SNW)} Es_{NW} + \tilde{\varepsilon}_{(FNW, S2T)} Es_{2T} + \tilde{\varepsilon}_{(FNW, S3T)} Es_{3T} + \tilde{\varepsilon}_{(FNW, S4T)} Es_{4T} + \tilde{\varepsilon}_{(FNW, PDP)} Ep_{DP} + EZ_{T}$

(A2.207) $EQ_{DP} = \tilde{\varepsilon}_{(QDP, PDP)} Ep_{DP} + \tilde{\varepsilon}_{(QDP, S2T)} Es_{2T} + \tilde{\varepsilon}_{(QDP, S3T)} Es_{3T} + \tilde{\varepsilon}_{(QDP, S4T)} Es_{4T} + \tilde{\varepsilon}_{(QDP, SNW)} Es_{NW} + EZ_{T}$

Other input supply to export greasy wool shipment sectors

(A2.208) $EZ_{NM} = \varepsilon_{(ZNM,\ UNM)}(Eu_{NM} - t_{ZNM})$

(A2.209) $EZ_{FM} = \varepsilon_{(ZFM,\ UFM)}(Eu_{FM} - t_{ZFM})$

(A2.210) $EZ_{MM} = \varepsilon_{(ZMM,\ UMM)}(Eu_{MM} - t_{ZMM})$

(A2.211) $EZ_{BM} = \varepsilon_{(ZBM,\ UBM)}(Eu_{BM} - t_{ZBM})$

Other input supply to export carbonised wool shipment sector

(A2.212) $EF_{CB} = \varepsilon_{(FCB,\ SCB)}(Es_{CB} - t_{FCB})$

Other input supply to export scoured wool shipment sectors

(A2.213) $EF_{NS} = \varepsilon_{(FNS,\ SNS)}(Es_{NS} - t_{FNS})$

(A2.214) $EF_{FS} = \varepsilon_{(FFS,\ SFS)}(Es_{FS} - t_{FFS})$

(A2.215) $EF_{MS} = \varepsilon_{(FMS,\ SMS)}(Es_{MS} - t_{FMS})$

(A2.216) $EF_{BS} = \varepsilon_{(FBS,\ SBS)}(Es_{BS} - t_{FBS})$

Other input supply to export wool tops shipment sectors

(A2.217) $EF_{FT} = \varepsilon_{(FFT,\ SFT)}(Es_{FT} - t_{FFT})$

(A2.218) $EF_{MT} = \varepsilon_{(FMT,\ SMT)}(Es_{MT} - t_{FMT})$

(A2.219) $EF_{BT} = \varepsilon_{(FBT,\ SBT)}(Es_{BT} - t_{FBT})$

(A2.220) $EF_{NE} = \varepsilon_{(FNE,\ SNE)}(Es_{NE} - t_{FNE})$

Output constrained input demand of export greasy wool shipment sectors

(A2.221) $EZ_{1W} = \tilde{\eta}_{(Z1W,\ U1W)} Eu_{1W} + \tilde{\eta}_{(Z1W,\ UNM)} Eu_{NM} + EQ_{1W}$

(A2.222) $EZ_{NM} = \tilde{\eta}_{(ZNM,\ U1W)} Eu_{1W} + \tilde{\eta}_{(ZNM,\ UNM)} Eu_{NM} + EQ_{1W}$

(A2.223) $EZ_{2W} = \tilde{\eta}_{(Z2W,\ U2W)} Eu_{2W} + \tilde{\eta}_{(Z2W,\ UFM)} Eu_{FM} + EQ_{2W}$

(A2.224) $EZ_{FM} = \tilde{\eta}_{(ZFM,\ U2W)} Eu_{2W} + \tilde{\eta}_{(ZFM,\ UFM)} Eu_{FM} + EQ_{2W}$

(A2.225) $EZ_{3W} = \tilde{\eta}_{(Z3W,\ U3W)} Eu_{3W} + \tilde{\eta}_{(Z3W,\ UMM)} Eu_{MM} + EQ_{3W}$

(A2.226) $EZ_{MM} = \tilde{\eta}_{(ZMM,\ U3W)} Eu_{3W} + \tilde{\eta}_{(ZMM,\ UMM)} Eu_{MM} + EQ_{3W}$

(A2.227) $EZ_{4W} = \tilde{\eta}_{(Z4W,\ U4W)} Eu_{4W} + \tilde{\eta}_{(Z4W,\ UBM)} Eu_{BM} + EQ_{4W}$

(A2.228) $EZ_{BM} = \tilde{\eta}_{(ZBM,\ U4W)} Eu_{4W} + \tilde{\eta}_{(ZBM,\ UBM)} Eu_{BM} + EQ_{4W}$

Output constrained input demand of export carbonised wool shipment sectors

(A2.229) $EF_{CW} = \tilde{\eta}_{(FCW,\ SCW)} Es_{CW} + \tilde{\eta}_{(FCW,\ SCB)} Es_{CB} + EQ_{CW}$

(A2.230) $EF_{CB} = \tilde{\eta}_{(FCB,\ SCW)} Es_{CW} + \tilde{\eta}_{(FCB,\ SCB)} Es_{CB} + EQ_{CW}$

Output constrained input demand of export scoured wool shipment sectors

(A2.231) $EF_{1S} = \tilde{\eta}_{(F1S, S1S)} Es_{1S} + \tilde{\eta}_{(F1S, SNS)} Es_{NS} + EQ_{1S}$

(A2.232) $EF_{NS} = \tilde{\eta}_{(FNS, S1S)} Es_{1S} + \tilde{\eta}_{(FNS, SNS)} Es_{NS} + EQ_{1S}$

(A2.233) $EF_{2S} = \tilde{\eta}_{(F2S, S2S)} Es_{2S} + \tilde{\eta}_{(F2S, SFS)} Es_{FS} + EQ_{2S}$

(A2.234) $EF_{FS} = \tilde{\eta}_{(FFS, S2S)} Es_{2S} + \tilde{\eta}_{(FFS, SFS)} Es_{FS} + EQ_{2S}$

(A2.235) $EF_{3S} = \tilde{\eta}_{(F3S, S3S)} Es_{3S} + \tilde{\eta}_{(F3S, SMS)} Es_{MS} + EQ_{3S}$

(A2.236) $EF_{MS} = \tilde{\eta}_{(FMS, S3S)} Es_{3S} + \tilde{\eta}_{(FMS, SMS)} Es_{MS} + EQ_{3S}$

(A2.237) $EF_{4S} = \tilde{\eta}_{(F4S, S4S)} Es_{4S} + \tilde{\eta}_{(F4S, SBS)} Es_{BS} + EQ_{4S}$

(A2.238) $EF_{BS} = \tilde{\eta}_{(FBS, S4S)} Es_{4S} + \tilde{\eta}_{(FBS, SBS)} Es_{BS} + EQ_{4S}$

Output constrained input demand of export wool top shipment sectors

(A2.239) $EF_{2T} = \tilde{\eta}_{(F2T, S2T)} Es_{2T} + \tilde{\eta}_{(F2T, SFT)} Es_{FT} + EQ_{2T}$

(A2.240) $EF_{FT} = \tilde{\eta}_{(FFT, S2T)} Es_{2T} + \tilde{\eta}_{(FFT, SFT)} Es_{FT} + EQ_{2T}$

(A2.241) $EF_{3T} = \tilde{\eta}_{(F3T, S3T)} Es_{3T} + \tilde{\eta}_{(F3T, SMT)} Es_{MT} + EQ_{3T}$

(A2.242) $EF_{MT} = \tilde{\eta}_{(FMT, S3T)} Es_{3T} + \tilde{\eta}_{(FMT, SMT)} Es_{MT} + EQ_{3T}$

(A2.243) $EF_{4T} = \tilde{\eta}_{(F4T, S4T)} Es_{4T} + \tilde{\eta}_{(F4T, SBT)} Es_{BT} + EQ_{4T}$

(A2.244) $EF_{BT} = \tilde{\eta}_{(FBT, S4T)} Es_{4T} + \tilde{\eta}_{(FBT, SBT)} Es_{BT} + EQ_{4T}$

(A2.245) $EF_{NW} = \tilde{\eta}_{(FNW, SNW)} Es_{NW} + \tilde{\eta}_{(FNW, SNE)} Es_{NE} + EQ_{NW}$

(A2.246) $EF_{NE} = \tilde{\eta}_{(FNE, SNW)} Es_{NW} + \tilde{\eta}_{(FNE, SNE)} Es_{NE} + EQ_{NW}$

Export greasy wool shipment sector equilibrium

(A2.247) $Ep_{1W} = k_{Z1W}Eu_{1W} + k_{ZNM}Eu_{NM}$

(A2.248) $Ep_{2W} = k_{Z2W}Eu_{2W} + k_{ZFM}Eu_{FM}$

(A2.249) $Ep_{3W} = k_{Z3W}Eu_{3W} + k_{ZMM}Eu_{MM}$

(A2.250) $Ep_{4W} = k_{Z4W}Eu_{4W} + k_{ZBM}Eu_{BM}$

Export carbonised wool shipment sector equilibrium

(A2.251) $Ep_{CW} = k_{FCW}Es_{CW} + k_{FCB}Es_{CB}$

Export scoured wool shipment sector equilibrium

(A2.252) $Ep_{1S} = k_{F1S}Es_{1S} + k_{FNS}Es_{NS}$

(A2.253) $Ep_{2S} = k_{F2S}Es_{2S} + k_{FFS}Es_{FS}$

(A2.254) $Ep_{3S} = k_{F3S}Es_{3S} + k_{FMS}Es_{MS}$

$$(A2.255) \quad Ep_{4S} = k_{F4S}Es_{4S} + k_{FBS}Es_{BS}$$

Export wool tops shipment sector equilibrium

$$(A2.256) \quad Ep_{2T} = k_{F2T}Es_{2T} + k_{FFT}Es_{FT}$$

$$(A2.257) \quad Ep_{3T} = k_{F3T}Es_{3T} + k_{FMT}Es_{MT}$$

$$(A2.258) \quad Ep_{4T} = k_{F4T}Es_{4T} + k_{FBT}Es_{BT}$$

$$(A2.259) \quad Ep_{NW} = k_{FNW}Es_{NW} + k_{FNE}Es_{NE}$$

Other input supply to lamb and mutton marketing sectors

$$(A2.260) \quad EZ_{1L} = \varepsilon_{(Z1L,\ U1L)}(Eu_{1L} - t_{Z1L})$$

$$(A2.261) \quad EZ_{2L} = \varepsilon_{(Z2L,\ U2L)}(Eu_{2L} - t_{Z2L})$$

$$(A2.262) \quad EZ_{1M} = \varepsilon_{(Z1M,\ U1M)}(Eu_{1M} - t_{Z1M})$$

$$(A2.263) \quad EZ_{2M} = \varepsilon_{(Z2M,\ U2M)}(Eu_{2M} - t_{Z2M})$$

Output constrained input demand of lamb and mutton marketing sectors

$$(A2.264) \quad EZ_{LE} = \tilde{\eta}_{(ZLE,\ ULE)}\,Eu_{LE} + \tilde{\eta}_{(ZLE,\ U1L)}\,Eu_{1L} + EQ_{LE}$$

$$(A2.265) \quad EZ_{1L} = \tilde{\eta}_{(Z1L,\ ULE)}\,Eu_{LE} + \tilde{\eta}_{(Z1L,\ U1L)}\,Eu_{1L} + EQ_{LE}$$

$$(A2.266) \quad EZ_{LD} = \tilde{\eta}_{(ZLD,\ ULD)}\,Eu_{LD} + \tilde{\eta}_{(ZLD,\ U2L)}\,Eu_{2L} + EQ_{LD}$$

$$(A2.267) \quad EZ_{2L} = \tilde{\eta}_{(Z2L,\ ULD)}\,Eu_{LD} + \tilde{\eta}_{(Z2L,\ U2L)}\,Eu_{2L} + EQ_{LD}$$

$$(A2.268) \quad EZ_{MD} = \tilde{\eta}_{(ZMD,\ UMD)}\,Eu_{MD} + \tilde{\eta}_{(ZMD,\ U2M)}\,Eu_{2M} + EQ_{MD}$$

$$(A2.269) \quad EZ_{2M} = \tilde{\eta}_{(Z2M,\ UMD)}\,Eu_{MD} + \tilde{\eta}_{(Z2M,\ U2M)}\,Eu_{2M} + EQ_{MD}$$

$$(A2.270) \quad EZ_{ME} = \tilde{\eta}_{(ZME,\ UME)}\,Eu_{ME} + \tilde{\eta}_{(ZME,\ U1M)}\,Eu_{1M} + EQ_{ME}$$

$$(A2.271) \quad EZ_{1M} = \tilde{\eta}_{(Z1M,\ UME)}\,Eu_{ME} + \tilde{\eta}_{(Z1M,\ U1M)}\,Eu_{1M} + EQ_{ME}$$

Lamb and mutton marketing sectors equilibrium

$$(A2.272) \quad Ep_{LE} = k_{ZLE}Eu_{LE} + k_{Z1L}Eu_{1L}$$

$$(A2.273) \quad Ep_{LD} = k_{ZLD}Eu_{LD} + k_{Z2L}Eu_{2L}$$

$$(A2.274) \quad Ep_{MD} = k_{ZMD}Eu_{MD} + k_{Z2M}Eu_{2M}$$

$$(A2.275) \quad Ep_{ME} = k_{ZME}Eu_{ME} + k_{Z1M}Eu_{1M}$$

Origin of live sheep exports

$$(A2.276) \quad EQ_{SE} = \beta_{Y7E}EY_{7E} + \beta_{Y8E}EY_{8E} + \beta_{Y9E}EY_{9E}$$

Export demand for Australian greasy wool

(A2.277) $EQ_{1W} = \eta_{(Q1W,\ P1W)}(Ep_{1W} - n_{Q1W})$

(A2.278) $EQ_{2W} = \eta_{(Q2W,\ P2W)}(Ep_{2W} - n_{Q2W})$

(A2.279) $EQ_{3W} = \eta_{(Q3W,\ P3W)}(Ep_{3W} - n_{Q3W})$

(A2.280) $EQ_{4W} = \eta_{(Q4W,\ P4W)}(Ep_{4W} - n_{Q4W})$

Export demand for Australian carbonised wool

(A2.281) $EQ_{CW} = \eta_{(QCW,\ PCW)}(Ep_{CW} - n_{QCW})$

Export demand for Australian scoured wool

(A2.282) $EQ_{1S} = \eta_{(Q1S,\ P1S)}(Ep_{1S} - n_{Q1S})$

(A2.283) $EQ_{2S} = \eta_{(Q2S,\ P2S)}(Ep_{2S} - n_{Q2S})$

(A2.284) $EQ_{3S} = \eta_{(Q3S,\ P3S)}(Ep_{3S} - n_{Q3S})$

(A2.285) $EQ_{4S} = \eta_{(Q4S,\ P4S)}(Ep_{4S} - n_{Q4S})$

Export demand for Australian wool tops

(A2.286) $EQ_{2T} = \eta_{(Q2T,\ P2T)}(Ep_{2T} - n_{Q2T})$

(A2.287) $EQ_{3T} = \eta_{(Q3T,\ P3T)}(Ep_{3T} - n_{Q3T})$

(A2.288) $EQ_{4T} = \eta_{(Q4T,\ P4T)}(Ep_{4T} - n_{Q4T})$

Export demand for Australian noils/other wool

(A2.289) $EQ_{NW} = \eta_{(QNW,\ PNW)}(Ep_{NW} - n_{QNW})$

Domestic demand for LSP wool

(A2.290) $EQ_{DP} = \eta_{(QDP,\ PDP)}(Ep_{DP} - n_{QDP})$

Export demand for Australian lamb and mutton

(A2.291) $EQ_{LE} = \eta_{(QLE,\ PLE)}(Ep_{LE} - n_{QLE})$

(A2.292) $EQ_{ME} = \eta_{(QME,\ PME)}(Ep_{ME} - n_{QME})$

Export demand for Australian live sheep

(A2.293) $EQ_{SE} = \eta_{(QSE,\ PSE)}(Ep_{SE} - n_{QSE})$

Domestic retail demand for Australian lamb and mutton

(A2.294) $EQ_{LD} = \eta_{(QLD, PLD)}(Ep_{LD} - n_{QLD}) + \eta_{(QLD, PMD)}(Ep_{MD} - n_{QMD})$

(A2.295) $EQ_{MD} = \eta_{(QMD, PLD)}(Ep_{LD} - n_{QLD}) + \eta_{(QMD, PMD)}(Ep_{MD} - n_{QMD})$

The Equilibrium Displacement Model with Integrability Conditions

Input supply to farm enterprises

(A2.1)’ $EX_1 = \varepsilon_{(X1, W1)}(Ew_1 - t_{X1})$

(A2.2)’ $EX_{1W} = \varepsilon_{(X1W, W1W)}(Ew_{1W} - t_{X1W})$

(A2.3)’ $EX_{23} = \varepsilon_{(X23, W23)}(Ew_{23} - t_{X23})$

(A2.4)’ $EX_{21W} = \varepsilon_{(X21W, W21W)}(Ew_{21W} - t_{X21W})$

(A2.5)’ $EX_{31W} = \varepsilon_{(X31W, W31W)}(Ew_{31W} - t_{X31W})$

(A2.6)’ $EX_{23} = \beta_{X21}EX_{21} + \beta_{X31}EX_{31}$

(A2.7)’ $EX_{45} = \varepsilon_{(X45, W45)}(Ew_{45} - t_{X45})$

(A2.8)’ $EX_{41W} = \varepsilon_{(X41W, W41W)}(Ew_{41W} - t_{X41W})$

(A2.9)’ $EX_{51W} = \varepsilon_{(X51W, W51W)}(Ew_{51W} - t_{X51W})$

(A2.10)’ $EX_{45} = \beta_{X41}EX_{41} + \beta_{X51}EX_{51}$

(A2.11)’ $EX_{61} = \varepsilon_{(X61, W61)}(Ew_{61} - t_{X61})$

(A2.12)’ $EX_{61W} = \varepsilon_{(X61W, W61W)}(Ew_{61W} - t_{X61W})$

(A2.13)’ $EX_{71} = \varepsilon_{(X71, W71)}(Ew_{71} - t_{X71})$

(A2.14)’ $EX_{71W} = \varepsilon_{(X71W, W71W)}(Ew_{71W} - t_{X71W})$

(A2.15)’ $EX_{81} = \varepsilon_{(X81, W81)}(Ew_{81} - t_{X81})$

(A2.16)’ $EX_{81W} = \varepsilon_{(X81W, W81W)}(Ew_{81W} - t_{X81W})$

(A2.17)’ $EX_{91} = \varepsilon_{(X91, W91)}(Ew_{91} - t_{X91})$

(A2.18)’ $EX_{91W} = \varepsilon_{(X91W, W91W)}(Ew_{91W} - t_{X91W})$

Output constrained input demands of farm enterprises

(A2.19)’ $EX_1 = - k_{X1W}\sigma_{(X1, X1W)} Ew_1 + k_{X1W}\sigma_{(X1, X1W)}Ew_{1W} + EY_1$

(A2.20)’ $EX_{1W} = k_{X1}\sigma_{(X1, X1W)}Ew_1 - k_{X1}\sigma_{(X1, X1W)}Ew_{1W} + EY_1$

(A2.21)’ $EX_{21} = - k_{X21W}\sigma_{(X21, X21W)} Ew_{23} + k_{X21W}\sigma_{(X21, X21W)}Ew_{21W} + EY_2$

(A2.22)’ $EX_{21W} = k_{X21}\sigma_{(X21, X21W)}Ew_{23} - k_{X21}\sigma_{(X21, X21W)}Ew_{21W} + EY_2$

(A2.23)’ $EX_{31} = - k_{X31W}\sigma_{(X31, X31W)} Ew_{23} + k_{X31W}\sigma_{(X31, X31W)}Ew_{31W} + EY_3$

(A2.24)’ $EX_{31W} = k_{X31}\sigma_{(X31, X31W)}Ew_{23} - k_{X31}\sigma_{(X31, X31W)}Ew_{31W} + EY_3$

(A2.25)’ $EX_{41} = - k_{X41W}\sigma_{(X41, X41W)} Ew_{45} + k_{X41W}\sigma_{(X41, X41W)}Ew_{41W} + EY_4$

(A2.26)’ $EX_{41W} = k_{X41}\sigma_{(X41, X41W)}Ew_{45} - k_{X41}\sigma_{(X41, X41W)}Ew_{41W} + EY_4$

(A2.27)’ $EX_{51} = - k_{X51W}\sigma_{(X51, X51W)} Ew_{45} + k_{X51W}\sigma_{(X51, X51W)}Ew_{51W} + EY_5$

(A2.28)’ $EX_{51W} = k_{X51}\sigma_{(X51, X51W)}Ew_{45} - k_{X51}\sigma_{(X51, X51W)}Ew_{51W} + EY_5$

(A2.29)’ $EX_{61} = - k_{X61W}\sigma_{(X61, X61W)} Ew_{61} + k_{X61W}\sigma_{(X61, X61W)}Ew_{61W} + EY_6$

(A2.30)’ $EX_{61W} = k_{X61}\sigma_{(X61, X61W)}Ew_{61} - k_{X61}\sigma_{(X61, X61W)}Ew_{61W} + EY_6$

(A2.31)’ $EX_{71} = - k_{X71W}\sigma_{(X71, X71W)} Ew_{71} + k_{X71W}\sigma_{(X71, X71W)}Ew_{71W} + EY_7$

(A2.32)’ $EX_{71W} = k_{X71}\sigma_{(X71, X71W)}Ew_{71} - k_{X71}\sigma_{(X71, X71W)}Ew_{71W} + EY_7$

(A2.33)’ $EX_{81} = - k_{X81W}\sigma_{(X81, X81W)} Ew_{81} + k_{X81W}\sigma_{(X81, X81W)}Ew_{81W} + EY_8$

(A2.34)’ $EX_{81W} = k_{X81}\sigma_{(X81, X81W)}Ew_{81} - k_{X81}\sigma_{(X81, X81W)}Ew_{81W} + EY_8$

(A2.35)’ $EX_{91} = - k_{X91W}\sigma_{(X91, X91W)} Ew_{91} + k_{X91W}\sigma_{(X91, X91W)}Ew_{91W} + EY_9$

(A2.36)’ $EX_{91W} = k_{X91}\sigma_{(X91, X91W)}Ew_{91} - k_{X91}\sigma_{(X91, X91W)}Ew_{91W} + EY_9$

Farm enterprise equilibriums

(A2.37)’ $k_{X1}EX_1 + k_{X1W}EX_{1W} = \gamma_{Y13W}EY_{13W} + \gamma_{Y13W}EY_{14W} + \gamma_{Y1L}EY_{1L} + \gamma_{Y1M}EY_{1M}$

(A2.38)’ $k_{X1}Ew_1 + k_{X1W}Ew_{1W} = \gamma_{Y13W}Ev_{13W} + \gamma_{Y14W}Ev_{14W} + \gamma_{Y1L}Ev_{1L} + \gamma_{Y1M}Ev_{1M}$

(A2.39)’ $k_{X21}EX_{21} + k_{X21W}EX_{21W} = \gamma_{Y21W}EY_{21W} + \gamma_{Y22W}EY_{22W} + \gamma_{Y23W}EY_{23W} + \gamma_{Y2L}EY_{2L} + \gamma_{Y2M}EY_{2M}$

(A2.40)’ $k_{X21}Ew_{23} + k_{X21W}Ew_{21W} = \gamma_{Y21W}Ev_{21W} + \gamma_{Y22W}Ev_{22W} + \gamma_{Y23W}Ev_{23W} + \gamma_{Y2L}Ev_{2L} + \gamma_{Y2M}Ev_{2M}$

(A2.41)’ $k_{X31}EX_{31} + k_{X31W}EX_{31W} = \gamma_{Y31W}EY_{31W} + \gamma_{Y32W}EY_{32W} + \gamma_{Y33W}EY_{33W} + \gamma_{Y3L}EY_{3L} + \gamma_{Y3M}EY_{3M}$

(A2.42)’ $k_{X31}Ew_{23} + k_{X31W}Ew_{31W} = \gamma_{Y31W}Ev_{31W} + \gamma_{Y32W}Ev_{32W} + \gamma_{Y33W}Ev_{33W} + \gamma_{Y3L}Ev_{3L} + \gamma_{Y3M}Ev_{3M}$

(A2.43)’ $k_{X41}EX_{41} + k_{X41W}EX_{41W} = \gamma_{Y41W}EY_{41W} + \gamma_{Y42W}EY_{42W} + \gamma_{Y43W}EY_{43W} + \gamma_{Y4L}EY_{4L} + \gamma_{Y4M}EY_{4M}$

(A2.44)’ $k_{X41}Ew_{45} + k_{X41W}Ew_{41W} = \gamma_{Y41W}Ev_{41W} + \gamma_{Y42W}Ev_{42W} + \gamma_{Y43W}Ev_{43W} + \gamma_{Y4L}Ev_{4L} + \gamma_{Y4M}Ev_{4M}$

(A2.45)’ $k_{X51}EX_{51} + k_{X51W}EX_{51W} = \gamma_{Y51W}EY_{51W} + \gamma_{Y52W}EY_{52W} + \gamma_{Y53W}EY_{53W} + \gamma_{Y5L}EY_{5L} + \gamma_{Y5M}EY_{5M}$

(A2.46)’ $k_{X51}Ew_{45} + k_{X51W}Ew_{51W} = \gamma_{Y51W}Ev_{51W} + \gamma_{Y52W}Ev_{52W} + \gamma_{Y53W}Ev_{53W} + \gamma_{Y5L}Ev_{5L} + \gamma_{Y5M}Ev_{5M}$

(A2.47)’ $k_{X61}EX_{61} + k_{X61W}EX_{61W} = \gamma_{Y61W}EY_{61W} + \gamma_{Y62W}EY_{62W} + \gamma_{Y63W}EY_{63W} + \gamma_{Y6L}EY_{6L} + \gamma_{Y6M}EY_{6M}$

(A2.48)’ $k_{X61}Ew_{61} + k_{X61W}Ew_{61W} = \gamma_{Y61W}Ev_{61W} + \gamma_{Y62W}Ev_{62W} + \gamma_{Y63W}Ev_{63W} + \gamma_{Y6L}Ev_{6L} + \gamma_{Y6M}Ev_{6M}$

(A2.49)’ $k_{X71}EX_{71} + k_{X71W}EX_{71W} = \gamma_{Y71W}EY_{71W} + \gamma_{Y72W}EY_{72W} + \gamma_{Y73W}EY_{73W} + \gamma_{Y7E}EY_{7E} + \gamma_{Y7M}EY_{7M}$

(A2.50)’ $k_{X71}Ew_{71} + k_{X71W}Ew_{71W} = \gamma_{Y71W}Ev_{71W} + \gamma_{Y72W}Ev_{72W} + \gamma_{Y73W}Ev_{73W} + \gamma_{Y7E}Ep_{SE} + \gamma_{Y7M}Ev_{7M}$

(A2.51)’ $k_{X81}EX_{81} + k_{X81W}EX_{81W} = \gamma_{Y81W}EY_{81W} + \gamma_{Y82W}EY_{82W} + \gamma_{Y83W}EY_{83W} + \gamma_{Y8E}EY_{8E} + \gamma_{Y8M}EY_{8M}$

(A2.52)’ $k_{X81}Ew_{81} + k_{X81W}Ew_{81W} = \gamma_{Y81W}Ev_{81W} + \gamma_{Y82W}Ev_{82W} + \gamma_{Y83W}Ev_{83W} + \gamma_{Y8E}Ep_{SE} + \gamma_{Y8M}Ev_{8M}$

(A2.53)’ $k_{X91}EX_{91} + k_{X91W}EX_{91W} = \gamma_{Y91W}EY_{91W} + \gamma_{Y92W}EY_{92W} + \gamma_{Y93W}EY_{93W} + \gamma_{Y9E}EY_{9E} + \gamma_{Y9M}EY_{9M}$

(A2.54)’ $k_{X91}Ew_{91} + k_{X91W}Ew_{91W} = \gamma_{Y91W}Ev_{91W} + \gamma_{Y92W}Ev_{92W} + \gamma_{Y93W}Ev_{93W} + \gamma_{Y9E}Ep_{SE} + \gamma_{Y9M}Ev_{9M}$

Input constrained output supply of farm enterprises

(A2.55)’ $EY_{13W} = -(\gamma_{Y14W}\tau_{(Y13W,\ Y14W)} + \gamma_{Y1L}\tau_{(Y13W,\ Y1L)} + \gamma_{Y1M}\tau_{(Y13W,\ Y1M)})Ev_{13W} + \gamma_{Y14W}\tau_{(Y13W,\ Y14W)}Ev_{14W} + \gamma_{Y1L}\tau_{(Y13W,\ Y1L)}Ev_{1L} + \gamma_{Y1M}\tau_{(Y13W,\ Y1M)}Ev_{1M} + EX_N$

(A2.56)’ $EY_{14W} = -(\gamma_{Y13W}\tau_{(Y13W,\ Y14W)} + \gamma_{Y1L}\tau_{(Y14W,\ Y1L)} + \gamma_{Y1M}\tau_{(Y14W,\ Y1M)})Ev_{14W} + \gamma_{Y13W}\tau_{(Y13W,\ Y14W)}Ev_{13W} + \gamma_{Y1L}\tau_{(Y14W,\ Y1L)}Ev_{1L} + \gamma_{Y1M}\tau_{(Y14W,\ Y1M)}Ev_{1M} + EX_N$

(A2.57)’ $EY_{1L} = -(\gamma_{Y13W}\tau_{(Y13W,\ Y1L)} + \gamma_{Y14W}\tau_{(Y14W,\ Y1L)} + \gamma_{Y1M}\tau_{(Y1L,\ Y1M)})Ev_{1L} + \gamma_{Y13W}\tau_{(Y13W,\ Y1L)}Ev_{13W} + \gamma_{Y14W}\tau_{(Y14W,\ Y1L)}Ev_{14W} + \gamma_{Y1M}\tau_{(Y1L,\ Y1M)}Ev_{1M} + EX_N$

(A2.58)’ $EY_{1M} = -(\gamma_{Y13W}\tau_{(Y13W,\ Y1M)} + \gamma_{Y14W}\tau_{(Y14W,\ Y1M)} + \gamma_{Y1L}\tau_{(Y1L,\ Y1M)})Ev_{1M} + \gamma_{Y13W}\tau_{(Y13W,\ Y1M)}Ev_{13W} + \gamma_{Y14W}\tau_{(Y14W,\ Y1M)}Ev_{14W} + \gamma_{Y1L}\tau_{(Y1L,\ Y1M)}Ev_{1L} + EX_N$

(A2.59)’ $EY_{21W} = -(\gamma_{Y22W}\tau_{(Y21W,\ Y22W)} + \gamma_{Y23W}\tau_{(Y21W,\ Y23W)} + \gamma_{Y2L}\tau_{(Y21W,\ Y2L)} + \gamma_{Y2M}\tau_{(Y21W,\ Y2M)})Ev_{21W} + \gamma_{Y22W}\tau_{(Y21W,\ Y22W)}Ev_{22W} + \gamma_{Y23W}\tau_{(Y21W,\ Y23W)}Ev_{23W} + \gamma_{Y2L}\tau_{(Y21W,\ Y2L)}Ev_{2L} + \gamma_{Y2M}\tau_{(Y21W,\ Y2M)}Ev_{2M} + EX_2$

(A2.60)’ $EY_{22W} = -(\gamma_{Y21W}\tau_{(Y21W,\ Y22W)} + \gamma_{Y23W}\tau_{(Y22W,\ Y23W)} + \gamma_{Y2L}\tau_{(Y22W,\ Y2L)} + \gamma_{Y2M}\tau_{(Y22W,\ Y2M)})Ev_{22W} + \gamma_{Y21W}\tau_{(Y21W,\ Y22W)}Ev_{21W} + \gamma_{Y23W}\tau_{(Y22W,\ Y23W)}Ev_{23W} + \gamma_{Y2L}\tau_{(Y22W,\ Y2L)}Ev_{2L} + \gamma_{Y2M}\tau_{(Y22W,\ Y2M)}Ev_{2M} + EX_2$

(A2.61)’ $EY_{23W} = -(\gamma_{Y21W}\tau_{(Y21W,\ Y23W)} + \gamma_{Y22W}\tau_{(Y22W,\ Y23W)} + \gamma_{Y2L}\tau_{(Y23W,\ Y2L)} + \gamma_{Y2M}\tau_{(Y23W,\ Y2M)})Ev_{23W} + \gamma_{Y21W}\tau_{(Y21W,\ Y23W)}Ev_{21W} + \gamma_{Y22W}\tau_{(Y22W,\ Y23W)}Ev_{22W} + \gamma_{Y2L}\tau_{(Y23W,\ Y2L)}Ev_{2L} + \gamma_{Y2M}\tau_{(Y23W,\ Y2M)}Ev_{2M} + EX_2$

(A2.62)’ $EY_{2L} = -(\gamma_{Y21W}\tau_{(Y21W,\ Y2L)} + \gamma_{Y22W}\tau_{(Y22W,\ Y2L)} + \gamma_{Y23W}\tau_{(Y23W,\ Y2L)} + \gamma_{Y2M}\tau_{(Y2L,\ Y2M)})Ev_{2L} + \gamma_{Y21W}\tau_{(Y21W,\ Y2L)}Ev_{21W} + \gamma_{Y22W}\tau_{(Y22W,\ Y2L)}Ev_{22W} + \gamma_{Y23W}\tau_{(Y23W,\ Y2L)}Ev_{23W} + \gamma_{Y2M}\tau_{(Y2L,\ Y2M)}Ev_{2M} + EX_2$

(A2.63)’ $EY_{2M} = -(\gamma_{Y21W}\tau_{(Y21W,\ Y2M)} + \gamma_{Y22W}\tau_{(Y22W,\ Y2M)} + \gamma_{Y23W}\tau_{(Y23W,\ Y2M)} + \gamma_{Y2L}\tau_{(Y2L,\ Y2M)})Ev_{2M} + \gamma_{Y21W}\tau_{(Y21W,\ Y2M)}Ev_{21W} + \gamma_{Y22W}\tau_{(Y22W,\ Y2M)}Ev_{22W} + \gamma_{Y23W}\tau_{(Y23W,\ Y2M)}Ev_{23W} + \gamma_{Y2L}\tau_{(Y2L,\ Y2M)}Ev_{2M} + EX_2$

(A2.64)’ $EY_{31W} = -(\gamma_{Y32W}\tau_{(Y31W,\ Y32W)} + \gamma_{Y33W}\tau_{(Y31W,\ Y33W)} + \gamma_{Y3L}\tau_{(Y31W,\ Y3L)} + \gamma_{Y3M}\tau_{(Y31W,\ Y3M)})Ev_{31W} + \gamma_{Y32W}\tau_{(Y31W,\ Y32W)}Ev_{32W} + \gamma_{Y33W}\tau_{(Y31W,\ Y33W)}Ev_{33W} + \gamma_{Y3L}\tau_{(Y31W,\ Y3L)}Ev_{3L} + \gamma_{Y3M}\tau_{(Y31W,\ Y3M)}Ev_{3M} + EX_3$

(A2.65)’ $EY_{32W} = -(\gamma_{Y31W}\tau_{(Y31W,\ Y32W)} + \gamma_{Y33W}\tau_{(Y32W,\ Y33W)} + \gamma_{Y3L}\tau_{(Y32W,\ Y3L)} + \gamma_{Y3M}\tau_{(Y32W,\ Y3M)})Ev_{32W} + \gamma_{Y31W}\tau_{(Y31W,\ Y32W)}Ev_{31W} + \gamma_{Y33W}\tau_{(Y32W,\ Y33W)}Ev_{33W} + \gamma_{Y3L}\tau_{(Y32W,\ Y3L)}Ev_{3L} + \gamma_{Y3M}\tau_{(Y32W,\ Y3M)}Ev_{3M} + EX_3$

(A2.66)’ $EY_{33W} = -(\gamma_{Y31W}\tau_{(Y31W,\ Y33W)} + \gamma_{Y32W}\tau_{(Y32W,\ Y33W)} + \gamma_{Y3L}\tau_{(Y33W,\ Y3L)} + \gamma_{Y3M}\tau_{(Y33W,\ Y3M)})Ev_{33W} + \gamma_{Y31W}\tau_{(Y31W,\ Y33W)}Ev_{31W} + \gamma_{Y32W}\tau_{(Y32W,\ Y33W)}Ev_{32W} + \gamma_{Y3L}\tau_{(Y33W,\ Y3L)}Ev_{3L} + \gamma_{Y3M}\tau_{(Y33W,\ Y3M)}Ev_{3M} + EX_3$

(A2.67)’ $EY_{3L} = -(\gamma_{Y31W}\tau_{(Y31W,\ Y3L)} + \gamma_{Y32W}\tau_{(Y32W,\ Y3L)} + \gamma_{Y33W}\tau_{(Y33W,\ Y3L)} + \gamma_{Y3M}\tau_{(Y3L,\ Y3M)})Ev_{3L} + \gamma_{Y31W}\tau_{(Y31W,\ Y3L)}Ev_{31W} + \gamma_{Y32W}\tau_{(Y32W,\ Y3L)}Ev_{32W} + \gamma_{Y33W}\tau_{(Y33W,\ Y3L)}Ev_{33W} + \gamma_{Y3M}\tau_{(Y3L,\ Y3M)}Ev_{3M} + EX_3$

(A2.68)’ $$EY_{3M} = -(\gamma_{Y31W}\tau_{(Y31W,\, Y3M)} + \gamma_{Y32W}\tau_{(Y32W,\, Y3M)} + \gamma_{Y33W}\tau_{(Y33W,\, Y3M)} + \gamma_{Y3L}\tau_{(Y3L,\, Y3M)})Ev_{3M} + \gamma_{Y31W}\tau_{(Y31W,\, Y3M)}Ev_{31W} + \gamma_{Y32W}\tau_{(Y32W,\, Y3M)}Ev_{32W} + \gamma_{Y33W}\tau_{(Y33W,\, Y3M)}Ev_{33W} + \gamma_{Y3L}\tau_{(Y3L,\, Y3M)}Ev_{3M} + EX_3$$

(A2.69)’ $$EY_{41W} = -(\gamma_{Y42W}\tau_{(Y41W,\, Y42W)} + \gamma_{Y43W}\tau_{(Y41W,\, Y43W)} + \gamma_{Y4L}\tau_{(Y41W,\, Y4L)} + \gamma_{Y4M}\tau_{(Y41W,\, Y4M)})Ev_{41W} + \gamma_{Y42W}\tau_{(Y41W,\, Y42W)}Ev_{42W} + \gamma_{Y43W}\tau_{(Y41W,\, Y43W)}Ev_{43W} + \gamma_{Y4L}\tau_{(Y41W,\, Y4L)}Ev_{4L} + \gamma_{Y4M}\tau_{(Y41W,\, Y4M)}Ev_{4M} + EX_4$$

(A2.70)’ $$EY_{42W} = -(\gamma_{Y41W}\tau_{(Y41W,\, Y42W)} + \gamma_{Y43W}\tau_{(Y42W,\, Y43W)} + \gamma_{Y4L}\tau_{(Y42W,\, Y4L)} + \gamma_{Y4M}\tau_{(Y42W,\, Y4M)})Ev_{42W} + \gamma_{Y41W}\tau_{(Y41W,\, Y42W)}Ev_{41W} + \gamma_{Y43W}\tau_{(Y42W,\, Y43W)}Ev_{43W} + \gamma_{Y4L}\tau_{(Y42W,\, Y4L)}Ev_{4L} + \gamma_{Y4M}\tau_{(Y42W,\, Y4M)}Ev_{4M} + EX_4$$

(A2.71)’ $$EY_{43W} = -(\gamma_{Y41W}\tau_{(Y41W,\, Y43W)} + \gamma_{Y42W}\tau_{(Y42W,\, Y43W)} + \gamma_{Y4L}\tau_{(Y43W,\, Y4L)} + \gamma_{Y4M}\tau_{(Y43W,\, Y4M)})Ev_{43W} + \gamma_{Y41W}\tau_{(Y41W,\, Y43W)}Ev_{41W} + \gamma_{Y42W}\tau_{(Y42W,\, Y43W)}Ev_{42W} + \gamma_{Y4L}\tau_{(Y43W,\, Y4L)}Ev_{4L} + \gamma_{Y4M}\tau_{(Y43W,\, Y4M)}Ev_{4M} + EX_4$$

(A2.72)’ $$EY_{4L} = -(\gamma_{Y41W}\tau_{(Y41W,\, Y4L)} + \gamma_{Y42W}\tau_{(Y42W,\, Y4L)} + \gamma_{Y43W}\tau_{(Y43W,\, Y4L)} + \gamma_{Y4M}\tau_{(Y4L,\, Y4M)})Ev_{4L} + \gamma_{Y41W}\tau_{(Y41W,\, Y4L)}Ev_{41W} + \gamma_{Y42W}\tau_{(Y42W,\, Y4L)}Ev_{42W} + \gamma_{Y43W}\tau_{(Y43W,\, Y4L)}Ev_{43W} + \gamma_{Y4M}\tau_{(Y4L,\, Y4M)}Ev_{4M} + EX_4$$

(A2.73)’ $$EY_{4M} = -(\gamma_{Y41W}\tau_{(Y41W,\, Y4M)} + \gamma_{Y42W}\tau_{(Y42W,\, Y4M)} + \gamma_{Y43W}\tau_{(Y43W,\, Y4M)} + \gamma_{Y4L}\tau_{(Y4L,\, Y4M)})Ev_{4M} + \gamma_{Y41W}\tau_{(Y41W,\, Y4M)}Ev_{41W} + \gamma_{Y42W}\tau_{(Y42W,\, Y4M)}Ev_{42W} + \gamma_{Y43W}\tau_{(Y43W,\, Y4M)}Ev_{43W} + \gamma_{Y4L}\tau_{(Y4L,\, Y4M)}Ev_{4M} + EX_4$$

(A2.74)’ $$EY_{51W} = -(\gamma_{Y52W}\tau_{(Y51W,\, Y52W)} + \gamma_{Y53W}\tau_{(Y51W,\, Y53W)} + \gamma_{Y5L}\tau_{(Y51W,\, Y5L)} + \gamma_{Y5M}\tau_{(Y51W,\, Y5M)})Ev_{51W} + \gamma_{Y52W}\tau_{(Y51W,\, Y52W)}Ev_{52W} + \gamma_{Y53W}\tau_{(Y51W,\, Y53W)}Ev_{53W} + \gamma_{Y5L}\tau_{(Y51W,\, Y5L)}Ev_{5L} + \gamma_{Y5M}\tau_{(Y51W,\, Y5M)}Ev_{5M} + EX_5$$

(A2.75)’ $$EY_{52W} = -(\gamma_{Y51W}\tau_{(Y51W,\, Y52W)} + \gamma_{Y53W}\tau_{(Y52W,\, Y53W)} + \gamma_{Y5L}\tau_{(Y52W,\, Y5L)} + \gamma_{Y5M}\tau_{(Y52W,\, Y5M)})Ev_{52W} + \gamma_{Y51W}\tau_{(Y51W,\, Y52W)}Ev_{51W} + \gamma_{Y53W}\tau_{(Y52W,\, Y53W)}Ev_{53W} + \gamma_{Y5L}\tau_{(Y52W,\, Y5L)}Ev_{5L} + \gamma_{Y5M}\tau_{(Y52W,\, Y5M)}Ev_{5M} + EX_5$$

(A2.76)’ $$EY_{53W} = -(\gamma_{Y51W}\tau_{(Y51W,\, Y53W)} + \gamma_{Y52W}\tau_{(Y52W,\, Y53W)} + \gamma_{Y5L}\tau_{(Y53W,\, Y5L)} + \gamma_{Y5M}\tau_{(Y53W,\, Y5M)})Ev_{53W} + \gamma_{Y51W}\tau_{(Y51W,\, Y53W)}Ev_{51W} + \gamma_{Y52W}\tau_{(Y52W,\, Y53W)}Ev_{52W} + \gamma_{Y5L}\tau_{(Y53W,\, Y5L)}Ev_{5L} + \gamma_{Y5M}\tau_{(Y53W,\, Y5M)}Ev_{5M} + EX_5$$

(A2.77)’ $$EY_{5L} = -(\gamma_{Y51W}\tau_{(Y51W,\, Y5L)} + \gamma_{Y52W}\tau_{(Y52W,\, Y5L)} + \gamma_{Y53W}\tau_{(Y53W,\, Y5L)} + \gamma_{Y5M}\tau_{(Y5L,\, Y5M)})Ev_{5L} + \gamma_{Y51W}\tau_{(Y51W,\, Y5L)}Ev_{51W} + \gamma_{Y52W}\tau_{(Y52W,\, Y5L)}Ev_{52W} + \gamma_{Y53W}\tau_{(Y53W,\, Y5L)}Ev_{53W} + \gamma_{Y5M}\tau_{(Y5L,\, Y5M)}Ev_{5M} + EX_5$$

(A2.78)’ $$EY_{5M} = -(\gamma_{Y51W}\tau_{(Y51W,\, Y5M)} + \gamma_{Y52W}\tau_{(Y52W,\, Y5M)} + \gamma_{Y53W}\tau_{(Y53W,\, Y5M)} + \gamma_{Y5L}\tau_{(Y5L,\, Y5M)})Ev_{5M} + \gamma_{Y51W}\tau_{(Y51W,\, Y5M)}Ev_{51W} + \gamma_{Y52W}\tau_{(Y52W,\, Y5M)}Ev_{52W} + \gamma_{Y53W}\tau_{(Y53W,\, Y5M)}Ev_{53W} + \gamma_{Y5L}\tau_{(Y5L,\, Y5M)}Ev_{5M} + EX_5$$

(A2.79)’ $$EY_{61W} = -(\gamma_{Y62W}\tau_{(Y61W,\, Y62W)} + \gamma_{Y63W}\tau_{(Y61W,\, Y63W)} + \gamma_{Y6L}\tau_{(Y61W,\, Y6L)} + \gamma_{Y6M}\tau_{(Y61W,\, Y6M)})Ev_{61W} + \gamma_{Y62W}\tau_{(Y61W,\, Y62W)}Ev_{62W} + \gamma_{Y63W}\tau_{(Y61W,\, Y63W)}Ev_{63W} + \gamma_{Y6L}\tau_{(Y61W,\, Y6L)}Ev_{6L} + \gamma_{Y6M}\tau_{(Y61W,\, Y6M)}Ev_{6M} + EX_6$$

(A2.80)’ $$EY_{62W} = -(\gamma_{Y61W}\tau_{(Y61W,\, Y62W)} + \gamma_{Y63W}\tau_{(Y62W,\, Y63W)} + \gamma_{Y6L}\tau_{(Y62W,\, Y6L)} + \gamma_{Y6M}\tau_{(Y62W,\, Y6M)})Ev_{62W} + \gamma_{Y61W}\tau_{(Y61W,\, Y62W)}Ev_{61W} + \gamma_{Y63W}\tau_{(Y62W,\, Y63W)}Ev_{63W} + \gamma_{Y6L}\tau_{(Y62W,\, Y6L)}Ev6_{L} + \gamma_{Y6M}\tau_{(Y62W,\, Y6M)}Ev_{6M} + EX_6$$

(A2.81)’ $$EY_{63W} = -(\gamma_{Y61W}\tau_{(Y61W,\, Y63W)} + \gamma_{Y62W}\tau_{(Y62W,\, Y63W)} + \gamma_{Y6L}\tau_{(Y63W,\, Y6L)} + \gamma_{Y6M}\tau_{(Y63W,\, Y6M)})Ev_{63W} + \gamma_{Y61W}\tau_{(Y61W,\, Y63W)}Ev_{61W} + \gamma_{Y62W}\tau_{(Y62W,\, Y63W)}Ev_{62W} + \gamma_{Y6L}\tau_{(Y63W,\, Y6L)}Ev_{6L} + \gamma_{Y6M}\tau_{(Y63W,\, Y6M)}Ev_{6M} + EX_6$$

(A2.82)' $EY_{6L} = -(\gamma_{Y61W}\tau_{(Y61W, Y6L)} + \gamma_{Y62W}\tau_{(Y62W, Y6L)} + \gamma_{Y63W}\tau_{(Y63W, Y6L)} + \gamma_{Y6M}\tau_{(Y6L, Y6M)})Ev_{6L} + \gamma_{Y61W}\tau_{(Y61W, Y6L)}Ev_{61W} + \gamma_{Y62W}\tau_{(Y62W, Y6L)}Ev_{62W} + \gamma_{Y63W}\tau_{(Y63W, Y6L)}Ev_{63W} + \gamma_{Y6M}\tau_{(Y6L, Y6M)}Ev_{6M} + EX_6$

(A2.83)' $EY_{6M} = -(\gamma_{Y61W}\tau_{(Y61W, Y6M)} + \gamma_{Y62W}\tau_{(Y62W, Y6M)} + \gamma_{Y63W}\tau_{(Y63W, Y6M)} + \gamma_{Y6L}\tau_{(Y6L, Y6M)})Ev_{6M} + \gamma_{Y61W}\tau_{(Y61W, Y6M)}Ev_{61W} + \gamma_{Y62W}\tau_{(Y62W, Y6M)}Ev_{62W} + \gamma_{Y63W}\tau_{(Y63W, Y6M)}Ev_{63W} + \gamma_{Y6L}\tau_{(Y6L, Y6M)}Ev_{6M} + EX_6$

(A2.84)' $EY_{71W} = -(\gamma_{Y72W}\tau_{(Y71W, Y72W)} + \gamma_{Y73W}\tau_{(Y71W, Y73W)} + \gamma_{Y7E}\tau_{(Y71W, Y7E)} + \gamma_{Y7M}\tau_{(Y71W, Y7M)})Ev_{71W} + \gamma_{Y72W}\tau_{(Y71W, Y72W)}Ev_{72W} + \gamma_{Y73W}\tau_{(Y71W, Y73W)}Ev_{73W} + \gamma_{Y7E}\tau_{(Y71W, Y7E)}Ep_{SE} + \gamma_{Y7M}\tau_{(Y71W, Y7M)}Ev_{7M} + EX_7$

(A2.85)' $EY_{72W} = -(\gamma_{Y71W}\tau_{(Y71W, Y72W)} + \gamma_{Y73W}\tau_{(Y72W, Y73W)} + \gamma_{Y7E}\tau_{(Y72W, Y7E)} + \gamma_{Y7M}\tau_{(Y72W, Y7M)})Ev_{72W} + \gamma_{Y71W}\tau_{(Y71W, Y72W)}Ev_{71W} + \gamma_{Y73W}\tau_{(Y72W, Y73W)}Ev_{73W} + \gamma_{Y7E}\tau_{(Y72W, Y7E)}Ep_{SE} + \gamma_{Y7M}\tau_{(Y72W, Y7M)}Ev_{7M} + EX_7$

(A2.86)' $EY_{73W} = -(\gamma_{Y71W}\tau_{(Y71W, Y73W)} + \gamma_{Y72W}\tau_{(Y72W, Y73W)} + \gamma_{Y7E}\tau_{(Y73W, Y7E)} + \gamma_{Y7M}\tau_{(Y73W, Y7M)})Ev_{73W} + \gamma_{Y71W}\tau_{(Y71W, Y73W)}Ev_{71W} + \gamma_{Y72W}\tau_{(Y72W, Y73W)}Ev_{72W} + \gamma_{Y7E}\tau_{(Y73W, Y7E)}Ep_{SE} + \gamma_{Y7M}\tau_{(Y73W, Y7M)}Ev_{7M} + EX_7$

(A2.87)' $EY_{7E} = -(\gamma_{Y71W}\tau_{(Y71W, Y7E)} + \gamma_{Y72W}\tau_{(Y72W, Y7E)} + \gamma_{Y73W}\tau_{(Y73W, Y7E)} + \gamma_{Y7M}\tau_{(Y7E, Y7M)})Ep_{SE} + \gamma_{Y71W}\tau_{(Y71W, Y7E)}Ev_{71W} + \gamma_{Y72W}\tau_{(Y72W, Y7E)}Ev_{72W} + \gamma_{Y73W}\tau_{(Y73W, Y7E)}Ev_{73W} + \gamma_{Y7M}\tau_{(Y7E, Y7M)}Ev_{7M} + EX_7$

(A2.88)' $EY_{7M} = -(\gamma_{Y71W}\tau_{(Y71W, Y7M)} + \gamma_{Y72W}\tau_{(Y72W, Y7M)} + \gamma_{Y73W}\tau_{(Y73W, Y7M)} + \gamma_{Y7E}\tau_{(Y7E, Y7M)})Ev_{7M} + \gamma_{Y71W}\tau_{(Y71W, Y7M)}Ev_{71W} + \gamma_{Y72W}\tau_{(Y72W, Y7M)}Ev_{72W} + \gamma_{Y73W}\tau_{(Y73W, Y7M)}Ev_{73W} + \gamma_{Y7E}\tau_{(Y7E, Y7M)}Ev_{7E} + EX_7$

(A2.89)' $EY_{81W} = -(\gamma_{Y82W}\tau_{(Y81W, Y82W)} + \gamma_{Y83W}\tau_{(Y81W, Y83W)} + \gamma_{Y8E}\tau_{(Y81W, Y8E)} + \gamma_{Y8M}\tau_{(Y81W, Y8M)})Ev_{81W} + \gamma_{Y82W}\tau_{(Y81W, Y82W)}Ev_{82W} + \gamma_{Y83W}\tau_{(Y81W, Y83W)}Ev_{83W} + \gamma_{Y8E}\tau_{(Y81W, Y8E)}Ep_{SE} + \gamma_{Y8M}\tau_{(Y81W, Y8M)}Ev_{8M} + EX_8$

(A2.90)' $EY_{82W} = -(\gamma_{Y81W}\tau_{(Y81W, Y82W)} + \gamma_{Y83W}\tau_{(Y82W, Y83W)} + \gamma_{Y8E}\tau_{(Y82W, Y8E)} + \gamma_{Y8M}\tau_{(Y82W, Y8M)})Ev_{82W} + \gamma_{Y81W}\tau_{(Y81W, Y82W)}Ev_{81W} + \gamma_{Y83W}\tau_{(Y82W, Y83W)}Ev_{83W} + \gamma_{Y8E}\tau_{(Y82W, Y8E)}Ep_{SE} + \gamma_{Y8M}\tau_{(Y82W, Y8M)}Ev_{8M} + EX_8$

(A2.91)' $EY_{83W} = -(\gamma_{Y81W}\tau_{(Y81W, Y83W)} + \gamma_{Y82W}\tau_{(Y82W, Y83W)} + \gamma_{Y8E}\tau_{(Y83W, Y8E)} + \gamma_{Y8M}\tau_{(Y83W, Y8M)})Ev_{83W} + \gamma_{Y81W}\tau_{(Y81W, Y83W)}Ev_{81W} + \gamma_{Y82W}\tau_{(Y82W, Y83W)}Ev_{82W} + \gamma_{Y8E}\tau_{(Y83W, Y8E)}Ep_{SE} + \gamma_{Y8M}\tau_{(Y83W, Y8M)}Ev_{8M} + EX_8$

(A2.92)' $EY_{8E} = -(\gamma_{Y81W}\tau_{(Y81W, Y8E)} + \gamma_{Y82W}\tau_{(Y82W, Y8E)} + \gamma_{Y83W}\tau_{(Y83W, Y8E)} + \gamma_{Y8M}\tau_{(Y8E, Y8M)})Ep_{SE} + \gamma_{Y81W}\tau_{(Y81W, Y8E)}Ev_{81W} + \gamma_{Y82W}\tau_{(Y82W, Y8E)}Ev_{82W} + \gamma_{Y83W}\tau_{(Y83W, Y8E)}Ev_{83W} + \gamma_{Y8M}\tau_{(Y8E, Y8M)}Ev_{8M} + EX_8$

(A2.93)' $EY_{8M} = -(\gamma_{Y81W}\tau_{(Y81W, Y8M)} + \gamma_{Y82W}\tau_{(Y82W, Y8M)} + \gamma_{Y83W}\tau_{(Y83W, Y8M)} + \gamma_{Y8E}\tau_{(Y8E, Y8M)})Ev_{8M} + \gamma_{Y81W}\tau_{(Y81W, Y8M)}Ev_{81W} + \gamma_{Y82W}\tau_{(Y82W, Y8M)}Ev_{82W} + \gamma_{Y83W}\tau_{(Y83W, Y8M)}Ev_{83W} + \gamma_{Y8E}\tau_{(Y8E, Y8M)}Ev_{8E} + EX_8$

(A2.94)' $EY_{91W} = -(\gamma_{Y92W}\tau_{(Y91W, Y92W)} + \gamma_{Y93W}\tau_{(Y91W, Y93W)} + \gamma_{Y9E}\tau_{(Y91W, Y9E)} + \gamma_{Y9M}\tau_{(Y91W, Y9M)})Ev_{91W} + \gamma_{Y92W}\tau_{(Y91W, Y92W)}Ev_{92W} + \gamma_{Y93W}\tau_{(Y91W, Y93W)}Ev_{93W} + \gamma_{Y9E}\tau_{(Y91W, Y9E)}Ep_{SE} + \gamma_{Y9M}\tau_{(Y91W, Y9M)}Ev_{9M} + EX_9$

(A2.95)' $EY_{92W} = -(\gamma_{Y91W}\tau_{(Y91W, Y92W)} + \gamma_{Y93W}\tau_{(Y92W, Y93W)} + \gamma_{Y9E}\tau_{(Y92W, Y9E)} + \gamma_{Y9M}\tau_{(Y92W, Y9M)})Ev_{92W} + \gamma_{Y91W}\tau_{(Y91W, Y92W)}Ev_{91W} + \gamma_{Y93W}\tau_{(Y92W, Y93W)}Ev_{93W} + \gamma_{Y9E}\tau_{(Y92W, Y9E)}Ep_{SE} + \gamma_{Y9M}\tau_{(Y92W, Y9M)}Ev_{9M} + EX$

(A2.96)' $EY_{93W} = - (\gamma_{Y91W}\tau_{(Y91W,\ Y93W)} + \gamma_{Y92W}\tau_{(Y92W,\ Y93W)} + \gamma_{Y9E}\tau_{(Y93W,\ Y9E)} + \gamma_{Y9M}\tau_{(Y93W,\ Y9M)})Ev_{93W} + \gamma_{Y91W}\tau_{(Y91W,\ Y93W)}Ev_{91W} + \gamma_{Y92W}\tau_{(Y92W,\ Y93W)}Ev_{92W} + \gamma_{Y9E}\tau_{(Y93W,\ Y9E)}Ep_{SE} + \gamma_{Y9M}\tau_{(Y93W,\ Y9M)}Ev_{9M} + EX_9$

(A2.97)' $EY_{9E} = - (\gamma_{Y91W}\tau_{(Y91W,\ Y9E)} + \gamma_{Y92W}\tau_{(Y92W,\ Y9E)} + \gamma_{Y93W}\tau_{(Y93W,\ Y9E)} + \gamma_{Y9M}\tau_{(Y9E,\ Y9M)})Ep_{SE} + \gamma_{Y91W}\tau_{(Y91W,\ Y9E)}Ev_{91W} + \gamma_{Y92W}\tau_{(Y92W,\ Y9E)}Ev_{92W} + \gamma_{Y93W}\tau_{(Y93W,\ Y9E)}Ev_{93W} + \gamma_{Y9M}\tau_{(Y9E,\ Y9M)}Ev_{9M} + EX_9$

(A2.98)' $EY_{9M} = - (\gamma_{Y91W}\tau_{(Y91W,\ Y9M)} + \gamma_{Y92W}\tau_{(Y92W,\ Y9M)} + \gamma_{Y93W}\tau_{(Y93W,\ Y9M)} + \gamma_{Y9E}\tau_{(Y9E,\ Y9M)})Ev_{9M} + \gamma_{Y91W}\tau_{(Y91W,\ Y9M)}Ev_{91W} + \gamma_{Y92W}\tau_{(Y92W,\ Y9M)}Ev_{92W} + \gamma_{Y93W}\tau_{(Y93W,\ Y9M)}Ev_{93W} + \gamma_{Y9E}\tau_{(Y9E,\ Y9M)}Ev_{9E} + EX_9$

Other input supply to wool warehouse sectors

(A2.99)' $EY_{NM} = \varepsilon_{(YNM,\ VNM)}(Ev_{NM} - t_{YNM})$

(A2.100)' $EY_{BM} = \varepsilon_{(YBM,\ VBM)}(Ev_{BM} - t_{YBM})$

(A2.101)' $EY_{MM} = \varepsilon_{(YMM,\ VMM)}(Ev_{MM} - t_{YMM})$

(A2.102)' $EY_{FM} = \varepsilon_{(YFM,\ VFM)}(Ev_{FM} - t_{YFM})$

Other input supply to lamb and mutton slaughtering/processing sectors

(A2.103)' $EY_{SL} = \varepsilon_{(YSL,\ VSL)}(Ev_{SL} - t_{YSL})$

(A2.104)' $EY_{SM} = \varepsilon_{(YSM,\ VSM)}(Ev_{SM} - t_{YSM})$

Output constrained input demand of wool warehouse sectors

(A2.105)' $EY_{14W} = - k_{YNM}\sigma_{(Y14W,\ YNM)} Ev_{14W} + k_{YNM}\sigma_{(Y14W,\ YNM)}Ev_{NM} + EZ_1$

(A2.106)' $EY_{NM} = k_{Y14W}\sigma_{(Y14W,\ YNM)}Ev_{14W} - k_{Y14W}\sigma_{(Y14W,\ YNM)}Ev_{NM} + EZ_1$

(A2.107)' $EY_{21W} = - (k_{Y31W}\sigma_{(Y21W,\ Y31W)} + k_{Y41W}\sigma_{(Y21W,\ Y41W)} + k_{Y51W}\sigma_{(Y21W,\ Y51W)} + k_{Y61W}\sigma_{(Y21W,\ Y61W)} + k_{Y71W}\sigma_{(Y21W,\ Y71W)} + k_{Y81W}\sigma_{(Y21W,\ Y81W)} + k_{Y91W}\sigma_{(Y21W,\ Y91W)} + k_{YFM}\sigma_{(Y21W,\ YFM)})Ev_{21W} + k_{Y31W}\sigma_{(Y21W,\ Y31W)} Ev_{31W} + k_{Y41W}\sigma_{(Y21W,\ Y41W)} Ev_{41W} + k_{Y51W}\sigma_{(Y21W,\ Y51W)} Ev_{51W} + k_{Y61W}\sigma_{(Y21W,\ Y61W)} Ev_{61W} + k_{Y71W}\sigma_{(Y21W,\ Y71W)} Ev_{71W} + k_{Y81W}\sigma_{(Y21W,\ Y81W)} Ev_{81W} + k_{Y91W}\sigma_{(Y21W,\ Y91W)} Ev_{91W} + k_{YFM}\sigma_{(Y21W,\ YFM)}Ev_{FM} + EZ_2$

(A2.108)' $EY_{31W} = - (k_{Y21W}\sigma_{(Y21W,\ Y31W)} + k_{Y41W}\sigma_{(Y31W,\ Y41W)} + k_{Y51W}\sigma_{(Y31W,\ Y51W)} + k_{Y61W}\sigma_{(Y31W,\ Y61W)} + k_{Y71W}\sigma_{(Y31W,\ Y71W)} + k_{Y81W}\sigma_{(Y31W,\ Y81W)} + k_{Y91W}\sigma_{(Y31W,\ Y91W)} + k_{YFM}\sigma_{(Y31W,\ YFM)})Ev_{31W} + k_{Y21W}\sigma_{(Y21W,\ Y31W)} Ev_{21W} + k_{Y41W}\sigma_{(Y31W,\ Y41W)} Ev_{41W} + k_{Y51W}\sigma_{(Y31W,\ Y51W)} Ev_{51W} + k_{Y61W}\sigma_{(Y31W,\ Y61W)} Ev_{61W} + k_{Y71W}\sigma_{(Y31W,\ Y71W)} Ev_{71W} + k_{Y81W}\sigma_{(Y31W,\ Y81W)} Ev_{81W} + k_{Y91W}\sigma_{(Y31W,\ Y91W)} Ev_{91W} + k_{YFM}\sigma_{(Y31W,\ YFM)}Ev_{FM} + EZ_2$

(A2.109)' $EY_{41W} = - (k_{Y21W}\sigma_{(Y41W,\ Y21W)} + k_{Y31W}\sigma_{(Y31W,\ Y41W)} + k_{Y51W}\sigma_{(Y41W,\ Y51W)} + k_{Y61W}\sigma_{(Y41W,\ Y61W)} + k_{Y71W}\sigma_{(Y41W,\ Y71W)} + k_{Y81W}\sigma_{(Y41W,\ Y81W)} + k_{Y91W}\sigma_{(Y41W,\ Y91W)} + k_{YFM}\sigma_{(Y41W,\ YFM)})Ev_{41W} + k_{Y21W}\sigma_{(Y41W,\ Y21W)} Ev_{21W} + k_{Y31W}\sigma_{(Y31W,\ Y41W)} Ev_{31W} + k_{Y51W}\sigma_{(Y41W,\ Y51W)} Ev_{51W} + k_{Y61W}\sigma_{(Y41W,\ Y61W)} Ev_{61W} + k_{Y71W}\sigma_{(Y41W,\ Y71W)} Ev_{71W} + k_{Y81W}\sigma_{(Y41W,\ Y81W)} Ev_{81W} + k_{Y91W}\sigma_{(Y41W,\ Y91W)} Ev_{91W} + k_{YFM}\sigma_{(Y41W,\ YFM)}Ev_{FM} + EZ_2$

(A2.110)' $EY_{51W} = - (k_{Y21W}\sigma_{(Y51W,\ Y21W)} + k_{Y31W}\sigma_{(Y51W,\ Y31W)} + k_{Y41W}\sigma_{(Y51W,\ Y41W)} + k_{Y61W}\sigma_{(Y51W,\ Y61W)} + k_{Y71W}\sigma_{(Y51W,\ Y71W)} + k_{Y81W}\sigma_{(Y51W,\ Y81W)} + k_{Y51W}\sigma_{(Y51W,$

$_{Y91W)} + k_{YFM}\sigma_{(Y51W,\ YFM)})Ev_{51W} + k_{Y21W}\sigma_{(Y51W,\ Y21W)}\ Ev_{21W} + k_{Y31W}\sigma_{(Y51W,\ Y31W)}\ Ev_{31W} + k_{Y41W}\sigma_{(Y51W,\ Y41W)}\ Ev_{41W} + k_{Y61W}\sigma_{(Y51W,\ Y61W)}\ Ev_{61W} + k_{Y71W}\sigma_{(Y51W,\ Y71W)}\ Ev_{71W} + k_{Y81W}\sigma_{(Y51W,\ Y81W)}\ Ev_{81W} + k_{Y91W}\sigma_{(Y51W,\ Y91W)}\ Ev_{91W} + k_{YFM}\sigma_{(Y51W,\ YFM)}Ev_{FM} + EZ_2$

(A2.111)’ $EY_{61W} = -(k_{Y21W}\sigma_{(Y61W,\ Y21W)} + k_{Y31W}\sigma_{(Y61W,\ Y31W)} + k_{Y41W}\sigma_{(Y61W,\ Y41W)} + k_{Y51W}\sigma_{(Y61W,\ Y51W)} + k_{Y71W}\sigma_{(Y61W,\ Y71W)} + k_{Y81W}\sigma_{(Y61W,\ Y81W)} + k_{Y91W}\sigma_{(Y61W,\ Y91W)} + k_{YFM}\sigma_{(Y61W,\ YFM)})Ev_{61W} + k_{Y21W}\sigma_{(Y61W,\ Y21W)}\ Ev_{21W} + k_{Y31W}\sigma_{(Y61W,\ Y31W)}\ Ev_{31W} + k_{Y41W}\sigma_{(Y61W,\ Y41W)}\ Ev_{41W} + k_{Y51W}\sigma_{(Y61W,\ Y51W)}\ Ev_{51W} + k_{Y71W}\sigma_{(Y61W,\ Y71W)}\ Ev_{71W} + k_{Y81W}\sigma_{(Y61W,\ Y81W)}\ Ev_{81W} + k_{Y91W}\sigma_{(Y61W,\ Y91W)}\ Ev_{91W} + k_{YFM}\sigma_{(Y61W,\ YFM)}Ev_{FM} + EZ_2$

(A2.112)’ $EY_{71W} = -(k_{Y21W}\sigma_{(Y71W,\ Y21W)} + k_{Y31W}\sigma_{(Y71W,\ Y31W)} + k_{Y41W}\sigma_{(Y71W,\ Y41W)} + k_{Y51W}\sigma_{(Y71W,\ Y51W)} + k_{Y61W}\sigma_{(Y71W,\ Y61W)} + k_{Y81W}\sigma_{(Y71W,\ Y81W)} + k_{Y91W}\sigma_{(Y71W,\ Y91W)} + k_{YFM}\sigma_{(Y71W,\ YFM)})Ev_{71W} + k_{Y21W}\sigma_{(Y71W,\ Y21W)}\ Ev_{21W} + k_{Y31W}\sigma_{(Y71W,\ Y31W)}\ Ev_{31W} + k_{Y41W}\sigma_{(Y71W,\ Y41W)}\ Ev_{41W} + k_{Y51W}\sigma_{(Y71W,\ Y51W)}\ Ev_{51W} + k_{Y61W}\sigma_{(Y71W,\ Y61W)}\ Ev_{61W} + k_{Y81W}\sigma_{(Y71W,\ Y81W)}\ Ev_{81W} + k_{Y91W}\sigma_{(Y71W,\ Y91W)}\ Ev_{91W} + k_{YFM}\sigma_{(Y71W,\ YFM)}Ev_{FM} + EZ_2$

(A2.113)’ $EY_{81W} = -(k_{Y21W}\sigma_{(Y81W,\ Y21W)} + k_{Y31W}\sigma_{(Y81W,\ Y31W)} + k_{Y41W}\sigma_{(Y81W,\ Y41W)} + k_{Y51W}\sigma_{(Y81W,\ Y51W)} + k_{Y61W}\sigma_{(Y81W,\ Y61W)} + k_{Y71W}\sigma_{(Y81W,\ Y71W)} + k_{Y91W}\sigma_{(Y81W,\ Y91W)} + k_{YFM}\sigma_{(Y81W,\ YFM)})Ev_{81W} + k_{Y21W}\sigma_{(Y81W,\ Y21W)}\ Ev_{21W} + k_{Y31W}\sigma_{(Y81W,\ Y31W)}\ Ev_{31W} + k_{Y41W}\sigma_{(Y81W,\ Y41W)}\ Ev_{41W} + k_{Y51W}\sigma_{(Y81W,\ Y51W)}\ Ev_{51W} + k_{Y61W}\sigma_{(Y81W,\ Y61W)}\ Ev_{61W} + k_{Y71W}\sigma_{(Y81W,\ Y71W)}\ Ev_{71W} + k_{Y91W}\sigma_{(Y81W,\ Y91W)}\ Ev_{91W} + k_{YFM}\sigma_{(Y81W,\ YFM)}Ev_{FM} + EZ_2$

(A2.114)’ $EY_{91W} = -(k_{Y21W}\sigma_{(Y91W,\ Y21W)} + k_{Y31W}\sigma_{(Y91W,\ Y31W)} + k_{Y41W}\sigma_{(Y91W,\ Y41W)} + k_{Y51W}\sigma_{(Y91W,\ Y51W)} + k_{Y61W}\sigma_{(Y91W,\ Y61W)} + k_{Y71W}\sigma_{(Y91W,\ Y71W)} + k_{Y81W}\sigma_{(Y91W,\ Y81W)} + k_{YFM}\sigma_{(Y91W,\ YFM)})Ev_{91W} + k_{Y21W}\sigma_{(Y91W,\ Y21W)}\ Ev_{21W} + k_{Y31W}\sigma_{(Y91W,\ Y31W)}\ Ev_{31W} + k_{Y41W}\sigma_{(Y91W,\ Y41W)}\ Ev_{41W} + k_{Y51W}\sigma_{(Y91W,\ Y51W)}\ Ev_{51W} + k_{Y61W}\sigma_{(Y91W,\ Y61W)}\ Ev_{61W} + k_{Y71W}\sigma_{(Y91W,\ Y71W)}\ Ev_{71W} + k_{Y81W}\sigma_{(Y91W,\ Y81W)}\ Ev_{81W} + k_{YFM}\sigma_{(Y91W,\ YFM)}Ev_{FM} + EZ_2$

(A2.115)’ $EY_{FM} = -(k_{Y21W}\sigma_{(YFM,\ Y21W)} + k_{Y31W}\sigma_{(YFM,\ Y31W)} + k_{Y41W}\sigma_{(YFM,\ Y41W)} + k_{Y51W}\sigma_{(YFM,\ Y51W)} + k_{Y61W}\sigma_{(YFM,\ Y61W)} + k_{Y71W}\sigma_{(YFM,\ Y71W)} + k_{Y81W}\sigma_{(YFM,\ Y81W)} + k_{Y91W}\sigma_{(YFM,\ Y91W)})Ev_{FM} + k_{Y21W}\sigma_{(YFM,\ Y21W)}\ Ev_{21W} + k_{Y31W}\sigma_{(YFM,\ Y31W)}\ Ev_{31W} + k_{Y41W}\sigma_{(YFM,\ Y41W)}\ Ev_{41W} + k_{Y51W}\sigma_{(YFM,\ Y51W)}\ Ev_{51W} + k_{Y61W}\sigma_{(YFM,\ Y61W)}\ Ev_{61W} + k_{Y71W}\sigma_{(YFM,\ Y71W)}\ Ev_{71W} + k_{Y81W}\sigma_{(YFM,\ Y81W)}\ Ev_{81W} + k_{Y91W}\sigma_{(YFM,\ Y91W)}Ev_{91W} + EZ_2$

(A2.116)’ $EY_{22W} = -(k_{Y32W}\sigma_{(Y22W,\ Y32W)} + k_{Y42W}\sigma_{(Y22W,\ Y42W)} + k_{Y52W}\sigma_{(Y22W,\ Y52W)} + k_{Y62W}\sigma_{(Y22W,\ Y62W)} + k_{Y72W}\sigma_{(Y22W,\ Y72W)} + k_{Y82W}\sigma_{(Y22W,\ Y82W)} + k_{Y92W}\sigma_{(Y22W,\ Y92W)} + k_{YMM}\sigma_{(Y22W,\ YMM)})Ev_{22W} + k_{Y32W}\sigma_{(Y22W,\ Y32W)}\ Ev_{32W} + k_{Y42W}\sigma_{(Y22W,\ Y42W)}\ Ev_{42W} + k_{Y52W}\sigma_{(Y22W,\ Y52W)}\ Ev_{52W} + k_{Y62W}\sigma_{(Y22W,\ Y62W)}\ Ev_{62W} + k_{Y72W}\sigma_{(Y22W,\ Y72W)}\ Ev_{72W} + k_{Y82W}\sigma_{(Y22W,\ Y82W)}\ Ev_{82W} + k_{Y92W}\sigma_{(Y22W,\ Y92W)}\ Ev_{92W} + k_{YMM}\sigma_{(Y22W,\ YMM)}Ev_{MM} + EZ_3$

(A2.117)’ $EY_{32W} = -(k_{Y22W}\sigma_{(Y22W,\ Y32W)} + k_{Y42W}\sigma_{(Y32W,\ Y42W)} + k_{Y52W}\sigma_{(Y32W,\ Y52W)} + k_{Y62W}\sigma_{(Y32W,\ Y62W)} + k_{Y72W}\sigma_{(Y32W,\ Y72W)} + k_{Y82W}\sigma_{(Y32W,\ Y82W)} + k_{Y92W}\sigma_{(Y32W,\ Y92W)} + k_{YMM}\sigma_{(Y32W,\ YMM)})Ev_{32W} + k_{Y22W}\sigma_{(Y22W,\ Y32W)}\ Ev_{22W} + k_{Y42W}\sigma_{(Y32W,\ Y42W)}\ Ev_{42W} + k_{Y52W}\sigma_{(Y32W,\ Y52W)}\ Ev_{52W} + k_{Y62W}\sigma_{(Y32W,\ Y62W)}\ Ev_{62W} + k_{Y72W}\sigma_{(Y32W,\ Y72W)}\ Ev_{72W} + k_{Y82W}\sigma_{(Y32W,\ Y82W)}\ Ev_{82W} + k_{Y92W}\sigma_{(Y32W,\ Y92W)}\ Ev_{92W} + k_{YMM}\sigma_{(Y32W,\ YMM)}Ev_{MM} + EZ_3$

(A2.118)' $EY_{42W} = -(k_{Y22W}\sigma_{(Y42W,\ Y22W)} + k_{Y32W}\sigma_{(Y32W,\ Y42W)} + k_{Y52W}\sigma_{(Y42W,\ Y52W)} + k_{Y62W}\sigma_{(Y42W,\ Y62W)} + k_{Y72W}\sigma_{(Y42W,\ Y72W)} + k_{Y82W}\sigma_{(Y42W,\ Y82W)} + k_{Y92W}\sigma_{(Y42W,\ Y92W)} + k_{YMM}\sigma_{(Y42W,\ YMM)})Ev_{42W} + k_{Y22W}\sigma_{(Y42W,\ Y22W)} Ev_{22W} + k_{Y32W}\sigma_{(Y32W,\ Y42W)} Ev_{32W} + k_{Y52W}\sigma_{(Y42W,\ Y52W)} Ev_{52W} + k_{Y62W}\sigma_{(Y42W,\ Y62W)} Ev_{62W} + k_{Y72W}\sigma_{(Y42W,\ Y72W)} Ev_{72W} + k_{Y82W}\sigma_{(Y42W,\ Y82W)} Ev_{82W} + k_{Y92W}\sigma_{(Y42W,\ Y92W)} Ev_{92W} + k_{YMM}\sigma_{(Y42W,\ YMM)}Ev_{MM} + EZ_3$

(A2.119)' $EY_{52W} = -(k_{Y22W}\sigma_{(Y52W,\ Y22W)} + k_{Y32W}\sigma_{(Y52W,\ Y32W)} + k_{Y42W}\sigma_{(Y52W,\ Y4W)} + k_{Y62W}\sigma_{(Y52W,\ Y62W)} + k_{Y72W}\sigma_{(Y52W,\ Y72W)} + k_{Y82W}\sigma_{(Y52W,\ Y82W)} + k_{Y52W}\sigma_{(Y52W,\ Y92W)} + k_{YMM}\sigma_{(Y52W,\ YMM)})Ev_{52W} + k_{Y22W}\sigma_{(Y52W,\ Y22W)} Ev_{22W} + k_{Y32W}\sigma_{(Y52W,\ Y32W)} Ev_{32W} + k_{Y42W}\sigma_{(Y52W,\ Y42W)} Ev_{42W} + k_{Y62W}\sigma_{(Y52W,\ Y62W)} Ev_{62W} + k_{Y72W}\sigma_{(Y52W,\ Y72W)} Ev_{72W} + k_{Y82W}\sigma_{(Y52W,\ Y82W)} Ev_{82W} + k_{Y92W}\sigma_{(Y52W,\ Y92W)} Ev_{92W} + k_{YMM}\sigma_{(Y52W,\ YMM)}Ev_{MM} + EZ_3$

(A2.120)' $EY_{62W} = -(k_{Y21W}\sigma_{(Y62W,\ Y22W)} + k_{Y32W}\sigma_{(Y62W,\ Y32W)} + k_{Y42W}\sigma_{(Y62W,\ Y42W)} + k_{Y52W}\sigma_{(Y62W,\ Y52W)} + k_{Y72W}\sigma_{(Y62W,\ Y72W)} + k_{Y82W}\sigma_{(Y62W,\ Y82W)} + k_{Y92W}\sigma_{(Y62W,\ Y92W)} + k_{YMM}\sigma_{(Y62W,\ YMM)})Ev_{62W} + k_{Y22W}\sigma_{(Y62W,\ Y22W)} Ev_{22W} + k_{Y32W}\sigma_{(Y62W,\ Y32W)} Ev_{32W} + k_{Y42W}\sigma_{(Y62W,\ Y42W)} Ev_{42W} + k_{Y52W}\sigma_{(Y62W,\ Y52W)} Ev_{52W} + k_{Y72W}\sigma_{(Y62W,\ Y72W)} Ev_{72W} + k_{Y82W}\sigma_{(Y62W,\ Y82W)} Ev_{82W} + k_{Y92W}\sigma_{(Y62W,\ Y92W)} Ev_{92W} + k_{YMM}\sigma_{(Y62W,\ YMM)}Ev_{MM} + EZ_3$

(A2.121)' $EY_{72W} = -(k_{Y22W}\sigma_{(Y72W,\ Y22W)} + k_{Y32W}\sigma_{(Y72W,\ Y32W)} + k_{Y42W}\sigma_{(Y72W,\ Y42W)} + k_{Y52W}\sigma_{(Y72W,\ Y52W)} + k_{Y62W}\sigma_{(Y72W,\ Y62W)} + k_{Y82W}\sigma_{(Y72W,\ Y82W)} + k_{Y92W}\sigma_{(Y72W,\ Y92W)} + k_{YMM}\sigma_{(Y72W,\ YMM)})Ev_{72W} + k_{Y22W}\sigma_{(Y72W,\ Y22W)} Ev_{22W} + k_{Y32W}\sigma_{(Y72W,\ Y32W)} Ev_{32W} + k_{Y42W}\sigma_{(Y72W,\ Y42W)} Ev_{42W} + k_{Y52W}\sigma_{(Y72W,\ Y52W)} Ev_{52W} + k_{Y62W}\sigma_{(Y72W,\ Y62W)} Ev_{62W} + k_{Y82W}\sigma_{(Y72W,\ Y82W)} Ev_{82W} + k_{Y92W}\sigma_{(Y72W,\ Y92W)} Ev_{92W} + k_{YMM}\sigma_{(Y72W,\ YMM)}Ev_{MM} + EZ_3$

(A2.122)' $EY_{82W} = -(k_{Y22W}\sigma_{(Y82W,\ Y22W)} + k_{Y32W}\sigma_{(Y82W,\ Y32W)} + k_{Y42W}\sigma_{(Y82W,\ Y42W)} + k_{Y52W}\sigma_{(Y82W,\ Y52W)} + k_{Y62W}\sigma_{(Y82W,\ Y62W)} + k_{Y72W}\sigma_{(Y82W,\ Y72W)} + k_{Y92W}\sigma_{(Y82W,\ Y92W)} + k_{YMM}\sigma_{(Y82W,\ YMM)})Ev_{82W} + k_{Y22W}\sigma_{(Y82W,\ Y22W)} Ev_{22W} + k_{Y32W}\sigma_{(Y82W,\ Y32W)} Ev_{32W} + k_{Y42W}\sigma_{(Y82W,\ Y42W)} Ev_{42W} + k_{Y52W}\sigma_{(Y82W,\ Y52W)} Ev_{52W} + k_{Y62W}\sigma_{(Y82W,\ Y62W)} Ev_{62W} + k_{Y72W}\sigma_{(Y82W,\ Y72W)} Ev_{72W} + k_{Y92W}\sigma_{(Y82W,\ Y92W)} Ev_{92W} + k_{YMM}\sigma_{(Y82W,\ YMM)}Ev_{2M} + EZ_3$

(A2.123)' $EY_{92W} = -(k_{Y22W}\sigma_{(Y92W,\ Y22W)} + k_{Y32W}\sigma_{(Y92W,\ Y32W)} + k_{Y42W}\sigma_{(Y92W,\ Y42W)} + k_{Y52W}\sigma_{(Y92W,\ Y52W)} + k_{Y62W}\sigma_{(Y92W,\ Y62W)} + k_{Y72W}\sigma_{(Y92W,\ Y72W)} + k_{Y82W}\sigma_{(Y92W,\ Y82W)} + k_{YMM}\sigma_{(Y92W,\ YMM)})Ev_{92W} + k_{Y22W}\sigma_{(Y92W,\ Y22W)} Ev_{22W} + k_{Y32W}\sigma_{(Y92W,\ Y32W)} Ev_{32W} + k_{Y42W}\sigma_{(Y92W,\ Y42W)} Ev_{42W} + k_{Y52W}\sigma_{(Y92W,\ Y52W)} Ev_{52W} + k_{Y62W}\sigma_{(Y92W,\ Y62W)} Ev_{62W} + k_{Y72W}\sigma_{(Y92W,\ Y72W)} Ev_{72W} + k_{Y82W}\sigma_{(Y92W,\ Y82W)} Ev_{82W} + k_{YMM}\sigma_{(Y92W,\ YMM)}Ev_{MM} + EZ_3$

(A2.124)' $EY_{MM} = -(k_{Y22W}\sigma_{(YMM,\ Y22W)} + k_{Y32W}\sigma_{(YM2,\ Y32W)} + k_{Y42W}\sigma_{(YMM,\ Y42W)} + k_{Y52W}\sigma_{(YMM,\ Y52W)} + k_{Y62W}\sigma_{(YMM,\ Y62W)} + k_{Y72W}\sigma_{(YMM,\ Y72W)} + k_{Y82W}\sigma_{(YMM,\ Y82W)} + k_{Y92W}\sigma_{(YMM,\ Y92W)})Ev_{MM} + k_{Y22W}\sigma_{(YMM,\ Y22W)} Ev_{22W} + k_{Y32W}\sigma_{(YMM,\ Y32W)} Ev_{32W} + k_{Y42W}\sigma_{(YMM,\ Y42W)} Ev_{42W} + k_{Y52W}\sigma_{(YMM,\ Y52W)} Ev_{52W} + k_{Y62W}\sigma_{(YMM,\ Y62W)} Ev_{62W} + k_{Y72W}\sigma_{(YMM,\ Y72W)} Ev_{72W} + k_{Y82W}\sigma_{(YMM,\ Y82W)} Ev_{82W} + k_{Y92W}\sigma_{(YMM,\ Y92W)}Ev_{92W} + EZ_3$

(A2.125)' $EY_{13W} = -(k_{Y23W}\sigma_{(Y13W,\ Y23W)} + k_{Y33W}\sigma_{(Y13W,\ Y33W)} + k_{Y43W}\sigma_{(Y13W,\ Y43W)} + k_{Y53W}\sigma_{(Y13W,\ Y53W)} + k_{Y63W}\sigma_{(Y13W,\ Y63W)} + k_{Y73W}\sigma_{(Y13W,\ Y73W)} + k_{Y83W}\sigma_{(Y13W,\ Y83W)} + k_{Y93W}\sigma_{(Y13W,\ Y93W)} + k_{YBM}\sigma_{(Y13W,\ YBM)})Ev_{13W} + k_{Y23W}\sigma_{(Y13W,\ Y23W)} Ev_{23W} + k_{Y33W}\sigma_{(Y13W,\ Y23W)} Ev_{33W} + k_{Y43W}\sigma_{(Y13W,\ Y43W)} Ev_{43W} + k_{Y53W}\sigma_{(Y13W,}$

$$_{Y53W)} Ev_{53W} + k_{Y63W}\sigma_{(Y13W,\ Y63W)} Ev_{63W} + k_{Y73W}\sigma_{(Y13W,\ Y73W)} Ev_{73W} + k_{Y83W}\sigma_{(Y13W,\ Y83W)} Ev_{83W} + k_{Y93W}\sigma_{(Y13W,\ Y93W)} Ev_{93W} + k_{YBM}\sigma_{(Y13W,\ YBM)} Ev_{BM} + EZ_4$$

(A2.126)’
$$EY_{23W} = -(k_{Y13W}\sigma_{(Y13W,\ Y23W)} + k_{Y33W}\sigma_{(Y23W,\ Y33W)} + k_{Y43W}\sigma_{(Y23W,\ Y43W)} + k_{Y53W}\sigma_{(Y23W,\ Y53W)} + k_{Y63W}\sigma_{(Y23W,\ Y63W)} + k_{Y73W}\sigma_{(Y23W,\ Y73W)} + k_{Y83W}\sigma_{(Y23W,\ Y83W)} + k_{Y93W}\sigma_{(Y23W,\ Y93W)} + k_{YBM}\sigma_{(Y23W,\ YBM)})Ev_{23W} + k_{Y13W}\sigma_{(Y13W,\ Y23W)} Ev_{13W} + k_{Y33W}\sigma_{(Y23W,\ Y33W)} Ev_{33W} + k_{Y43W}\sigma_{(Y23W,\ Y43W)} Ev_{43W} + k_{Y53W}\sigma_{(Y23W,\ Y53W)} Ev_{53W} + k_{Y63W}\sigma_{(Y23W,\ Y63W)} Ev_{63W} + k_{Y73W}\sigma_{(Y23W,\ Y73W)} Ev_{73W} + k_{Y83W}\sigma_{(Y23W,\ Y83W)} Ev_{83W} + k_{Y93W}\sigma_{(Y23W,\ Y93W)} Ev_{93W} + k_{YBM}\sigma_{(Y23W,\ YBM)} Ev_{BM} + EZ_4$$

(A2.127)’
$$EY_{33W} = -(k_{Y13W}\sigma_{(Y33W,\ Y13W)} + k_{Y23W}\sigma_{(Y23W,\ Y33W)} + k_{Y43W}\sigma_{(Y33W,\ Y43W)} + k_{Y53W}\sigma_{(Y33W,\ Y53W)} + k_{Y63W}\sigma_{(Y33W,\ Y63W)} + k_{Y73W}\sigma_{(Y33W,\ Y73W)} + k_{Y83W}\sigma_{(Y33W,\ Y83W)} + k_{Y93W}\sigma_{(Y33W,\ Y93W)} + k_{YBM}\sigma_{(Y33W,\ YBM)})Ev_{33W} + k_{Y13W}\sigma_{(Y33W,\ Y13W)} Ev_{13W} + k_{Y23W}\sigma_{(Y23W,\ Y33W)} Ev_{23W} + k_{Y43W}\sigma_{(Y33W,\ Y43W)} Ev_{43W} + k_{Y53W}\sigma_{(Y33W,\ Y53W)} Ev_{53W} + k_{Y63W}\sigma_{(Y33W,\ Y63W)} Ev_{63W} + k_{Y73W}\sigma_{(Y33W,\ Y73W)} Ev_{73W} + k_{Y83W}\sigma_{(Y33W,\ Y83W)} Ev_{83W} + k_{Y93W}\sigma_{(Y33W,\ Y93W)} Ev_{93W} + k_{YBM}\sigma_{(Y33W,\ YBM)} Ev_{BM} + EZ_4$$

(A2.128)’
$$EY_{43W} = -(k_{Y13W}\sigma_{(Y43W,\ Y13W)} + k_{Y23W}\sigma_{(Y43W,\ Y23W)} + k_{Y33W}\sigma_{(Y33W,\ Y43W)} + k_{Y53W}\sigma_{(Y43W,\ Y53W)} + k_{Y63W}\sigma_{(Y43W,\ Y63W)} + k_{Y73W}\sigma_{(Y43W,\ Y73W)} + k_{Y83W}\sigma_{(Y43W,\ Y83W)} + k_{Y93W}\sigma_{(Y43W,\ Y93W)} + k_{YBM}\sigma_{(Y43W,\ YBM)})Ev_{43W} + k_{Y13W}\sigma_{(Y43W,\ Y13W)} Ev_{13W} + k_{Y23W}\sigma_{(Y43W,\ Y23W)} Ev_{23W} + k_{Y33W}\sigma_{(Y33W,\ Y43W)} Ev_{33W} + k_{Y53W}\sigma_{(Y43W,\ Y53W)} Ev_{53W} + k_{Y63W}\sigma_{(Y43W,\ Y63W)} Ev_{63W} + k_{Y73W}\sigma_{(Y43W,\ Y73W)} Ev_{73W} + k_{Y83W}\sigma_{(Y43W,\ Y83W)} Ev_{83W} + k_{Y93W}\sigma_{(Y43W,\ Y93W)} Ev_{93W} + k_{YBM}\sigma_{(Y43W,\ YBM)} Ev_{BM} + EZ_4$$

(A2.129)’
$$EY_{53W} = -(k_{Y13W}\sigma_{(Y53W,\ Y13W)} + k_{Y23W}\sigma_{(Y53W,\ Y23W)} + k_{Y33W}\sigma_{(Y53W,\ Y33W)} + k_{Y43W}\sigma_{(Y53W,\ Y43W)} + k_{Y63W}\sigma_{(Y53W,\ Y63W)} + k_{Y73W}\sigma_{(Y53W,\ Y73W)} + k_{Y83W}\sigma_{(Y53W,\ Y83W)} + k_{Y93W}\sigma_{(Y53W,\ Y93W)} + k_{YBM}\sigma_{(Y53W,\ YBM)})Ev_{53W} + k_{Y13W}\sigma_{(Y53W,\ Y13W)} Ev_{13W} + k_{Y23W}\sigma_{(Y53W,\ Y23W)} Ev_{23W} + k_{Y33W}\sigma_{(Y53W,\ Y33W)} Ev_{33W} + k_{Y43W}\sigma_{(Y53W,\ Y43W)} Ev_{43W} + k_{Y63W}\sigma_{(Y53W,\ Y63W)} Ev_{63W} + k_{Y73W}\sigma_{(Y53W,\ Y73W)} Ev_{73W} + k_{Y83W}\sigma_{(Y53W,\ Y83W)} Ev_{83W} + k_{Y93W}\sigma_{(Y53W,\ Y93W)} Ev_{93W} + k_{YBM}\sigma_{(Y53W,\ YBM)} Ev_{BM} + EZ_4$$

(A2.130)’
$$EY_{63W} = -(k_{Y13W}\sigma_{(Y63W,\ Y13W)} + k_{Y23W}\sigma_{(Y63W,\ Y23W)} + k_{Y33W}\sigma_{(Y63W,\ Y33W)} + k_{Y43W}\sigma_{(Y63W,\ Y43W)} + k_{Y53W}\sigma_{(Y53W,\ Y63W)} + k_{Y73W}\sigma_{(Y63W,\ Y73W)} + k_{Y83W}\sigma_{(Y63W,\ Y83W)} + k_{Y93W}\sigma_{(Y63W,\ Y93W)} + k_{YBM}\sigma_{(Y63W,\ YBM)})Ev_{63W} + k_{Y13W}\sigma_{(Y63W,\ Y13W)} Ev_{13W} + k_{Y23W}\sigma_{(Y63W,\ Y23W)} Ev_{23W} + k_{Y33W}\sigma_{(Y63W,\ Y33W)} Ev_{33W} + k_{Y43W}\sigma_{(Y63W,\ Y43W)} Ev_{43W} + k_{Y53W}\sigma_{(Y53W,\ Y63W)} Ev_{53W} + k_{Y73W}\sigma_{(Y63W,\ Y73W)} Ev_{73W} + k_{Y83W}\sigma_{(Y63W,\ Y83W)} Ev_{83W} + k_{Y93W}\sigma_{(Y63W,\ Y93W)} Ev_{93W} + k_{YBM}\sigma_{(Y63W,\ YBM)} Ev_{BM} + EZ_4$$

(A2.131)’
$$EY_{73W} = -(k_{Y13W}\sigma_{(Y73W,\ Y13W)} + k_{Y23W}\sigma_{(Y73W,\ Y23W)} + k_{Y33W}\sigma_{(Y73W,\ Y33W)} + k_{Y43W}\sigma_{(Y73W,\ Y43W)} + k_{Y53W}\sigma_{(Y73W,\ Y53W)} + k_{Y63W}\sigma_{(Y73W,\ Y63W)} + k_{Y83W}\sigma_{(Y73W,\ Y83W)} + k_{Y93W}\sigma_{(Y73W,\ Y93W)} + k_{YBM}\sigma_{(Y73W,\ YBM)})Ev_{73W} + k_{Y13W}\sigma_{(Y73W,\ Y13W)} Ev_{13W} + k_{Y23W}\sigma_{(Y73W,\ Y23W)} Ev_{23W} + k_{Y33W}\sigma_{(Y73W,\ Y33W)} Ev_{33W} + k_{Y43W}\sigma_{(Y73W,\ Y43W)} Ev_{43W} + k_{Y53W}\sigma_{(Y73W,\ Y53W)} Ev_{53W} + k_{Y63W}\sigma_{(Y73W,\ Y63W)} Ev_{63W} + k_{Y83W}\sigma_{(Y73W,\ Y83W)} Ev_{83W} + k_{Y93W}\sigma_{(Y73W,\ Y93W)} Ev_{93W} + k_{YBM}\sigma_{(Y73W,\ YBM)} Ev_{BM} + EZ_4$$

(A2.132)’
$$EY_{83W} = -(k_{Y13W}\sigma_{(Y83W,\ Y13W)} + k_{Y23W}\sigma_{(Y83W,\ Y23W)} + k_{Y33W}\sigma_{(Y83W,\ Y33W)} + k_{Y43W}\sigma_{(Y83W,\ Y43W)} + k_{Y53W}\sigma_{(Y83W,\ Y53W)} + k_{Y63W}\sigma_{(Y83W,\ Y63W)} + k_{Y73W}\sigma_{(Y83W,\ Y73W)} + k_{Y93W}\sigma_{(Y83W,\ Y93W)} + k_{YBM}\sigma_{(Y83W,\ YBM)})Ev_{83W} + k_{Y13W}\sigma_{(Y83W,\ Y13W)} Ev_{13W} + k_{Y23W}\sigma_{(Y83W,\ Y23W)} Ev_{23W} + k_{Y33W}\sigma_{(Y83W,\ Y33W)} Ev_{33W} + k_{Y43W}\sigma_{(Y83W,\ Y43W)} Ev_{43W} + k_{Y53W}\sigma_{(Y83W,\ Y53W)} Ev_{53W} + k_{Y63W}\sigma_{(Y83W,\ Y63W)} Ev_{63W} + k_{Y73W}\sigma_{(Y83W,\ Y73W)} Ev_{73W} + k_{Y93W}\sigma_{(Y83W,\ Y93W)} Ev_{93W} + k_{YBM}\sigma_{(Y83W,\ YBM)} Ev_{BM} + EZ_4$$

(A2.133)’
$$EY_{93W} = -(k_{Y13W}\sigma_{(Y93W,\ Y13W)} + k_{Y23W}\sigma_{(Y93W,\ Y23W)} + k_{Y33W}\sigma_{(Y93W,\ Y33W)} + k_{Y43W}\sigma_{(Y93W,\ Y43W)} + k_{Y53W}\sigma_{(Y93W,\ Y53W)} + k_{Y63W}\sigma_{(Y93W,\ Y63W)} + k_{Y73W}\sigma_{(Y93W,\ Y73W)} + k_{Y83W}\sigma_{(Y93W,\ Y83W)} + k_{YBM}\sigma_{(Y93W,\ YBM)})Ev_{93W} + k_{Y13W}\sigma_{(Y93W,\ Y13W)}$$

$Ev_{13W} + k_{Y23W}\sigma_{(Y93W,\ Y23W)}\ Ev_{23W} + k_{Y33W}\sigma_{(Y93W,\ Y33W)}\ Ev_{33W} + k_{Y43W}\sigma_{(Y93W,\ Y43W)}\ Ev_{43W} + k_{Y53W}\sigma_{(Y93W,\ Y53W)}\ Ev_{53W} + k_{Y63W}\sigma_{(Y93W,\ Y63W)}\ Ev_{63W} + k_{Y73W}\sigma_{(Y93W,\ Y73W)}\ Ev_{73W} + k_{Y83W}\sigma_{(Y93W,\ Y83W)}\ Ev_{83W} + k_{YBM}\sigma_{(Y93W,\ YBM)}Ev_{BM} + EZ_4$

(A2.134)' $EY_{BM} = -(k_{Y13W}\sigma_{(YBM,\ Y13W)} + k_{Y23W}\sigma_{(YBM,\ Y23W)} + k_{Y33W}\sigma_{(YBM,\ Y33W)} + k_{Y43W}\sigma_{(YBM,\ Y43W)} + k_{Y53W}\sigma_{(YBM,\ Y53W)} + k_{Y63W}\sigma_{(YBM,\ Y63W)} + k_{Y73W}\sigma_{(YBM,\ Y73W)} + k_{Y83W}\sigma_{(YBM,\ Y83W)} + k_{Y93W}\sigma_{(YBM,\ Y93W)})Ev_{BM} + k_{Y13W}\sigma_{(YBM,\ Y13W)}\ Ev_{13W} + k_{Y23W}\sigma_{(YBM,\ Y23W)}\ Ev_{23W} + k_{Y33W}\sigma_{(YBM,\ Y33W)}\ Ev_{33W} + k_{Y43W}\sigma_{(YBM,\ Y43W)}\ Ev_{43W} + k_{Y53W}\sigma_{(YBM,\ Y53W)}\ Ev_{53W} + k_{Y63W}\sigma_{(YBM,\ Y63W)}\ Ev_{63W} + k_{Y73W}\sigma_{(YBM,\ Y73W)}\ Ev_{73W} + k_{Y83W}\sigma_{(YBM,\ Y83W)}\ Ev_{83W} + k_{93W}\sigma_{(YBM,\ Y93W)}Ev_{93W} + EZ_4$

<u>*Output constrained input demand of lamb and mutton slaughtering/processing sectors*</u>

(A2.135)' $EY_{1L} = -(k_{Y2L}\sigma_{(Y1L,\ Y2L)} + k_{Y3L}\sigma_{(Y1L,\ Y3L)} + k_{Y4L}\sigma_{(Y1L,\ Y4L)} + k_{Y5L}\sigma_{(Y1L,\ Y5L)} + k_{Y6L}\sigma_{(Y1L,\ Y6L)} + k_{YSL}\sigma_{(Y1L,\ YSL)})Ev_{1L} + k_{Y2L}\sigma_{(Y1L,\ Y2L)}\ Ev_{2L} + k_{Y3L}\sigma_{(Y1L,\ Y3L)}\ Ev_{3L} + k_{Y4L}\sigma_{(Y1L,\ Y4L)}\ Ev_{4L} + k_{Y5L}\sigma_{(Y1L,\ Y5L)}\ Ev_{5L} + k_{Y6L}\sigma_{(Y1L,\ Y6L)}\ Ev_{6L} + k_{YSL}\sigma_{(Y1L,\ YSL)}\ Ev_{SL} + EZ_L$

(A2.136)' $EY_{2L} = -(k_{Y1L}\sigma_{(Y2L,\ Y1L)} + k_{Y3L}\sigma_{(Y2L,\ Y3L)} + k_{Y4L}\sigma_{(Y2L,\ Y4L)} + k_{Y5L}\sigma_{(Y2L,\ Y5L)} + k_{Y6L}\sigma_{(Y2L,\ Y6L)} + k_{YSL}\sigma_{(Y2L,\ YSL)})Ev_{2L} + k_{Y1L}\sigma_{(Y1L,\ Y2L)}\ Ev_{1L} + k_{Y3L}\sigma_{(Y2L,\ Y3L)}\ Ev_{3L} + k_{Y4L}\sigma_{(Y2L,\ Y4L)}\ Ev_{4L} + k_{Y5L}\sigma_{(Y2L,\ Y5L)}\ Ev_{5L} + k_{Y6L}\sigma_{(Y2L,\ Y6L)}\ Ev_{6L} + k_{YSL}\sigma_{(Y2L,\ YSL)}\ Ev_{SL} + EZ_L$

(A2.137)' $EY_{3L} = -(k_{Y1L}\sigma_{(Y3L,\ Y1L)} + k_{Y2L}\sigma_{(Y3L,\ Y2L)} + k_{Y4L}\sigma_{(Y3L,\ Y4L)} + k_{Y5L}\sigma_{(Y3L,\ Y5L)} + k_{Y6L}\sigma_{(Y3L,\ Y6L)} + k_{YSL}\sigma_{(Y3L,\ YSL)})Ev_{3L} + k_{Y1L}\sigma_{(Y3L,\ Y1L)}\ Ev_{1L} + k_{Y2L}\sigma_{(Y3L,\ Y2L)}\ Ev_{2L} + k_{Y4L}\sigma_{(Y3L,\ Y4L)}\ Ev_{4L} + k_{Y5L}\sigma_{(Y3L,\ Y5L)}\ Ev_{5L} + k_{Y6L}\sigma_{(Y3L,\ Y6L)}\ Ev_{6L} + k_{YSL}\sigma_{(Y3L,\ YSL)}\ Ev_{SL} + EZ_L$

(A2.138)' $EY_{4L} = -(k_{Y1L}\sigma_{(Y4L,\ Y1L)} + k_{Y2L}\sigma_{(Y4L,\ Y2L)} + k_{Y3L}\sigma_{(Y4L,\ Y3L)} + k_{Y5L}\sigma_{(Y4L,\ Y5L)} + k_{Y6L}\sigma_{(Y4L,\ Y6L)} + k_{YSL}\sigma_{(Y4L,\ YSL)})Ev_{4L} + k_{Y1L}\sigma_{(Y4L,\ Y1L)}\ Ev_{1L} + k_{Y2L}\sigma_{(Y4L,\ Y2L)}\ Ev_{2L} + k_{Y3L}\sigma_{(Y4L,\ Y3L)}\ Ev_{3L} + k_{Y5L}\sigma_{(Y4L,\ Y5L)}\ Ev_{5L} + k_{Y6L}\sigma_{(Y4L,\ Y6L)}\ Ev_{6L} + k_{YSL}\sigma_{(Y4L,\ YSL)}\ Ev_{SL} + EZ_L$

(A2.139)' $EY_{5L} = -(k_{Y1L}\sigma_{(Y5L,\ Y1L)} + k_{Y2L}\sigma_{(Y5L,\ Y2L)} + k_{Y3L}\sigma_{(Y5L,\ Y3L)} + k_{Y4L}\sigma_{(Y5L,\ Y4L)} + k_{Y6L}\sigma_{(Y5L,\ Y6L)} + k_{YSL}\sigma_{(Y5L,\ YSL)})Ev_{5L} + k_{Y1L}\sigma_{(Y5L,\ Y1L)}\ Ev_{1L} + k_{Y2L}\sigma_{(Y5L,\ Y2L)}\ Ev_{2L} + k_{Y3L}\sigma_{(Y5L,\ Y3L)}\ Ev_{3L} + k_{Y4L}\sigma_{(Y5L,\ Y4L)}\ Ev_{4L} + k_{Y6L}\sigma_{(Y5L,\ Y6L)}\ Ev_{6L} + k_{YSL}\sigma_{(Y5L,\ YSL)}\ Ev_{SL} + EZ_L$

(A2.140)' $EY_{6L} = -(k_{Y1L}\sigma_{(Y6L,\ Y1L)} + k_{Y2L}\sigma_{(Y6L,\ Y2L)} + k_{Y3L}\sigma_{(Y6L,\ Y3L)} + k_{Y4L}\sigma_{(Y6L,\ Y4L)} + k_{Y5L}\sigma_{(Y6L,\ Y5L)} + k_{YSL}\sigma_{(Y6L,\ YSL)})Ev_{6L} + k_{Y1L}\sigma_{(Y6L,\ Y1L)}\ Ev_{1L} + k_{Y2L}\sigma_{(Y6L,\ Y2L)}\ Ev_{2L} + k_{Y3L}\sigma_{(Y6L,\ Y3L)}\ Ev_{3L} + k_{Y4L}\sigma_{(Y6L,\ Y4L)}\ Ev_{4L} + k_{Y5L}\sigma_{(Y6L,\ Y5L)}\ Ev_{5L} + k_{YSL}\sigma_{(Y6L,\ YSL)}\ Ev_{SL} + EZ_L$

(A2.141)' $EY_{SL} = -(k_{Y1L}\sigma_{(YSL,\ Y1L)} + k_{Y2L}\sigma_{(YSL,\ Y2L)} + k_{Y3L}\sigma_{(YSL,\ Y3L)} + k_{Y4L}\sigma_{(YSL,\ Y4L)} + k_{Y5L}\sigma_{(YSL,\ Y5L)} + k_{Y6L}\sigma_{(YSL,\ Y6L)})Ev_{SL} + k_{Y1L}\sigma_{(YSL,\ Y1L)}\ Ev_{1L} + k_{Y2L}\sigma_{(YSL,\ Y2L)}\ Ev_{2L} + k_{Y3L}\sigma_{(YSL,\ Y3L)}\ Ev_{3L} + k_{Y4L}\sigma_{(YSL,\ Y4L)}\ Ev_{4L} + k_{Y5L}\sigma_{(YSL,\ Y5L)}\ Ev_{5L} + k_{Y6L}\sigma_{(YSL,\ Y6L)}\ Ev_{6L} + EZ_L$

(A2.142)' $EY_{1M} = -(k_{Y2M}\sigma_{(Y1M,\ Y2M)} + k_{Y3M}\sigma_{(Y1M,\ Y3M)} + k_{Y4M}\sigma_{(Y1M,\ Y4M)} + k_{Y5M}\sigma_{(Y1M,\ Y5M)} + k_{Y6M}\sigma_{(Y1M,\ Y6M)} + k_{Y7M}\sigma_{(Y1M,\ Y7M)} + k_{Y8M}\sigma_{(Y1M,\ Y8M)} + k_{Y9M}\sigma_{(Y1M,\ Y9M)} + k_{YSM}\sigma_{(Y1M,\ YSM)})Ev_{1M} + k_{Y2M}\sigma_{(Y1M,\ Y2M)}\ Ev_{2M} + k_{Y3M}\sigma_{(Y1M,\ Y3M)}\ Ev_{3M} + k_{Y4M}\sigma_{(Y1M,\ Y4M)}\ Ev_{4M} + k_{Y5M}\sigma_{(Y1M,\ Y5M)}\ Ev_{5M} + k_{Y6M}\sigma_{(Y1M,\ Y6M)}\ Ev_{6M} + k_{Y7M}\sigma_{(Y1M,\ Y7M)}\ Ev_{7M} + k_{Y8M}\sigma_{(Y1M,\ Y8M)}\ Ev_{8M} + k_{Y9M}\sigma_{(Y1M,\ Y9M)}\ Ev_{9M} + k_{YSM}\sigma_{(Y1M,\ YSM)}\ Ev_{SM} + EZ_M$

(A2.143)' $EY_{2M} = - (k_{Y1M}\sigma_{(Y2M, Y1M)} + k_{Y3M}\sigma_{(Y2M, Y3M)} + k_{Y4M}\sigma_{(Y2M, Y4M)} + k_{Y5M}\sigma_{(Y2M, Y5M)} + k_{Y6M}\sigma_{(Y2M, Y6M)} + k_{Y7M}\sigma_{(Y2M, Y7M)} + k_{Y8M}\sigma_{(Y2M, Y8M)} + k_{Y9M}\sigma_{(Y2M, Y9M)} + k_{YSM}\sigma_{(Y2M, YSM)})Ev_{2M} + k_{Y1M}\sigma_{(Y2M, Y1M)} Ev_{1M} + k_{Y3M}\sigma_{(Y2M, Y3M)} Ev_{3M} + k_{Y4M}\sigma_{(Y2M, Y4M)} Ev_{4M} + k_{Y5M}\sigma_{(Y2M, Y5M)} Ev_{5M} + k_{Y6M}\sigma_{(Y2M, Y6M)} Ev_{6M} + k_{Y7M}\sigma_{(Y2M, Y7M)} Ev_{7M} + k_{Y8M}\sigma_{(Y2M, Y8M)} Ev_{8M} + k_{Y9M}\sigma_{(Y2M, Y9M)} Ev_{9M} + k_{YSM}\sigma_{(Y2M, YSM)} Ev_{SM} + EZ_M$

(A2.144)' $EY_{3M} = - (k_{Y1M}\sigma_{(Y3M, Y1M)} + k_{Y2M}\sigma_{(Y3M, Y2M)} + k_{Y4M}\sigma_{(Y3M, Y4M)} + k_{Y5M}\sigma_{(Y3M, Y5M)} + k_{Y6M}\sigma_{(Y3M, Y6M)} + k_{Y7M}\sigma_{(Y3M, Y7M)} + k_{Y8M}\sigma_{(Y3M, Y8M)} + k_{Y9M}\sigma_{(Y3M, Y9M)} + k_{YSM}\sigma_{(Y3M, YSM)})Ev_{3M} + k_{Y1M}\sigma_{(Y3M, Y1M)} Ev_{1M} + k_{Y2M}\sigma_{(Y3M, Y2M)} Ev_{2M} + k_{Y4M}\sigma_{(Y3M, Y4M)} Ev_{4M} + k_{Y5M}\sigma_{(Y3M, Y5M)} Ev_{5M} + k_{Y6M}\sigma_{(Y3M, Y6M)} Ev_{6M} + k_{Y7M}\sigma_{(Y3M, Y7M)} Ev_{7M} + k_{Y8M}\sigma_{(Y3M, Y8M)} Ev_{8M} + k_{Y9M}\sigma_{(Y3M, Y9M)} Ev_{9M} + k_{YSM}\sigma_{(Y3M, YSM)} Ev_{SM} + EZ_M$

(A2.145)' $EY_{4M} = - (k_{Y1M}\sigma_{(Y4M, Y1M)} + k_{Y2M}\sigma_{(Y4M, Y2M)} + k_{Y3M}\sigma_{(Y4M, Y3M)} + k_{Y5M}\sigma_{(Y4M, Y5M)} + k_{Y6M}\sigma_{(Y4M, Y6M)} + k_{Y7M}\sigma_{(Y4M, Y7M)} + k_{Y8M}\sigma_{(Y4M, Y8M)} + k_{Y9M}\sigma_{(Y4M, Y9M)} + k_{YSM}\sigma_{(Y4M, YSM)})Ev_{4M} + k_{Y1M}\sigma_{(Y4M, Y1M)} Ev_{1M} + k_{Y2M}\sigma_{(Y4M, Y2M)} Ev_{2M} + k_{Y3M}\sigma_{(Y4M, Y3M)} Ev_{3M} + k_{Y5M}\sigma_{(Y4M, Y5M)} Ev_{5M} + k_{Y6M}\sigma_{(Y4M, Y6M)} Ev_{6M} + k_{Y7M}\sigma_{(Y4M, Y7M)} Ev_{7M} + k_{Y8M}\sigma_{(Y4M, Y8M)} Ev_{8M} + k_{Y9M}\sigma_{(Y4M, Y9M)} Ev_{9M} + k_{YSM}\sigma_{(Y4M, YSM)} Ev_{SM} + EZ_M$

(A2.146)' $EY_{5M} = - (k_{Y1M}\sigma_{(Y5M, Y1M)} + k_{Y2M}\sigma_{(Y5M, Y2M)} + k_{Y3M}\sigma_{(Y5M, Y3M)} + k_{Y4M}\sigma_{(Y5M, Y4M)} + k_{Y6M}\sigma_{(Y5M, Y6M)} + k_{Y7M}\sigma_{(Y5M, Y7M)} + k_{Y8M}\sigma_{(Y5M, Y8M)} + k_{Y9M}\sigma_{(Y5M, Y9M)} + k_{YSM}\sigma_{(Y5M, YSM)})Ev_{5M} + k_{Y1M}\sigma_{(Y5M, Y1M)} Ev_{1M} + k_{Y2M}\sigma_{(Y5M, Y2M)} Ev_{2M} + k_{Y3M}\sigma_{(Y5M, Y3M)} Ev_{3M} + k_{Y4M}\sigma_{(Y5M, Y4M)} Ev_{4M} + k_{Y6M}\sigma_{(Y5M, Y6M)} Ev_{6M} + k_{Y7M}\sigma_{(Y5M, Y7M)} Ev_{7M} + k_{Y8M}\sigma_{(Y5M, Y8M)} Ev_{8M} + k_{Y9M}\sigma_{(Y5M, Y9M)} Ev_{9M} + k_{YSM}\sigma_{(Y5M, YSM)} Ev_{SM} + EZ_M$

(A2.147)' $EY_{6M} = - (k_{Y1M}\sigma_{(Y6M, Y1M)} + k_{Y2M}\sigma_{(Y6M, Y2M)} + k_{Y3M}\sigma_{(Y6M, Y3M)} + k_{Y4M}\sigma_{(Y6M, Y4M)} + k_{Y5M}\sigma_{(Y6M, Y5M)} + k_{Y7M}\sigma_{(Y6M, Y7M)} + k_{Y8M}\sigma_{(Y6M, Y8M)} + k_{Y9M}\sigma_{(Y6M, Y9M)} + k_{YSM}\sigma_{(Y6M, YSM)})Ev_{6M} + k_{Y1M}\sigma_{(Y6M, Y1M)} Ev_{1M} + k_{Y2M}\sigma_{(Y6M, Y2M)} Ev_{2M} + k_{Y3M}\sigma_{(Y6M, Y3M)} Ev_{3M} + k_{Y4M}\sigma_{(Y6M, Y4M)} Ev_{4M} + k_{Y5M}\sigma_{(Y6M, Y5M)} Ev_{5M} + k_{Y7M}\sigma_{(Y6M, Y7M)} Ev_{7M} + k_{Y8M}\sigma_{(Y6M, Y8M)} Ev_{8M} + k_{Y9M}\sigma_{(Y6M, Y9M)} Ev_{9M} + k_{YSM}\sigma_{(Y6M, YSM)} Ev_{SM} + EZ_M$

(A2.148)' $EY_{7M} = - (k_{Y1M}\sigma_{(Y7M, Y1M)} + k_{Y2M}\sigma_{(Y7M, Y2M)} + k_{Y3M}\sigma_{(Y7M, Y3M)} + k_{Y4M}\sigma_{(Y7M, Y4M)} + k_{Y5M}\sigma_{(Y7M, Y5M)} + k_{Y6M}\sigma_{(Y7M, Y6M)} + k_{Y8M}\sigma_{(Y7M, Y8M)} + k_{Y9M}\sigma_{(Y7M, Y9M)} + k_{YSM}\sigma_{(Y7M, YSM)})Ev_{7M} + k_{Y1M}\sigma_{(Y7M, Y1M)} Ev_{1M} + k_{Y2M}\sigma_{(Y7M, Y2M)} Ev_{2M} + k_{Y3M}\sigma_{(Y7M, Y3M)} Ev_{3M} + k_{Y4M}\sigma_{(Y7M, Y4M)} Ev_{4M} + k_{Y5M}\sigma_{(Y7M, Y5M)} Ev_{5M} + k_{Y6M}\sigma_{(Y7M, Y6M)} Ev_{6M} + k_{Y8M}\sigma_{(Y7M, Y8M)} Ev_{8M} + k_{Y9M}\sigma_{(Y7M, Y9M)} Ev_{9M} + k_{YSM}\sigma_{(Y7M, YSM)} Ev_{SM} + EZ_M$

(A2.149)' $EY_{8M} = - (k_{Y1M}\sigma_{(Y8M, Y1M)} + k_{Y2M}\sigma_{(Y8M, Y2M)} + k_{Y3M}\sigma_{(Y8M, Y3M)} + k_{Y4M}\sigma_{(Y8M, Y4M)} + k_{Y5M}\sigma_{(Y8M, Y5M)} + k_{Y6M}\sigma_{(Y8M, Y6M)} + k_{Y7M}\sigma_{(Y8M, Y7M)} + k_{Y9M}\sigma_{(Y8M, Y9M)} + k_{YSM}\sigma_{(Y8M, YSM)})Ev_{8M} + k_{Y1M}\sigma_{(Y8M, Y1M)} Ev_{1M} + k_{Y2M}\sigma_{(Y8M, Y2M)} Ev_{2M} + k_{Y3M}\sigma_{(Y8M, Y3M)} Ev_{3M} + k_{Y4M}\sigma_{(Y8M, Y4M)} Ev_{4M} + k_{Y5M}\sigma_{(Y8M, Y5M)} Ev_{5M} + k_{Y6M}\sigma_{(Y8M, Y6M)} Ev_{6M} + k_{Y7M}\sigma_{(Y8M, Y7M)} Ev_{7M} + k_{Y9M}\sigma_{(Y8M, Y9M)} Ev_{9M} + k_{YSM}\sigma_{(Y8M, YSM)} Ev_{SM} + EZ_M$

(A2.150)' $EY_{9M} = - (k_{Y1M}\sigma_{(Y9M, Y1M)} + k_{Y2M}\sigma_{(Y9M, Y2M)} + k_{Y3M}\sigma_{(Y9M, Y3M)} + k_{Y4M}\sigma_{(Y9M, Y4M)} + k_{Y5M}\sigma_{(Y9M, Y5M)} + k_{Y6M}\sigma_{(Y9M, Y6M)} + k_{Y7M}\sigma_{(Y9M, Y7M)} + k_{Y8M}\sigma_{(Y9M, Y8M)} + k_{YSM}\sigma_{(Y9M, YSM)})Ev_{9M} + k_{Y1M}\sigma_{(Y9M, Y1M)} Ev_{1M} + k_{Y2M}\sigma_{(Y9M, Y2M)} Ev_{2M} + k_{Y3M}\sigma_{(Y9M, Y3M)} Ev_{3M} + k_{Y4M}\sigma_{(Y9M, Y4M)} Ev_{4M} + k_{Y5M}\sigma_{(Y9M, Y5M)} Ev_{5M} + k_{Y6M}\sigma$ (Y9M,

$_{Y6M)}\ Ev_{6M} + k_{Y7M}\sigma_{(Y9M,\ Y7M)}\ Ev_{7M} + k_{Y8M}\sigma_{(Y9M,\ Y8M)}\ Ev_{8M} + k_{YSM}\sigma_{(Y9M,\ YSM)}\ Ev_{SM} + EZ_M$

(A2.151)' $EY_{SM} = -\ (k_{Y1M}\sigma_{(YSM,\ Y1M)} + k_{Y2M}\sigma_{(YSM,\ Y2M)} + k_{Y3M}\sigma_{(YSM,\ Y3M)} + k_{Y4M}\sigma_{(YSM,\ Y4M)} + k_{Y5M}\sigma_{(YSM,\ Y5M)} + k_{Y6M}\sigma_{(YSM,\ Y6M)} + k_{Y7M}\sigma_{(YSM,\ Y7M)} + k_{Y8M}\sigma_{(YSM,\ Y8M)} + k_{Y9M}\sigma_{(YSM,\ Y9M)})Ev_{SM} + k_{Y1M}\sigma_{(YSM,\ Y1M)}\ Ev_{1M} + k_{Y2M}\sigma_{(YSM,\ Y2M)}\ Ev_{2M} + k_{Y3M}\sigma_{(YSM,\ Y3M)}\ Ev_{3M} + k_{Y4M}\sigma_{(YSM,\ Y4M)}\ Ev_{4M} + k_{Y5M}\sigma_{(YSM,\ Y5M)}\ Ev_{5M} + k_{Y6M}\sigma_{(YSM,\ Y6M)}\ Ev_{6M} + k_{Y7M}\sigma_{(YSM,\ Y7M)}\ Ev_{7M} + k_{Y8M}\sigma_{(YSM,\ Y8M)}\ Ev_{8M} + k_{Y9M}\sigma_{(YSM,\ Y9M)}\ Ev_{9M} + EZ_M$

Wool warehouse sectors equilibrium

(A2.152)' $k_{Y14W}EY_{14W} + k_{YNM}EY_{NM} = \gamma_{Z1W}EZ_{1W} + \gamma_{Z1S}EZ_{1S}$

(A2.153)' $k_{Y14W}Ev_{14W} + k_{YNM}Ev_{NM} = \gamma_{Z1W}Eu_{1W} + \gamma_{Z1S}Eu_{1S}$

(A2.154)' $k_{Y21W}EY_{21W} + k_{Y31W}EY_{31W} + k_{Y41W}EY_{41W} + k_{Y51W}EY_{51W} + k_{Y61W}EY_{61W} + k_{Y71W}EY_{71W} + k_{Y81W}EY_{81W} + k_{Y91W}EY_{91W} + k_{YFM}EY_{FM} = \gamma_{Z2W}EZ_{2W} + \gamma_{Z2S}EZ_{2S}$

(A2.155)' $k_{Y21W}Ev_{21W} + k_{Y31W}Ev_{31W} + k_{Y41W}Ev_{41W} + k_{Y51W}Ev_{51W} + k_{Y61W}Ev_{61W} + k_{Y71W}Ev_{71W} + k_{Y81W}Ev_{81W} + k_{Y91W}Ev_{91W} + k_{YFM}Ev_{FM} = \gamma_{Z2W}Eu_{2W} + \gamma_{Z2S}Eu_{2S}$

(A2.156)' $k_{Y22W}EY_{22W} + k_{Y32W}EY_{32W} + k_{Y42W}EY_{42W} + k_{Y52W}EY_{52W} + k_{Y62W}EY_{62W} + k_{Y72W}EY_{72W} + k_{Y82W}EY_{82W} + k_{Y92W}EY_{92W} + k_{YMM}EY_{MM} = \gamma_{Z3W}EZ_{3W} + \gamma_{Z3S}EZ_{3S}$

(A2.157)' $k_{Y22W}Ev_{22W} + k_{Y32W}Ev_{32W} + k_{Y42W}Ev_{42W} + k_{Y52W}Ev_{52W} + k_{Y62W}Ev_{62W} + k_{Y72W}Ev_{72W} + k_{Y82W}Ev_{82W} + k_{Y92W}Ev_{92W} + k_{YMM}Ev_{MM} = \gamma_{Z3W}Eu_{3W} + \gamma_{Z3S}Eu_{3S}$

(A2.158)' $k_{Y13W}EY_{13W} + k_{Y23W}EY_{23W} + k_{Y33W}EY_{33W} + k_{Y43W}EY_{43W} + k_{Y53W}EY_{53W} + k_{Y63W}EY_{63W} + k_{Y73W}EY_{73W} + k_{Y83W}EY_{83W} + k_{Y93W}EY_{93W} + k_{YBM}EY_{BM} = \gamma_{Z4W}EZ_{4W} + \gamma_{Z4S}EZ_{4S}$

(A2.159)' $k_{Y13W}Ev_{13W} + k_{Y23W}Ev_{23W} + k_{Y33W}Ev_{33W} + k_{Y43W}Ev_{43W} + k_{Y53W}Ev_{53W} + k_{Y63W}Ev_{63W} + k_{Y73W}Ev_{73W} + k_{Y83W}Ev_{83W} + k_{Y93W}Ev_{93W} + k_{YBM}Ev_{BM} = \gamma_{Z4W}Eu_{4W} + \gamma_{Z4S}Eu_{4S}$

Lamb and mutton slaughtering/processing sectors equilibrium

(A2.160)' $k_{Y1L}EY_{1L} + k_{Y2L}EY_{2L} + k_{Y3L}EY_{3L} + k_{Y4L}EY_{4L} + k_{Y5L}EY_{5L} + k_{Y6L}EY_{6L} + k_{YSL}EY_{SL} = \gamma_{ZLE}EZ_{LE} + \gamma_{ZLD}EZ_{LD}$

(A2.161)' $k_{Y1L}Ev_{1L} + k_{Y2L}Ev_{2L} + k_{Y3L}Ev_{3L} + k_{Y4L}Ev_{4L} + k_{Y5L}Ev_{5L} + k_{Y6L}Ev_{6L} + k_{YSL}Ev_{SL} = \gamma_{ZLE}Eu_{LE} + \gamma_{ZLD}Eu_{LD}$

(A2.162)' $k_{Y1M}EY_{1M} + k_{Y2M}EY_{2M} + k_{Y3M}EY_{3M} + k_{Y4M}EY_{4M} + k_{Y5M}EY_{5M} + k_{Y6M}EY_{6M} + k_{Y7M}EY_{7M} + k_{Y8M}EY_{8M} + k_{Y9M}EY_{9M} + k_{YSM}EY_{SM} = \gamma_{ZME}EZ_{ME} + \gamma_{ZMD}EZ_{MD}$

(A2.163)' $k_{Y1M}Ev_{1M} + k_{Y2M}Ev_{2M} + k_{Y3M}Ev_{3M} + k_{Y4M}Ev_{4M} + k_{Y5M}Ev_{5M} + k_{Y6M}Ev_{6M} + k_{Y7M}Ev_{7M} + k_{Y8M}Ev_{8M} + k_{Y9M}Ev_{9M} + k_{YSM}Ev_{SM} = \gamma_{ZME}Eu_{ME} + \gamma_{ZMD}Eu_{MD}$

Input constrained output supply of wool warehouse sectors

(A2.164)' $EZ_{1W} = -\ \gamma_{Z1S}\tau_{(Z1W,\ Z1S)}Eu_{1W} + \gamma_{Z1S}\tau_{(Z1W,\ Z1S)}Eu_{1S} + EY_N$

(A2.165)' $EZ_{1S} = \gamma_{Z1W}\tau_{(Z1W,\ Z1S)}Eu_{1W} - \gamma_{Z1W}\tau_{(Z1W,\ Z1S)}Eu_{1S} + EY_N$

(A2.166)’ $EZ_{2W} = - \gamma_{Z2S}\tau_{(Z2W,\ Z2S)}Eu_{2W} + \gamma_{Z2S}\tau_{(Z2W,\ Z2S)}Eu_{2S} + EY_N$

(A2.167)’ $EZ_{2S} = \gamma_{Z2W}\tau_{(Z2W,\ Z2S)}Eu_{2W} - \gamma_{Z2W}\tau_{(Z2W,\ Z2S)}Eu_{2S} + EY_N$

(A2.168)’ $EZ_{3W} = - \gamma_{Z3S}\tau_{(Z3W,\ Z3S)}Eu_{3W} + \gamma_{Z3S}\tau_{(Z3W,\ Z3S)}Eu_{3S} + EY_N$

(A2.169)’ $EZ_{3S} = \gamma_{Z3W}\tau_{(Z3W,\ Z3S)}Eu_{3W} - \gamma_{Z3W}\tau_{(Z3W,\ Z3S)}Eu_{3S} + EY_N$

(A2.170)’ $EZ_{4W} = - \gamma_{Z4S}\tau_{(Z4W,\ Z4S)}Eu_{4W} + \gamma_{Z4S}\tau_{(Z4W,\ Z4S)}Eu_{4S} + EY_N$

(A2.171)’ $EZ_{4S} = \gamma_{Z4W}\tau_{(Z4W,\ Z4S)}Eu_{4W} - \gamma_{Z4W}\tau_{(Z4W,\ Z4S)}Eu_{4S} + EY_N$

Input constrained output supply of lamb and mutton slaughtering/processing sectors

(A2.172)’ $EZ_{LE} = - \gamma_{ZLD}\tau_{(ZLE,\ ZLD)}Eu_{LE} + \gamma_{ZLD}\tau_{(ZLE,\ ZLD)}Eu_{LD} + EY_L$

(A2.173)’ $EZ_{LD} = \gamma_{ZLE}\tau_{(ZLE,\ ZLD)}Eu_{LE} - \gamma_{ZLE}\tau_{(ZLE,\ ZLD)}Eu_{LD} + EY_L$

(A2.174)’ $EZ_{ME} = - \gamma_{ZMD}\tau_{(ZME,\ ZMD)}Eu_{ME} + \gamma_{ZMD}\tau_{(ZME,\ ZMD)}Eu_{MD} + EY_M$

(A2.175)’ $EZ_{MD} = \gamma_{ZME}\tau_{(ZME,\ ZMD)}Eu_{ME} - \gamma_{ZME}\tau_{(ZME,\ ZMD)}Eu_{MD} + EY_M$

Other input supply to wool scouring sector

(A2.176)’ $EZ_{CS} = \varepsilon_{(ZCS,\ UCS)}(Eu_{CS} - t_{ZCS})$

Output constrained input demand of wool scouring sector

(A2.177)’ $EZ_{1S} = - (k_{Z2S}\sigma_{(Z1S,\ Z2S)} + k_{Z3S}\sigma_{(Z1S,\ Z3S)} + k_{Z4S}\sigma_{(Z1S,\ Z4S)} + k_{ZCS}\sigma_{(Z1S,\ ZCS)})Eu_{1S} + k_{Z2S}\sigma_{(Z1S,\ Z2S)} Eu_{2S} + k_{Z3S}\sigma_{(Z1S,\ Z3S)} Eu_{3S} + k_{Z4S}\sigma_{(Z1S,\ Z4S)} Eu_{4S} + k_{ZCS}\sigma_{(Z1S,\ ZCS)} Eu_{CS} + EZ_S$

(A2.178)’ $EZ_{2S} = - (k_{Z1S}\sigma_{(Z2S,\ Z1S)} + k_{Z3S}\sigma_{(Z2S,\ Z3S)} + k_{Z4S}\sigma_{(Z2S,\ Z4S)} + k_{ZCS}\sigma_{(Z2S,\ ZCS)})Eu_{2S} + k_{Z1S}\sigma_{(Z2S,\ Z1S)} Eu_{1S} + k_{Z3S}\sigma_{(Z2S,\ Z3S)} Eu_{3S} + k_{Z4S}\sigma_{(Z2S,\ Z4S)} Eu_{4S} + k_{ZCS}\sigma_{(Z2S,\ ZCS)} Eu_{CS} + EZ_S$

(A2.179)’ $EZ_{3S} = - (k_{Z1S}\sigma_{(Z3S,\ Z1S)} + k_{Z2S}\sigma_{(Z3S,\ Z2S)} + k_{Z4S}\sigma_{(Z3S,\ Z4S)} + k_{ZCS}\sigma_{(Z3S,\ ZCS)})Eu_{3S} + k_{Z1S}\sigma_{(Z3S,\ Z1S)} Eu_{1S} + k_{Z2S}\sigma_{(Z3S,\ Z2S)} Eu_{2S} + k_{Z4S}\sigma_{(Z3S,\ Z4S)} Eu_{4S} + k_{ZCS}\sigma_{(Z3S,\ ZCS)} Eu_{CS} + EZ_S$

(A2.180)’ $EZ_{4S} = - (k_{Z1S}\sigma_{(Z4S,\ Z1S)} + k_{Z2S}\sigma_{(Z4S,\ Z2S)} + k_{Z3S}\sigma_{(Z4S,\ Z3S)} + k_{ZCS}\sigma_{(Z4S,\ ZCS)})Eu_{4S} + k_{Z1S}\sigma_{(Z4S,\ Z1S)} Eu_{1S} + k_{Z2S}\sigma_{(Z4S,\ Z2S)} Eu_{2S} + k_{Z3S}\sigma_{(Z4S,\ Z3S)} Eu_{3S} + k_{ZCS}\sigma_{(Z4S,\ ZCS)} Eu_{CS} + EZ_S$

(A2.181)’ $EZ_{CS} = - (k_{Z1S}\sigma_{(ZCS,\ Z1S)} + k_{Z2S}\sigma_{(ZCS,\ Z2S)} + k_{Z3S}\sigma_{(ZCS,\ Z3S)} + k_{Z4S}\sigma_{(ZCS,\ Z4S)})Eu_{CS} + k_{Z1S}\sigma_{(ZCS,\ Z1S)} Eu_{1S} + k_{Z2S}\sigma_{(ZCS,\ Z2S)} Eu_{2S} + k_{Z3S}\sigma_{(ZCS,\ Z3S)} Eu_{3S} + k_{Z4S}\sigma_{(ZCS,\ Z4S)} Eu_{4S} + EZ_S$

Wool scouring sector equilibrium

(A2.182)’ $k_{ZIS}EZ_{1S} + k_{Z2S}EZ_{2S} + k_{Z3S}EZ_{3S} + k_{Z4S}EZ_{4S} + k_{ZCS}EZ_{CS} = \gamma_{ZCW}EZ_{CW} + \gamma_{F1S}EF_{1S} + \gamma_{F2S}EF_{2S} + \gamma_{F3S}EF_{3S} + \gamma_{F4S}EF_{4S} + \gamma_{Z2T}EZ_{2T} + \gamma_{Z3T}EZ_{3T} + \gamma_{Z4T}EZ_{4T}$

(A2.183)’ $k_{ZIS}Eu_{1S} + k_{Z2S}Eu_{2S} + k_{Z3S}Eu_{3S} + k_{Z4S}Eu_{4S} + k_{ZCS}Eu_{CS} = \gamma_{ZCW}Eu_{CW} + \gamma_{F1S}Es_{1S} + \gamma_{F2S}Es_{2S} + \gamma_{F3S}Es_{3S} + \gamma_{F4S}Es_{4S} + \gamma_{Z2T}Eu_{2T} + \gamma_{Z3T}Eu_{3T} + \gamma_{Z4T}Eu_{4T}$

Input constrained output supply of wool scouring sector

(A2.184)’ $EF_{1S} = - (\gamma_{F2S}\tau_{(F1S,\ F2S)} + \gamma_{F3S}\tau_{(F1S,\ F3S)} + \gamma_{F4S}\tau_{(F1S,\ F4S)} + \gamma_{ZCW}\tau_{(F1S,\ ZCW)} + \gamma_{Z2T}\tau_{(F1S,\ Z2T)} + \gamma_{Z3T}\tau_{(F1S,\ Z3T)} + \gamma_{Z4T}\tau_{(F1S,\ Z4T)})Es_{1S} + \gamma_{F2S}\tau_{(F1S,\ F2S)}\ Es_{2S} + \gamma_{F3S}\tau_{(F1S,\ F3S)}\ Es_{3S} + \gamma_{F4S}\tau_{(F1S,\ F4S)}\ Es_{4S} + \gamma_{ZCW}\tau_{(F1S,\ ZCW)}\ Eu_{CW} + \gamma_{Z2T}\tau_{(F1S,\ Z2T)}\ Eu_{2T} + \gamma_{Z3T}\tau_{(F1S,\ Z3T)}\ Eu_{3T} + \gamma_{Z4T}\tau_{(F1S,\ Z4T)}\ Eu_{4T} + EZ_C$

(A2.185)’ $EF_{2S} = - (\gamma_{F1S}\tau_{(F1S,\ F2S)} + \gamma_{F3S}\tau_{(F2S,\ F3S)} + \gamma_{F4S}\tau_{(F2S,\ F4S)} + \gamma_{ZCW}\tau_{(F2S,\ ZCW)} + \gamma_{Z2T}\tau_{(F2S,\ Z2T)} + \gamma_{Z3T}\tau_{(F2S,\ Z3T)} + \gamma_{Z4T}\tau_{(F2S,\ Z4T)})Es_{2S} + \gamma_{F1S}\tau_{(F1S,\ F2S)}\ Es_{1S} + \gamma_{F3S}\tau_{(F2S,\ F3S)}\ Es_{3S} + \gamma_{F4S}\tau_{(F2S,\ F4S)}\ Es_{4S} + \gamma_{ZCW}\tau_{(F2S,\ ZCW)}\ Eu_{CW} + \gamma_{Z2T}\tau_{(F2S,\ Z2T)}\ Eu_{2T} + \gamma_{Z3T}\tau_{(F2S,\ Z3T)}\ Eu_{3T} + \gamma_{Z4T}\tau_{(F2S,\ Z4T)}\ Eu_{4T} + EZ_C$

(A2.186)’ $EF_{3S} = - (\gamma_{F1S}\tau_{(F1S,\ F3S)} + \gamma_{F2S}\tau_{(F2S,\ F3S)} + \gamma_{F4S}\tau_{(F3S,\ F4S)} + \gamma_{ZCW}\tau_{(F3S,\ ZCW)} + \gamma_{Z2T}\tau_{(F3S,\ Z2T)} + \gamma_{Z3T}\tau_{(F3S,\ Z3T)} + \gamma_{Z4T}\tau_{(F3S,\ Z4T)})Es_{3S} + \gamma_{F1S}\tau_{(F1S,\ F3S)}\ Es_{1S} + \gamma_{F2S}\tau_{(F2S,\ F3S)}\ Es_{2S} + \gamma_{F4S}\tau_{(F3S,\ F4S)}\ Es_{4S} + \gamma_{ZCW}\tau_{(F3S,\ ZCW)}\ Eu_{CW} + \gamma_{Z2T}\tau_{(F3S,\ Z2T)}\ Eu_{2T} + \gamma_{Z3T}\tau_{(F3S,\ Z3T)}\ Eu_{3T} + \gamma_{Z4T}\tau_{(F3S,\ Z4T)}\ Eu_{4T} + EZ_C$

(A2.187)’ $EF_{4S} = - (\gamma_{F1S}\tau_{(F1S,\ F4S)} + \gamma_{F2S}\tau_{(F2S,\ F4S)} + \gamma_{F3S}\tau_{(F3S,\ F4S)} + \gamma_{ZCW}\tau_{(F4S,\ ZCW)} + \gamma_{Z2T}\tau_{(F4S,\ Z2T)} + \gamma_{Z3T}\tau_{(F4S,\ Z3T)} + \gamma_{Z4T}\tau_{(F4S,\ Z4T)})Es_{4S} + \gamma_{F1S}\tau_{(F1S,\ F4S)}\ Es_{1S} + \gamma_{F2S}\tau_{(F2S,\ F4S)}\ Es_{2S} + \gamma_{F3S}\tau_{(F3S,\ F4S)}\ Es_{3S} + \gamma_{ZCW}\tau_{(F4S,\ ZCW)}\ Eu_{CW} + \gamma_{Z2T}\tau_{(F4S,\ Z2T)}\ Eu_{2T} + \gamma_{Z3T}\tau_{(F4S,\ Z3T)}\ Eu_{3T} + \gamma_{Z4T}\tau_{(F4S,\ Z4T)}\ Eu_{4T} + EZ_C$

(A2.188)’ $EZ_{CW} = - (\gamma_{F1S}\tau_{(F1S,\ ZCW)} + \gamma_{F2S}\tau_{(F2S,\ ZCW)} + \gamma_{F3S}\tau_{(F3S,\ ZCW)} + \gamma_{F4S}\tau_{(F4S,\ ZCW)} + \gamma_{Z2T}\tau_{(Z2T,\ ZCW)} + \gamma_{Z3T}\tau_{(Z3T,\ ZCW)} + \gamma_{Z4T}\tau_{(Z4T,\ ZCW)})Eu_{CW} + \gamma_{F1S}\tau_{(F1S,\ ZCW)}\ Es_{1S} + \gamma_{F2S}\tau_{(F2S,\ ZCW)}\ Es_{2S} + \gamma_{F3S}\tau_{(F3S,\ ZCW)}\ Es_{3S} + \gamma_{F4S}\tau_{(F4S,\ ZCW)}\ Es_{4S} + \gamma_{Z2T}\tau_{(Z2T,\ ZCW)}\ Eu_{2T} + \gamma_{Z3T}\tau_{(Z3T,\ ZCW)}\ Eu_{3T} + \gamma_{Z4T}\tau_{(Z4T,\ ZCW)}\ Eu_{4T} + EZ_C$

(A2.189)’ $EZ_{2T} = - (\gamma_{F1S}\tau_{(F1S,\ Z2T)} + \gamma_{F2S}\tau_{(F2S,\ Z2T)} + \gamma_{F3S}\tau_{(F3S,\ Z2T)} + \gamma_{F4S}\tau_{(F4S,\ Z2T)} + \gamma_{ZCW}\tau_{(Z2T,\ ZCW)} + \gamma_{Z3T}\tau_{(Z2T,\ Z3T)} + \gamma_{Z4T}\tau_{(Z2T,\ Z4T)})Eu_{2T} + \gamma_{F1S}\tau_{(F1S,\ Z2T)}\ Es_{1S} + \gamma_{F2S}\tau_{(F2S,\ Z2T)}\ Es_{2S} + \gamma_{F3S}\tau_{(F3S,\ Z2T)}\ Es_{3S} + \gamma_{F4S}\tau_{(F4S,\ Z2T)}\ Es_{4S} + \gamma_{ZCW}\tau_{(Z2T,\ ZCW)}\ Eu_{CW} + \gamma_{Z3T}\tau_{(Z2T,\ Z3T)}\ Eu_{3T} + \gamma_{Z4T}\tau_{(Z2T,\ Z4T)}\ Eu_{4T} + EZ_C$

(A2.190)’ $EZ_{3T} = - (\gamma_{F1S}\tau_{(F1S,\ Z3T)} + \gamma_{F2S}\tau_{(F2S,\ Z3T)} + \gamma_{F3S}\tau_{(F3S,\ Z3T)} + \gamma_{F4S}\tau_{(F4S,\ Z3T)} + \gamma_{ZCW}\tau_{(Z3T,\ ZCW)} + \gamma_{Z2T}\tau_{(Z2T,\ Z3T)} + \gamma_{Z4T}\tau_{(Z3T,\ Z4T)})Eu_{3T} + \gamma_{F1S}\tau_{(F1S,\ Z3T)}\ Es_{1S} + \gamma_{F2S}\tau_{(F2S,\ Z3T)}\ Es_{2S} + \gamma_{F3S}\tau_{(F3S,\ Z3T)}\ Es_{3S} + \gamma_{F4S}\tau_{(F4S,\ Z3T)}\ Es_{4S} + \gamma_{ZCW}\tau_{(Z3T,\ ZCW)}\ Eu_{CW} + \gamma_{Z2T}\tau_{(Z2T,\ Z3T)}\ Eu_{2T} + \gamma_{Z4T}\tau_{(Z3T,\ Z4T)}\ Eu_{4T} + EZ_C$

(A2.191)’ $EZ_{4T} = - (\gamma_{F1S}\tau_{(F1S,\ Z4T)} + \gamma_{F2S}\tau_{(F2S,\ Z4T)} + \gamma_{F3S}\tau_{(F3S,\ Z4T)} + \gamma_{F4S}\tau_{(F4S,\ Z4T)} + \gamma_{ZCW}\tau_{(Z4T,\ ZCW)} + \gamma_{Z2T}\tau_{(Z2T,\ Z4T)} + \gamma_{Z3T}\tau_{(Z3T,\ Z4T)})Eu_{4T} + \gamma_{F1S}\tau_{(F1S,\ Z4T)}\ Es_{1S} + \gamma_{F2S}\tau_{(F2S,\ Z4T)}\ Es_{2S} + \gamma_{F3S}\tau_{(F3S,\ Z4T)}\ Es_{3S} + \gamma_{F4S}\tau_{(F4S,\ Z4T)}\ Es_{4S} + \gamma_{ZCW}\tau_{(Z4T,\ ZCW)}\ Eu_{CW} + \gamma_{Z2T}\tau_{(Z2T,\ Z4T)}\ Eu_{2T} + \gamma_{Z3T}\tau_{(Z3T,\ Z4T)}\ Eu_{3T} + EZ_C$

Other input supply to wool carbonising sector

(A2.192)’ $EZ_{CB} = \varepsilon_{(ZCB,\ UCB)}(Eu_{CB} - t_{ZCB})$

Output constrained input demand of wool carbonising sector

(A2.193)’ $EZ_{CW} = - k_{ZCB}\sigma_{\ (ZCW,\ ZCB)}\ Eu_{CW} + k_{ZCB}\sigma_{\ (ZCW,\ ZCB)}Eu_{CB} + EF_{CW}$

(A2.194)’ $EZ_{CB} = k_{ZCW}\sigma_{\ (ZCW,\ ZCB)}\ Eu_{CW} - k_{ZCW}\sigma_{\ (ZCW,\ ZCB)}Eu_{CB} + EF_{CW}$

Wool carbonising sector equilibrium

(A2.195)’ $Es_{CW} = k_{ZCW}Eu_{CW} + k_{ZCB}Eu_{CB}$

Other input supply to wool topmaking sector

(A2.196)' $EZ_{WT} = \varepsilon_{(ZWT, UWT)}(Eu_{WT} - t_{ZWT})$

Output constrained input demand of wool topmaking sector

(A2.197)' $EZ_{2T} = -(k_{Z3T}\sigma_{(Z2T, Z3T)} + k_{Z4T}\sigma_{(Z2T, Z4T)} + k_{ZWT}\sigma_{(Z2T, ZWT)})Eu_{2T} + k_{Z3T}\sigma_{(Z2T, Z3T)} Eu_{3T} + k_{Z4T}\sigma_{(Z2T, Z4T)} Eu_{4T} + k_{ZWT}\sigma_{(Z2T, ZWT)} Eu_{WT} + EF_T$

(A2.198)' $EZ_{3T} = -(k_{Z2T}\sigma_{(Z3T, Z2T)} + k_{Z4T}\sigma_{(Z3T, Z4T)} + k_{ZWT}\sigma_{(Z3T, ZWT)})Eu_{3T} + k_{Z2T}\sigma_{(Z3T, Z2T)} Eu_{2T} + k_{Z4T}\sigma_{(Z3T, Z4T)} Eu_{4T} + k_{ZWT}\sigma_{(Z3T, ZWT)} Eu_{WT} + EF_T$

(A2.199)' $EZ_{4T} = -(k_{Z2T}\sigma_{(Z4T, Z2T)} + k_{Z3T}\sigma_{(Z4T, Z3T)} + k_{ZWT}\sigma_{(Z4T, ZWT)})Eu_{4T} + k_{Z2T}\sigma_{(Z4T, Z2T)} Eu_{2T} + k_{Z3T}\sigma_{(Z4T, Z3T)} Eu_{3T} + k_{ZWT}\sigma_{(Z4T, ZWT)} Eu_{WT} + EF_T$

(A2.200)' $EZ_{WT} = -(k_{Z2T}\sigma_{(ZWT, Z2T)} + k_{Z3T}\sigma_{(ZWT, Z3T)} + k_{Z4T}\sigma_{(ZWT, Z4T)})Eu_{WT} + k_{Z2T}\sigma_{(ZWT, Z2T)} Eu_{2T} + k_{Z3T}\sigma_{(ZWT, Z3T)} Eu_{3T} + k_{Z4T}\sigma_{(ZWT, Z4T)} Eu_{4T} + EF_T$

Wool topmaking sector equilibrium

(A2.201)' $k_{Z2T}EZ_{2T} + k_{Z3T}EZ_{3T} + k_{Z4T}EZ_{4T} + k_{ZWT}EZ_{WT} = \gamma_{F2T}EF_{2T} + \gamma_{F3T}EF_{3T} + \gamma_{F4T}EF_{4T} + \gamma_{FNW}EF_{NW} + \gamma_{QDP}EQ_{DP}$

(A2.202)' $k_{Z2T}Eu_{2T} + k_{Z3T}Eu_{3T} + k_{Z4T}Eu_{4T} + k_{ZWT}Eu_{WT} = \gamma_{F2T}Es_{2T} + \gamma_{F3T}Es_{3T} + \gamma_{F4T}Es_{4T} + \gamma_{FNW}Es_{NW} + \gamma_{QDP}Ep_{DP}$

Input constrained output supply of wool topmaking sector

(A2.203)' $EF_{2T} = -(\gamma_{F3T}\tau_{(F2T, F3T)} + \gamma_{F4T}\tau_{(F2T, F4T)} + \gamma_{FNW}\tau_{(F2T, FNW)} + \gamma_{QDP}\tau_{(F2T, QDP)})Es_{2T} + \gamma_{F3T}\tau_{(F2T, F3T)} Es_{3T} + \gamma_{F4T}\tau_{(F2T, F4T)} Es_{4T} + \gamma_{FNW}\tau_{(F2T, FNW)} Es_{NW} + \gamma_{QDP}\tau_{(F2T, QDP)} Ep_{DP} + EZ_T$

(A2.204)' $EF_{3T} = -(\gamma_{F2T}\tau_{(F2T, F3T)} + \gamma_{F4T}\tau_{(F3T, F4T)} + \gamma_{FNW}\tau_{(F3T, FNW)} + \gamma_{QDP}\tau_{(F3T, QDP)})Es_{3T} + \gamma_{F2T}\tau_{(F2T, F3T)} Es_{2T} + \gamma_{F4T}\tau_{(F2T, F4T)} Es_{4T} + \gamma_{FNW}\tau_{(F3T, FNW)} Es_{NW} + \gamma_{QDP}\tau_{(F3T, QDP)} Ep_{DP} + EZ_T$

(A2.205)' $EF_{4T} = -(\gamma_{F2T}\tau_{(F2T, F4T)} + \gamma_{F3T}\tau_{(F3T, F4T)} + \gamma_{FNW}\tau_{(F4T, FNW)} + \gamma_{QDP}\tau_{(F4T, QDP)})Es_{4T} + \gamma_{F2T}\tau_{(F2T, F4T)} Es_{2T} + \gamma_{F3T}\tau_{(F3T, F4T)} Es_{3T} + \gamma_{FNW}\tau_{(F4T, FNW)} Es_{NW} + \gamma_{QDP}\tau_{(F4T, QDP)} Ep_{DP} + EZ_T$

(A2.206)' $EF_{NW} = -(\gamma_{F2T}\tau_{(F2T, FNW)} + \gamma_{F3T}\tau_{(F3T, FNW)} + \gamma_{F4T}\tau_{(F4T, FNW)} + \gamma_{QDP}\tau_{(FNW, QDP)})Es_{NW} + \gamma_{F2T}\tau_{(F2T, FNW)} Es_{2T} + \gamma_{F3T}\tau_{(F2T, FNW)} Es_{3T} + \gamma_{F4T}\tau_{(F4T, FNW)} Es_{4T} + \gamma_{QDP}\tau_{(FNW, QDP)} Ep_{DP} + EZ_T$

(A2.207)' $EQ_{DP} = -(\gamma_{F2T}\tau_{(F2T, QDP)} + \gamma_{F3T}\tau_{(F3T, QDP)} + \gamma_{F4T}\tau_{(F4T, QDP)} + \gamma_{FNW}\tau_{(FNW, QDP)})Ep_{DP} + \gamma_{F2T}\tau_{(F2T, QDP)} Es_{2T} + \gamma_{F3T}\tau_{(F2T, QDP)} Es_{3T} + \gamma_{F4T}\tau_{(F4T, QDP)} Es_{4T} + \gamma_{FNW}\tau_{(FNW, QDP)} Es_{NW} + EZ_T$

Other input supply to export greasy wool shipment sectors

(A2.208)' $EZ_{NM} = \varepsilon_{(ZNM, UNM)}(Eu_{NM} - t_{ZNM})$

(A2.209)' $EZ_{FM} = \varepsilon_{(ZFM, UFM)}(Eu_{FM} - t_{ZFM})$

(A2.210)' $EZ_{MM} = \varepsilon_{(ZMM, UMM)}(Eu_{MM} - t_{ZMM})$

(A2.211)' $EZ_{BM} = \varepsilon_{(ZBM, UBM)}(Eu_{BM} - t_{ZBM})$

Other input supply to export carbonised wool shipment sector

(A2.212)' $EF_{CB} = \varepsilon_{(FCB, SCB)}(Es_{CB} - t_{FCB})$

Other input supply to export scoured wool shipment sectors

(A2.213)' $EF_{NS} = \varepsilon_{(FNS, SNS)}(Es_{NS} - t_{FNS})$

(A2.214)' $EF_{FS} = \varepsilon_{(FFS, SFS)}(Es_{FS} - t_{FFS})$

(A2.215)' $EF_{MS} = \varepsilon_{(FMS, SMS)}(Es_{MS} - t_{FMS})$

(A2.216)' $EF_{BS} = \varepsilon_{(FBS, SBS)}(Es_{BS} - t_{FBS})$

Other input supply to export wool tops shipment sectors

(A2.217)' $EF_{FT} = \varepsilon_{(FFT, SFT)}(Es_{FT} - t_{FFT})$

(A2.218)' $EF_{MT} = \varepsilon_{(FMT, SMT)}(Es_{MT} - t_{FMT})$

(A2.219)' $EF_{BT} = \varepsilon_{(FBT, SBT)}(Es_{BT} - t_{FBT})$

(A2.220)' $EF_{NE} = \varepsilon_{(FNE, SNE)}(Es_{NE} - t_{FNE})$

Output constrained input demand of export greasy wool shipment sectors

(A2.221)' $EZ_{1W} = - k_{ZNM}\sigma_{(Z1W, ZNM)} Eu_{1W} + k_{ZNM}\sigma_{(Z1W, ZNM)}Eu_{NM} + EQ_{1W}$

(A2.222)' $EZ_{NM} = k_{Z1W}\sigma_{(Z1W, ZNM)} Eu_{1W} - k_{Z1W}\sigma_{(Z1W, ZNM)}Eu_{NM} + EQ_{1W}$

(A2.223)' $EZ_{2W} = - k_{ZFM}\sigma_{(Z2W, ZFM)} Eu_{2W} + k_{ZFM}\sigma_{(Z2W, ZFM)}Eu_{FM} + EQ_{2W}$

(A2.224)' $EZ_{FM} = k_{Z2W}\sigma_{(Z2W, ZFM)} Eu_{2W} - k_{Z2W}\sigma_{(Z2W, ZFM)}Eu_{FM} + EQ_{2W}$

(A2.225)' $EZ_{3W} = - k_{ZMM}\sigma_{(Z3W, ZMM)} Eu_{3W} + k_{ZMM}\sigma_{(Z3W, ZMM)}Eu_{MM} + EQ_{3W}$

(A2.226)' $EZ_{MM} = k_{Z3W}\sigma_{(Z3W, ZMM)} Eu_{3W} - k_{Z3W}\sigma_{(Z3W, ZMM)}Eu_{MM} + EQ_{3W}$

(A2.227)' $EZ_{4W} = - k_{ZBM}\sigma_{(Z4W, ZBM)} Eu_{4W} + k_{ZBM}\sigma_{(Z4W, ZBM)}Eu_{BM} + EQ_{4W}$

(A2.228)' $EZ_{BM} = k_{Z4W}\sigma_{(Z4W, ZBM)} Eu_{4W} - k_{Z4W}\sigma_{(Z4W, ZBM)}Eu_{BM} + EQ_{4W}$

Output constrained input demand of export carbonised wool shipment sector

(A2.229)' $EF_{CW} = - k_{FCB}\sigma_{(FCW, FCB)} Es_{CW} + k_{FCB}\sigma_{(FCW, FCB)}Es_{CB} + EQ_{CW}$

(A2.230)' $EF_{CB} = k_{FCW}\sigma_{(FCW, FCB)} Es_{CW} - k_{FCW}\sigma_{(FCW, FCB)}Es_{CB} + EQ_{CW}$

Output constrained input demand of export scoured wool shipment sector

(A2.231)' $EF_{1S} = - k_{FNS}\sigma_{(F1S, FNS)} Es_{1S} + k_{FNS}\sigma_{(F1S, FNS)}Es_{NS} + EQ_{1S}$

(A2.232)' $EF_{NS} = k_{F1S}\sigma_{(F1S, FNS)} Es_{1S} - k_{F1S}\sigma_{(F1S, FNS)}Es_{NS} + EQ_{1S}$

(A2.233)' $EF_{2S} = - k_{FFS}\sigma_{(F2S, FFS)} Es_{2S} + k_{FFS}\sigma_{(F2S, FFS)}Es_{FS} + EQ_{2S}$

(A2.234)' $EF_{FS} = k_{F2S}\sigma_{(F2S, FFS)} Es_{2S} - k_{F2S}\sigma_{(F2S, FFS)}Es_{FS} + EQ_{2S}$

(A2.235)' $EF_{3S} = - k_{FMS}\sigma_{(F3S, FMS)} Es_{3S} + k_{FMS}\sigma_{(F3S, FMS)}Es_{MS} + EQ_{3S}$

(A2.236)' $EF_{MS} = k_{F3S}\sigma_{(F3S, FMS)} Es_{3S} - k_{F3S}\sigma_{(F3S, FMS)}Es_{MS} + EQ_{3S}$

(A2.237)' $EF_{4S} = - k_{FBS}\sigma_{(F4S, FBS)} Es_{4S} + k_{FBS}\sigma_{(F4S, FBS)}Es_{BS} + EQ_{4S}$

(A2.238)’ $EF_{BS} = k_{F4S}\sigma_{(F4S,\ FBS)} Es_{4S} - k_{F4S}\sigma_{(F4S,\ FBS)} Es_{BS} + EQ_{4S}$

Output constrained input demand of export wool tops shipment sectors

(A2.239)’ $EF_{2T} = - k_{FFT}\sigma_{(F2T,\ FFT)} Es_{2T} + k_{FFT}\sigma_{(F2T,\ FFT)} Es_{FT} + EQ_{2T}$

(A2.240)’ $EF_{FT} = k_{F2T}\sigma_{(F2T,\ FFT)} Es_{2T} - k_{F2T}\sigma_{(F2T,\ FFT)} Es_{FT} + EQ_{2T}$

(A2.241)’ $EF_{3T} = - k_{FMT}\sigma_{(F3T,\ FMT)} Es_{3T} + k_{FMT}\sigma_{(F3T,\ FMT)} Es_{MT} + EQ_{3T}$

(A2.242)’ $EF_{MT} = k_{F3T}\sigma_{(F3T,\ FMT)} Es_{3T} - k_{F3T}\sigma_{(F3T,\ FMT)} Es_{MT} + EQ_{3T}$

(A2.243)’ $EF_{4T} = - k_{FBT}\sigma_{(F4T,\ FBT)} Es_{4T} + k_{FBT}\sigma_{(F4T,\ FBT)} Es_{BT} + EQ_{4T}$

(A2.244)’ $EF_{BT} = k_{F4T}\sigma_{(F4T,\ FBT)} Es_{4T} - k_{F4T}\sigma_{(F4T,\ FBT)} Es_{BT} + EQ_{4T}$

(A2.245)’ $EF_{NW} = - k_{FNE}\sigma_{(FNW,\ FNE)} Es_{NW} + k_{FNE}\sigma_{(FNW,\ FNE)} Es_{NE} + EQ_{NW}$

(A2.246)’ $EF_{NE} = k_{FNW}\sigma_{(FNW,\ FNE)} Es_{NW} - k_{FNW}\sigma_{(FNW,\ FNE)} Es_{NE} + EQ_{NW}$

Export greasy wool shipment sector equilibrium

(A2.247)’ $Ep_{1W} = k_{Z1W}Eu_{1W} + k_{ZNM}Eu_{NM}$

(A2.248)’ $Ep_{2W} = k_{Z2W}Eu_{2W} + k_{ZFM}Eu_{FM}$

(A2.249)’ $Ep_{3W} = k_{Z3W}Eu_{3W} + k_{ZMM}Eu_{MM}$

(A2.250)’ $Ep_{4W} = k_{Z4W}Eu_{4W} + k_{ZBM}Eu_{BM}$

Export carbonised wool shipment sector equilibrium

(A2.251)’ $Ep_{CW} = k_{FCW}Es_{CW} + k_{FCB}Es_{CB}$

Export scoured wool shipment sector equilibrium

(A2.252)’ $Ep_{1S} = k_{F1S}Es_{1S} + k_{FNS}Es_{NS}$

(A2.253)’ $Ep_{2S} = k_{F2S}Es_{2S} + k_{FFS}Es_{FS}$

(A2.254)’ $Ep_{3S} = k_{F3S}Es_{3S} + k_{FMS}Es_{MS}$

(A2.255)’ $Ep_{4S} = k_{F4S}Es_{4S} + k_{FBS}Es_{BS}$

Export wool tops shipment sector equilibrium

(A2.256)’ $Ep_{2T} = k_{F2T}Es_{2T} + k_{FFT}Es_{FT}$

(A2.257)’ $Ep_{3T} = k_{F3T}Es_{3T} + k_{FMT}Es_{MT}$

(A2.258)’ $Ep_{4T} = k_{F4T}Es_{4T} + k_{FBT}Es_{BT}$

(A2.259)’ $Ep_{NW} = k_{FNW}Es_{NW} + k_{FNE}Es_{NE}$

Other input supply to lamb and mutton marketing sectors

(A2.260)’ $EZ_{1L} = \varepsilon_{(Z1L,\ U1L)}(Eu_{1L} - t_{Z1L})$

(A2.261)’ $EZ_{2L} = \varepsilon_{(Z2L,\ U2L)}(Eu_{2L} - t_{Z2L})$

(A2.262)’ $EZ_{1M} = \varepsilon_{(Z1M,\ U1M)}(Eu_{1M} - t_{Z1M})$

(A2.263)’ $EZ_{2M} = \varepsilon_{(Z2M,\, U2M)}(Eu_{2M} - t_{Z2M})$

Output constrained input demand of lamb and mutton marketing sectors

(A2.264)’ $EZ_{LE} = - k_{Z1L}\sigma_{(ZLE,\, Z1L)} Eu_{LE} + k_{Z1L}\sigma_{(ZLE,\, Z1L)}Eu_{1L} + EQ_{LE}$

(A2.265)’ $EZ_{1L} = - k_{ZLE}\sigma_{(ZLE,\, Z1L)} Eu_{LE} + k_{Z1L}\sigma_{(ZLE,\, Z1L)}Eu_{1L} + EQ_{LE}$

(A2.266)’ $EZ_{LD} = - k_{Z2L}\sigma_{(ZLD,\, Z2L)} Eu_{LD} + k_{Z2L}\sigma_{(ZLD,\, Z2L)}Eu_{2L} + EQ_{LD}$

(A2.267)’ $EZ_{2L} = - k_{ZLD}\sigma_{(ZLD,\, Z2L)} Eu_{LD} + k_{Z2L}\sigma_{(ZLD,\, Z2L)}Eu_{2L} + EQ_{LD}$

(A2.268)’ $EZ_{MD} = - k_{Z2M}\sigma_{(ZMD,\, Z2M)} Eu_{MD} + k_{Z2M}\sigma_{(ZMD,\, Z2M)}Eu_{2M} + EQ_{MD}$

(A2.269)’ $EZ_{2M} = - k_{ZMD}\sigma_{(ZMD,\, Z2M)} Eu_{MD} + k_{ZMD}\sigma_{(ZMD,\, Z2M)}Eu_{2M} + EQ_{MD}$

(A2.270)’ $EZ_{ME} = - k_{Z1M}\sigma_{(ZME,\, Z1M)} Eu_{ME} + k_{Z1M}\sigma_{(ZME,\, Z1M)}Eu_{1M} + EQ_{ME}$

(A2.271)’ $EZ_{1M} = - k_{ZME}\sigma_{(ZME,\, Z1M)} Eu_{ME} + k_{Z1M}\sigma_{(ZME,\, Z1M)}Eu_{1M} + EQ_{ME}$

Lamb and mutton marketing sectors equilibrium

(A2.272)’ $Ep_{LE} = k_{ZLE}Eu_{LE} + k_{Z1L}Eu_{1L}$

(A2.273)’ $Ep_{LD} = k_{ZLD}Eu_{LD} + k_{Z2L}Eu_{2L}$

(A2.274)’ $Ep_{MD} = k_{ZMD}Eu_{MD} + k_{Z2M}Eu_{2M}$

(A2.275)’ $Ep_{ME} = k_{ZME}Eu_{ME} + k_{Z1M}Eu_{1M}$

Origin of live sheep exports

(A2.276)’ $EQ_{SE} = \beta_{Y7E}EY_{7E} + \beta_{Y8E}EY_{8E} + \beta_{Y9E}EY_{9E}$

Export demand for Australian greasy wool

(A2.277)’ $EQ_{1W} = \eta_{(Q1W,\, P1W)}(Ep_{1W} - n_{Q1W})$

(A2.278)’ $EQ_{2W} = \eta_{(Q2W,\, P2W)}(Ep_{2W} - n_{Q2W})$

(A2.279)’ $EQ_{3W} = \eta_{(Q3W,\, P3W)}(Ep_{3W} - n_{Q3W})$

(A2.280)’ $EQ_{4W} = \eta_{(Q4W,\, P4W)}(Ep_{4W} - n_{Q4W})$

Export demand for Australian scoured wool

(A2.281)’ $EQ_{1S} = \eta_{(Q1S,\, P1S)}(Ep_{1S} - n_{Q1S})$

(A2.282)’ $EQ_{2S} = \eta_{(Q2S,\, P2S)}(Ep_{2S} - n_{Q2S})$

(A2.283)’ $EQ_{3S} = \eta_{(Q3S,\, P3S)}(Ep_{3S} - n_{Q3S})$

(A2.284)’ $EQ_{4S} = \eta_{(Q4S,\, P4S)}(Ep_{4S} - n_{Q4S})$

Export demand for Australian carbonised wool

(A2.285)’ $EQ_{CW} = \eta_{(QCW,\, PCW)}(Ep_{CW} - n_{QCW})$

Export demand for Australian wool tops

(A2.286)' $EQ_{2T} = \eta_{(Q2T,\ P2T)}(Ep_{2T} - n_{Q2T})$

(A2.287)' $EQ_{3T} = \eta_{(Q3T,\ P3T)}(Ep_{3T} - n_{Q3T})$

(A2.288)' $EQ_{4T} = \eta_{(Q4T,\ P4T)}(Ep_{4T} - n_{Q4T})$

Export demand for Australian noils/other wool

(A2.289)' $EQ_{NW} = \eta_{(QNW,\ PNW)}(Ep_{NW} - n_{QNW})$

Domestic Demand for Australian wool tops

(A2.290)' $EQ_{DP} = \eta_{(QDP,\ PDP)}(Ep_{DP} - n_{QDP})$

Export demand for Australian lamb and mutton

(A2.291)' $EQ_{LE} = \eta_{(QLE,\ PLE)}(Ep_{LE} - n_{QLE})$

(A2.292)' $EQ_{ME} = \eta_{(QME,\ PME)}(Ep_{ME} - n_{QME})$

Export demand for Australian live sheep

(A2.293)' $EQ_{SE} = \eta_{(QSE,\ PSE)}(Ep_{SE} - n_{QSE})$

Domestic retail demand for Australian lamb and mutton

(A2.294)' $EQ_{LD} = \eta_{(QLD,\ PLD)}(Ep_{LD} - n_{QLD}) + \eta_{(QLD,\ PMD)}(Ep_{MD} - n_{QMD})$

(A2.295)' $EQ_{MD} = \eta_{(QMD,\ PLD)}(Ep_{LD} - n_{QLD}) + \eta_{(QMD,\ PMD)}(Ep_{MD} - n_{QM})$

Appendix 2. Calculation of Sheep Supply Elasticities

Where joint products are produced in approximately fixed proportions from a basic commodity, the price elasticity of the basic commodity can be computed as (Tomek and Robinson 1995, p45)

(A3.1) $$\varepsilon_X = \frac{P_1 w_1 + P_2 w_2}{\frac{1}{\varepsilon_1}(P_1 w_1) + \frac{1}{\varepsilon_2}(P_2 w_2)}$$

Where *n* joint products are produced, A3.1 can be extended to

(A3.2) $$\varepsilon_X = \frac{P_1 w_1 + P_2 w_2 + \ldots + P_n w_n}{\frac{1}{\varepsilon_1}(P_1 w_1) + \frac{1}{\varepsilon_2}(P_2 w_2) + \ldots + \frac{1}{\varepsilon_n}(P_n w_n)}$$

Non-Merino Sheep

For the basic commodity of non-Merino sheep, X_1 = 150.47 kt carcass weight and the joint products produced are wool: Y_{13W} = 6.20 kt and Y_{14W} = 22.81 kt; mutton: Y_{1M} = 16.67 kt; and lamb: Y_{1L} = 120.60 kt. The prices in \$/kg corresponding to the joint products are v_{13W} = 4.39, v_{14W} = 3.37, v_{1M} = 1.75 and v_{1L} = 3.58. Each level of output is divided by X_1 to obtain output per kt carcass weight of sheep. These are denoted as y_{13W} = 6.20/150.47 = 0.041, y_{14W} = 22.81/150.47 = 0.152, y_{1M} = 16.67/150.47 = 0.111 and y_{1L} = 120.60/150.47 = 0.801. Estimated elasticities of the supply of wool and sheep meat used in the model are ε_1 = 0.9 and ε_2 = 1.3, respectively. Substitution into Equation A3.2 yields

(A3.3) $$\varepsilon_{X1} = \frac{(v_{13W})(y_{13W}) + (v_{14W})(y_{14W}) + (v_{1M})(y_{1M}) + (v_{1L})(y_{1L})}{\frac{1}{\varepsilon_1}(v_{13W})(y_{13W}) + \frac{1}{\varepsilon_1}(v_{14W})(y_{14W}) + \frac{1}{\varepsilon_2}(v_{1M})(y_{1M}) + \frac{1}{\varepsilon_2}(v_{1L})(y_{1L})}$$

(A3.4) $$\varepsilon_{X1} = \frac{(4.39)(0.041) + (3.37)(0.152) + (1.75)(0.111) + (3.58)(0.801)}{\frac{1}{0.9}(4.39)(0.041) + \frac{1}{0.9}(3.37)(0.152) + \frac{1}{1.3}(1.75)(0.111) + \frac{1}{1.3}(3.58)(0.801)}$$

(A3.5) $$\varepsilon_{X1} = 1.2$$

The supply elasticity for Merino sheep was estimated accordingly. Calculations are not presented.

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