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The ABARES bilateral trade decomposition model

Technical annex to 'South America: an emerging competitor for Australia's beef industry'

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1 Introduction

This technical annex provides a description of the bilateral trade decomposition model used in the report ‘South America: An emerging competitor for Australia’s beef industry’ (Hyde et al. 2016). The report focuses on the beef industries of Brazil, Argentina, Uruguay, Paraguay and Australia. There are two objectives. The first is to assess the main drivers behind growth of beef exports from each country between 2000 and 2014. The second is to project the value of beef exports between 2014 and 2030 under three policy scenarios.

A bilateral trade decomposition model was designed to quantify the historical drivers of beef exports from Australia and its major competitors in South America, with the aim of drawing implications for projections of future bilateral trade flows. Projections are determined from 2014 to 2030 that are indicative of the prospects for both regions to expand their exports. In addition, further scenarios have been developed to assess the effects of changes in policies on the projection. These policy changes include

removal of Argentine agricultural export restrictions

improved market access for South American beef exports

improvements in domestic transport infrastructure in Brazil and Australia.

Chapter 2 provides an overview of the model and key assumptions. Chapter 3 contains a detailed algebraic description of the technical features and the closure of the model, and Chapter 4 outlines data sources and other techniques applied to the exogenous data.

2 Modelling approach

This section outlines the partial equilibrium model used in Hyde et al. (2016) and expands on its concept and methodology. The model is comprised of a set of simultaneous behavioural equations which can be used to undertake two forms of analysis. In the first instance, the decomposition analysis is applied to historical data to separate export growth from 2000 to 2014 between four key drivers. The model is then used to project beef export growth between 2014 and 2030 under a baseline and three policy scenarios.

The model assumes all beef from each exporting region is a homogeneous product. That is, the model does not differentiate between high and low-quality beef. Beef is differentiated in import markets by region of origin. For simplicity, the model covers boxed and carcass beef only. It excludes highly processed beef and exports of live cattle.

Some beef importing countries are combined into regions for simplicity, while others are explicitly defined. These countries and regions are identified and discussed in Chapter 4.

Historical decomposition

The decomposition model analyses historical beef trade data to identify and compare the main drivers of beef export revenue growth in constant 2000 domestic currency in the selected South American countries and Australia. It quantifies the channel through which each of these drivers played a role between 2000 and 2014.

The four export drivers are:

- export supply costs
- market access
- real exchange rates
- income growth.

Export supply costs

The export supply costs driver captures a range of factors that affect the cost of exporting beef. These costs are a key determinant of the competitiveness of beef exporting countries as they affect the relative export prices of different countries. For example, a technological improvement in a region's production process allows producers to supply beef to the export market more cheaply.

Examples of factors that change export supply costs are:

- improvements in on-farm productivity
- a disease outbreak, affecting the availability of slaughter cattle
- lower transport costs following investment in infrastructure
- adverse seasonal conditions, such as a drought, affecting slaughter cattle availability
- changes to government regulations.

These factors are not specified in the model but describe the influences behind changes in export supply costs more generally.

Export supply costs are split into two separate categories in the decomposition analysis: 'own export supply costs' and 'competitor export supply costs'. Own export supply costs for a given exporter are based on changes to that region’s export supply costs. An increase in own export supply costs would reduce demand for that region’s exports and cause export revenue to fall.

Competitor export supply costs reflect the contribution to a given region’s exports from changes in export supply costs in all other exporting regions. For example, in the case of Brazil, if other regions experience an increase in supply costs, there would be a positive effect on Brazil's exports because, everything else being equal, Brazil’s export price would be comparatively lower.

For ease of reading, graphical representation of results presented in the paper are displayed as the net result of own and competitor export supply costs. Supporting tables identify the separate contribution of own and competitor export costs.

In Chapter 3, export supply costs are discussed in terms of technical advance. An improvement in technical advance lowers export supply costs and vice versa.

Market access

The market access driver captures changes to the cost of exporting beef from one region to each importing region. Implicitly, market access is the sum of tariff barriers and the tariff equivalent of non-tariff barriers and transport costs. Market access is affected by changes to:

- trade barriers, such as import tariffs, export taxes, tariff-rate quotas and sanitary or phytosanitary (SPS) regulations
- non-tariff barriers, including embargoes and sanitary requirements
- transport costs.

As with export supply costs, market access costs are split into two separate categories for the purpose of this analysis—own market access costs and competitor market access costs.

Real exchange rates

Movements in the bilateral exchange rate between the local currencies of each exporter and importer also influence export performance by changing the relative import price of different suppliers. A lower real exchange rate makes a region’s exports more competitive relative to its competitors (in US dollar terms), and vice versa. More detail on the method used to account for real exchange rates is provided in Chapter 3.

Real exchange rates are also split into two separate categories for the purpose of this analysis—own real exchange rates and competitor real exchange rates.

Income growth

In the model, income growth is included to reflect changes in beef import demand, since higher incomes increase the demand for beef. For example, an increase in a region’s exports may occur because of stronger demand from a beef importing region, which has resulted from rising incomes over time.

Growth in the real gross domestic product (GDP) in beef importing regions is used as a proxy for income growth.

Scenario analysis

The second part of the analysis is the extension of the model to generate baseline projections of potential future beef export growth for Australia and the selected South American countries from 2014 to 2030. The baseline projection assumes no policy changes over the projected period, although it does include outcomes from recent free trade agreements and the Trans-Pacific Partnership agreement. Other assumptions include projections of income and technological progress.

Three additional scenarios which assume a policy change in one or more of the selected beef exporting countries and in Australia are subsequently investigated. These scenarios are:

1) removal of Argentine agricultural export restrictions
2) improved market access for South American beef
3) improvements in domestic transport infrastructure in Brazil and Australia.

The scenario analysis is undertaken in order to generate estimates of the potential effects of the policy changes on future export growth relative to the baseline. The results from each policy scenario are compared with the baseline results in order to estimate the relative direction and magnitude of the change in real export values.

Economic assumptions

The projections of beef exports use the same model as the historical decomposition analysis. Assumptions about the future of the global economy and trade agreements, derived from external sources, are applied. Specific assumptions about projected growth rates for the main export drivers—export supply costs, market access, real exchange rates and import demand—are outlined below.

Export supply costs

In the historical analysis the export supply cost driver captures more than the effects of productivity growth alone. It picks up changes in effective input use, such that an outward shift in export supply is either from improved input productivity, reduced input costs or both. In the model, the export price is the full unit cost of the product from farm gate, including light processing and transport to the export border. This includes any export tax or subsidy incurred.

However, for the projections, productivity growth is used as the proxy for changes in export supply costs since changes to input costs, including from the effect of seasonal conditions, are unpredictable. Productivity growth is assumed to be constant over the medium term.

In the baseline projection scenario, productivity assumptions vary by exporting region. Because a consistent series of beef sector productivity growth estimates across regions is not available, the analysis uses average annual agricultural total factor productivity (TFP) growth between 2001 and 2012 for each projection year (Table 1).

Table 1 Assumed average annual productivity growth rates from 2014 to 2030

Exporting region	Australia	Argentina	Brazil	Uruguay	Paraguay	EU	North America	India	New Zealand
unit	%	%	%	%	%	%	%	%	%
Productivity growth	1.60	0.51	3.23	2.01	0.19	1.28	1.96	2.32	0.98

Sources: USDA–ERS 2015, ABARES calculations

Market access

Market access is assumed to remain at its 2014 level in the baseline projection. In general, no additional market access is assumed, including for countries actively attempting to reopen markets (for example, Argentina and the United States). However, the baseline projection does include Australia's free trade agreements (FTA) with China, Japan and the Republic of Korea, which do not appear in the historical decomposition as they were not in force in 2014. These agreements will further improve market access for Australia over the projection period. Other agreements explicitly included are the Trans-Pacific Partnership agreement and the Republic of Korea's FTAs with the United States and the European Union.

Real exchange rates

Real exchange rates are assumed constant at their 2014 average.

Import demand

Economic growth drives beef import demand in the model. For this analysis, GDP growth projections between 2015 and 2020 from the International Monetary Fund (IMF 2015) are extended to 2030 (Table 2). Real GDP growth for each region is an average of the countries within that region, weighted by the share of regional GDP.

Table 2 Assumed average annual GDP growth rates, 2014 to 2030

Importing region	China	EU	North Asia	ASEAN	North America	Middle East	Russian Federation	Hong Kong	Rest of South America
unit	%	%	%	%	%	%	%	%	%
Income growth	6.3	1.9	1.6	5.4	2.3	4.2	1.9	3.1	3.0

Source: IMF 2015

Scenario overview

Scenario 1 Removal of Argentine agricultural export restrictions

Despite being the fourth largest beef producer in the world, Argentina is only a relatively minor exporter. The majority of beef production is consumed domestically because exports have been limited by export taxes and quantitative restrictions. Argentina's restrictions on beef exports were lifted in December 2015 and this scenario explores potential changes to beef trade.

The baseline projection assumes the continuation of Argentina's agricultural export restrictions. This scenario is modelled by removing the constraints on Argentina's exports. The quantitative export restriction constraint is removed and Argentina's export taxes are reduced to zero, which allows Argentina's beef exports to increase in response to global demand. This scenario also examines the impact of removing Argentina's restrictions on the other selected countries' beef exports.

The scenario is modelled by decreasing Argentina's export supply costs, which occurs because the removal of the restrictions allows for higher export supply. Average annual productivity growth, used as a proxy for declining unit export costs, is 4.96 per cent a year between 2014 and 2030 in this scenario, compared with the baseline average annual productivity growth of 0.51 per cent.

Scenario 2 Improved market access for South American beef

This scenario explores the effects of improved market access for South American beef exports to regions that currently either restrict or ban imports because of foot and mouth disease (FMD), including Japan, the Republic of Korea and the United States.

There are three parts to this scenario:

1) improved access for South America to China–Hong Kong and ASEAN
2) improved access for South America to North America and North Asia
3) improved access for South America to all four regions.

These scenarios are modelled by gradually improving market access for South American exporters in the relevant markets. By 2030, each country's access is set equal to the most favoured nation (MFN) tariff rates faced by other beef exporting regions.

Scenario 3 Improvements in transport infrastructure in Brazil and Australia

The effects of improvements in transport infrastructure in Brazil and Australia are examined through two separate scenarios.

The scenarios assume an increase in Brazilian and Australian infrastructure investment, respectively. Under each scenario the projected changes to Brazil and Australia's beef exports in 2030 are compared with the baseline in which infrastructure efficiency does not increase.

Both scenarios are modelled as a 15 per cent reduction in transport costs in 2030 compared with 2014 for the given country, compared with the baseline. As transport costs are a larger share of export supply costs in Brazil, this equates to modelled export supply costs being around 8 per cent lower in 2030, while Australian export supply costs are around 6 per cent lower.

3 Technical features and implementation

The bilateral trade decomposition model, used in Hyde et al. (2016), is documented in algebraic form below. The model is used to assess recent history as well as project future beef exports from South America and Australia by using recent historical data. Beef export revenues are obtained from simulating a structural simultaneous equation model of bilateral beef trade flows across international borders. In the model, real export revenue is considered proportionate to real profit, or producer surplus, for beef exporting firms.

Modelling features

The choice of modelling features reflects the analytical needs of the study. The model used is in a structural form and applied to bilateral trade of a single good. Importers regard products from different regions as different goods, but exporters charge the same price for a product sold to different markets. This allows an importing region to import from different exporting regions at different prices, implying differences in product quality or consumer preference based on region of origin.

The technique used to simulate historical outcomes is taken from the computable general equilibrium literature (see the discussion of closures in Dixon, Koopman & Rimmer 2012). The model contains a system of simultaneous equations explaining bilateral trade in a single good, with four types of shocks driving changes in bilateral trade and real export revenue (as described in Chapter 2).

Avoiding the complexities caused by volatile data is a key reason for adopting the deterministic decomposition approach rather than an econometric approach. The 'on or off' switching of trade routes causes complexity in econometric estimation of structural gravity models (see the introduction to gravity theory and estimation in Head & Mayer 2013 and the discussion on treatment of zeros in Burger, van Oort & Linders 2009).

A further advantage of this approach is the relatively small dataset required—bilateral trade data, common macroeconomic data and selected assumptions concerning price and income elasticities. This is in contrast to other competitiveness indicators, which often require datasets that may be less easily available or not comparable between regions.

Feenstra's restricted translog expenditure share system is used in place of the Armington parameterization to capture substitution between import suppliers (Feenstra 2003; Novy 2011). The Armington approach to model import demand (Armington 1969) is used in the standard GTAP model (Hertel 1997) as well as previous ABARES bilateral trade models. Compared with the Armington approach, Feenstra's parameterization restricts share, rather than quantity substitution, to one common cross term referred to as *gamma*.

The advantage of using the restricted translog approach in the model is that it will easily capture a significant structural shift in import volume (from zero to a large volume or to zero from a large volume), given relative price changes. This 'on or off' switching of trade routes is common in agricultural commodity markets and is not possible under an Armington approach.

There are four factors or drivers that explain annual changes in real export revenues. They are

1. export supply costs
2. import demand (or income growth)
3. border costs, which are divided into
    i. market access factors, and
    ii. the real bilateral exchange rate.

The export supply cost curve shifts down from a reduction in input costs. This occurs if inputs are used more productively or if input prices fall. Shifting the curve downwards lowers export supply costs and increases exports.

Trade volume also increases when real income growth shifts the aggregate export demand curve out. Prices increase as a result if there is no corresponding shift in the supply curve.

Market access includes the ad valorem import tariff as well as the tariff equivalent of non-tariff barriers and imputed transport costs. The border cost term incorporates all costs to move product from the exporter to the importer.

The modelled import price is the export price marked up by the border cost. An appreciation in the real exchange rate for an exporter is equivalent to an increase in the border cost.

Model settings

The historical and projection simulations share a common framework. The historical analysis is undertaken in two settings:

1) the 'decomposition' setting
2) the 'standard' setting.

The projection simulations use the standard setting and are most readily understood, hence they are discussed first. In the standard setting, a simulation is undertaken by imposing one or more shocks to the drivers on a baseline model. The effects of these shock on bilateral trade volumes and export revenue are then compared with those in the baseline. In so doing, the impact of the drivers (the exogenous variables) on bilateral trade and export revenue (the endogenous variables) are traced. For the projections, the baseline comprises a number of shocks to generate a likely path for the endogenous variables over time. Any alternative simulations involve changing one or more economic conditions, including trade policy measures, and examining the deviation of the endogenous variables from the baseline path.

The purpose of the historical decomposition analysis is to estimate the contribution of a set of exogenous drivers to the change in bilateral trade volumes and export revenue between 2000 and 2014. The contribution is expressed as a share of the change that occurred to these variables. Specifically, the contribution can be interpreted as follows: *x* per cent of the historical change in *variable y* is the result of the observed change in *driver z*.

In the historical decomposition analysis the magnitude by which the drivers affect trade flows is first determined by running the model in the decomposition setting. In this setting, bilateral trade volumes and export revenues are exogenous and are the difference between 2014 levels and 2000 levels (the base year). The contribution of the export drivers (described above) to the trade flow changes are calculated by the model. The simulation then is rerun in the standard setting with the driver contributions applied as exogenous variables. The bilateral trade volume and export revenue results are generated endogenously in this setting.

The second step involves apportioning the drivers' shocks (the exogenous variables) to the endogenous bilateral trade volume and export revenue results. In so doing, the change in these variable over the period 2000 to 2014 are explained by the each of the drivers. If there were only one driver (and hence only a single shock), then only a single simulation would be necessary because the contribution of that driver would explain 100 per cent of the observed change in the variable of interest. However, with two or more drivers, it is necessary to use a suite of standard simulations to build up the functional profile between the shocks and the trade volume and export revenue outcomes. This is required in order to take into account any interaction between the drivers and their combined impact on trade volumes and export revenue.

Decomposition technique

The standard decomposition approach is to select a logical ordering for the shocks and measure the effect on real export revenue of adding each additional shock until all drivers are included. The idea is to sum alternative pasts to obtain the past in a single sum.

However, the results are sensitive to the choice of sequence—applying the shocks in different orders affects the relative contribution of each shock. Harrison, Horridge & Pearson (2000) propose a 'straight line integral' approach that avoids the conditional results from specific sequencing by applying each shock simultaneously in small increments. This approach is used in the 'standard' analysis, following the approach applied by Bohringer & Rutherford (2003), which involves an outer and inner loop of 'standard mode' simulations.

Although results are reported in terms of aggregate shocks (for example, to export supply costs), the model applies a large set of small shocks—for example, the change in export supply costs for each individual region is an individual shock. These are then aggregated *ex post* into the results reported in the paper. Analysing these individual shocks provides further information as to what drove real export revenue for a given region.

Model implementation

The model is implemented in the General Algebraic Modeling System (GAMS) using the PATH solver. In GAMS, sets, parameters and variables of the model are first defined, followed by a declaration of the simultaneous equations that constitute the model. Features of the modelling closure are discussed below, while data sources and regional aggregation are described in Chapter 4.

The model is presented below without an explicit time dimension. However, change over time is modelled by imposing a single or multiple loop of time periods defined by the exogenous variable shocks, which runs from 2000 to 2014 in the historical application. All variables are expressed in index form with a base year of 2000.

Price indexes for the historical analysis are measured in base year real domestic currency. For the projections analysis, price indexes are measured in base year 2014 US dollars. Real bilateral exchange rates are held constant, as discussed further in Chapter 4.

The sets r, r2 and r3 refer to the importing and exporting regions included in the model, as defined in Chapter 4.

Parameters

Parameters are calibrated at the beginning of the model run and are held constant in equations (Table 3).

Table 3 Parameter definitions

Dummy variables	
dvtr(r2,r)	dummy variable, value is 1 if trade flow is modelled from exporting region r2 to importing region r
dvexp(r2)	dummy variable, value is 1 if aggregate exports are modelled for region r2
dvimp(r)	dummy variable, value is 1 if aggregate imports are modelled for region r
Behavioural parameters	
ed(r)	price elasticity of aggregate import demand in region r
ey(r)	income elasticity of aggregate import demand in region r
es(r)	price elasticity of aggregate export supply from region r
gamma(r2,r3,r)	change in the expenditure share on import from r2 to r per log change in the price of import from r3 to r
Share parameters	
scshmv(r2,r)	base year expenditure share of exporter r2 in importer r's total imports
scshexvol(r,r2)	base year volume share of r2 in r's total exports

Endogenous variables

Endogenous variables are specified as solutions to the simultaneous equations and their values are calculated by the model (Table 4).

Table 4 Endogenous variable definitions

Endogenous variables	
qmgi(r)	aggregate import demand index by region r
pmgri(r)	aggregate import price index in region r
shmv(r2,r)	import expenditure share from region r2 to r
qtri(r2,r)	bilateral trade flow from region r2 to r
pmri(r2,r)	import price index from region r2 to r
peri(r)	export supply price index from region r
qei(r)	aggregate export supply from region r

Exogenous variables

Exogenous variables are specified to reflect external shocks. In simulations, they are derived from external sources—either historical data or by assumption (Table 5).

Table 5 Exogenous variable definitions

Exogenous variables	
xyinci(r)	real income index/import demand shifter on aggregate import demand by region r
bci(r2,r)	border cost index comprising reri and ttctxpowi
reri(r2,r)	real bilateral exchange rate index on bilateral trade flow r2 to r—an increase is a real appreciation of currency r2 against r
ttctxpowi(r2,r)	index of the power of the effective border tax, the ad valorem tariff and tariff equivalent of non-tariff and unit transport border costs on bilateral trade flow r2 to r
ttechi(r)	technical change/export supply shifter on aggregate export supply from region r

Model equations

The model consists of seven groups of equations. The equation names are at the left hand side of the formulas below, while the equation itself is to the right of the double dots. Dollar sign commands (for example, '$dvimp') are GAMS shorthand for 'if' functions. For example, 'qmgieq(r)$dvimp' implies that the equation 'qmgieq(r)' only applies for values of 'r' where dvimp(r) is not equal to zero.

Generally, equations are solved with respect to the variable named in the equation. Exceptions are noted at the end of this section.

Aggregate import demand function

qmgieq(r)$dvimp(r).. qmgi(r)=(pmgri(r)**ed(r))*(xyinci(r)**ey(r))

Aggregate import demand refers to import demand for the product from all suppliers. Demand decreases with higher aggregate price and increases with higher real income. In the applications, price and income elasticities of aggregate import demand are based on ABARES assumptions. The default own-price demand elasticity is –1.5, while the default income elasticity is 0.5.

Aggregate import price function

pmgrieq(r)$dvimp(r).. pmgri(r)=prod(r2$dvtr(r2,r),pmri(r2,r)**shmv(r2,r))

The aggregate import price index is defined as a Stone Geary index or a geometric weighted average of the real import price indices from each exporter. The weights are the import cost shares. This equation provides a linear approximation of the translog functional form.

Import expenditure share

shmveq(r2,r)$dvtr(r2,r)..
shmv(r2,r)=scshmv(r2,r)+sum(r3$dvtr(r3,r),gamma(r2,r3,r)*log(pmri(r3,r)))

Once the importer decides on the aggregate demand, the value share of total imports from each source is allocated according to the translog form (Berndt 1991, chapter 9) depending on their relative import prices.

A region's import expenditure share increases if the relative price of imports from that region falls, and vice versa. If there are no relative price changes, the shares are constant at the base value. *Gamma* refers to the translog slope term and is unique to each pair of exporting regions in a given importing region. If *gamma* equals zero, the shares are constant and the function is in Cobb–Douglas form.

Import shares must sum to unity. This is imposed by choosing one region's import share (the reference region) as the residual. It is necessary that the reference region trades in every year for the analysis, so the reference region is chosen to be the region with the largest expenditure share in the base year by default. If that region does not export in every year, the reference region is adjusted manually.

As only relative prices matter, the gamma term for each importing country must sum to zero. This is imposed by expressing each export region's price relative to the price of imports from the reference region. In this exercise, the gamma term is restricted using Feenstra's approach (see Feenstra 2003 and Novy 2011) to a common cross-price and common own-price term for each import region. The default value for this model is 1. The cross-price term is the general term divided by the number of possible trade sources. The own-price term is the cross-price term multiplied by the number of trade sources minus one.

Bilateral trade flow index

qtrieq(r2,r)$dvtr(r2,r).. scshmv(r2,r)*pmri(r2,r)*qtri(r2,r)=shmv(r2,r)*pmgi(r)*qmgi(r)

The import expenditure share for a trade flow is the specific import expenditure for that region divided by aggregate import expenditure.

Import price index definition

pmrieq(r2,r)$dvtr(r2,r).. pmri(r2,r)=peri(r2)* bci(r2,r)

where:

bci(r2,r)=reri(r2,r)*ttctxpowi(r2,r)

The import price index is the export price index times the border cost index. The border cost increases if the real bilateral exchange rate appreciates (in terms of the exporting region's currency) or the power of the effective border tax rises. Border costs are defined as the sum of the ad valorem tariff and the tariff equivalent of non-tariff trade and transport costs.

Export supply function

perieq(r)$dvexp(r).. qeri(r)=(peri(r)**es(r))*ttechi(r)

Export supply increases with the real export price and an outward shift in technology. The default value for the export price elasticity (*es*) is 2. A 1 per cent increase in the technology index produces a 1/*es* per cent fall in export cost (if the export quantity is unchanged) or a 1 per cent increase in exports (if the export price is held constant).

Export balance

qeieq(r)$dvexp(r).. qei(r)=sum(r2$dvtr(r,r2),scshexvol(r,r2)*qtri(r,r2))

The export balance equation ensures that aggregate exports from a region equal the sum of the bilateral trade flows from that region to all importing regions.

Modelling closure

In the applications, the model is run in either standard or decomposition mode, as described in the modelling features section. The above categorisation of the model variables as endogenous and exogenous is for the standard closure mode, which is the default mode for a counterfactual simulation, such as the forward projections.

In contrast, in the decomposition mode the export price index and the trade flow indexes become exogenous (set to the observed bilateral trade data) while the technical change and border tax indexes become endogenous (determined in the model).

In the standard closure, all equation names are associated with the corresponding variable names. That is, the equations are solved by changing the value of the corresponding variable. However, in the calibration mode there are three exceptions:

1. The export price index equation (perieq) is associated with the technical change index (ttechi). The technical change index for each region is thus calibrated to fit the observed export price series.
2. The import quantity equation (qtrieq) is associated with the real import price index (pmri). This generates an import price series, which is not explicit in the observed data.
3. The import price equation (pmrieq) is associated with the border costs index (ttcxpowi). The border costs index for each bilateral pair of regions is thus calibrated to fit the import price series generated above.

Movements in the real income index and real bilateral exchange rate are set exogenously in all applications. These are observed macroeconomic variables determined outside of the model.

4 Data treatment

Data sources

The trade data used in this analysis is sourced from UN Comtrade (United Nations Statistics Division 2015), which provides volume and value of annual bilateral trade in beef, expressed in current US dollars. The exporter is used as the reporter for the years 2000 to 2014, with coverage over two Harmonised System (HS) 4-digit headings 0201 and 0202 (fresh and frozen beef and veal). The bilateral trade data was cleaned to remove minor trade flows and aggregated into the regions outlined in Table 6. Intra-regional trade flows were also removed.

Bilateral export values in US dollars were converted to domestic currency using the annual average exchange rate in index form. The resulting values were deflated according to the exporters' consumer price index. The average real export price is the total export value from the region divided by the total export volume.

The real bilateral exchange rate formula follows from recognizing the export series is in real domestic export currency and needs to be converted to real domestic import currency. Abstracting from the border tax for simplicity, the export series is multiplied by the nominal exchange rate (importer currency per unit of export currency), and then multiplied by the export inflation and divided by the import inflation.

The nominal exchange rates were sourced from the IMF as reported in the World Bank's World Development Indicators Data Base (World Bank 2015). The consumer price and real GDP indices for each country are sourced from the IMF World Economic Outlook (WEO) database in the October 2015 update (IMF 2015). The percentage growth rate for the region as a whole is the sum of the purchasing power real GDP weighted average sum of the growth rates in the individual indexes for the countries in that region. The purchasing power weights are also sourced from the WEO database.

In calculating the base year import expenditure shares used in the translog form, the base year import values are approximated by the corresponding free-on-board export values. The import price index is then determined in the model.

Regions

The aggregation of export and import regions reflects the research objective to analyse international competition between Australia and South America in the world's beef trade. This competition is both direct (in the same destination market) and indirect (a third region competes with Australia or South America in either country's main export markets). In particular, nine export regions and eight import regions are separately identified in the model (Table 6).

Table 6 Countries and regions included in the bilateral trade model

Region	Abbreviation	Region type	Coverage
Argentina	ARG	Exporter	Argentina
ASEAN	ASEAN	Importer	Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam.
Australia	AUS	Exporter	Australia
Brazil	BRZ	Exporter	Brazil
China–Hong Kong	CHN-HKG	Importer	China and Hong Kong
European Union	EU	Importer and exporter	EU–27: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden and the United Kingdom
India	IND	Exporter	India
Middle East	MID	Importer	Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, State of Palestine, Saudi Arabia, Syria, United Arab Emirates and Yemen
New Zealand	NZL	Exporter	New Zealand
North America	NAM	Importer and exporter	United States, Canada and Mexico
North Asia	JPKR	Importer	Japan and Republic of Korea
Paraguay	PARAG	Exporter	Paraguay
Rest of South America	RSAM	Importer	Bolivia, Chile, Colombia, Ecuador, Falkland Islands, French Guiana, Guyana, Peru, Suriname and Venezuela
Russia	RUS	Importer	Russian Federation, Ukraine and Belarus
Uruguay	URUG	Exporter	Uruguay

Australia and the South American countries of Brazil, Argentina, Uruguay and Paraguay are identified as major beef exporters. Importing regions of importance to Australia are mainly in Asia or North America. Here, North America comprises Canada, Mexico and the United States. For Australia there are three Asian import regions of major interest that are separately identified. The highest quality beef product is typically demanded by Japan and the Republic of Korea. These two countries are joined together into the North Asia region. Lower-quality product is sold to North America and this import region is also identified. The remaining major export destinations for Australian beef in recent history are ASEAN and China–Hong Kong.

For the South American exporters, major export destinations also requiring separate identification in the model are the European Union, China–Hong Kong, the Middle East, Rest of South America and Russia. The European Union is identified as EU–27 in all time periods and Russia comprises the Russian Federation, Ukraine and Belarus.

North America is identified separately as it is an important exporter to China–Hong Kong and North Asia. The European Union is identified separately as it is an important exporter to the Middle East and Russian markets, as well as a major importer. India, which produces buffalo product, is separated as an exporter due to its significance in ASEAN and the Middle East. New Zealand is included mainly to account for exports to ASEAN, China–Hong Kong and North America.

Time periods

The model simulations cover both the past and the future. The past is defined in the model applications as the change over the period 2000 to 2014.

The model can be run over periods of increasing length from the base year. That means each year can be compared to the base year of 2000 and the annual change can be calculated over adjacent periods. In this report, results from 2014 are compared only to the base year 2000 and not to adjacent periods.

The future is defined as the change over the period 2014 to 2030. The model can be run annually, with shocks updated each year. For simplicity in the forward projections, the real bilateral exchange rates are held constant at the 2014 values against the US currency and the analysis is conducted with real price indexes measured in constant 2014 US dollars. Exogenous projections for real income growth are sourced from the IMF. Technical change shocks reflect average productivity growth rates calculated by the USDA over the past decade (USDA–ERS 2015), except for Australia, where ABARES assumptions are used.

Real bilateral exchange rate movements

The treatment of the real bilateral exchange rate in the model requires further explanation. The traditional approach in general equilibrium modelling is to subsume the real exchange rate in the analysis and not report it separately. Analysis is done in a common international currency, which is usually real US dollars. The trade data for each year is given in a single currency, adjusted for inflation by a common price series so that values are in real terms. In this case, the real exchange rate index in the model is set to 1 in all years. This approach is common in multi-region whole-of-economy models, such as in the standard GTAP model, where values are often expressed in base year US dollars (Hertel 1997).

However, as the focus of the bilateral decomposition model is on relative competitiveness, and exogenous changes in real exchange rates have effects on price competitiveness, the analysis would be incomplete without acknowledging these effects. The analysis was therefore done with the real bilateral exchange rate as a separately identified border cost component from the border tax component. In this case, aggregate exports from a region and import prices to a region are measured in the model in the relevant region's base year real domestic currency.

Note that the technical change indexes will be different in the historical decomposition depending on which approach is taken. This is because the value of the technical change index is determined uniquely from the export price equation 'perieq', where the export quantity is given. However, the export price can be presented in either real US dollars or a domestic currency.

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