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A Further Update of an Equilibrium Displacement Model of the Australian Pig Meat Industry[1]

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Abstract

In this paper, a further update of an equilibrium displacement model of the Australian pig meat industry is reported. New price and quantity data for the period 2017-2022 are described and added, and compared to values used in three previous versions of the model. Elasticity parameters are modified to take account of these new data. Then two hypothetical simulations are run, one for a farm productivity improvement and one for a consumer demand expansion, and the results of these are compared to identical simulations previously reported for the earlier versions of the model.

Key words: pig meat, EDM, update, elasticities, simulation

Background

Some 20 years ago, an equilibrium displacement model (EDM) of the Australian pig industry was constructed and used to examine a range of research and development (R&D) and marketing issues relevant to this industry at the time (Mounter et al., 2004). One issue was the typical question asked by agricultural industries about the relative payoffs from investment in farm level R&D vs investments in promotion campaigns in consumer markets. Another was the role that imports play in the distribution of the benefits from such investments. A detailed description of this model, and the results of those initial analyses, can be found in Mounter et al. (2004, 2005a, 2005b). A feature of this model is that it provides a detailed disaggregation across the value chain. This is important information since many innovations are adopted at other than the farm level and many of the investors backing these innovations are looking at returns to particular sectors of the value chain.

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To recap from previous explanations (such as in Zhang et al., 2018), the broad EDM approach employs comparative static analysis in a partial equilibrium framework. The framework is partial in the sense that prices in markets not included in the model are assumed constant. The approach offers a number of advantages over other modelling approaches in that it provides a consistent economic framework for examining various broad types of research and promotion, and it is not overly data-intensive. Compared with the onerous historical time series requirements of econometric modelling (see for example, Vere and Griffith, 2004), EDM needs only one set of base equilibrium price and quantity data, and values for market parameters such as Marshallian demand and supply elasticities. Representation of an industry by an EDM is done by specifying a system of supply and demand equations. The equations are expressed in terms of relative changes and elasticities by total differentiation of the general functional form equations and conversion into elasticity form. The impacts of exogenous changes, such as new cost-saving technologies or effective promotions, are modelled as shifts in supply or demand curves in the relevant input or output markets. From the resulting price and quantity changes in all markets, the welfare changes to the various industry participants are estimated as changes in producer and consumer surplus. These changes in surplus measures indicate the benefits or costs from the exogenous change that is modelled.

The structure of the model as first specified in 2003 is shown in Figure 1. Given this defined structure, three sets of data are required to implement the model: first, price and quantity values in the 12 product and input markets for a representative or typical year to provide the initial equilibrium points against which any simulated changes are measured; second, measures of producer and consumer responsiveness to changes in those equilibrium prices (price elasticities); and third, measures of whichever specified initial shifts in the market (the disequilibrium events) are of current interest. Such shifts may be in any of the demand or supply curves embedded in the model structure.

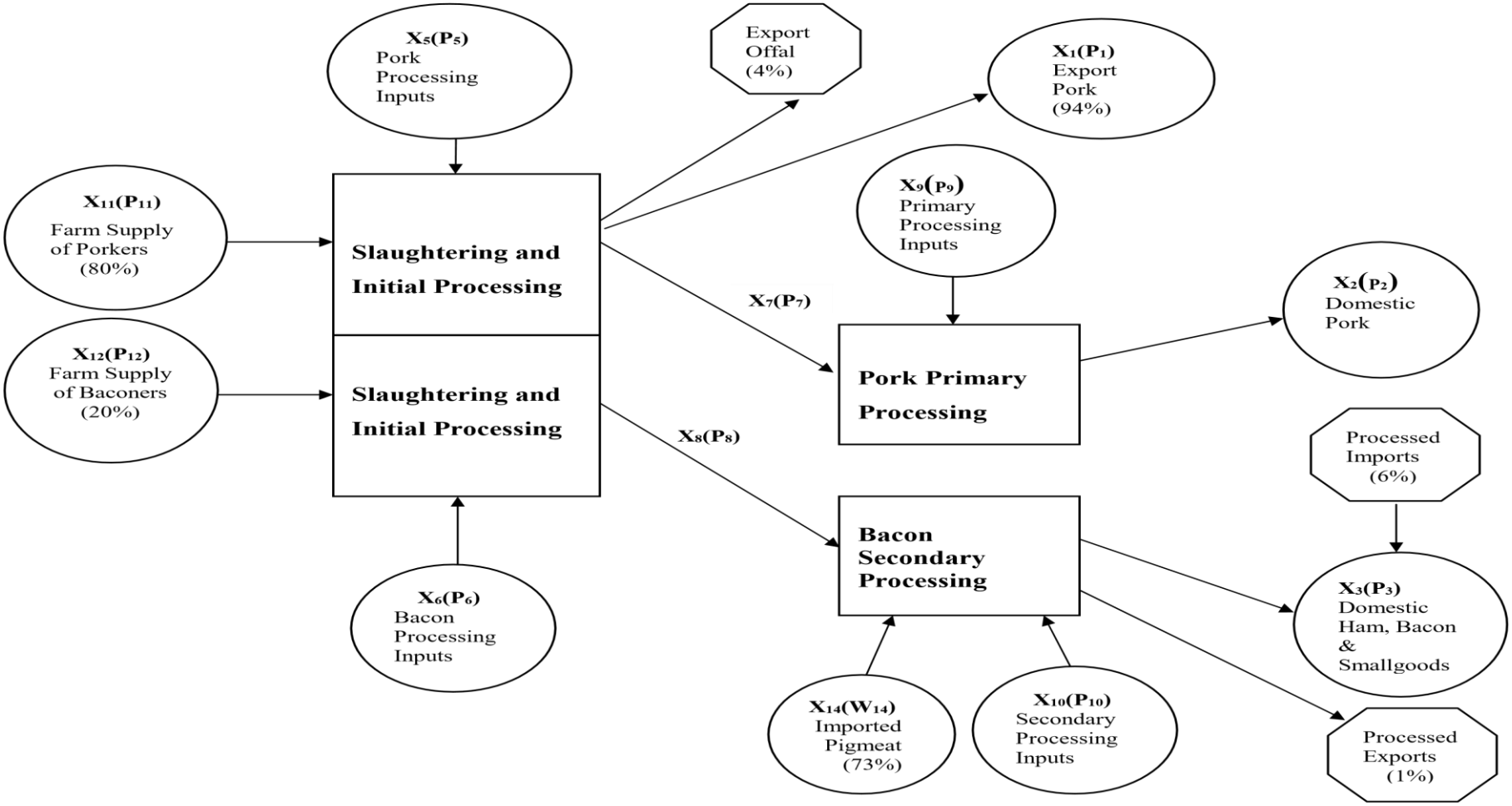
Definitions of the variables and parameters in this model and their sources are shown in Appendix 1. The model, as initially developed, was calibrated on data averaged over the period 2000-2002. The percentage values shown in Figure 1 represent the 2000-2002 situation. The model was updated in 2010 based on 2009 data (Griffith et al., 2010), and again in 2017-2018 based on data covering the period 2012-2016 (Zhang et al., 2018). In both cases, as part of the updating process, the model structure was examined to see if it needed modifying, and the results of the updating were compared to the original model results for an equivalent range of simulated disequilibria.

It is now six years since the most recent update, and new uses for the model have been suggested; so again, the model updating process is required so that the model best represents the current structure and behaviour of the industry.

The Structure of the Industry

Although the relative volumes flowing through the various market channels have changed over the years, the current structure of the Australian pig meat industry remains similar to what was defined in the early 2000s. That is, total pig meat production is made up of carcases destined for the fresh pork market and carcases destined for the processed pig meat market (often referred to as “bacon, ham and smallgoods”).

Figure 1. Pig meat EDM structure

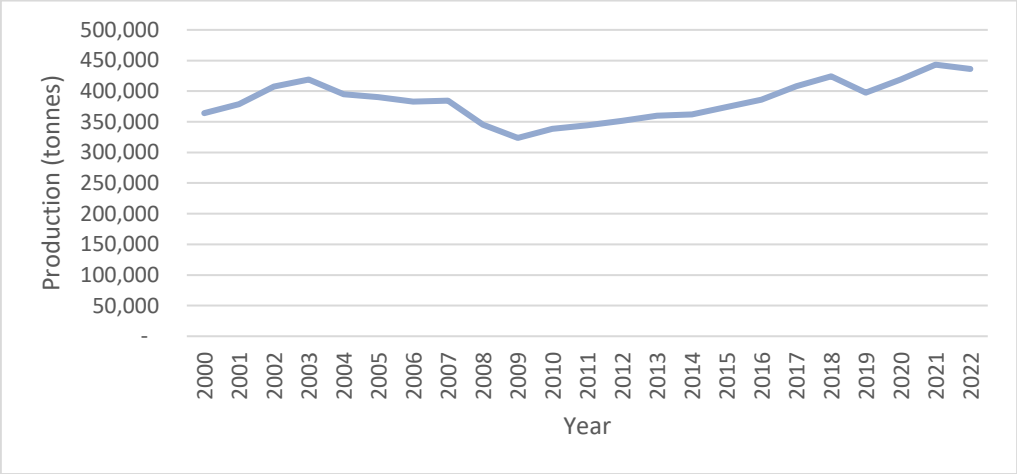


Some pork carcases and cuts are exported, while there are also substantial imports of pig meat destined for processing. The majority of processed pig meat products are derived from imported pig meat. Exports of other than fresh pork, and imports of other than carcases/cuts destined for processing, remain minor.

The Price and Quantity Data

The data shown in Figure 2, and as described in related APL (2022a, 2023a) reports, indicate that total Australian pig meat production has recovered from the substantial decline in 2008 and 2009. Production in 2009 was the lowest for 20 years. Aggregate average production of all pig meat during 2017-2022 was 420,000 tonnes carcase weight (cw); well above the long term average volume. The composition of production has also changed dramatically over time, with fresh pork production almost doubling and processed pig meat production halving from the volumes in the early 2000s.

Figure 2. Pig meat production, Australia, 2000-2022, tonnes CW

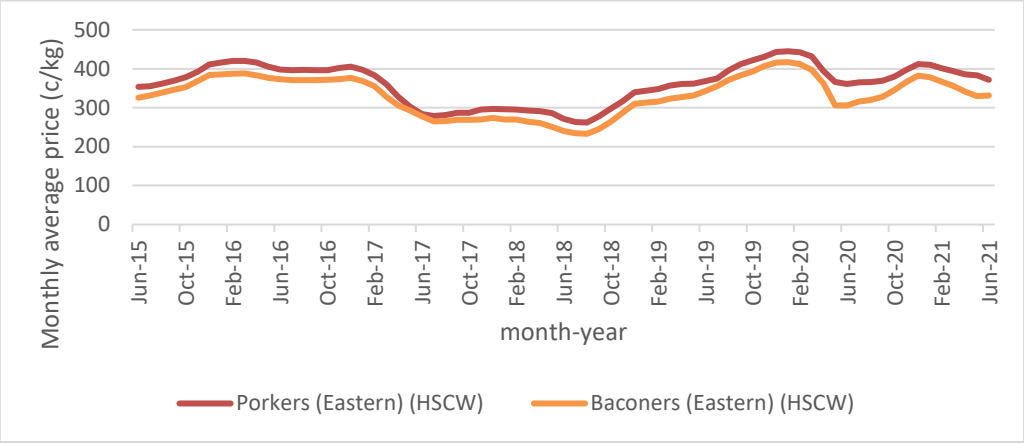


Source: FAOSTAT (2024)

As shown in Figure 3, the pig price trend has been relatively steady over the seven years to 2021, although with substantial short-term variability, after trending up over the past two decades (DPI, 2021). In 2009, prices were relatively high when supply was restricted, but then slumped in 2010 by almost $1/kg. Then, after another peak in 2016, prices fell dramatically again in 2017/18 by some 25 per cent, back to levels last seen in 2011. Further variability followed. While the representative year concept employed here (the average over 2017-2022) smooths out these large swings in prices, any single year of data could be used to calibrate the model. Thus the structure of the model is amenable to being used for a “high price” year and a “low price” year, as well as for the average 2017-2022 year.

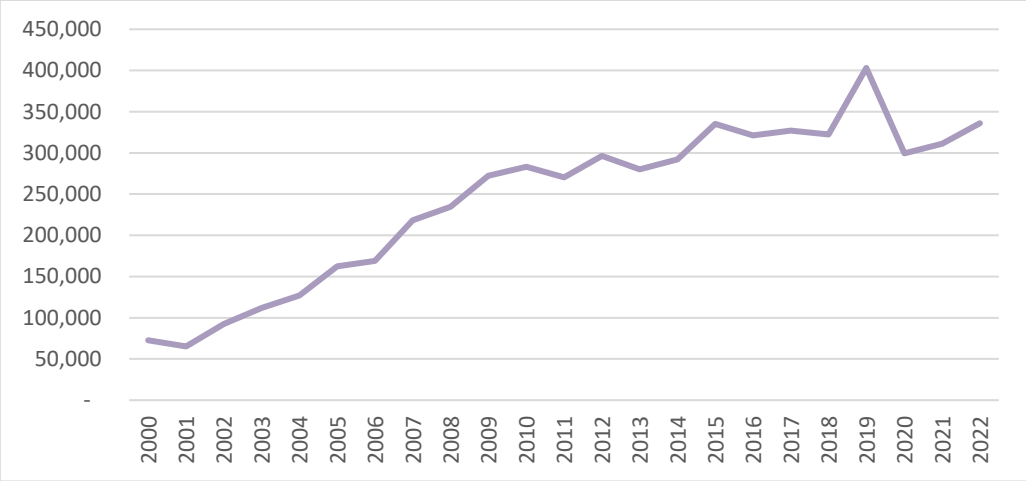
The other major driver of the Australian pig meat industry, the volume of imports, has been increasing significantly over the past two decades, although it has been relatively stable in the range 300,000-350,00 tonnes over the past six or so years (Figure 4).

Figure 3. Baconer and porker price, Australia, 2015-2021, c/kg CWE



Source: DPI (2021)

Figure 4. Pig meat imports, Australia, 2000-2022, tonnes CWE



Source: ABARES (2022)

Figure 5. Pork exports, Australia, 2020-2022, tonnes SW

Source: APL (2023b)

Pork exports (Figure 5) have increased since the early 2000s but have been quite stable in the last decade at around 45,000-50,000 tonnes. Most of these exports are to high value markets such as Singapore.

Based on the information shown, it is evident that the base price and quantity data require updating. Production is higher, imports are higher, and prices are higher, compared to the last updated set of values covering the 2012-2016 period. The gross value of production at the farm level is almost 50 per cent higher than it was in the early 2000s. The new base equilibrium values are specified as the average prices and quantities for 2017-2022. This time period was chosen to include years before, during and since the COVID-19 disruptions to markets. Input cost shares and output revenue shares are derived accordingly. The new price and quantity data, and the associated sector total values, are reported in Table 1, while the derived cost shares and/or revenue shares are shown in Table 2. All quantity values are expressed in terms of carcase weight equivalent tonnes. Details of the sources and the assumptions made for all inputs and outputs of all sectors for each year of 2017-2022 are described below.

Quantities

ABARES (2022, Table 14.3) reports aggregate supply and disposition data for pig meat. Total production, total imports, and total exports are recorded, and total apparent disappearance is calculated as the net available for the domestic market. This is all in carcase weight equivalents. Recorded export and import data are converted from shipped weight to carcase weight by the use of standard conversion factors. The resulting (rounded off) average values for 2017-2022 were total production (X_{11} + X_{12}) 420,000, total imports (X_{14}) 336,000, total exports (X_1) 51,000, and total apparent consumption (X_2 + X_3) 705,000, all in tonnes carcase weight.

Total production (X_{11} + X_{12}) split into production of porkers X_{11} and production of baconers X_{12} : APL have provided unpublished data which shows that total pigmeat production in Australia is very close to 70 per cent porker weights and 30 per cent baconer weights. Thus production of pigmeat for fresh pork consumption (X_{11}) would be 0.7 times 420,000 or 294,000 tonnes, and production of pigmeat for further processing (X_{12}) would be the residual: 126,000 tonnes.

Locally produced pork for the domestic market X_7 and X_2 : If production of pigmeat for fresh pork (X_{11}) is 294,000 tonnes annually, and all exports of pig meat (X_1, 51,000 tonnes) are unprocessed, then domestically produced pig meat for the fresh market (X_7) has to be 243,000 tonnes. This volume is also equal to retail consumption of fresh pork X_2 in carcase weight terms.

Locally produced bacon and ham for the domestic market X_8: With the assumption that there are no exports of processed pigmeat products from Australia, domestically produced pig meat for processing (X_8) has to be 126,000 tonnes cw.

Total consumption of bacon and ham in the domestic market (X_8 + X_{14}) : Consumption of processed pigmeat is therefore X_8 plus X_{14}, 461,000 tonnes cw.

Table 1. Base equilibrium prices and quantities, average of 2017-2022 compared to 2000-2002, 2009, and 2012-2016 (Quantity, CWE tonnes; Price, $/kg; TV, $m)

	2000-2002 typical year	2009 typical year	2012-2016 typical year	2017-2022 typical year
Final pig meat products	Domestic Bacon/Ham	Domestic bacon/ham	Domestic bacon/ham	Domestic bacon/ham
	X_3 = 297,991	X_3=439,528	X_3=376,000	X_3=461,000
	P_3 = 18.65	P_3=19.52	P_3=10.14	P_3=11.14
	TV_3 = 5557.5	TV_3=8,579.6	TV_3=3,812.64	TV_3=3,843
	Domestic Pork	Domestic pork	Domestic pork	Domestic pork
	X_2 = 88,101	X_2=86,94	X_2=251,000	X_2=243,466
	P_2 = 11.97	P_2=15.55	P_2=11.53	P_2=12.48
	TV_2 = 1054.6	TV_2=1,351.9	TV_2=2,894.03	TV_2=3,040
Wholesale carcass	Domestic Bacon Carcass	Domestic bacon carcass	Domestic bacon carcass	Domestic bacon carcass
	X_8 = 230,033	X_8=197,433	X_8=68,000	X_8=126,108
	P_8 = 3.57	P_8=4.48	P_8=5.01	P_8=5.24
	TV_8 = 821.2	TV_8=884.5	TV_8=340.68	TV_8=661
	Imported Carcass	Imported carcass	Imported carcass	Imported carcass
	X_{14} = 67,958	X_{14}=242,095	X_{14}=308,000	X_{14}=335,895
	W_{14} = 2.36	W_{14}=2.06	W_{14}=2.99	W_{14}=4.73
	TV_{14} = 160.4	TV_{14}=498.7	TV_{14}=920.92	TV_{14}=1,760
	Domestic Pork Carcass	Domestic pork carcass	Domestic pork carcass	Domestic pork carcass
	X_7 = 88,101	X_7=86,942	X_7=251,000	X_7=243,466
	P_7 = 3.70	P_7=4.91	P_7=5.24	P_7=5.62
	TV_7 = 326.0	TV_7=426.9	TV_7=1,315.24	TV_7=1,368
	Export Pork Carcass	Export Pork Carcass	Export Pork Carcass	Export Pork Carcass
	X_1 = 65,255	X_1=44,680	X_1=46,000	X_1=50,785
	P_1 = 3.29	P_1=2.89	P_1=2.52	P_1=4.25
	TV_1 = 214.7	TV_1=129.1	TV_1=115.92	TV_1=216
	$TV_{(1+7)}$ = 540.7	$TV_{(1+7)}$=555.9	$TV_{(1+7)}$= 1,431.16	$TV_{(1+7)}$= 1,584

Live pig	Baconers	Baconers	Baconers	Baconers
	X_{12} = 230,033	X_{12}=197,433	X_{12}=68,000	X_{12}=126,108
	P_{12} = 2.47	P_{12}=3.35	P_{12}=3.68	P_{12}=3.30
	TV_{12} = 568.2	TV_{12}=661.4	TV_{12}=250.24	TV_{12}=417
	Porkers	Porkers	Porkers	Porkers
	X_{11} = 153,356	X_{11}=131,622	X_{11}=297,000	X_{11}=294,252
	P_{11} = 2.80	P_{11}=3.75	P_{11}=4.03	P_{11}=3.62
	TV_{11} = 429.4	TV_{11}=493.6	TV_{11}=1,196.91	TV_{11}=1,066

Table 2. Base equilibrium revenue and cost shares, average of 2017-2022 compared to 2000-2002, 2009 and 2012-2016

	2000-2002 typical year	2009 typical year	2012-2016 typical year	2017-2022 typical year
Wholesale carcass	Bacon/ham secondary processing cost shares k_{X8}=0.15 k_{x10}=0.82 k_{x14}=0.03	Bacon/ham secondary processing cost shares k_{X8}=0.10 k_{x10}=0.84 k_{x14}=0.06	Bacon/ham secondary processing cost shares k_{X8}=0.09 k_{x10}=0.67 k_{x14}=0.24	Bacon/ham secondary processing cost shares k_{X8}=0.17 k_{x10}=0.56 k_{x14}=0.27
	Pork primary processing cost shares k_{X7}=0.31 k_{x9}=0.69	Pork primary processing cost shares k_{X7}=0.32 k_{x9}=0.68	Pork primary processing cost shares k_{X7}=0.45 k_{x9}=0.55	Pork primary processing cost shares k_{X7}=0.45 k_{x9}=0.55
	Pork initial processing revenue shares γ_{X1}=0.40 γ_{x7}=0.60	Pork initial processing revenue shares γ_{X1}=0.23 γ_{x7}=0.77	Pork initial processing revenue shares γ_{X1}=0.08 γ_{x7}=0.92	Pork initial processing revenue shares γ_{X1}=0.14 γ_{x7}=0.86
Live pig	Bacon/ham initial processing cost shares k_{X6}=0.31 k_{x12}=0.69 Pork initial processing cost shares k_{X5}=0.21 k_{x11}=0.79	Bacon/ham initial processing cost shares k_{X6}=0.25 k_{x12}=0.75 Pork initial processing cost shares k_{X5}=0.11 k_{x11}=0.89	Bacon/ham initial processing cost shares k_{X6}=0.27 k_{x12}=0.73 Pork initial processing cost shares k_{X5}=0.16 k_{x11}=0.84	Bacon/ham initial processing cost shares k_{X6}=0.37 k_{x12}=0.63 Pork initial processing cost shares k_{X5}=0.33 k_{x11}=0.67

Prices

Price of exports P_1 and imports W_{14}: APL (2022b,2023b) reports monthly and annual pig meat export values and pig meat import values as well as relevant quantities. The price of exported pork and the price of imported pig meat were calculated as export unit values and import unit values, respectively.

Retail price of pork P_2 and bacon P_3: The price of fresh pork in domestic retail markets was taken from MLA (2023). There has been no retail price of bacon reported since 2011. The average price in 2010/2011 was used as the base sourcing from ABS (2011), and this was adjusted by the food and non-alcoholic beverage component of the CPI for later years.

Wholesale price of porker P_7 and baconer P_8 : The wholesale prices for porker and baconer carcases were taken from APL (2022c).

Farm price of porker and baconers P_{11}, P_{12}: APL (2022c) also reports weekly porker and baconer buyer and seller prices in four weight categories: 45kg-60kg, 60.1-75kg, 75.1-85kg, and 85kg above. It does not indicate the price for particular enduses. The carcasses used for bacon/ham production are normally heavier than the carcasses used for fresh pork. Therefore, the seller price for weight category 45kg-60kg was considered as the porker price; the seller price for weight category 60.1-75kg was considered as the baconer price.

The Elasticity Values

The model requires values for 11 medium-term demand, supply, price transmission, input substitution and output transformation elasticities, which define the responsiveness of market participants to price changes. The original assumed values are detailed in Table 2 of Mounter et al. (2005a) and justified in the accompanying text.

The final consideration in the model updating process is whether current industry responses to price changes are sufficiently similar to those assumed to hold first during the period 2000-2002, and confirmed for 2009 and for 2012-2016, so that the main adjustment processes captured in the model framework are still relevant to current research problems. This involves assessing whether there have been any changes in underlying consumer preferences in different pig meat markets, or in technologies in different pig meat production or processing activities, that would be sufficient to alter the nature of the assumed demand, supply, input substitution and product transformation relationships. Again, this meant examining the industry reports detailed above, plus any empirical evidence available on the changing nature of price responsiveness over time, or on the nature of competition in these markets (Chung and Griffith, 2009).

There is now new empirical evidence available that market elasticity values have changed since the initial assumptions made in the early 2000s. Reviews of past studies in Mounter et al. (2012) and Ulubasoglu et al. (2016) suggested that the own-price elasticity for pork was becoming more inelastic over time, and detailed demand systems studies reported in Tighe et al. (2019) and Wong et al. (2015) confirmed this trend. These studies provided consistent estimates of -0.44 and -0.42 respectively.

Wong et al. (2015) referred to pork as a "necessity". On the other hand, Ulubasoglu et al. (2016) reported an estimate of -2.20 and called pork a "luxury" product. However, that study was based on household expenditure data whereas the other two studies were based on aggregate time series data. For bacon and ham, Ulubasoglu et al. (2016) provide an estimate for an aggregate "other meat" category of -0.85, which includes smallgoods, and which is lower than our previous estimates of -1.19 and -0.95.

For this update (as shown in Table 3), the own-price elasticity for pork is assumed to be -0.50, the own-price elasticty for bacon and ham is assumed to be -1.00, and the two cross-price elasticities are assumed to be 0.25, reflecting the more inelastic nature of pig meat demand in general and the decrease in substitution opportunities between these increasingly differentiated products[2]. The own-price elasticity of export demand for pork is also reduced from -5.00 to -2.00 to take account of the fact that exports are now quite stable and primarily to high-value markets such as Singapore and New Zealand, rather than being a residual market as in the past.

Table 3. Market elasticity values in the pig meat industry model, 2017-2022 version

Own price elasticity of demand for pork: $\eta_{(x2, p2)} = -0.5$
Own price elasticity of demand for bacon/ham: $\eta_{(x3, p3)} = -1.00$
Own price elasticity of demand for export pork: $\eta_{(x1, p1)} = -2$
Elasticity of demand for pork with respect to the price of bacon/ham: $\eta_{(x2, p3)} = 0.25$
Elasticity of demand for bacon/ham with respect to the price of pork: $\eta_{(x3, p2)} = 0.25$
Own price elasticity of supply of pigs: $\varepsilon = 1.0$
Inverse of elasticity of supply of input x ($x = X_5, X_6, X_9, X_{10}$): $Sx = 0.3$
Elasticity of price transmission between farm prices of pigs: $\theta = 0.74$
Elasticity of substitution between domestic and imported pig meat: $\sigma_{(x8, x14)} = 0.2$
Allen's elasticity of input substitution between input x and input y: $\sigma_{(x, y)} = 0.1$
Allen's elasticity of product transformation between output x and output y: $\tau_{(x7, x1)} = -0.2$
Quantity share of porkers in total pig meat production: $\beta x_{11} = 0.7$
Quantity share of baconers in total pig meat production: $\beta x_{12} = 0.3$

Changes have been made to supply side elasticities as well. The domestic pork production industry, in particular, is now quite concentrated and integrated with more than half of production in the hands of a few large producers. These are capital-intensive operations with largely contracted output, so responsiveness to price changes will be much less flexible than 20 years ago. The own-price elasticity of supply has been reduced to 1.00. The own-price elasticities of supply of inputs into pig production, slaughtering and further processing are similarly reduced, to 3.00. Also reduced are the possibility for

[2] In the absence of specific estimated values, we assume symmetry between the cross-price elasticites. Recognising that these are dependent on unavailable income and substitution effects of a price change (Tomek and Kaiser, 2014), equal cross-price elasticities are assumed. We could account for any higher or lower values using sensitivity analysis.

substitution between imported and locally produced pigmeat for bacon and ham production, and the possibility of switching pork outputs between the domestic and export markets.

The other set of new information relates to the competitive structure of the industry. Hilli and Griffith (2022) reported the existence of market power in the purchase of live pigs by the Australian pork value chain. The cause of such a diversion from competitive behaviour cannot be determined from the type of modelling framework used, but the authors surmised that it was due to the increasingly vertically integrated nature of pork production and processing. Given that some account of this integration has already been made through the choices of the supply elasticities, no further change is required at this stage.

As already mentioned, sensitivity analyses can always be conducted if the underlying assumptions are criticised or if new information comes to light casting doubt on the specific values.

The Hypothetical Simulations

The input file for the pig meat EDM was updated with the new price, quantity, cost share and revenue share data, and two hypothetical simulations were run to test the impact of recalibrating the model to the new initial equilibrium. The results were then compared to the same simulation results as reported in Mounter et al. (2005b, Table 3) based on the 2000-2002 data set, in Griffith et al. (2010, Table 2) based on the 2009 data set, and in Zhang et al. (2018) based on the 2012-2016 data set, using the same numbering system. These simulations were done using the Time Series Processor 4.5 econometric package (Hall and Cummins, 2003), as were all three past sets of results. The simulations were as follows:

- Scenario 1: a 1 per cent upward shift in the domestic demand curve for pork (N2 in Appendix 1) due to a hypothesised successful consumer advertising campaign; and
- Scenario 4: a 1 per cent downward shift in the supply curve of porkers (T1 in Appendix 1) due to a hypothesised successful R&D outcome which reduces the cost of production of porker pigs.

The results of this comparison are reported in Tables 4 and 5.

Discussion and Conclusions

For scenario 1 (a demand increase for pork), steady increases are seen in the value of total economic surplus over the four 'typical' years. The value of total surplus based on 2017-2022 data was $30.56m, compared to $29.05m in 2012-2016, $13.57m in 2009 and $10.58m in 2000-2002. These more-than-threefold total surplus estimates are due to the recent rapid growth in the Australian fresh pork sector, as shown in Table 1. The total value of the pork sector at retail is estimated to be just over $3 billion per annum during the 2017-2022 period, but was just $1.1 billion per annum in 2000-2002.

For scenario 4 (a cost decrease for porker production), a similar trend is evident. The total surplus value based on 2017-2022 data was $10.68m, compared to the equivalent earlier values of $11.99m, $4.94m and $4.30m, respectively. As shown in Table 1, the total value of the pork sector at the farm

gate is estimated to be over $1 billion per annum during the 2017-2022 period, and has more than doubled from $429 million per annum in 2009.

Table 4. Economic surplus changes ($ million) and percentage shares of total surplus changes (%) to pig producers and domestic pig meat consumers from selected advertising and R&D investment scenarios, 2000-2002 data and 2009 data

	2000-2002 average				2009			
Change in economic surplus to	Scenario 1 domestic pork advertising		Scenario 4 porker production R&D		Scenario 1 domestic pork advertising		Scenario 4 porker production R&D	
	$m	%	$m	%	$m	%	$m	%
pig producers	1.52	14.40	1.11	25.70	1.93	14.22	1.06	21.46
domestic consumers	7.31	69.10	2.82	65.60	9.57	70.52	3.84	77.73
Total Surplus	10.58	100	4.30	100	13.57	100	4.94	100

Table 5. Economic surplus changes ($ million) and percentage shares of total surplus changes (%) to pig producers and domestic pig meat consumers from selected advertising and R&D investment scenarios, 2012-2016 data and 2017-2022 data

	2012-2016 average				2017-2022 average			
Change in economic surplus to	Scenario 1 domestic pork advertising		Scenario 4 porker production R&D		Scenario 1 domestic pork advertising		Scenario 4 porker production R&D	
	$m	%	$m	%	$m	%	$m	%
pig producers	2.83	9.75	1.35	11.23	5.54	18.12	0.70	6.55
domestic consumers	23.09	79.5	9.52	79.36	10.94	35.80	3.50	32.77
Total Surplus	29.05	100	11.99	100	30.56	100	10.68	100

The change in total surplus from these hypothetical 1 per cent shifts is approximately equal to 1 per cent of the total value of the displaced sector (it would be exactly 1 per cent if fixed proportions was assumed). For example, in scenario 1 (demand increase), the change of total surplus in 2017-2022 was $30.56m resulting from a 1 per cent upward shift in the domestic demand for pork. This value is similar

to $30.40m, 1 per cent of the 2017-2022 total value of the fresh pork sector at retail ($3,040m in Table 1). This result confirms that the total surplus is solely determined by the size of the sector and the size of the displacement (Griffith et al., 2010).

Also of interest is the distribution of this total surplus value. In the three previous iterations of the model, the share of the change in total surplus accruing to pig meat producers was trending down, while the share of the change in total surplus accruing to consumers was trending up, in both selected scenarios. This was argued (Zhang et al., 2018) to be due to the increasingly smaller share of consumption filled by domestically produced pig meat. In the more recent periods, domestic production accounted for between 50-60 per cent of consumption, while in the early 2000s that share was 82 per cent. The share of total surplus going to value chain participants was minimal, typically less than 10 per cent.

However, in the most recent version, these shares are markedly different. This is due to the major changes that have been made to crucial elasticity values. The shares to pigmeat producers remains low, less than 20 per cent, but the shares to domestic consumers has been reduced from near 80 per cent to about 35 per cent, and the other value chain participants, in aggregate, now receive about half of the benefits from the modelled disequilibria. The supply of inputs they provide has been made less elastic and the possibilities of substitution and transformation effects are now much less likely, all in the context of a more inelastic market structure.

The complete distribution of the change in total surplus for the two modelled scenarios for the 2017-2022 period is shown in Table 6, with the underlying changes in prices and quantities of all the endogenous variable reported in Appendix 2. Pork and bacon/ham are now very weak substitutes in demand and there is now less flexibility in input use in pig meat slaughtering and processing (Table 3). However, these parameters are sufficient to produce some negative impacts on the bacon/ham sector from enhancements in the fresh pork sector. When fresh pork is effectively advertised domestically, and when pork producers adopt cost saving technology, domestic bacon/ham consumers lose as do suppliers of initial processing inputs into the bacon/ham production sector.

Tracing through the different price and quantity changes in Appendix 2 explains these results. For example for scenario 4, the 1 per cent productivity improvement in porker production increases the output of porker pigs (X11), exports of pork (X1) and domestic consumption of pork (X2, X7). Inputs used in pork processing increase (X5, X9). Conversely, domestic consumption of bacon/ham (X3, X8) decreases, and this drives down imports (X14), production of baconer pigs (X12) and inputs used in bacon/ham processing (X6, X10). As expected, prices move in opposite direction for pigmeat products but in similar directions for inputs. Overall, the industry expands by 0.4 per cent (Z, Y).

A similar description could be given for the advertising scenario.

Table 6. Economic surplus changes ($ million) and percentage shares of total surplus changes (%) to all participants from selected advertising and R&D investment scenarios, 2017-2022 data

Variable/ component of the value chain	Scenario 1 domestic pork advertising		Scenario 4 porker production R&D	
	$m	%	$m	%
X11: Porker producers	4.31	14.10	0.54	5.06
X12: Baconer producers	1.23	4.02	0.16	1.50
Pig meat producers	**5.54**	**18.12**	**0.70**	**6.55**
X5: Suppliers of initial processing inputs in the pork industry	1.76	5.76	0.51	4.78
X6: Suppliers of initial processing inputs in the bacon industry	-0.87	-	-0.60	-
X9: Suppliers of primary processing inputs in the domestic pork industry	5.86	19.18	1.57	14.70
X10: Suppliers of secondary processing inputs in the bacon industry	6.31	20.65	4.48	41.95
All input suppliers	**13.05**	**42.70**	**5.97**	**55.90**
Domestic pork consumers	17.60	57.59	7.54	70.60
Domestic bacon/ham consumers	-6.66	-	-4.04	-
All domestic consumers	10.94	35.80	3.50	32.77
Export pork consumers	1.03	3.37	0.51	4.78
All consumers	**11.97**	**39.17**	**4.01**	**37.55**
Total	**30.56**	**100**	**10.68**	**100**

Conclusion

The updated model detailed in this paper provides a framework that reflects the current size and structure of the Australian pig meat industry, based on available information. However, as shown by the simulation results, it is important to reiterate that the results from the model are conditional on the

price and quantity values specified for each market, their underlying assumptions and calculations, and the parameter values used to represent industry responses to price changes. The differences between the 2012-2016 results and the 2017-2022 results are again emphasised. Hence, the accuracy of the results is very much dependent on having accurate estimates of prices, quantities and parameter values.

When researchers are confident of such values, the model can be used to estimate total annual

benefits and their distribution among industry participants from defined disequilibrium scenarios. These scenarios might be successful new technologies at different levels of the industry or for different products, new or expanded successful advertising campaigns in the fresh or processed pig meat market, or policy proposals that might place restrictions on price or quantity values at different points in the chain. Proper benefit cost analyses can then be done with assumptions about investment costs over time and the patterns of adoption of technology or consumer responses to advertising campaigns, so as to provide evidence for the allocation of industry research and marketing funds.

The discussion has emphasised, however, that there are some parameter values that are unknown or out of date, and reasoned assumptions have had to be made. Further research on these values is warranted. Of particular interest would be empirical studies of import demand for pigmeat for further processing, and export demand for Australian pork in overseas markets. The other major change has been in the changing nature of pigmeat production and the increasing integration of production and processing (Hilli and Griffith, 2022). Some evidence of market power has been found. While some attempt has been made to accommodate this more-integrated production system in the supply elasticities chosen, a more formal examination of this production environment would be useful.

References

Australian Bureau of Agricultural and Resource Economics and Sciences (2022), *Agricultural Commodity Statistics*, Canberra, December. Available at: https://doi.org/10.25814/p6td-nm60

Australian Bureau of Statistics (2011), *Average Retail Prices of Selected Items*, Canberra. Available at: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/6403.0.55.001June%202011?OpenDocument

Australian Pork Limited (2022a), *Domestic Production Report March Quarter*, Australian Pork Limited, Canberra.

Australian Pork Limited (2022b), *Import and Export Report March 2022*, Australian Pork Limited, Canberra.

Australian Pork Limited (2022c), *Eyes and Ears Report*, Australian Pork Limited, Canberra.

Australian Pork Limited (2023a), *Domestic Production Report March Quarter*, Australian Pork Limited, Canberra.

Australian Pork Limited (2023b), *Import and Export Report March 2023*, Australian Pork Limited, Canberra.

Chung, K.C. and Griffith, G.R. (2009), "Another look at market power in the Australian fresh meat industries", *Australasian Agribusiness Review* Volume 17 (Paper 12).
Available at: http://www.agrifood.info/review/2009/Chung_Griffith.pdf.

DPI (2021), *Pork: Price*, NSW Department of Primary Industries, Orange. Available at: https://www.dpi.nsw.gov.au/about-us/publications/dpi/2021/pork

FAOSTAT (2024), *Crops and livestock products*, Food and Agriculture Organisation of the United Nations, Rome. Available at: https://www.fao.org/faostat/en/#data/QCL

Griffith, G.R., Malcolm, L.R., Mounter, S.W. and Slattery, H. (2010), "Old model, new problem: when should you update a model and what happens when you do?", *Australian Agribusiness Review,* Volume 18 (Paper 8). Available at: http://www.agrifood.info/review/2010/Griffith_et_al.pdf.

Hall, Bronwyn H. and Cummins, Clint (2003), *Time Series Processor Version 4.5 Reference Manual*, TSP International, Palo Alto, United States.

Hilli, Alastair and Griffith, Garry (2022), "Re-examining market power in the domestic fresh meat market", *Australasian Agribusiness Review* Volume 30, Paper 8, 190-217.

Meat and Livestock Australia (2023), *Australian meat prices*, MLA, Sydney. Available at: https://www.mla.com.au/prices-markets/statistics/australian-retail-meat-prices/

Mounter, S., Griffith, G. & Piggott, R. (2004), *Generic advertising and the Australian pig industry: allowing for trade.* Paper presented at the 48th Annual Conference of the Australian Agricultural and Resource Economics Society, Melbourne, February.

Mounter, S.W., Griffith, G.R. & Piggott, R.R. (2005a), "The payoff from generic advertising by the Australian pig industry, in the presence of trade", *Australasian Agribusiness Review,* Volume 13 (Paper 4). Available at: http://www.agrifood.info/Publications_Review/Mounter_Griffith_Piggott.htm.

Mounter, S.W., Griffith, G.R., Piggott, R.R. and Mullen, J.D. (2005b), "The payoff from generic advertising by the Australian pig industry: further results relative to the payoff from R&D", *Australasian Agribusiness Review* Volume 13 (Paper 19).
Available at: http://www.agrifood.info/review/2005/Mounter_et_al.html

Mounter, S., Villano, R. and Griffith, G. (2012), *Updating a Model of Meat Demand in Australia to Test for the Impact of MSA*, Final Report to Meat and Livestock Australia on Project B COM 0336, University of New England, Armidale.

Tighe, Kara, Piggott, Nicholas, Cacho, Oscar, Mounter, Stuart and Villano, Renato (2019), "Does consumer interest in the live export trade affect Australian meat demand?", *Australasian Agribusiness Review* Volume 27, Paper 8, 177-199.

Tomek, William G. and Kaiser, Harry M. (2014), *Agricultural Product Prices. Fifth Edition*, Cornell University Pres, Ithaca, 39-40.

Ulubasoglu, et al. (2016), “Food demand elasticities for Australia”, *Australian Journal of Agricultural and Resource Economics* 60, 2, 177-195.

Vere, D.T. and Griffith, G.R. (2004), "Structural econometric modelling in Australia’s livestock production and marketing systems: the potential benefits of model integration for industry analysis”, *Agricultural Systems* 81(2), 115-131.

Wong, L. et al. (2015), “Modelling the meat consumption patterns in Australia”, *Economic Modelling* 49, September, 1-10.

Zhang, Yue, Mounter, Stuart and Griffith, Garry (2018), “Updating and recalibrating equilibrium displacement models of the Australian livestock industries: pig meat”, *Australasian Agribusiness Review,* Volume 26, Paper 5, 68-81.

Appendix 1. Definition of Variables and Parameters

Endogenous Variables:

X1: Quantity of exported pork
X2: Quantity of domestic pork
X3: Quantity of domestic bacon
X5: Quantity of initial processing inputs in the pork industry
X6: Quantity of initial processing inputs in the bacon industry
X7: Quantity of wholesale pork carcass for primary processing in the domestic pork industry
X8: Quantity of wholesale baconer carcass for secondary processing in the domestic bacon industry
X9: Quantity of primary processing inputs in the domestic pork industry
X10: Quantity of secondary processing inputs in the bacon industry
X11: Quantity of porkers
X12: Quantity of baconers
X14: Quantity of imported pig meat for secondary processing in the bacon industry
P1: Price of export pork
P2: Price of pork at retail
P3: Price of bacon at retail
P5: Price of initial processing inputs in the pork industry
P6: Price of initial processing inputs in the bacon industry
P7: Price of wholesale pork carcass for primary processing in the domestic pork industry
P8: Price of wholesale baconer carcass for secondary processing in the domestic bacon industry
P9: Price of primary processing inputs in the domestic pork industry
P10: Price of secondary processing inputs in the bacon industry
P11: Price of porkers
P12: Price of baconers
Z: Aggregated input index of initial processing sector
Y: Aggregated output index of initial processing sector

Exogenous Variables

W14: Price of imported pig meat for secondary processing in the bacon industry
N1: Demand shifter for export pork
N2: Demand shifter for domestic pork consumption
N3: Demand shifter for domestic bacon consumption
T1: Supply shifter for porkers
T2: Supply shifter for baconers
T3: Supply shifter for initial processing inputs in the pork industry
T5: Supply shifter for initial processing inputs in the bacon industry
T6: Supply shifter for secondary processing inputs in the bacon industry
T7: Supply shifter for primary processing inputs in the domestic pork industry

Appendix 2. Price and Quantity Changes in all Endogenous Variables from Selected Advertising and R&D Investment Scenarios, 2017-2022 data (%)

Variable	Scenario 1 domestic pork advertising	Scenario 4 porker production R&D
X1	0.95	0.47
X2	1.16	0.35
X3	-1.36	-0.95
X5	1.12	0.33
X6	-1.20	-0.81
X7	1.15	0.39
X8	-1.24	-0.83
X9	1.16	0.31
X10	-1.18	-0.84
X11	1.12	0.43
X12	-1.26	-0.84
X14	-1.21	-0.87
P1	-0.47	-0.24
P2	0.42	-0.25
P3	1.47	0.89
P5	0.34	0.10
P6	-0.36	-0.24
P7	0.52	-0.66
P8	0.05	-0.07
P9	0.35	0.09
P10	-0.35	-0.25
P11	0.40	-0.95
P12	0.30	0.04
Z	1.12	0.40
Y	1.12	0.40