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Abstract

Australian Pork Limited collects producer levies and matching contributions from the Federal government (on some of the levy income), and uses these funds to invest in R&D, domestic and export marketing campaigns and strategic policy development. In 2003/04, more than $18 million in funds were available. Levy payers and other stakeholders want to know that these funds are being well spent to generate positive net returns to the industry. This issue is particularly important at present, with the Australian pig meat industry competing in a global market environment, producing significant quantities of pork exports but also facing significant quantities of pork imports for further processing. An equilibrium displacement model of the Australian pig meat industry accounting for imports and exports was specified to study the annual returns to producers and other industry sectors from different hypothetical R&D and advertising scenarios. Total industry returns and returns to pig producers were estimated for each scenario. The results indicated that pig producers receive the largest potential returns from effective bacon/ham advertising and from effective pork advertising that increases the domestic demand for these products by 1 per cent, and from effective R&D that reduces the cost of production of porkers by 1 per cent. Other investment scenarios generated substantially lower returns. However these results do not say anything about the cost of achieving the hypothetical 1 per cent shifts in demand or supply curves. We can say however that investing in porker production R&D always provides the greatest share of total benefits to pig producers. We can also say, based on past empirical evidence, that it is extremely difficult to demonstrate any positive demand response to domestic advertising of pig meat.

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* This paper draws on material previously published in Mounter et al. (2004b) and Zhao, Griffith and Mullen (2001).

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1. Introduction

Australian Pork Limited (APL) is the industry agency that provides policy, R&D and marketing services for the Australian pig meat industry. APL is funded by statutory levies and government contributions. Domestic producers currently pay a levy of $2.43 per head on every pig slaughtered for human consumption, of which APL receives $2.35. Of this amount, $1.65 is allocated to marketing and $0.70 to R&D (APL 2004b). Total levy funds for the 2003/04 financial year amounted to $13.5 million and the Federal Government contributed an additional $4.6 million for R&D purposes (APL 2004). Some $9.2 million was spent on R&D, $4.9 million on domestic marketing, $0.9 million on export marketing and some $1.3 million on policy development and other corporate activity (APL 2004). In the R&D area, most of the expenditure is on on–farm competitiveness and environmental issues, with smaller expenditures on product integrity and product innovation issues. In the marketing area, APL mainly undertakes generic advertising of fresh pork in Australia, either individually or in conjunction with retail outlets. Brand advertising of processed pig meat such as bacon and ham is more likely to be undertaken by a specific manufacturer. APL launched a major national marketing campaign in March 2003 aimed at increasing domestic pork consumption.

Efficient allocation of R&D and advertising dollars is essential to achieve the highest possible return at any time, but more so in the current difficult trading environment. Australian pig producers now compete in a global market and face direct competition from subsidised lower-priced imports and higher production costs as a result of the recent drought.

While the drought has been a relatively short-term consideration, the structure of the Australian pig meat industry has changed significantly over the last fifteen years. Increased international competition, trade policy reforms and food safety concerns have exposed the industry to global market conditions. Prior to 1990, pig meat in Australia was almost exclusively produced for the domestic market as quarantine restrictions limited imports to minimal quantities of canned hams. Revisions of quarantine regulations in subsequent years have contributed to a sharp increase in the quantities of imported pig meat entering Australia (see Figure 1). Imported pig meat, in carcass weight equivalent terms, comprised only one per cent of Australian pig meat consumption in 1990 but, by 2003, this share had grown to represent nearly 20 per cent of consumption (APL 2003). Approximately 94 per cent of total pig meat imports are fresh, chilled or frozen cuts that must be boned-out prior to shipment, cooked on arrival in Australia (as required by quarantine) and used in the manufacturing of bacon, ham and smallgoods (APL 2002a). Consequently, the majority of imported pig meat competes directly with, and displaces, locally produced product on the domestic processed pig meat market. Subsidised pork products originating from Canada and Denmark accounted for more than 95 per cent of total import quantities in 2003 (APL 2003). The adverse impact of these imports on the domestic pig meat industry has been well-documented (Productivity Commission 1998, Griffith and Chang 2000).

Coinciding with the recent surge in imports has been the development of Australia's export markets (also shown in Figure 1). The Australian pig meat industry has been able to capitalise on its 'disease free' status following food safety concerns associated with animal disease outbreaks throughout the world, and proximity to Asia has enabled Australian exporters to access and expand shipments of pork into the Singapore and Japanese markets. In 2003, exports of pig meat accounted for approximately 20 per cent of Australian pig meat production compared to only three per cent in 1990 (APL 2003).

This paper develops an equilibrium displacement model (EDM) of the Australian pig meat industry to assess the relative economic impacts of effective R&D and advertising campaigns on returns to pig producers. Morris, Mullen, Griffith and Wohlgenant (1991) had earlier developed such a model, but in the context of the pre-1990s non-trading environment. The paper has three specific aims:

- Firstly, to update and extend the research of Morris *et al.* (1991) by developing a model that reflects the industry in its present form. This includes a separate sector representative of the export

industry and an allowance for substitution between imported pig meat and domestically produced carcasses in the manufacturing of processed pig meat;

- Secondly, to provide a relatively disaggregated framework, both vertically and horizontally, of the Australian pig meat industry to enable returns among various industry sectors and markets from various types of exogenous changes, such as new technologies or new advertising campaigns, to be estimated; and
- Thirdly, and more specifically, to estimate and compare the annual returns to pig producers from effective advertising in the domestic pork market, in the export pork market, and in the domestic processed pig meat market, and from effective porker and baconer R&D programs at the farm level and the post-farm level. In total, nine hypothetical R&D and advertising scenarios are examined.

This is the same type of model as was developed by Zhao, Griffith and Mullen (2001) for examining R&D and advertising scenarios in the Australian beef industry, published earlier in this *Review*.

2. The Structural Model

The structure of the model depicting the Australian pig meat industry is shown in Figure 2. Each rectangle represents a production function and each arrowed line represents the supply and demand for a product, with the non-arrowed end indicating the supply of the product and the arrowed end indicating the demand for the product. The supply and demand schedules, where an exogenous shift may occur, are represented by the ovals.

Horizontally, the industry is modelled as three main sectors producing exported pork, domestically consumed pork and domestically consumed processed pig meat. The three sectors are linked in farm production and the domestic pork and processed pig meat sectors are also linked by substitution in consumption. Vertically, the Australian pig meat supply chain consists of a series of linked and interacting sectors with some producers undertaking activities in more than one sector. In some cases, links extend from pig farming through to the processing of pig meat into bacon, ham and smallgoods. Larger abattoirs operate their own boning rooms but independent boning rooms, butchers, supermarkets and bacon, ham and smallgoods manufacturers also process a significant number of carcasses.

Vertical disaggregation of the industry as represented in the model is subject to a number of assumptions. The slaughtering and initial processing sectors are thought of as undertaking all activities, using processing inputs and suitable pigs, necessary to produce pork for the export market, and wholesale carcasses of porkers and baconers for further processing in the respective domestic sectors. The domestic pork primary processing sector undertakes boning and cutting operations, and distributes cuts of meat to the retail sector and food service industry. The process involves cutting the carcass into primal cuts such as shoulders, middles and legs, and the treatment of primal cuts to obtain end use products. This sector is assumed to include vertically integrated abattoir-boning rooms, independent boning rooms and butchers or supermarkets that may undertake the same process. The secondary-processing sector is assumed to carry out all boning, cutting, manufacturing and distribution activities necessary to supply bacon, ham and smallgoods to the retail sector and food service industry. The sector can purchase carcasses, half carcasses or boned/unboned primal cuts for use in manufacturing, depending on the price of each. For consistency within the model it is assumed that this sector purchases wholesale carcasses from the slaughtering and initial processing sector and has a choice between purchasing domestically produced wholesale carcasses or imported cuts of pork.

For this analysis, a few further simplifying assumptions relating to the structure of the industry have been made:

- The published data do not allow a precise estimate of the quantities of pig meat used for fresh and processed end uses. The fresh pork market (export and domestic) is assumed to comprise 40 per cent of total pig meat production with the processed pig meat market comprising 60 per cent of total pig meat production (McElhone, C. 2003, pers. comm).

- Exported pig meat classified under tariff code sub-heading 0203 (APL 2002a) comprising fresh, chilled or frozen carcasses, half carcasses and cuts of meat account for approximately 94 per cent of total pig meat exported. Roughly four per cent of total exports are offal and edible livers with the remaining two per cent consisting of preserved pig meat (APL 2002a). Preserved pig meat, offal and livers are not included due to the small share of total exports represented by each. It is assumed that total exports consist entirely of pork classified under tariff code sub-heading 0203 (APL 2002a).

- Approximately 94 per cent of all imported pig meat is used in the secondary processing sector. Imported pig meat in this category also falls under tariff code sub-heading 0203 and must be boned out prior to arriving in Australia. The remaining six per cent of total imports are preserved prior to shipment and are sold at the retail level (APL 2002a). Preserved or processed imports are not included in the model and it is assumed that 100 per cent of imports are used in secondary processing.

- Wohlgenant (1997) has shown that producer surplus measures may be incorrect when there are infra-marginal firms, as the shape of the supply curve for the industry may differ from that of an individual firm. To accurately calculate producer surplus changes under these circumstances, additional information such as the distribution of firms by cost structure are needed. This is particularly relevant when analysing the impact of a shift due to technical change, therefore it is assumed that all sectors within the industry are characterised by constant returns to scale.

The structural model of the Australian pig meat industry based on these assumptions is fully specified in Mounter *et al.* (2004a). This model defines equilibrium in all markets. As can be determined from Figure 2, there are 12 product markets comprising a possible 24 endogenous price and quantity variables. The export price is assumed to be endogenous in the model due to the disease-free, niche positioning of Australian pork in export markets (ie. import demand for Australian pork is not perfectly elastic). Thus Australian pork is different from other sources of pork sold in these markets. However, the import price is assumed to be exogenous (ie. import supply is perfectly elastic), so that imported pork from all sources is assumed to be identical. Also, there is one aggregated input index variable and one aggregated output index variable for the multi-output slaughtering and initial pork-processing sector. Hence the model is a system of 25 equations with 25 endogenous variables. The exogenous variables include the import price, the six possible supply shifters representing the impact of new technologies (the T variables) and the three possible demand shifters representing the impact of advertising (the N variables). Integrability conditions such as homogeneity and symmetry have been imposed implicitly.

The equilibrium displacement version of this model, the version used to conduct the simulation experiments, is outlined in the Appendix. Definitions of the variables and parameters in this model are given in Table 1.

3. Data Requirements

To solve the 25-equation equilibrium displacement model specified in the Appendix, estimates of a number of market parameters and base equilibrium values for all sectors are required. The various Marshallian demand and supply elasticities, and the elasticities of input substitution, product transformation and price transmission, were chosen on the basis of previous empirical estimates, theoretical considerations and the judgement of the authors. The elasticity values used in the model are provided in Table 2. The base equilibrium values and associated cost shares were taken as an average of prices and quantities for the three year period 2000-2002 and are summarised in Table 3. Finally, one or more of the supply and/or demand shifters has to be non-zero.

Demand elasticities

While there is a considerable amount of literature dealing with estimated demand elasticities for pig meat (Griffith *et al.* 2000), the availability of disaggregated estimates for fresh pork, bacon and ham is quite limited. Of the studies reviewed, Cashin (1991) is the most recent published study that provides elasticity values for Australian pig meat at a disaggregated level.

Cashin (1991) suggests that fresh pork and ham are substitutes, that fresh pork and bacon are complements and that ham and bacon are substitutes. In this study, bacon and ham are defined as a composite good and are assumed to be a substitute for pork in consumption. It would be expected that the own-price elasticity of bacon and ham as an aggregate would be smaller in absolute value than the individual own-price elasticities of each. In the base model, -0.9 and -1.2 are used as the bacon/ham and fresh pork elasticities for domestic demand, respectively.

Under the assumption that ham comprises a larger share than bacon in the processed pig meat market, a cross-price elasticity value of 0.6 is used to represent the cross-price elasticity of fresh pork with respect to changes in the price of bacon/ham as a composite good. Similarly, a value of 0.2 is used in the base model to represent the cross-price elasticity of bacon/ham with respect to changes in the price of fresh pork.

While there have been a few studies on the export demand elasticity for Australian beef, there have not been any studies on the export demand elasticity for Australian pork. Scobie and Johnson (1979) estimated a value of -10.3 for the export demand elasticity of Australian beef and Cronin (1979) estimated a value of -4 when Australian beef is not assumed to be homogeneous with beef from all other countries. Wittwer and Connolly (1993) calculated export beef demand elasticity values of -4.5 in the short run and -14 in the long run. In an equilibrium displacement model of the Australian beef industry, Zhao (1999) assumed export demand elasticities of -5 and -2.5 for grass-fed and grain-fed beef, respectively. Balancing the small country argument, that changes in the quantity of Australian pork exports exert little influence on export prices, and the perceived heterogeneity of Australian pork in its major markets, a value of -5 is assumed as the export pork demand elasticity in the base model.

Supply elasticities

Following Morris *et al.* (1991), the medium-run elasticity of supply of pigs in aggregate is assumed to be 1.5. As they pointed out, individually, the supplies of the two pig types are more elastic than this because increases in supply result from an increase in total production and by switching production from one pig type to another in response to relative price changes.

In general, it is believed that, since most of the other inputs in the processing sectors such as labour and capital are not specialised, the supply of these inputs is highly elastic (Zhao 1999). In the case of a nearly perfectly-elastic supply for mobile inputs, previous studies have chosen to use a value of 5 (Zhao 1999; Zhao, Anderson and Wittwer 2003). Similarly, a value of 5 is assumed for all other inputs to the pig industry processing sectors in the base model.

Elasticity of price transmission

It is reasonable to expect that there is a close relationship between the farm prices of porkers and baconers due to the possibility of substitution in production. Morris *et al.* (1991) commented that the price relationship could be estimated econometrically given a specification of the differences in feed costs and price differentials for quality. Alternatively, assuming that the supply of processing inputs is close to perfectly elastic, the elasticity of price transmission can be approximated as the ratio of the value of a porker to the value of a baconer. Using average prices and weights in 2002, this value was calculated as 0.74.

Elasticities of input substitution

For each of the industry sectors in the model, estimates for elasticities of input substitution are required. One approach is to assume farm inputs and other processing inputs are used in fixed proportions implying a zero elasticity of substitution. However, even a small degree of input substitution can have a significant impact on the distribution of benefits between producers and consumers (Alston and Scobie 1983; Mullen, Wohlgenant and Farris 1988). Diewert (1981) pointed out that input substitution at the industry level is generally greater than substitution displayed at the firm level. Wohlgenant (1989) estimated a substitution elasticity value of 0.35 for the US pork industry. Most EDM studies of agricultural industries have assumed a value of 0.1 for the elasticity of substitution between farm inputs and other inputs (Mullen, Wohlgenant and Farris 1988; Mullen, Alston and Wohlgenant 1989; Zhao *et al.* 2000; Zhao, Anderson and Wittwer 2003). Consequently, in the absence of any empirical estimates for Australia, an input substitution elasticity of 0.1 has been assumed between farm inputs and other processing inputs for all sectors in the base model.

There are no empirical estimates for the elasticity of substitution between domestically-produced pig meat and imported pig meat used in the secondary-processing sector. Dixon *et al.* (1997) used a value of 2 to represent the elasticity of substitution between various imported and domestic commodities in the ORANI computable equilibrium displacement (CGE) model of the Australian economy. Although it would seem reasonable to assume the substitution between domestic and imported pig meat may be quite high, quarantine restrictions and the decision by some major domestic manufacturers not to use imported product suggest the substitution possibilities are restricted to a certain extent. Here, a value of 0.5 is assumed for the elasticity of substitution between domestic and imported pig meat.

Elasticity of product transformation

In the ORANI model, a value of -2 is assumed for the product transformation elasticities among all agricultural products. For the slaughtering and initial pork processing sector, carcasses produced for the export and domestic markets exhibit some level of heterogeneity. A significant number of porkers are produced at the farm level specifically for sale in the export market. For example, 55 per cent of total pork exports are sold in the Singapore market where product specifications are for larger and heavier carcasses than those produced for the domestic market. However, some degree of product transformation is possible, as different product specifications are applicable to other export markets and unsold export quantities are inevitably processed in the domestic sector. In the base model, the product transformation elasticity between export and domestic carcasses for the slaughtering and initial pork processing sector is assumed to be -0.5.

Base equilibrium price and quantity values

All quantity values are expressed in terms of carcass-weight equivalent tonnes and all prices and quantities, with the exception of retail prices, were obtained from APL. Retail prices were sourced from the Australian Bureau of Statistics (ABS) and *Australian Commodity Statistics* (ABARE 2002). The cost and revenue shares required for the different sectors within the model are derived from the base price and quantity values. The cost shares for other inputs into the processing sectors are calculated as a residual from the specified equilibrium conditions for each sector. The equilibrium price and quantity values are defined as annual averages over the period 2000 to 2002.

The average annual quantity of pig meat produced for the period studied was 383,389 tonnes. Under the assumption that pork comprises 40 per cent of total pig meat production, the quantity of pork produced was 153,356 tonnes and the quantity of pig meat produced for the manufacture of bacon/ham was 230,033 tonnes. APL adjusted the shipped weight of exported pork to a carcass weight equivalent basis using a conversion factor of 0.8. Using this conversion factor, the average annual quantity of exported pork was

calculated as 65,255 tonnes, leaving the quantity of pork consumed at the domestic retail level as 88,101 tonnes. Similarly, based on APL adjustments, a conversion factor of 0.56 was used to derive an average annual carcass weight equivalent of 67,958 tonnes for imported pig meat. The imported pig meat quantity was added to the quantity of domestically produced bacon/ham to yield total consumption of bacon/ham at the retail level equivalent to 297,991 tonnes.

The farm prices for porkers and baconers of $2.80 and $2.47 per kilogram, respectively, are based on average national dressed carcass weight prices. The average wholesale price was estimated to be $3.70 per kilogram for a pork carcass and $3.57 per kilogram for a bacon carcass, based on Sydney wholesale prices. Export and import prices were calculated as per unit values by dividing the total dollar values of exports and imports by the respective carcass weight equivalent quantities. The average export price for pork was $3.29 per kilogram and the average price for imported pig meat was $2.36 per kilogram.

Data were not readily available to enable the calculation of retail carcass weight equivalent prices for pork and bacon/ham (see for example Griffith, Green and Duff (1991)). The retail price for pork was obtained from ABARE (2002) and is based on average retail prices of selected cuts of pork (weighted by expenditure) in state capitals. The average retail price of the bacon/ham composite good was obtained from ABS and is based on the average retail price of bacon rashers in state capitals, as price estimates for ham were unavailable. Average retail prices of pork and bacon/ham for the period 2000 to 2002 were estimated to be $11.97 per kilogram and $18.65 per kilogram, respectively. Note that, because carcass weight equivalent retail prices for pork and bacon/ham have not been used, the revenues or total sector values specified in Table 3 for the pork and bacon/ham retail-sectors (TV_2 and TV_3) are over-estimated. As a result, the cost shares associated with the other processing inputs used in the pork primary processing and bacon/ham secondary processing sectors (k_{X9} and k_{X10}) are also over-estimated.

Demand and supply shifters

In the model, there are six possible exogenous supply shift variables (representing porker production research, baconer production research, initial pork processing research, initial bacon/ham processing research, primary pork processing research and secondary bacon/ham processing research) and three possible exogenous demand shift variables (domestic pork advertising, domestic bacon/ham advertising, and export pork advertising). The aim of this study is to determine and compare the returns to the whole pig industry and to pig producers from different R&D and generic advertising scenarios. This involves simulating a separate, hypothetical 1 per cent vertical, parallel shift (or displacement) of the supply curve in each of the markets in which the R&D is assumed to occur (where the supply shift represents a 1 per cent *decrease* in the variable cost of producing the product due to the R&D); and a separate, hypothetical 1 per cent vertical, parallel shift of the demand curve in each of the markets in which the advertising is assumed to occur (where the demand shift represents a 1 per cent *increase* in consumers' willingness to pay due to the advertising)[1].

4. Results

The percentage changes in the price and quantity variables for each of the nine advertising and R&D scenarios are obtained by solving equations (13a) – (37a) (in the Appendix) with the relevant demand shifter set at 0.01 or the relevant supply shifter set to -0.01 (Table 4). The associated changes in producer surplus and consumer surplus at the different market levels are calculated using standard formulae (Alston, Norton and Pardey 1995). In particular, the changes in producer surplus to pig producers are

[1] In the advertising scenarios reported here, Australian pork is assumed to exhibit some degree of heterogeneity from pork originating in other countries (the pork export demand elasticity is set at -5 instead of a much larger value). In the results reported in Mounter *et al*. (2004b), various other advertising scenarios were examined including different assumptions about the trade status of the Australian pig meat industry and different assumptions about how the advertising expenditure was funded.

calculated as the sum of the producer surplus changes measured in each of the porker and baconer markets as follows:

$$\Delta PS = P_{11}X_{11}(EP_{11})(1+0.5EX_{11}) + P_{12}X_{12}(EP_{12})(1+0.5EX_{12})$$

where: $EP_x = (P_{xt2} - P_{xt1})/P_{xt1}$ and $EX_x = (X_{xt2} - X_{xt1})/X_{xt1}$

and t1 refers to the period prior to the displacement and t2 refers to the period after the displacement. The sum is a measure of the change in producer surplus for the two producer groups as a whole, not an estimate of the producer surplus changes to each producer group (Zhao, Mullen and Griffith 2001).

Price and quantity changes for each of the endogenous variables for each of the scenarios are reported in Table 5, and producer and consumer surplus changes for each of the scenarios are reported in Table 6.

General Comments About the Results

First, the results relate to equal 1 per cent, hypothetical, exogenous shifts in the relevant demand and supply curves. The question of how much money is required to bring about the 1 per cent demand shifts or cost reductions in the relevant sectors is not addressed here. Previous studies that have addressed this issue include Lemieux and Wohlgenant (1989), Scobie, Mullen and Alston (1991), Mullen and Cox (1995) and Cox, Mullen and Hu (1997). Thus, the monetary returns from the alternative scenarios reported in Table 6 are only directly comparable under the assumption of *equal investment efficiency*, in the sense that the investment costs of the 1 per cent shifts in all sectors are the same.

Second, although the same amount of monetary investments at different points of the industry may result in supply or demand shifts of different magnitudes, and although the actual returns in dollar terms are dependent on the magnitudes of the initial shifts, the distribution of the total benefits among industry groups for a particular scenario is independent of the size of the initial shift (Zhao 1999, p160). For example, the producers' percentage share of the total benefits from initial pork processing technology (i.e. 20.9 per cent for Scenario 6 in Table 6) is the same regardless of whether the technology reduces the processing cost by 1 per cent or 10 per cent. Therefore, comparison of *benefit shares* among alternative investment scenarios is always meaningful even without knowledge of the efficiency of research investments. This result follows from the assumed competitive structure of the pig meat industry and the assumed parallel supply and demand shifts.

Given these qualifications, consider now the total welfare gains from the alternative scenarios reported in Table 6. For the same 1 per cent exogenous shift, the size of the total welfare change from a scenario is predominantly determined by the gross revenue of the market where the exogenous shift occurs. Consequently, as can be seen from the last row of Table 6, for equal 1 per cent shifts in the relevant markets, the largest changes in total surplus result from Scenario 2 (almost $56 million annually) involving a 1 per cent exogenous shift in the retail demand curve for bacon/ham, and from Scenario 8 (almost $46 million annually) involving a 1 per cent exogenous shift in the supply curve for inputs into secondary bacon/ham processing. Based on the data available and the assumptions made, the processed pig meat industry is considerably larger and has a higher retail value than the pork industry, and a significant component of the final cost of bacon/ham is added at the secondary processing stage (as shown by the high cost share in Table 3).

Two other general comments about the results are worth noting. First, in all but Scenario 1, there are sectors of the pig meat industry that lose from the particular R&D or advertising scenario being modelled. In the bacon/ham advertising and R&D scenarios, pork initial and primary processors and overseas pork consumers always lose; while in the pork advertising and R&D scenarios, bacon/ham initial and secondary processors almost always lose. Pork and bacon/ham are substitutes in the minds of consumers, so changes

in prices brought about by advertising or R&D in one industry has an adverse effect on economic activity in the other industry. However, pig producers and domestic consumers of pig meat always win.

Second, in all but Scenario 3, the great majority of the benefits from the scenarios examined here accrue to domestic pig meat consumers. In those eight scenarios, the minimum share to domestic consumers is almost 66 per cent and in five of the cases the share is more than 80 per cent. The elasticity of domestic demand for pork and bacon/ham is considerable less than the elasticity of export demand and the elasticity of supply of pigs, and this implies a greater share of any benefits to domestic consumers relative to export consumers and domestic producers. In Scenario 3, overseas consumers receive some 83 per cent of the total benefit from export pork advertising, because exported pork is considered to be different to domestic pork.

Advertising Scenarios

As noted above, the largest changes in total surplus and in surplus accruing to pig producers result from Scenario 2 involving a 1 per cent exogenous shift in the demand curve for bacon/ham. The total industry benefit from effective domestic bacon/ham advertising is almost $56 million and the gain to pig producers is $2.63 million, annually. Surplus changes associated with a 1 per cent exogenous shift in the domestic demand for pork (Scenario 1) reveal that the industry as a whole benefits by almost $11 million and producers would receive $1.52 million, while only $2.15 million accrues to the industry from a 1 per cent exogenous shift in export demand (Scenario 3), of which producers receive $0.16 million. While exports are a relatively small part of the total industry, Australian pork is considered to be different from pork from other suppliers in the major markets so export demand is not perfectly elastic. Domestic advertising is therefore not just a re-allocation of product from export to domestic markets with no influence on export or domestic prices (as evident in some other studies of domestic advertising – see Piggott 1998).

In terms of shares to producers, domestic pork advertising provides some 14.4 per cent, while domestic bacon/ham advertising returns only 4.7 per cent.

On-farm R&D Scenarios

Research into new technologies in porker or baconer production (Scenarios 4 and 5), are regarded as 'traditional' on-farm research. Examples include genetic research increasing litter size and weaning percentage, nutrition research increasing feeding efficiency, environmental and animal welfare programs, or education initiatives improving producers' farm management.

The total benefits from baconer production R&D (Scenario 5) at $5.7 million annually are greater than the total benefits from porker production R&D (Scenario 4) at $4.3 million annually, but the actual benefits accruing to producers is the other way around due to the substantial differences in the producer shares of total benefits. Pig producers receive 25.7 per cent of the benefits from porker production R&D but only 7.5 per cent from baconer production R&D. In both cases, the majority of the total benefits accrue to domestic consumers while, as also noted above, pork processors lose from baconer R&D and bacon/ham processors lose from porker R&D.

Off-farm R&D Scenarios

Off-farm research is R&D beyond the farm gate. In the model, cost reductions in initial processing (Scenarios 6 and 7), pork primary processing (Scenario 9) and bacon/ham secondary processing (Scenario 8) relate to off-farm R&D investments.

Later stage processing R&D (Scenarios 8 and 9) generates greater total returns than either early stage processing R&D (Scenarios 6 and 7) or on-farm R&D. Secondary bacon/ham processing R&D in particular generates the second largest total return of some $46 million, due to the large value added to

baconer carcases during this process. However returns to producers are actually of a similar magnitude to the returns to producers from on-farm R&D because of the extremely small share of total benefits that gets back to producers in Scenario 8 (just 2.1 per cent). The total benefits from 1 per cent cost reductions in the early stage processing sectors (primarily slaughtering) are much smaller (less than $2.5 million) due to the small value added to the pig meat products in these sectors, and the supply curves of other inputs in these sectors are assumed to be highly elastic (with an elasticity value of 5). For the same reason, the shares of total benefits to these sectors in the other scenarios are quite small, and can be negative. However, the producers' share of pork initial processing R&D is quite high at 20.9 per cent.

In summary, the results from the present model are consistent with the previous literature in concluding that, in terms of the *shares* of total benefits, farmers should prefer on-farm R&D to R&D in the processing and domestic marketing sectors and to advertising. However, in terms of aggregate benefits, the largest returns result from advertising bacon/ham, and from off-farm R&D in secondary bacon/ham processing.

Further Considerations

The above comparison among alternative R&D and advertising investments has focused mainly on the percentage shares of the total benefits to individual groups. As the information on the costs involved in bringing about the same 1 per cent shifts in the various markets is unavailable, the conclusions that can be drawn from comparing the actual dollar returns from alternative investment scenarios are limited.

As noted above, one way around this is to make an assumption of *equally efficient* investments in all sectors (same $ investment for same % shift). For example, *if* the R&D investments in later stage processing research *were* equally efficient in the two processing sectors, producers would prefer secondary bacon/ham processing research ($0.95 million) to primary pork processing research ($0.78 million), even though the shares of total benefits give the opposite preference (2.1 per cent for the former and 10.66 per cent for the later). Or, from a different perspective, investment in primary pork processing research needs to be about 22 per cent more efficient (0.95/0.78 is 1.22) as investment in secondary bacon/ham processing research in order for pig producers to be indifferent about investing in the two processing sectors.

The rankings of preferences to pig producers among the nine alternative investment scenarios, in terms of their percentage shares of total benefits and in terms of their absolute monetary benefits respectively, are given in Table 7. The ranking in the first column is always true even though the information on the investment costs involved in the initial 1 per cent shifts is unavailable. The ranking in the second column is conditional on the assumption of equal investment efficiency across the nine scenarios. Obviously, the ranking of preferences in the two columns is rather different, although Scenario 1 and Scenario 4 are in the top three in each ranking.

Another way of presenting these data (Table 8) is to list the initial percentage shifts required in all scenarios that are necessary to achieve the same dollar benefits as that from Scenario 4. For example, in order for pig producers to receive the same monetary benefit of $1.11 million as from a 1 per cent cost reduction in porker production, costs in initial pork processing need to be reduced by 4.83 per cent (Scenario 6), or costs in secondary bacon/ham processing need to be reduced by 1.17 per cent (Scenario 8). Similarly, in order for pig producers to be indifferent about investing in domestic pork advertising (Scenario 1) or in primary pork processing research (Scenario 9), the cost of creating an advertising campaign that increases the demand for pork by 0.73 per cent needs to be the same as the cost of the R&D investment that reduces primary pork processing costs by 1.42 per cent. Thus, which of the two investment scenarios is preferable to producers is dependent upon the investment costs in bringing about the demand and supply shifts respectively in these two sectors.

Finally, the impact of levies paid to fund advertising and R&D is not discussed. In a competitive industry, the industry equilibrium will be displaced as a result of the imposition of a levy. For example, a levy on

pig producers would be regarded initially as an increase in pig production costs. However, through the interaction with other sectors in the production and marketing chain, this cost is ultimately shared with processors and consumers. Hence, producers do not bear the levy burden alone even if the levy is collected from them initially. There is also symmetry between how the benefits from technology are distributed between the different sectors in the pig meat industry and how the incidence of levies imposed to fund R&D and promotion are shared between the different sectors. A levy on the producers of porkers is distributed in exactly the same way as the benefits of new technology in growing porkers – these producers pay 25.7 per cent of the levy and gain 25.7 per cent of the benefits. However if the levy is used to fund primary pork processing research for example, they still pay 25.7 percent of the levy but receive only 10.66 per cent of the benefits. Primary pork processing research may still be a profitable investment for porker producers but the rate of total returns to investments in this area will have to be higher than from porker R&D to give the same net returns to porker producers. These issues are examined more fully in Alston and Mullen (1992), Piggott (1998) and Freebairn, Goddard and Griffith (2005), and an example in relation to pig meat advertising is given in Mounter *et al*. (2004b).

Sensitivity to Market Elasticity Values

The results presented above are based on a particular set of market-related elasticities which were chosen from published estimates, economic theory and the authors' subjective judgement. For some parameters, there are relatively more empirical studies available and the possible values of the parameters can be narrowed down to small ranges. However, for others, and in particular given the level of disaggregation in this study, very little empirical evidence is available. Specification of these parameter values in the base model has had to rely substantially on subjective judgement. Thus, it is essential to study the sensitivity of model results (see for example Zhao *et al.* 1999) and their policy-related conclusions to changes in values of parameters, and this is being taken up in future work.

Sensitivity to Market Equilibrium Values

The results are also dependent on assumptions made about the price and quantity data, and the sensitivity of these results to data assumptions is similarly essential. In particular, comments have been made above about the probable over-estimation of the retail prices of pork and bacon, and the consequent over-estimation of the returns to advertising and secondary bacon/ham processing R&D.

To illustrate the impacts of different assumptions about the retail prices, two further scenarios (2a and 5a) were run where the retail prices were halved. Scenario 2 is domestic bacon/ham advertising, where the impacts should be large, and Scenario 5 is baconer production R&D, where the impacts should be small. Thus, with reference to the values provided in Table 3, $P_2 = 5.985$ and $P_3 = 9.325$ (instead of $P_2 = 11.97$ and $P_3 = 18.65$); $TV_2 = 527.285$ and $TV_3 = 2778.765$ (instead of $TV_2 = 1054.57$ and $TV_3 = 5557.53$); and $k_{x8} = 0.30$, $k_{x10} = 0.64$, $k_{x14} = 0.06$, $k_{x7} = 0.62$ and $k_{x9} = 0.38$ (instead of $k_{X8} = 0.15$, $k_{X10} = 0.82$, $k_{X14} = 0.03$, $k_{X7} = 0.31$ and $k_{X9} = 0.69$). The impact of these changes in the retail prices on the total level of benefits and the distribution among the market participants is reported in Table 9.

For Scenario 2a, as expected for an advertising scenario, total surplus halved because total retail value halved. All component values were smaller, but mostly that to domestic consumers (down by $22m) and to pig producers (down nearly $5m). However, the share to pig producers rose from 4.72 per cent to 8.95 per cent. In contrast, for Scenario 5a, a farm level R&D scenario, total surplus was unchanged. However, due to the different cost shares, benefits to producers rose to $0.54m and the share to also producers rose, to 9.49 per cent.

Thus, while different assumptions about elasticity values influence the distribution of benefits from R&D and advertising, and leave total benefits unchanged, different assumptions about prices and quantities influence both total benefits and their shares.

5. Conclusions and implications

In this paper, an equilibrium displacement model of the Australian pig meat industry accounting for imports and exports was specified to study the annual returns to producers and other industry sectors from different hypothetical R&D and advertising scenarios. Total industry returns and returns to pig producers and other market participants were estimated for each scenario. The results indicate that pig producers receive the largest potential annual returns from effective bacon/ham advertising ($2.6 million) and from effective pork advertising ($1.5 million) that increases the domestic demand for these products by 1 per cent, and from effective R&D that reduces the cost of production of porkers by 1 per cent ($1.1 million). Other investment scenarios return substantially lower returns. However these results do not say anything about the cost of achieving the hypothetical 1 per cent shifts in demand or supply curves. The results also indicate that investing in porker production R&D always generates the greatest share of total benefits to pig producers (25.7 per cent), followed by pork initial processing R&D (20.9 per cent) and by domestic pork advertising (14.4 per cent).

These results are conditional on the price and quantity values and the parameter values used in the analysis. Comments made above about the uncertainty associated with some of these values, and the probable over-estimation of the retail prices of pork and bacon, and consequent over-estimation of the returns to advertising and secondary bacon/ham processing R&D, should be borne in mind when assessing these results. In particular, it was shown above that the benefits from advertising are very dependent on having accurate estimates of the retail prices for a carcase equivalent quantity.

More general though, and associated with the discussion about equal investment efficiency, is our knowledge about the relative effectiveness of R&D versus advertising in shifting supply and demand curves respectively. While most R&D evaluation studies have produced reasonably high benefit cost ratios or internal rates of return (see for example, Alston, Norton and Pardey 1995, Mullen and Cox 1995), based on past empirical evidence, it is extremely difficult to demonstrate any positive demand response to domestic advertising in the Australian pork market. All previous studies using Australian data (Piggott *et al.* 1996, Zhang and Goddard 1999) and all but one study using North American data (Brester and Schroeder 1995, Duffy and Goddard 1995) have estimated generic pork advertising elasticities not significantly different from zero. In such a case there would no benefit from advertising and producers would incur a loss equal to the amount of the advertising expenditure. Mounter *et al*. (2004b) showed that the Australian elasticity of demand response to generic pork advertising would have to exceed 0.035 for pig producers to gain from a generic advertising program for domestic pork, funded by a lump sum. This value is toward the upper end of any previously estimated values for the demand response to generic advertising. See also Freebairn, Goddard and Griffith (2005) for a more general treatment of the conditions under which generic advertising is likely to be cost effective to producers.

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Appendix 1. The Model in Displacement Form

Equations (13a)-(37a) reported below are derived by totally differentiating the system of general functional form equations (13)-(37) described in Mounter *et al.* (2004). The equations are differentiated at the initial equilibrium points and all market parameters refer to elasticity values at the initial equilibrium points (Zhao 1999). A small finite relative change of variable $(.)$ is expressed as $E(.) = \Delta(.)/(.)$. The equation numbers are kept the same as in the source document for ease of comparison.

Supply of Pigs

(13a) $\beta_{X11} EX_{11} + \beta_{X12} EX_{12} = \varepsilon(EP_{11} - ET_1)$

(14a) $EP_{12} = ET_2 + \theta(EP_{11} - ET_1)$

Other Slaughtering and Initial Pork Processing Inputs Supply

(15a) $EP_5 = s_{X5} EX_5 + ET_3$

Output Constrained Input Demand of Slaughtering and Initial Pork Processing Sector

(16a) $EX_{11} = -k_{X5}\sigma_{(X5,X11)} EP_{11} + k_{X5}\sigma_{(X5,X11)} EP_5 + EY$

(17a) $EX_5 = k_{X11}\sigma_{(X5,X11)} EP_{11} - k_{X11}\sigma_{(X5,X11)} EP_5 + EY$

Input Constrained Output Supply of Slaughtering and Initial Pork Processing Sector

(18a) $EX_7 = -\gamma_{X1}\tau_{(X7,X1)} EP_7 + \gamma_{X1}\tau_{(X7,X1)} EP_1 + EZ$

(19a) $EX_1 = \gamma_{X7}\tau_{(X7,X1)} EP_7 - \gamma_{X7}\tau_{(X7,X1)} EP_1 + EZ$

Slaughtering and Initial Pork Processing Sector Equilibrium

(20a) $k_{X5} EX_5 + k_{X11} EX_{11} = \gamma_{X7} EX_7 + \gamma_{X1} EX_1$

(21a) $k_{X5} EP_5 + k_{X11} EP_{11} = \gamma_{X7} EP_7 + \gamma_{X1} EP_1$

Export Demand for Australian Pork

(22a) $EX_1 = \eta_{(X1,P1)} EP_1 + EN_1$

Other Domestic Pork Primary Processing Inputs Supply

(23a) $EP_9 = s_{X9} EX_9 + ET_7$

Output Constrained Input Demand of Domestic Pork Primary Processing Sector

(24a) $EX_7 = -k_{X9}\sigma_{(X7,X9)} EP_7 + k_{X9}\sigma_{(X7,X9)} EP_9 + EX_2$

(25a) $EX_9 = k_{X7}\sigma_{(X7,X9)} EP_7 - k_{X7}\sigma_{(X7,X9)} EP_9 + EX_2$

Domestic Pork Primary Processing Sector Equilibrium

(26a) $EP_2 = k_{X7} EP_7 + k_{X9} EP_9$

Domestic Pork Retail Demand

(27a) $EX_2 = \eta_{(X2,P2)} EP_2 + \eta_{(X2,P3)} EP_3 + EN_2$

Other Slaughtering and Initial Bacon/Ham Processing Inputs Supply

(28a) $EP_6 = s_{X6} EX_6 + ET_5$

Output Constrained Input Demand of Slaughtering and Initial Bacon/Ham Processing Sector

(29a) $EX_6 = k_{X12}\sigma_{(X12,X6)}EP_{12} - k_{X12}\sigma_{(X12,X6)}EP_6 + EX_8$

(30a) $EX_{12} = -k_{X6}\sigma_{(X12,X6)}EP_{12} + k_{X6}\sigma_{(X12,X6)}EP_6 + EX_8$

Slaughtering and Initial Bacon/Ham Processing Sector Equilibrium

(31a) $EP_8 = k_{X6}EP_6 + k_{X12}EP_{12}$

Other Bacon/Ham Secondary Processing Inputs Supply

(32a) $EP_{10} = s_{X10}EX_{10} + ET_6$

Output Constrained Input Demand of Bacon/Ham Secondary Processing Sector

(33a) $EX_8 = -(k_{X10}\sigma_{(X8,X10)} + k_{X14}\sigma_{(X8,X14)})EP_8 + k_{X10}\sigma_{(X8,X10)}EP_{10} + k_{X14}\sigma_{(X8,X14)}EW_{14} + EX_3$

(34a) $EX_{10} = k_{X8}\sigma_{(X8,X10)}EP_8 - (k_{X8}\sigma_{(X8,X10)} + k_{X14}\sigma_{(X10,X14)})EP_{10} + k_{X14}\sigma_{(X10,X14)}EW_{14} + EX_3$

(35a) $EX_{14} = k_{X8}\sigma_{(X8,X14)}EP_8 + k_{X10}\sigma_{(X10,X14)}EP_{10} - (k_{X8}\sigma_{(X8,X14)} + k_{X10}\sigma_{(X10,X14)})EW_{14} + EX_3$

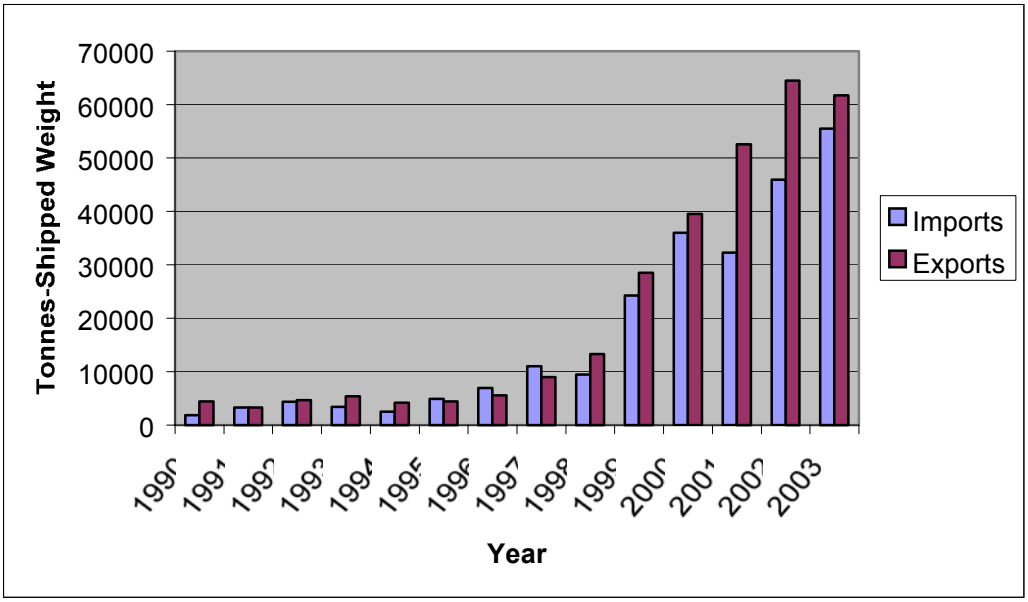
Bacon/Ham Secondary Processing Sector Equilibrium

(36a) $EP_3 = k_{X8}EP_8 + k_{X10}EP_{10} + k_{X14}EW_{14}$

Domestic Bacon/Ham Retail Demand

(37a) $EX_3 = \eta_{(X3,P3)}EP_3 + \eta_{(X3,P2)}EP_2 + EN_3$

Figure 1. Australian Pig Meat Imports and Exports, 1990-2003



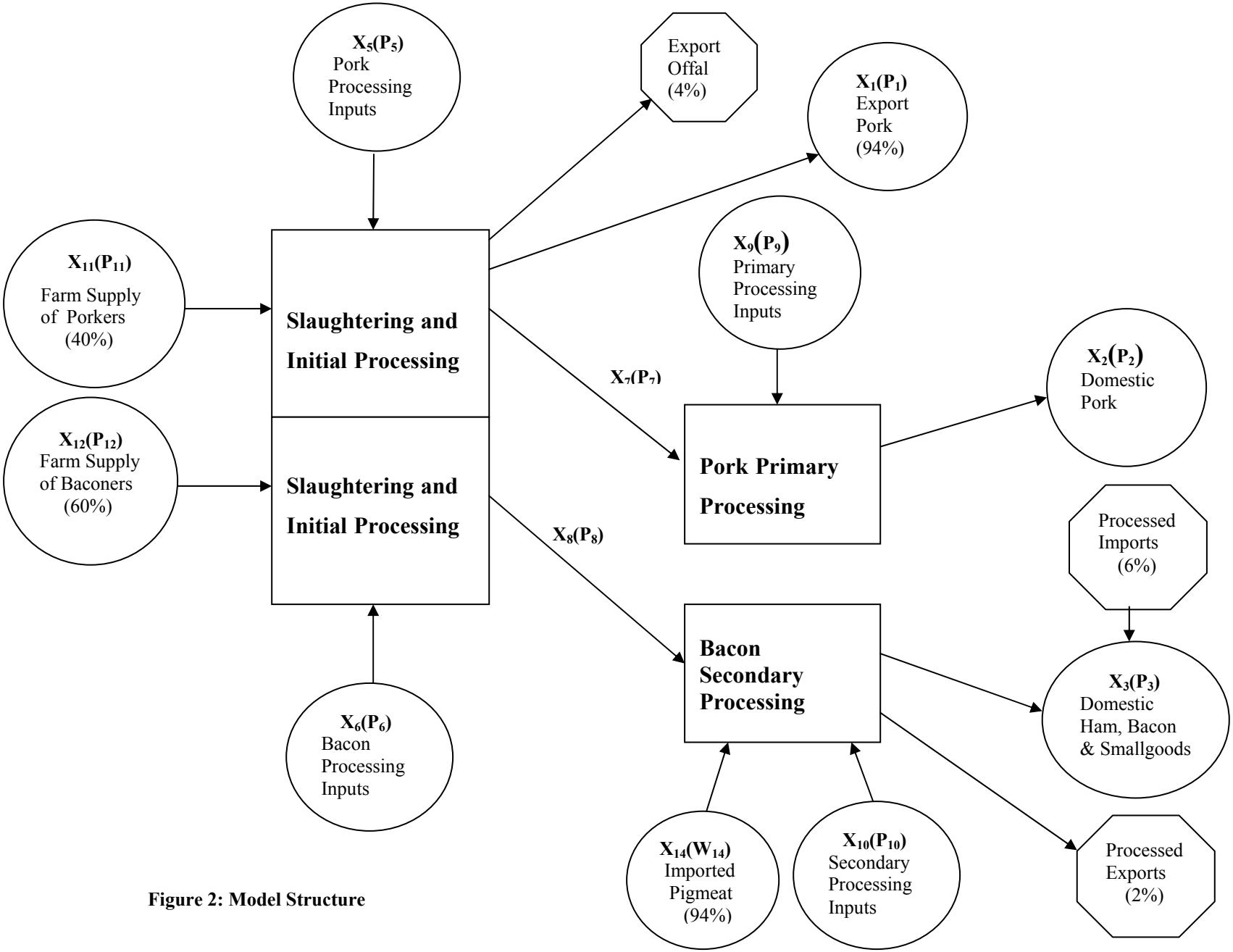


Figure 2: Model Structure

Table 1: Definition of Variables and Parameters

Endogenous Variables:

X_1: Quantity of exported pork

X_2: Quantity of domestic pork

X_3: Quantity of domestic bacon

X_5: Quantity of initial processing inputs in the pork industry

X_6: Quantity of initial processing inputs in the bacon industry

X_7: Quantity of wholesale pork carcass for primary processing in the domestic pork industry

X_8: Quantity of wholesale baconer carcass for secondary processing in the domestic bacon industry

X_9: Quantity of primary processing inputs in the domestic pork industry

X_{10}: Quantity of secondary processing inputs in the bacon industry

X_{11}: Quantity of porkers

X_{12}: Quantity of baconers

X_{14}: Quantity of imported pig meat for secondary processing in the bacon industry

P_1: Price of export pork

P_2: Price of pork at retail

P_3: Price of bacon at retail

P_5: Price of initial processing inputs in the pork industry

P_6: Price of initial processing inputs in the bacon industry

P_7: Price of wholesale pork carcass for primary processing in the domestic pork industry

P_8: Price of wholesale baconer carcass for secondary processing in the domestic bacon industry

P_9: Price of primary processing inputs in the domestic pork industry

P_{10}: Price of secondary processing inputs in the bacon industry

P_{11}: Price of porkers

P_{12}: Price of baconers

Z: Aggregated input index of initial processing sector

Y: Aggregated output index of initial processing sector

Exogenous Variables

W_{14}: Price of imported pig meat for secondary processing in the bacon industry

N_1: Demand shifter for export pork

N_2: Demand shifter for domestic pork consumption

N_3: Demand shifter for domestic bacon consumption

T_1: Supply shifter for porkers

T_2: Supply shifter for baconers

T_3: Supply shifter for initial processing inputs in the pork industry

T_5: Supply shifter for initial processing inputs in the bacon industry

T_6: Supply shifter for secondary processing inputs in the bacon industry

T_7: Supply shifter for primary processing inputs in the domestic pork industry

Table 2: **Market Elasticity Values**

Own price elasticity of demand for pork: $\eta_{(x2, p2)} = -1.2$
Own price elasticity of demand for bacon/ham: $\eta_{(x3, p3)} = -0.9$
Own price elasticity of demand for export pork: $\eta_{(x1, p1)} = -5$
Elasticity of demand for pork with respect to the price of bacon/ham: $\eta_{(x2, p3)} = 0.6$
Elasticity of demand for bacon/ham with respect to the price of pork: $\eta_{(x3, p2)} = 0.2$
Own price elasticity of supply of pigs: $\varepsilon = 1.5$
Inverse of elasticity of supply of input x ($x = X_5, X_6, X_9, X_{10}$): $Sx = 0.2$
Elasticity of price transmission between farm prices of pigs: $\theta = 0.74$
Elasticity of substitution between domestic and imported pig meat: $\sigma_{(x8, x14)} = 0.5$
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: $\tau_{(x7, x1)} = -0.5$
Quantity share of porkers in total pig meat production : $\beta x_{11} = 0.4$
Quantity share of baconers in total pig meat production: $\beta x_{12} = 0.6$

Table 3: **Base Equilibrium Prices, Quantities and Revenue and Cost Shares**

	Quantity (X variables, CWE tonnes) **Price (P variables, $/kg)** **Sector revenue (TV variables, $m)**	**Revenue and Cost Shares**
Final Pig Meat Products	<u>Domestic Bacon/Ham</u> $X_3 = 297{,}991$ $P_3 = 18.65$ $TV_3 = 5557.53$ <u>Domestic Pork</u> $X_2 = 88{,}101$ $P_2 = 11.97$ $TV_2 = 1054.57$	
Wholesale Carcass	<u>Domestic Bacon Carcass</u> $X_8 = 230{,}033$ $P_8 = 3.57$ $TV_8 = 821.22$ <u>Imported Carcass</u> $X_{14} = 67{,}958$ $W_{14} = 2.36$ $TV_{14} = 160.38$ <u>Domestic Pork Carcass</u> $X_7 = 88{,}101$ $P_7 = 3.70$ $TV_7 = 325.97$ <u>Export Pork Carcass</u> $X_1 = 65{,}255$ $P_1 = 3.29$ $TV_1 = 214.70$ $TV_{(1+7)} = 540.67$	<u>Bacon/Ham Secondary Processing Cost Shares</u> $k_{X8} = 0.15$ $k_{X10} = 0.82$ $k_{X14} = 0.03$ <u>Pork Primary Processing Cost Shares</u> $k_{X7} = 0.31$ $k_{X9} = 0.69$ <u>Pork Initial Processing Revenue Shares</u> $\gamma_{X1} = 0.40$ $\gamma_{X7} = 0.60$
Live Pig	<u>Baconers</u> $X_{12} = 230{,}033$ $P_{12} = 2.47$ $TV_{12} = 568.18$ <u>Porkers</u> $X_{11} = 153{,}356$ $P_{11} = 2.80$ $TV_{11} = 429.40$	<u>Bacon/Ham Initial Processing Cost Shares</u> $k_{X6} = 0.31$ $k_{X12} = 0.69$ <u>Pork Initial Processing Cost Shares</u> $k_{X5} = 0.21$ $k_{X11} = 0.79$

Table 4: Exogenous Shift Variables for Various Advertising and R&D Investment Scenarios

Scenario 1. Domestic Pork Advertising
N2 = 0.01, rest T(.) = 0 and N(.) = 0.
Increase in the 'willingness to pay' by domestic pork consumers due to pork advertising or changes in taste in the domestic market.

Scenario 2. Domestic Bacon/Ham Advertising
N3 = 0.01, rest T(.) = 0 and N(.) = 0.
Increase in the 'willingness to pay' by domestic bacon/ham consumers due to bacon/ham advertising or changes in taste in the domestic market.

Scenario 3. Export Pork Advertising
N1 = 0.01, rest T(.) = 0 and N(.) = 0.
Increase in the 'willingness to pay' by export pork consumers due to pork advertising or changes in taste in the overseas market.

Scenario 4. Porker Production Research
T1 = -0.01, rest T(.) = 0 and N(.) = 0.
Cost reduction in porker production resulting from any breeding or farm technologies that reduce the cost of producing porkers.

Scenario 5. Baconer Production Research
T2 = -0.01, rest T(.) = 0 and N(.) = 0.
Cost reduction in baconer production resulting from any breeding or farm technologies that reduce the cost of producing baconers.

Scenario 6. Initial Pork Processing Research
T3 = -0.01, rest T(.) = 0 and N(.) = 0.
Cost reductions in pork processing due to new technologies or management strategies in the initial pork processing sector.

Scenario 7. Initial Bacon/Ham Processing Research
T5 = -0.01, rest T(.) = 0 and N(.) = 0.
Cost reductions in bacon/ham processing due to new technologies or management strategies in the initial bacon/ham processing sector.

Scenario 8. Secondary Bacon/Ham Processing Research
T6 = -0.01, rest T(.) = 0 and N(.) = 0.
Cost reductions in bacon/ham processing due to new technologies or management strategies in the secondary bacon/ham processing, domestic marketing or retailing sector.

Scenario 9. Primary Pork Processing Research
T7 = -0.01, rest T(.) = 0 and N(.) = 0.
Cost reductions in pork processing due to new technologies or management strategies in the initial pork processing, domestic marketing or retailing sector.

Table 5: Percentage Change in Prices and Quantities for Alternative Advertising and R&D Investment Scenarios (%)

Variable	Scenario 1 (N2=0.01) domestic pork advertising	Scenario 2 (N3=0.01) domestic bacon/ham advertising	Scenario 3 (N1=0.01) export pork advertising	Scenario 4 (T1=-0.01) porker production R&D	Scenario 5 (T2=-0.01) baconer production R&D	Scenario 6 (T3=-0.01) initial pork processing R&D	Scenario 7 (T5=-0.01) initial bacon/ham processing R&D	Scenario 8 (T6=-0.01) primary pork processing R&D	Scenario 9 (T7=-0.01) secondary bacon/ham processing R&D
Quantities:	0.516	-0.220	0.156	0.819	-0.082	0.213	-0.023	-0.392	0.414
EX1	0.755	-0.030	0.026	0.325	-0.061	0.084	-0.022	-0.386	0.635
EX2	0.026	0.866	-0.005	-0.055	0.079	-0.014	0.035	0.627	-0.098
EX3	0.656	-0.095	0.082	0.488	-0.067	0.225	-0.022	-0.379	0.502
EX5	0.026	0.864	-0.005	-0.054	0.077	0.014	0.132	0.545	-0.097
EX6	0.742	-0.056	0.032	0.398	-0.065	0.103	-0.022	-0.396	0.560
EX7	0.017	0.860	-0.006	-0.062	0.144	-0.015	0.064	0.547	-0.103
EX8	0.761	-0.019	0.024	0.292	-0.059	0.076	-0.021	-0.381	0.668
EX9	0.027	0.866	-0.005	-0.053	0.069	-0.014	0.030	0.644	-0.097
EX10	0.651	-0.128	0.081	0.585	-0.073	0.127	-0.023	-0.398	0.503
EX11	0.013	0.858	-0.006	-0.065	0.175	-0.016	0.034	0.547	-0.106
EX12	0.033	0.896	-0.004	-0.051	0.031	-0.013	0.013	0.562	-0.096
EX14									
Prices:	-0.103	0.044	0.169	-0.164	0.016	0.043	0.005	0.078	-0.083
EP1	0.213	0.112	-0.022	-0.270	0.008	-0.070	-0.001	-0.030	-0.534
EP2	0.018	0.174	0.000	0.000	-0.086	0.000	-0.039	-0.704	-0.010
EP3	0.131	-0.019	0.016	0.098	-0.013	-0.955	-0.004	-0.076	0.100
EP5	0.005	0.173	0.000	-0.011	0.015	-0.003	-0.974	0.109	-0.019
EP6	0.348	0.372	-0.080	-1.000	0.051	-0.262	0.005	0.071	0.209
EP7	0.093	0.211	0.009	0.063	-0.661	0.013	-0.296	0.091	0.041
EP8	0.152	-0.004	0.005	0.058	-0.012	0.015	-0.004	-0.076	-0.866
EP9	0.005	0.173	0.000	-0.011	0.014	-0.003	0.006	-0.871	-0.019
EP10	0.179	0.309	0.019	-0.870	0.050	0.027	0.007	0.003	0.092
EP11	0.132	0.229	0.014	0.096	-0.963	0.020	0.005	-0.084	0.068
EP12									

Table 6: Economic Surplus Changes ($ million) and Percentage Shares of Total Surplus Changes (%) to Various Industry Groups from Alternative Advertising and R&D Investment Scenarios

Industry group	Scenario 1 (N2=0.01) domestic pork adverting		Scenario 2 (N3=0.01) domestic bacon/ham advertising		Scenario 3 (N1=0.01) export pork advertising		Scenario 4 (T1=-0.01) porker production R&D		Scenario 5 (T2=-0.01) baconer production R&D		Scenario 6 (T3=-0.01) initial pork processing R&D		Scenario 7 (T5=-0.01) initial bacon/ham processing R&D		Scenario 8 (T6=-0.01) primary pork processing R&D		Scenario 9 (T7=-0.01) secondary bacon/ham processing R&D	
	$m	%	$m	%	$m	%	$m	%	$m	%	$m	%	$m	%	$m	%	$m	%
ΔPS_X pig producers	1.52	14.40	2.63	4.72	0.16	7.59	1.11	25.70	0.43	7.51	0.23	20.91	0.06	2.50	0.95	2.10	0.78	10.66
ΔPS_{X5} pork initial processors	0.15	1.38	-0.02	-0.04	0.02	0.85	0.11	2.53	-0.01	-0.24	0.05	4.50	-0.01	-0.18	-0.08	-0.18	0.11	1.54
ΔPS_{X6} bacon/ham initial processors	0.01	0.13	0.44	0.79	0.00	-0.11	-0.03	-0.63	0.04	0.69	-0.01	-0.61	0.07	2.63	0.28	0.60	-0.05	-0.67
ΔPS_{X9} pork primary processors	1.11	10.52	-0.03	-0.05	0.03	1.60	0.43	9.90	-0.08	-1.50	0.11	9.93	-0.03	-1.23	-0.55	-1.20	0.98	13.36
ΔPS_{X10} bacon/ham secondary processors	0.25	2.37	7.96	14.26	-0.04	-2.00	-0.49	-11.30	0.63	11.14	-0.12	-11.15	0.28	10.91	5.91	12.88	-0.88	-12.12
ΔCS_{X1} overseas consumers	0.22	2.10	-0.09	-0.17	1.79	83.13	0.35	8.20	-0.04	-0.62	0.09	8.24	-0.01	-0.37	-0.17	-0.37	0.17	2.44
ΔCSX_{23} domestic consumers	7.31	69.10	44.92	80.49	0.19	8.94	2.82	65.60	4.72	83.02	0.76	68.18	2.17	85.74	39.56	86.17	6.20	84.79
Total Surplus	10.58	100	55.81	100	2.15	100	4.30	100	5.69	100	1.11	100	2.53	100	45.90	100	7.31	100

Table 7: Rankings of Preferences to Pig Producers Among the Alternate Advertising and R&D Investment Scenarios

Rank	In terms of % share of total benefits (%)	In terms of absolute benefits ($m)
1	Scenario 4 (25.7)	Scenario 2 (2.63)
2	Scenario 6 (20.9)	Scenario 1 (1.52)
3	Scenario 1 (14.4)	Scenario 4 (1.11)
4	Scenario 9 (10.7)	Scenario 8 (0.95)
5	Scenario 3 (7.6)	Scenario 9 (0.78)
6	Scenario 5 (7.5)	Scenario 5 (0.43)
7	Scenario 2 (4.7)	Scenario 6 (0.23)
8	Scenario 7 (2.5)	Scenario 3 (0.16)
9	Scenario 8 (2.1)	Scenario 7 (0.06)

Table 8: Required Percentage Shifts Necessary to Provide the Same Benefits to Pig Producers as from Scenario 4

	Scenario 1 domestic pork advertising	Scenario 2 domestic bacon/ham advertising	Scenario 3 export pork advertising	Scenario 4 porker production R&D	Scenario 5 baconer production R&D	Scenario 6 initial pork processing R&D	Scenario 7 initial bacon/ ham processing R&D	Scenario 8 primary pork processing R&D	Scenario 9 secondary bacon/ham processing R&D
Returns to Pig Producers ($million)	1.1	1.1	1.1	1.1	1.1`	1.1	1.1	1.1	1.1
Initial % Shifts Required (%)	0.73	0.42	6.94	1.00	2.58	4.83	18.5	1.17	1.42

Table 9: Economic Surplus Changes ($ million) and Percentage Shares of Total Surplus Changes (%) to Various Industry Groups from Scenario 2 and Scenario 5 with Retail Price Estimates Halved

Industry group	**Scenario 2a (N3=0.01) domestic bacon/ham advertising (retail prices halved)**		**Scenario 5a (T2=-0.01) baconer production R&D (retail prices halved)**	
	$m	**%**	**$m**	**%**
ΔPS_X pig producers	2.50	8.95	0.54	9.49
ΔPS_{X5} pork initial processors	-0.04	-0.14	-0.03	-0.52
ΔPS_{X6} bacon/ham initial processors	0.44	1.60	0.08	1.40
ΔPS_{X9} pork primary processors	-0.04	-0.16	-0.05	-0.90
ΔPS_{X10} bacon/ham secondary processors	3.18	11.41	0.50	8.92
ΔCS_{X1} overseas consumers	-0.12	-0.44	-0.06	-1.12
ΔCSX_{23} domestic consumers	21.99	78.78	4.71	82.72
Total Surplus	27.91	100	5.69	100