An economic model to assist with policy development in the citrus industry

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Centre for International Economics

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REPORT

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An economic model to assist with policy development in the citrus industry (CT02054)

Prepared for

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1 Background

In 2002, Horticulture Australia Ltd (HAL) commissioned the Centre for International Economics (CIE) to develop an economic model of the Australian orange and mandarin industries. This followed the development of the citrus industry strategic investment plan by the Citrus Industry Advisory Committee (CIAC). Under the plan, which covers expenditure on both R&D and marketing, around $22m of grower levy funds (including matching commonwealth government contribution) will be spent to enhance the growth prospects for the citrus industry and the profitability of growers.

Economic models, which describe the interactions between supply and demand, and compute the outcomes for prices and quantities, are often used in the development of industry plans. Consequently, they are a useful tool for analysing key developments on the domestic and export markets and how these developments may impact on the industry, for example, on profits.

This report details the key features and structure of the model that we have developed. In addition, the report presents some key model simulations, which highlight key interactions within the model and illustrate the ways in which it could be used for industry planning. The key steps involved in developing the model are:

- constructing a database;
- developing the models theoretical structure;
- implementing the model;
- model checking and testing; and
- undertaking simulations of interest to the citrus industry to demonstrate the model.

We have completed these steps. The purpose of this report is to provide an overview of the model as well as raise several issues for the citrus industry to consider.

2 Database development

There are two broad steps in developing the database for the model:

- development of the input-output database; and
- determining values for key parameters.

The input-output database

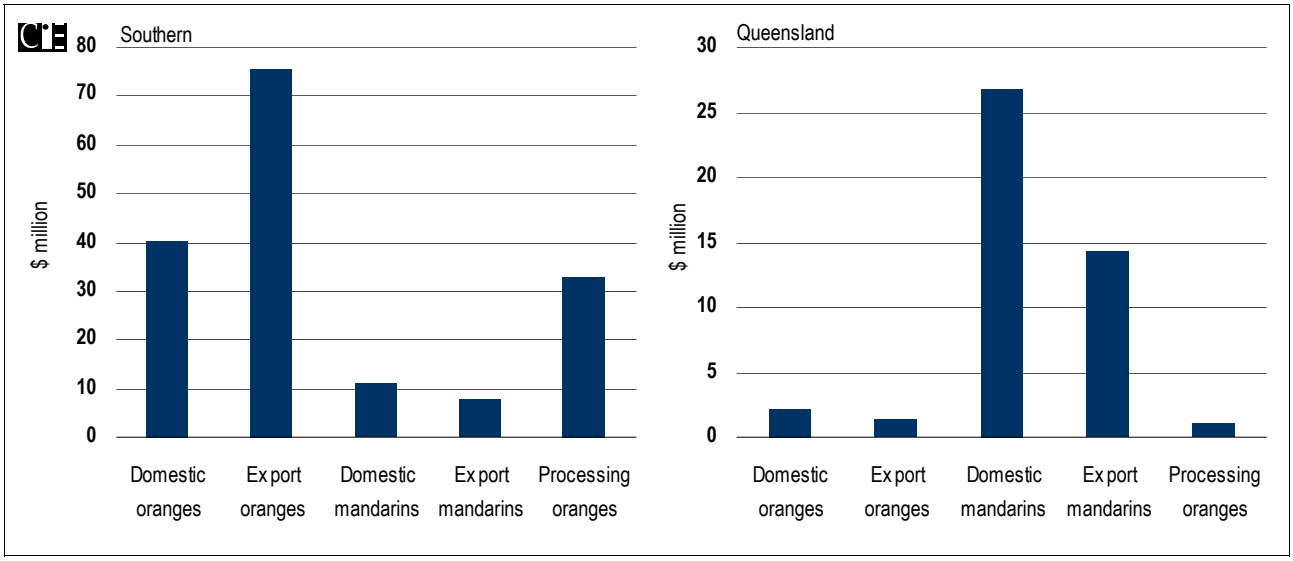
The input-output database describes all the key model flows, including:

- the use of inputs, including labour and capital on farm;
- sales of farm product to the domestic market, export market and processing industry; and
- the cost structure of the processing industry.

The citrus industry is interested in monitoring how their R&D program impacts on the profitability of the industry. In doing this, it is a useful exercise to examine how the income is generated within the industry. An input-output database is an ideal way to do this. Chart 2.1 shows the breakdown of farm output for both regions in the database, as well as by commodity and destination.

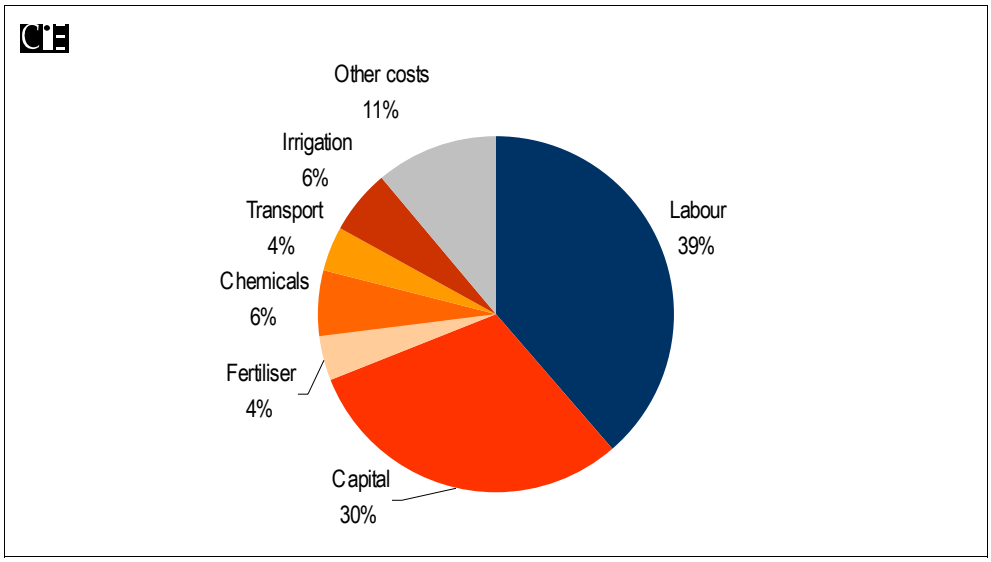
The chart clearly highlights several important characteristics of the Australian citrus industry. The first is the high value of orange exports relative to domestic consumption. This is partly driven by the relative quantities, however there is a price effect, particularly in high value orange exports to the US. In the southern regions, around 60 per cent of overall consumption of fresh oranges (not including processing oranges) is in export markets, while 65 per cent of the farm value of fresh orange production is derived from exports. The other feature is the high value of mandarin production relative to oranges in Queensland. Around 90 per cent of the total value of orange and mandarin production in Queensland is derived from mandarins.

2.1 Farm values by region



Data source: ABS.

2.2 On farm cost structure — orange production

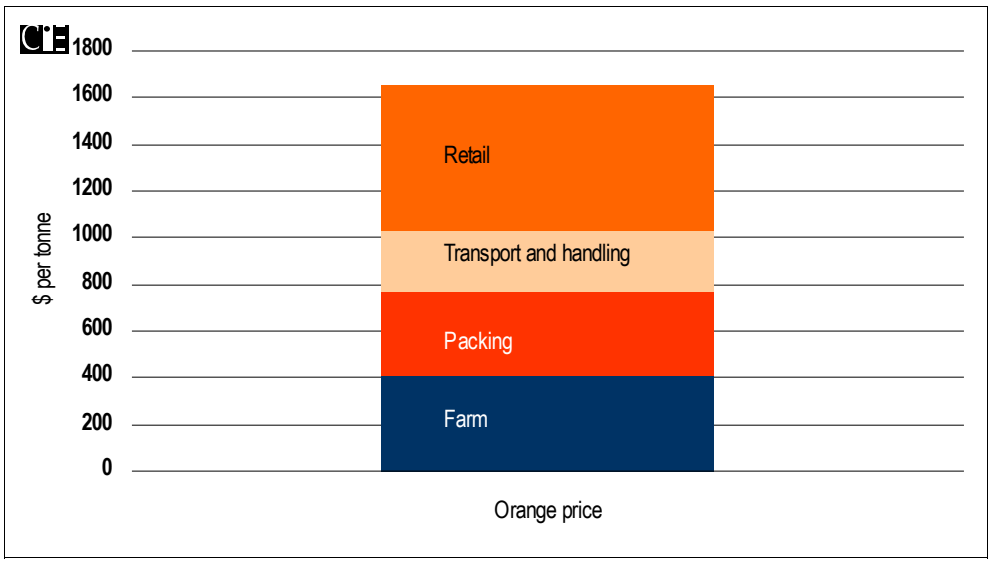


Data source: McGuickian 2001.

The other data of interest in the database are the breakdown of costs on farm and the structure of the various margins along the value chain. Chart 2.2 illustrates the farm cost structure. Around 70 per cent of total costs are labour and capital, with the rest made up of other costs such as irrigation, fertiliser and chemicals. The cost structure of an industry is important when considering an improvement in the productivity of one of the factors of production.

The margin structure used in the database is illustrated in chart 2.3.

2.3 **Breakdown of margins for oranges**



Data source: PC 2002.

The margin structure shown above is for fresh oranges sold on the domestic market. There is a farm price, onto which a packing margin is added, followed by transport and handling and finally a retail margin. The breakdown is slightly different for exports, since we are only concerned with the FOB export price. The database differentiates the various margins by destination. This means that the model has the capacity to simulate changes in just transport and handling for export markets for example.

Problems usually arise in database development where data are not readily available from recognised data sources such as the Australian Bureau of Statistics. In this case, there has been some trouble finding information from the processing industry on their cost structure. At this stage, we have estimated the information, but any further data that becomes available can easily be incorporated into the database for future use.

Estimating parameters

There are a number of parameters that need to be estimated to run the model. These parameters are called elasticities. An elasticity is a coefficient that indicates the responsiveness of a particular variable to a change in another variable. For example, the own price elasticity of the demand for oranges is the per cent change in demand that takes place as a result of a one per cent increase in price. Elasticities generally fall into the following categories:

- supply elasticity
  - own price
  - substitute
- demand elasticity
  - own price
  - substitute
  - income/expenditure

In the citrus model, the parameters that need to be estimated are:

- supply side
  - price elasticity of farm supply
  - substitution between the production of oranges and mandarins at the farm level
  - substitution between factors of production (labour and capital) in the processing industry
- demand side
  - domestic demand elasticity for farm product
  - export demand elasticity for farm product
  - domestic demand elasticity for processed product
  - export demand elasticity for processed product
  - import substitution elasticity for processed product
  - substitution between orange juice and other beverages at the retail level
  - substitution between citrus and other fruits at the retail level
  - expenditure elasticity

Elasticities are difficult to estimate in general, as there is usually little information available. Generally, elasticities are estimated using existing information on consumer and producer behaviour, adjusted to reflect the variations within a particular industry.

Table 2.4 shows the parameter values used in the model.

2.4 **Description of parameter values in model**

Parameter	*Description*	*Value*
Domestic demand elasticity – farm product	% change in domestic demand for a 1% increase in domestic price	-1
Domestic demand elasticity – processed product	% change in domestic demand for a 1% increase in domestic price	-2
Export demand elasticity – farm product	% change in Export demand for a 1% increase in Export price	-10
Export demand elasticity – processed product	% change in Export demand for a 1% increase in Export price	-10
Substitution between citrus in intermediate demand	% change in demand for processing input for a 1% change in other input price	1
Substitution between factors of production in processing industry	% change in demand for one factor for a 1% increase in price of another factor	0.5
Substitution to other fruit at the retail level	% change in demand for citrus products for 1% increase in price of other fruit	0.5
Substitution to other beverages at retail level	% change in demand for orange juice for 1% increase in price of other drinks	0.5
Import substitution for processed product	% change in demand for domestic orange juice for a 1% increase in price of imported juice	0.5
Supply expansion parameter	% change in total farm output for a 1% increase in the general price level	0.2
Farm substitution	% change in farm output of one commodity for a 1% increase in the price of another commodity	5
Expenditure elasticity	% change in demand for a 1% increase in real income	1

3 Model structure

The theoretical structure of the model describes the nature of the relationship between model variables. We have structured the citrus model as a typical value chain economic model. That is, the model traces production from the farm level through various margins to the final consumer (either Australian or overseas).

Farm production

At the farm level, the model distinguishes four commodities — oranges for processing, standard oranges, quality oranges and mandarins. The main reason for splitting oranges is to track high valued exports to the United States and lower value product sent to the processing industry. Obviously, it is important to represent the possible shifting of production between these differentiated markets.

Farm production is divided between Queensland and the southern states — accounting for the fact that a majority of mandarin production occurs in Queensland. Farm production is responsive to changes in the prices farmers receive for their product.

Margins

There are various margins imposed on commodities as they go through the value chain in the model. After produce leaves the farm, there is transport to the packing sheds, a packing margin, further transport and handling and a retail margin for domestic sales. These margins are specified for each commodity for both domestic and export markets.

Processing

At the farm gate, production is divided into that which is sold fresh to both domestic and export markets, and that which is sold to the processing industry. Once oranges have been sold to the processing industry, it then has a series of inputs and value adding factors (labour and capital) that

combine to produce orange juice, which is sold to both the domestic and export markets.

Exports

Exports are modelled for all farm commodities along with orange juice. Unique export demand elasticities are specified for each of these.

Domestic consumption

On the domestic market, consumer demand for farm product depends on income levels, the price of the product, as well as the price of substitutes. At the retail level, it is assumed that oranges and mandarins compete for the consumer dollar with other fruits. The degree of substitution depends on the fruit in question and consumers preferences. For ease of modelling, we have included a general price of other fruit variable, which can easily be changed to investigate the potential impact movements in the price of other fruits may have on the industry.

Demand for orange juice in the model is treated as a composite of demand for domestically produced orange juice and imported juice – generally frozen concentrate orange juice (FCOJ). Here, demand for orange juice in total depends on income, the overall price of orange juice (domestic and imported) and the price of substitutes. Substitutes in this case are other beverages, such as carbonated drinks, flavoured milk and other fruit juices that compete with orange juice at the retail level.

4 Simulations

There are many possible simulations that can be used to demonstrate how the model works. A useful starting point is the strategic investment plan prepared by the CIAC.

The plan identifies five areas of desired outcomes from the investment. Performance indicators have been formulated for each outcome. It is envisaged that these indicators will provide a means of measuring and monitoring progress in achieving desired outcomes throughout the life of the investment. An earlier report by the CIE (CIE 2002) evaluated the chosen indicators. This report highlighted the difficulties at looking at indicators in isolation. For example, what are the payoffs from a 10 per cent increase in export volumes compared with a 5 per cent increase in domestic consumption of Australian grown citrus products? The main problem with this is that the two indicators are not independent. This model provides the ideal opportunity to examine the relationships underlying how each of these scenarios will impact on the ultimate final outcome — citrus industry profitability.

The simulations we will be undertaking relate to the scenario described above. They are:

1. a ten per cent increase in export demand for oranges, mandarins and orange juice;
2. a five per cent increase in domestic demand for oranges, mandarins and orange juice;
3. a combination of simulation 1 and 2;
4. a ten per cent increase in farm output; and
5. sensitivity analysis around the supply elasticity.

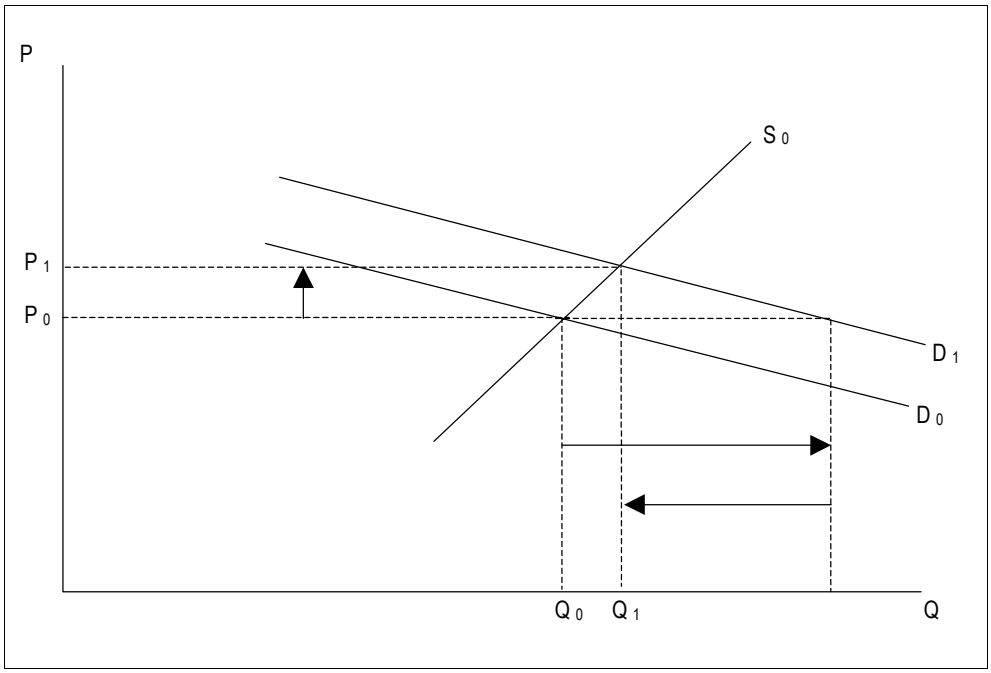
5 Results

Simulation 1: a ten per cent increase in export demand

Outcome 1 of the CIAC investment plan is increased demand for citrus products both domestically and overseas. The first indicator specifies an increase in tonnage in new export markets of 10 per cent at the end of the 5-year period. CIE's earlier report recommended using total export growth as the indicator, as the benefits of exporting to new markets as opposed to existing markets were not clear. The level of export demand is a better indicator than export quantities, however it would be a difficult indicator to formulate and monitor. Using the model however, it is possible to change the level of demand. This allows us to examine how the various interactions between demand and supply influence the impact of the change. Chart 5.1 illustrates the change.

The key parameters that determine what impact the shift in demand will have on the industry are the price elasticity of export demand and the

5.1 **Effects of an export demand shift**



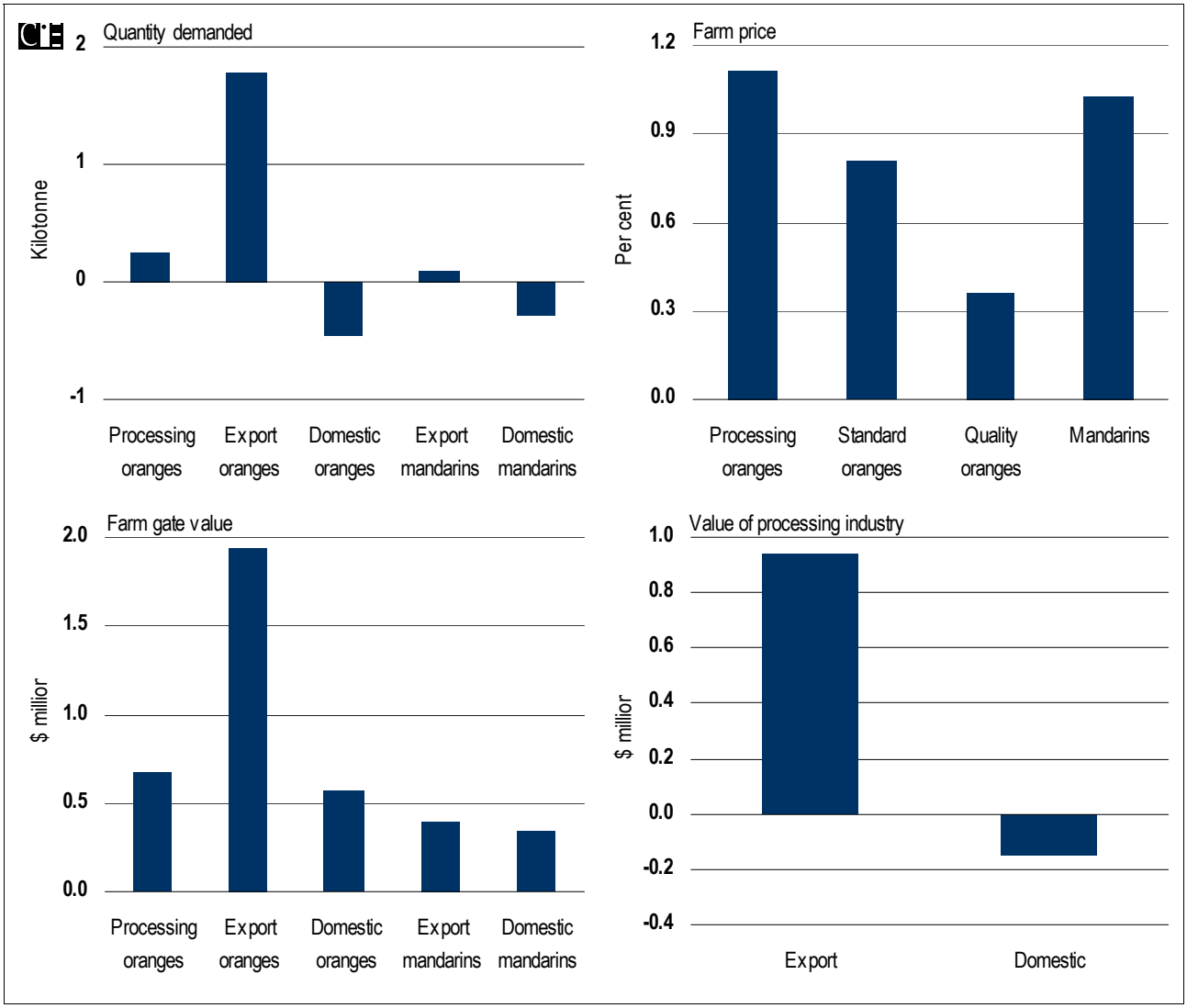
supply elasticity. In the short term, the elasticity of supply is fairly low for commodities such as oranges. This is reflected in the steep slope of the supply schedule. Export demand is generally more elastic than domestic demand, which is shown by the flat demand schedule. The initial change is in the quantity demanded, reflected in the movement outward at the initial price level P_0. Because supply is constrained, the price increases to P_1, which results in a movement along the demand curve and a reduction in quantity demanded. The relative slope of the demand and supply schedules determines the size of the increase in export quantity and price. The movement in prices then flows on to the domestic market where it impacts on consumption.

Chart 5.2 presents the results from the simulation. The export demand for all farm commodities, along with the export demand for orange juice is increased in this simulation.

As would be expected, the main impact of the change is on the exports of oranges and mandarins. The quantity of oranges exported increases by 1.8kt — an increase of just 1.2 per cent. Mandarin exports increase by 0.1kt or 0.4 per cent. These increases are small relative to the increase in demand due to an increase in prices. The impact on farm prices ranges from around 0.4 per cent to 1.1 per cent. These price increases are brought about by the fact that supply is constrained, and with a limited supply, an increase in demand pushes up the price. While this has the effect of choking off some of the export demand, it is interesting to note the effect on domestic consumption. Domestically, the consumption of both oranges and mandarins falls due to the increase in price. Despite this, the farm value of the domestic orange and mandarin industries increases in this simulation. This occurs due to the fact that the increase in farm price is sufficient in each case to offset the decrease in consumption. The key parameter in this case is the elasticity of domestic demand. If it were higher, consumption would decrease more, which may result in farm value decreasing. Overall, the farm value of orange production increases by around $3.2 million under this simulation — or around 2 per cent. The increase in demand for orange juice exports increases the value of processing exports and increases demand for processing oranges at the farm level.

The results of this simulation highlight the difficulty with targets involving increased consumption. Export consumption increases, but domestic consumption falls as prices increase. The next scenario deals with the reverse of this — an increase in domestic demand, and how this impacts on export demand.

5.2 **Results from simulation 1[a]**



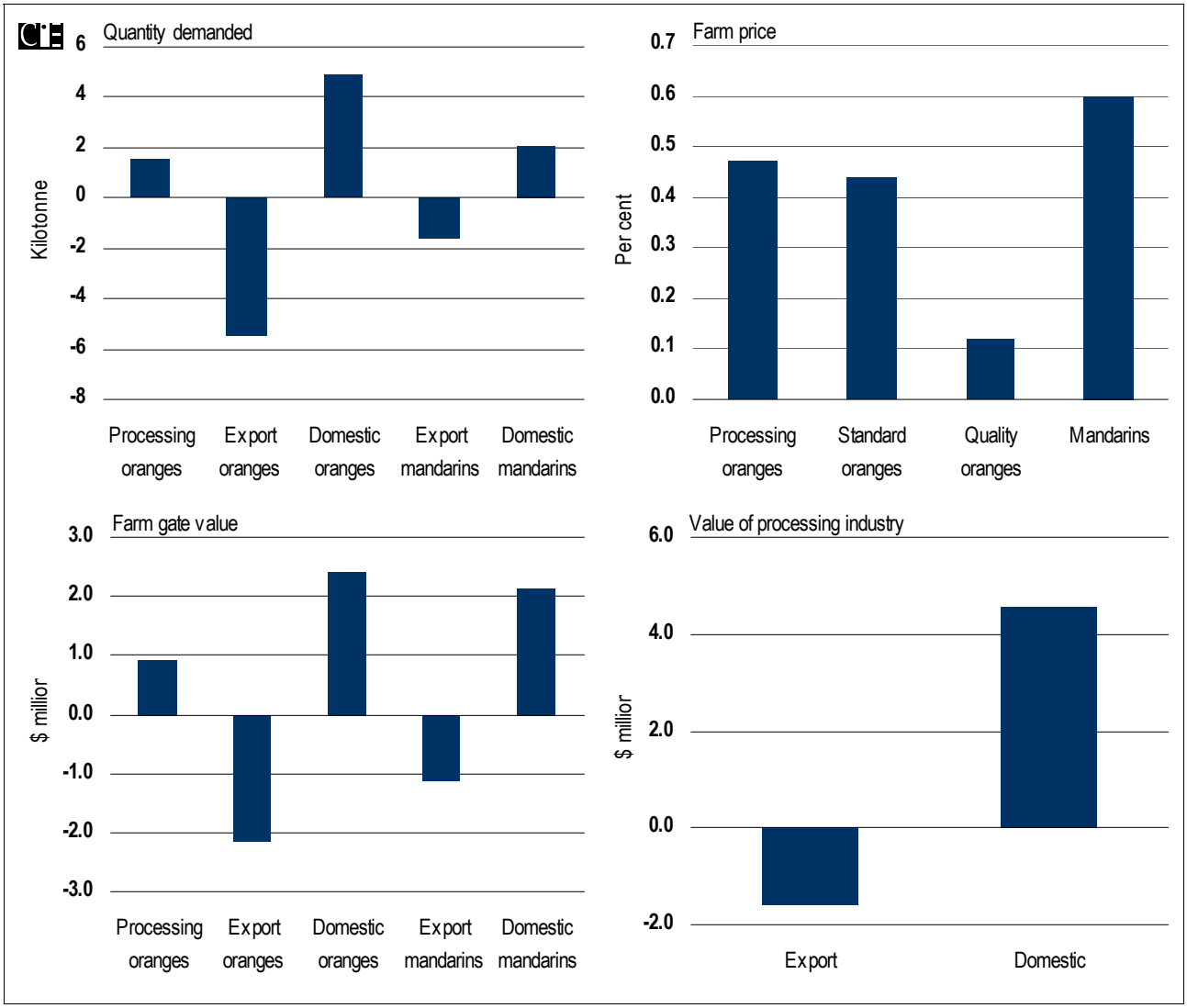
[a] Change from base.

Data source: CIE model.

Simulation 2: a five per cent increase in domestic demand

Simulation 1 dealt with a scenario where export demand for Australian citrus products increased by 10 per cent — in line with targets in the CIAC investment plan. Also under outcome 1 of the plan, the second indicator is that domestic consumption of Australian grown citrus products has increased by 5 per cent over the plan period. Once again, we will use the model to investigate a change in the level of domestic demand, rather than the quantity of domestic consumption. The results of this simulation are presented in chart 5.3.

5.3 **Results from simulation 2[a]**



[a] Change from base.

Data source: CIE model.

The first point that stands out in this simulation is that the increase in domestic demand has a large impact on export quantities. This occurs due to the fact that increasing domestic demand pushes farm prices up, which makes Australian citrus products less competitive on global markets and reduces demand. The reduction in demand is greater than the reduction in domestic demand experienced in simulation 1, both in absolute and percentage change terms. This occurs mainly because export demand is generally more elastic — so any increase in price has a larger impact on consumption in export markets than the domestic market.

Overall, the quantity of oranges demanded on the domestic market increases by around 5kt, while the quantity of oranges demanded by the processing industry increases by 3kt. In contrast, the quantity of oranges

exported falls by over 4kt. Domestic consumption of mandarins increases by 2kt, while exports fall by 1.6kt.

While in simulation 1 the farm value of domestic consumption increased despite a fall in consumption, a similar pattern does not occur for exports in this simulation. The farm value of domestic consumption of oranges increases by $2.4 million, while the farm value of orange exports falls by $2.2 million. Similarly, the farm value of domestic consumption of mandarins increases by $2.1 million while the farm value of mandarin exports falls by $1.1 million. Though there is still a net gain for both industries under this simulation, the gain is somewhat muted by the fall in exports.

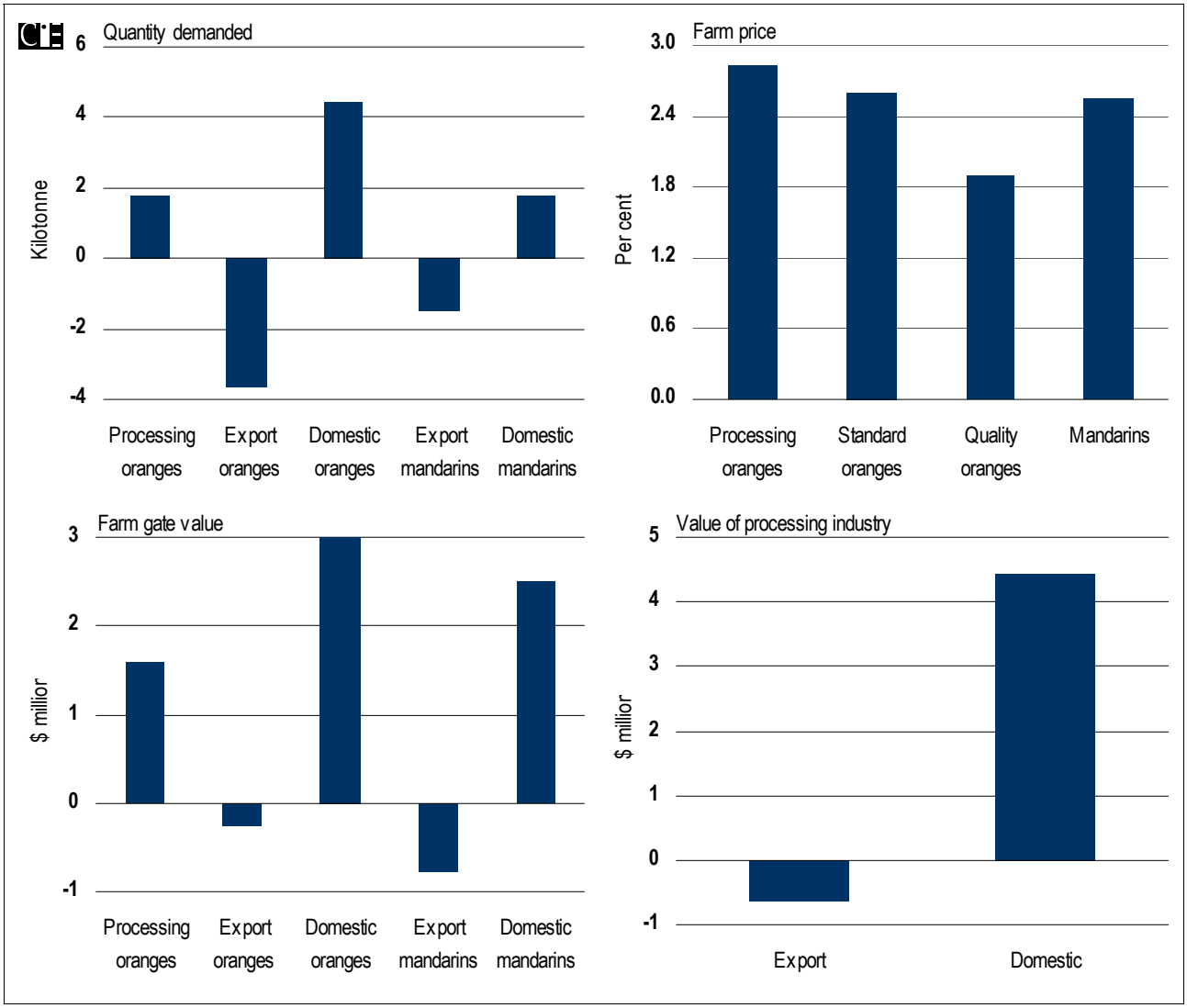
Simulation 3: a ten per cent increase in export demand and a five per cent increase in domestic demand

The results of the first two simulations demonstrate the difficulties in expanding either domestic or export markets independently. What may be of interest to the citrus industry is to examine the implications of an increase in demand both domestically and in export markets. The results of this simulation are presented in chart 5.4.

The quantity exported of both oranges and mandarins actually falls — despite one part of the change being a 10 per cent increase in export demand. This occurs as the combined pressure resulting from the domestic and export demand increase, along with a highly constrained supply pushes the price up to a level where exports fall. This is driven by the high export demand elasticity. Farm prices increase by as much as 2.8 per cent. The farm value of production increases for all commodities selling to the domestic market, with the value of exports falling. The combined fall in the value of exports is small relative to the decrease in quantities exported. Similar to simulation 1, this occurs because the increase in prices partially offset the reduction in consumption.

Overall, the farm value of total orange production increases by $2.7 million, while value of mandarin production increases by around $1.7 million. Once again, the key parameter driving the results of this simulation is the supply elasticity.

5.4 **Results from simulation 3[a]**



[a] Change from base.

Data source: CIE model.

Simulation 4: A ten per cent increase in farm output

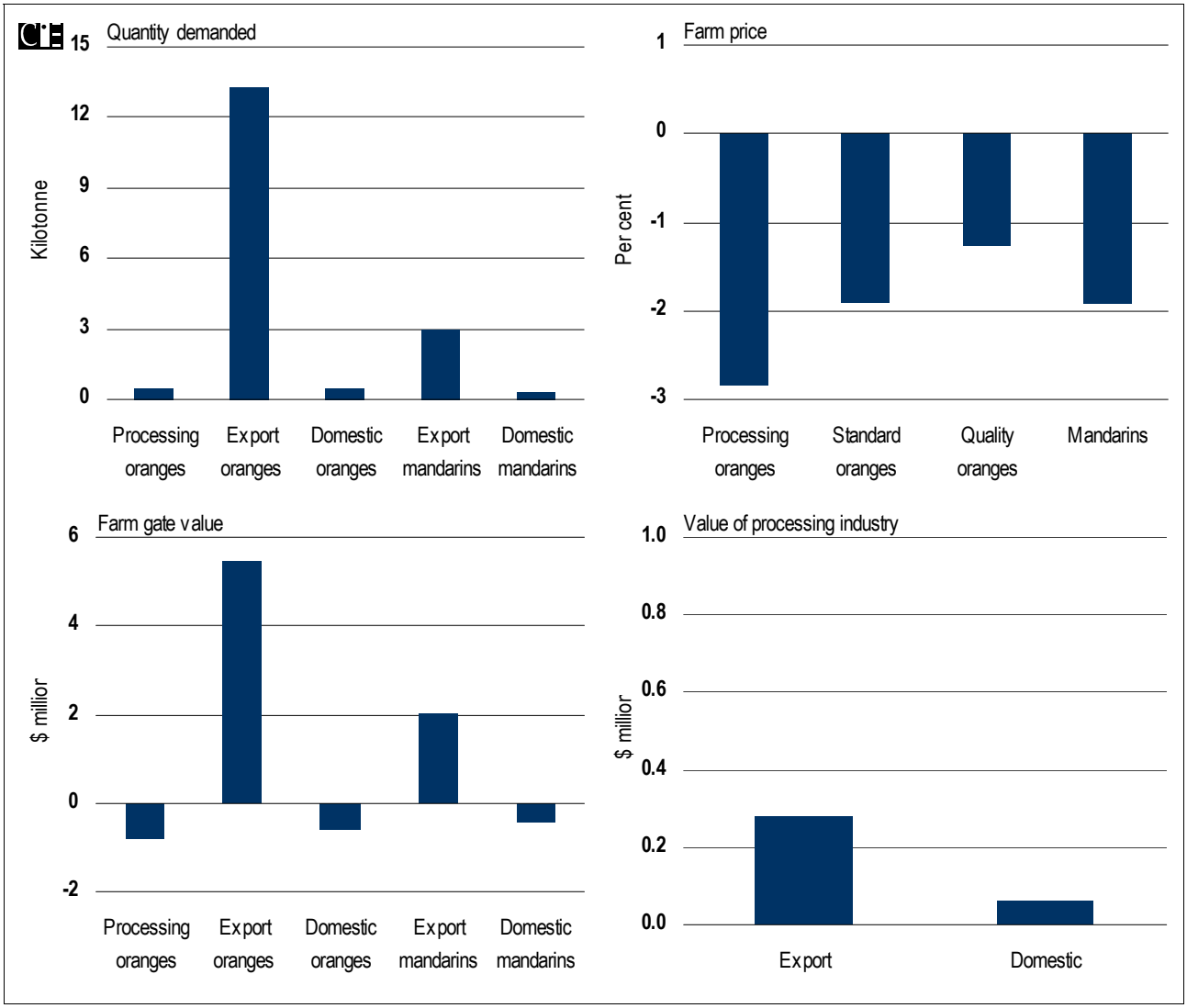
While it is useful from a marketing perspective to examine the effects of increases in demand in both the domestic and export market, a more regular issue that confronts the citrus industry is variations in supply. This simulation examines the effect of a 10 per cent increase in farm output. The results are presented in chart 5.5.

The main initial impact of an expansion in supply is to reduce prices. The farm price of all commodities falls, with the price of standard oranges falling by almost 2 per cent. This fall in price stimulates demand. The

increase in demand is particularly high on the export market, where the price elasticity of demand is relatively high. The quantity of oranges demanded on the export market increases by over 13kt, while the quantity of mandarins demanded on the export market increases by around 3kt. The quantity demanded on the domestic market increases significantly less, with the quantity of oranges increasing by just 0.5kt and the quantity of mandarins increasing by 0.35kt.

The farmgate value of orange exports increases by $5.5 million under this scenario. The value of mandarin exports increases by $2 million. In contrast, the farmgate value of oranges consumed on the domestic market falls by $0.61 million, while for mandarins the domestic value falls by $0.44

5.5 **Results of simulation 4[a]**



[a] Change from base.

Data source: CIE model.

million.

The main determinant of the impact of changes in supply on prices is the relative price elasticises of export and domestic demand. With a low domestic price elasticity, domestic consumption shows little increase in response to the fall in price. Export consumption is more price sensitive, so consumption increases more in export markets. If either domestic or export demand were more price sensitive, the price fall would be smaller. The impact on the processing industry is relatively small, with the overall value increasing by around $0.34 million.

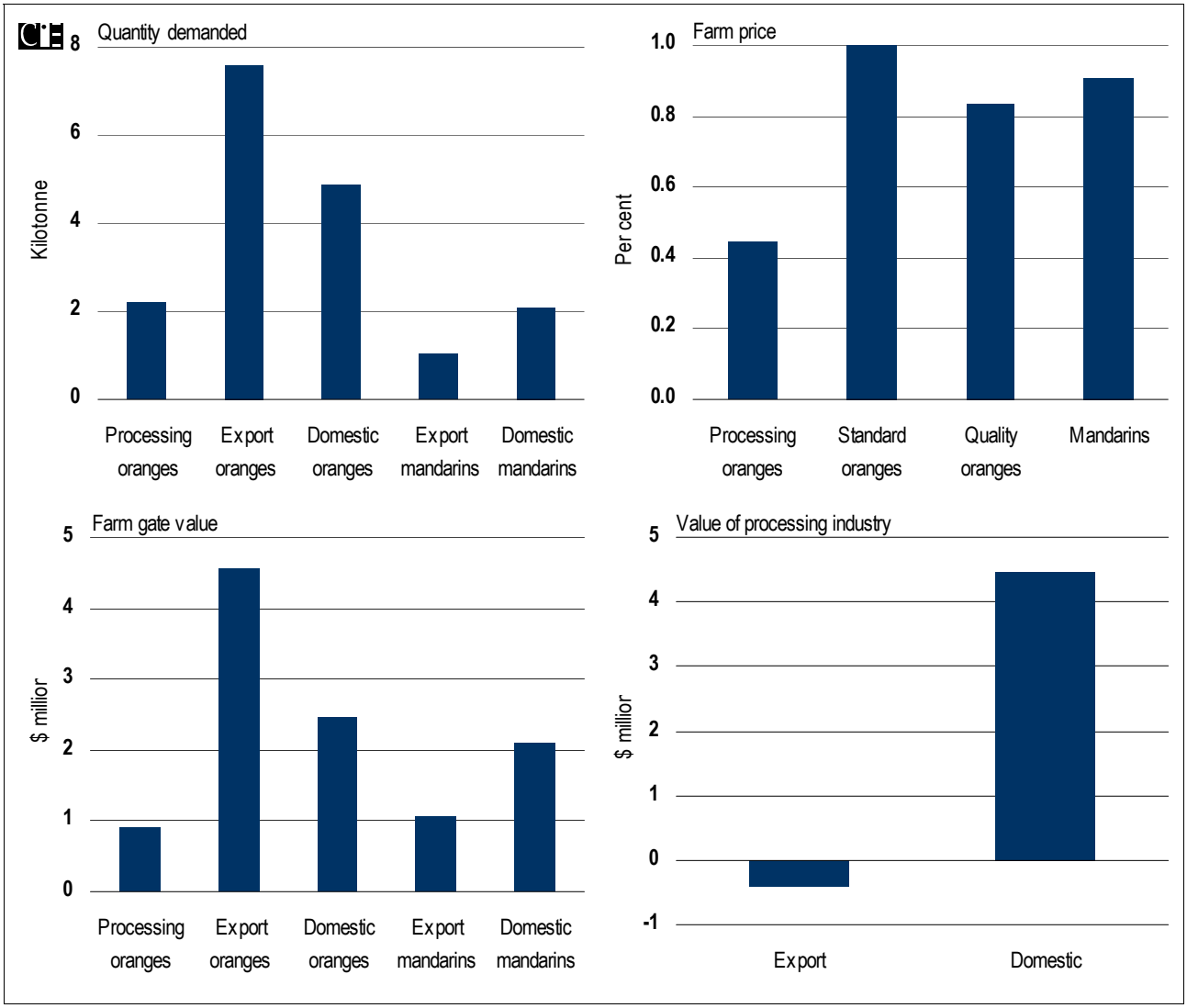
Sensitivity analysis: the supply elasticity

In the simulations presented above it was assumed that there was virtually no supply responsiveness. The supply elasticity used in each case was 0.1. This means that for every 1 per cent increase in the price of a commodity, for example mandarins, farmers would increase supply by 0.1 per cent. The reason such a low responsiveness was chosen was that the timeframe for the CIAC investment plan is five years. In this time, it would be reasonable to argue that supply response over that period would be quiet low. It takes five years for a newly planted citrus tree to begin bearing fruit — so any supply response over such a period would be limited to any excess capacity that is not presently being utilised.

In effect, the results presented earlier were short-run simulations. To demonstrate the effect of the choice of supply elasticity on the model results, we will test the sensitivity of the results from simulation 3 to the supply elasticity. To do this, we change the supply elasticity for the farm product from 0.1 to 5. This can be seen as a long-run simulation, where the industry has time to adjust supply to reflect changes in demand conditions. These results are presented in chart 5.5. As the results show, increasing the responsiveness of supply has a big impact on the outcome of the simulation.

The increase in export and domestic demand combined with greater supply responsiveness results in an increase in quantity demanded for all commodities. These impacts range from 1kt for export mandarins to 7.6kt for orange exports. The impact on farm prices is lower in this case than in simulation 3 — with increases of up to 1 per cent. This occurs as farm output is able to expand to meet the extra demand and the pressure on prices is therefore lower. Farm value increases for each commodity — the overall farm value of orange production increases by around $7.9 million, while the farm value of mandarin production increases by $3.2 million. These represent increases of around 5 per cent in the value of both commodities.

5.6 **Results of sensitivity analysis**[a]



[a] Change from base.

Data source: CIE model.

Relative to simulation 3, the farmgate value of orange production increases by $3.6 million, while the value of mandarin production increases by $1.4 million.

The impact of the demand increase on the processing industry is a small reduction in the value of exports and a large increase in the value of domestic consumption. While the level of export demand is increased in this simulation, the overall price increase of output from the processing industry actually results in a decrease in export quantity. This is due to the high export demand elasticity relative to domestic demand elasticity. The export quantity demanded decreases by around 2.5 per cent. The processing industry exports only a small proportion of their total output, so the change is only marginal in absolute terms.

This sensitivity analysis demonstrates the importance of the supply elasticity in the outcomes of simulations. This is especially important in simulations with demand side changes as the responsiveness of supply to price changes determines the changes in quantity demanded on both the domestic and export market. It also highlights the importance of distinguishing between short-run and long-run simulations. In the longer term, factors such as technological change and the level of capital are more variable. When deciding on future uses for the model, the citrus industry will need to identify in each case what timeframe is involved with each simulation.

6 Model development

Following initial feedback from the industry we have modified several model parameters and the results presented in this report are different to those presented previously. The next step is to identify areas where the model can be further modified and extended. This section will outline potential developments that have been raised by the industry.

There are several options for further development of the model. The advantage of the model structure is that it is expandable in terms of commodity coverage, industry coverage and export destinations. The model developments that could be considered include:

- expanding the commodities by splitting oranges into navel and valencia varieties to capture the difference in price and the different processing rate for each variety;
- incorporating different export destinations into the model. This would involve manipulating the current structure, which effectively has the US as a separate destination through assuming a different commodity is exported to the US. This accounts for the high price of exports to the US. With different destinations, the US and other markets could be included with a unique price and demand equation;
- expanding the processing industry as a part of the model by incorporating more accurate information on the cost structure of the industry. This would allow simulations specifically relating to the processing industry to be performed, but would rely on detailed information from the processing industry;
- incorporating a packing industry into the model. Once again, this would require detailed information on the cost structure of the packing industry; and
- expanding the commodity coverage to include other fruits. This could be done on a commodity by commodity basis, however it would be more cost effective to incorporate several additional commodities at once.

These options will have different costs attached to them[1]. There are opportunities to incorporate other sources of funding. For example, the processing industry could fund the development of the processing component of the model. Simulations of interest to the industry could be performed as part of the analysis to provide value to the processing industry and demonstrate the usefulness of the model in exploring issues of relevance to the industry. Similarly, the option of expanding the model to incorporate other horticulture products would require funding from the relevant industry associations. This is also one area where additional value could be provided to an organisation such as HAL, which has various industries under its banner and incorporating some of the major industries into a consistent framework has the potential to assist HAL with its overall strategic plan.

[1] Costings for the various options are provided in a separate document.

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