Endogenising structural change and the effect of imports on the Australian pig industry

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Abstract

We use a state-space representation of an ARMA model of the Australian pig industry to investigate the effect of imports on the pig industry. The results suggest that a decline in pigmeat exports, while at the same time imports continued to rise resulted in an acute but temporary oversupply, a loss of market confidence and an initial sharp fall in producer prices. A peak in imports the previous October, designed to capture the lucrative Christmas leg ham market, resulted in processors finding themselves with excess stock of pigmeat in Jaunary 1998 and accordingly slashed demand for both domestic and imported pigmeat. Both the fall in exports, resulting in domestic production being diverted to the domestic market, and the impact of increased imports resulted in a fall in producer prices. The role of the AQIS decision to lift quarantine restrictions on manufactured pigmeat products from Canada is not clear cut, but undoubtedly an opportunity for further importation contributed to the evaporation of market confidence and the subsequent crash in producer price.

1. Introduction

In 1990 the structure of the Australian pig industry changed significantly from being a inwardly looking industry with zoosanitary restrictions on imported pigmeat to one that faced significant competitive pressure from imports. The 1990 Australian Quarantine Inspection Service (AQIS) decision to allow imports of bone-out pigmeat from Canada resulted in domestic prices being subjected to downward pressure as domestic producers competed with lower cost imports.

The importation of pigmeat from Canada, although unwelcome by the domestic producers, was tolerated as average producer prices were still above the costs of production. This situation changed drastically in the last quarter of 1997 as producer prices fell rapidly below the cost of production. The substantial majority of producers were making an operating loss exacerbated by the need to continue feeding animals (feed comprising 60-70% of production costs), the virtual write-off of capital, and the increase in farm indebtedness both to banks and to feed mills who extended lines of credit when banks refused to extend overdrafts [20, 16].

The exact cause of this sudden fall in producer prices post 1997 has been hotly debated. Some of the various suggestions have been:

1. An increase in pigmeat production [2].

2. An oversupply of pigmeat and a fall in consumer demand[1] [6, 7].

3. An increase in imports [9, p. 16].

4. A fall in cattle prices resulting in a concomitant fall in pig prices [11].

5. A decision by a major retailer to cease exports of pigmeat due to the Asian financial crisis [8].

6. A change in AQIS import protocols allowing imports of manufactured pigmeat from Canada and bone-out pigmeat from Denmark [14].

7. A reduction in processor demand for domestic pigmeat due to imports capturing the Christmas market [2] [13].

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[1]An increase in production results from a rightward shift in the supply curve whereas an oversupply results from an upward movement along the supply curve out of or away from equilibrium.

[2] *"In January this year the situation came to a crunch. With large quantities of stock still in*

The contention that an increase in production or a fall in consumer demand is the cause of the decline in producer prices has been shown by Purcell and Harrison [18, pp. 74-101] to be unfounded. Production is below the long term trend and ABS consumer demand figures are calculated from supply data [18, pp. 74, 84],[12] thus separate estimation of demand is not possible. Further, Purcell and Harrison [18, p. 97] show that production is stable, with market equilibrium rapidly regained after a short run deviation. Thus it is unlikely that any oversupply in production will have a long term effect on the market.

Purcell and Harrison [18] quantify the effects of imports on producer prices and conclude that imports depress producer prices by around 10¢/kg for every 1000 tonnes imported. However, they only look at the period 1984:1 to 1997:2, and thus do not estimate what the effect of imports have been since the last quarter of 1997. It is to be expected that the effect of imports on producer prices would not have changed substantially over the intervening period, and thus the fall in producer price since the last quarter of 1997 would not be solely due to imports themselves, unless imports had substantially increased during this period.

Whereas cattle prices have fallen dramatically since January 1996, from 186¢/kg to a low of 131¢/kg in June 1996, before recovering, this drop has preceded by nearly two years the drop in pig producer prices. Purcell and Harrison [18] show that cattle prices do not contribute significantly to changes in pig producer prices, as substitution effects are isolated at the retail level.

The final three suggestions need further analysis as they suggest a combination of factors, imports, exports, and market confidence resulted in the observed decline in producer prices at the end of 1997.

The scenario suggested is that the reduction in exports by a major retailer, while at the same time a continuing rise in imports of pigmeat to cater for the Christmas leg ham market, resulted in an immediate 10¢/kg reduction in producer prices[3]. According to Queensland Pork Producers Organisation (QPPO) price data the turning point appears to be 22nd September 1997 with further sharp falls the fortnight leading up to the 7th November 1997 AQIS decision and following the resumption of selling after the Christmas break on 5th January 1998 (See Figure 1.1). After the reduction in exports, which appears not to have taken

store the only way any one boning pigs could operate was to buy them cheap enough so that (a) boneless leg cuts competed with Canadian product and (b) the other primals could also be priced low enough to maintain demand. To get prices back to these sorts of levels all processors and boning rooms simply cut back on purchases of livestock. The price consequently crashed"[13, p. 2].

[3]The source of this information requested to remain anonymous.

effect until November 1997 (See Figure 1.1), the market was further buffeted by the AQIS decision to allow imports of manufactured product from Canada, and bone-out processing pigmeat from Denmark. The final event which consolidated the slide in producer prices was the peak in imports the previous October (See Figure 1.2), designed to capture the lucrative Christmas leg ham market. At the beginning of 1998 processors found themselves with excess stock of pigmeat and accordingly slashed demand. These three events, a combination of increasing imports, decreasing exports, and an opportunity for further importation due to the lifting of quarantine restrictions, resulted in the evaporation of market confidence and the subsequent crash in producer price.

The partitioning and the quantification of the effects of imports and exports on producer prices has already been documented by Purcell and Harrison [18]. What has not been carried out is an analysis of the effects of the change in import protocols, along with the market confidence effects of the events in the last quarter of 1997 on producer prices.

One of the problems with the type of analysis carried out in the Purcell and Harrison report [18] is that the effect of a particular exogenous variable, say imports, on the endogenous variable, say producer prices, is an average effect over the whole time period under consideration. What the analysis does not show is how the relationship between the exogenous and endogenous variables change over time due to the changing institutional structure of the market. What we attempt to do in this paper is to show how the structure of the market changes over time and partition the fall in producer prices at the end of 1997 into the effect of imports, exports, and market confidence. We use a state-space model of the Australian pig industry to capture the institutional change and market dynamics.

2. Kalman filters and state-space models

A technique needs to be devised that isolates the internal dynamics of the industry from unique external circumstances and yet at the same time shows that these external factors are not part of the general economic climate. Tests of structural change do not show this as they are incapable of distinguishing between the impact of external and internal factors on changing industry structure.

The Kalman filter is a tried and tested estimation technique that has been in use for almost 40 years. It allows the estimation of empirical models where the model structure may be changing. Further, the method is robust against the omission of relevant variables as this simply leads to shifts in the systematic
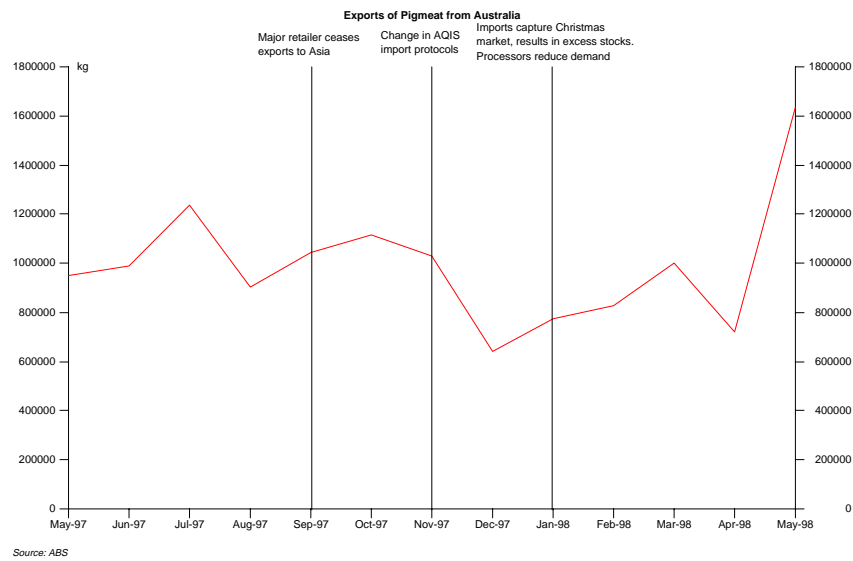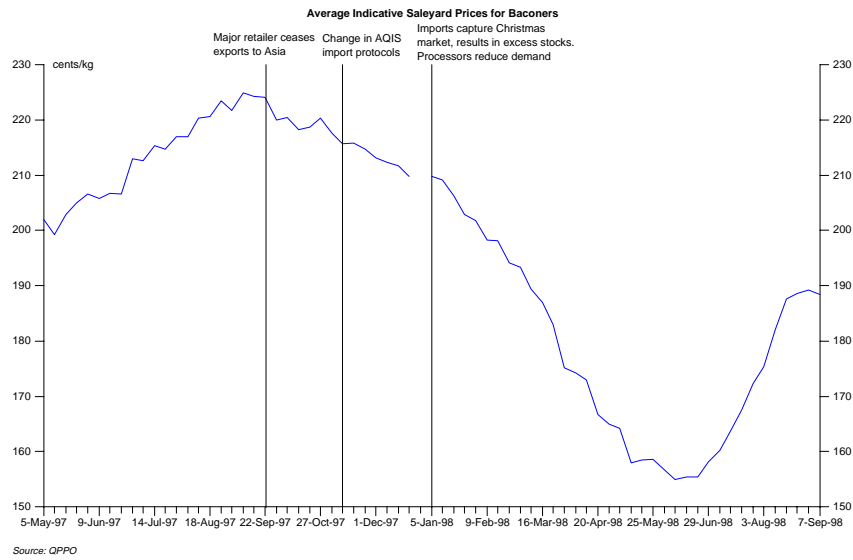
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Average Indicative Saleyard Prices for Baconers

Major retailer ceases exports to Asia

Change in AQIS import protocols

Imports capture Christmas market, results in excess stocks. Processors reduce demand

cents/kg

230
220
210
200
190
180
170
160
150

5-May-97 9-Jun-97 14-Jul-97 18-Aug-97 22-Sep-97 27-Oct-97 1-Dec-97 5-Jan-98 9-Feb-98 16-Mar-98 20-Apr-98 25-May-98 29-Jun-98 3-Aug-98 7-Sep-98

Source: QPPO

Exports of Pigmeat from Australia

Major retailer ceases exports to Asia

Change in AQIS import protocols

Imports capture Christmas market, results in excess stocks. Processors reduce demand

kg

1800000
1600000
1400000
1200000
1000000
800000
600000
400000
200000
0

May-97 Jun-97 Jul-97 Aug-97 Sep-97 Oct-97 Nov-97 Dec-97 Jan-98 Feb-98 Mar-98 Apr-98 May-98

Source: ABS

Figure 1.1: Producer prices and exports of pigmeat
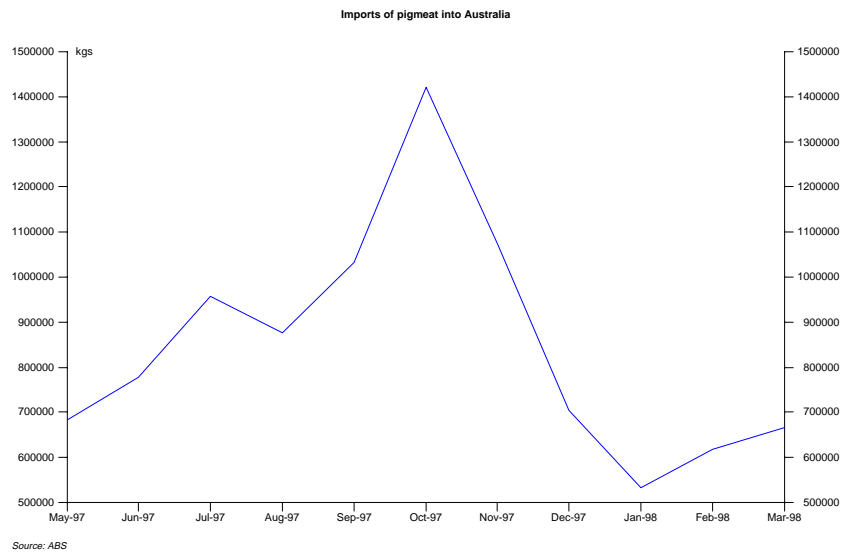
5

Imports of pigmeat into Australia

Figure 1.2: Imports of pigmeat into Australia (all sources)

component of any model, which the Kalman filter is designed to handle.

If an industry's dynamics were due solely to internal factors then using a Kalman filter to estimate the industry dynamics would be a simple matter. In the presence of exogenous but continuous variables the Kalman filter would still provide a relatively good fit as it is robust against omission of these variables. Thus latent variables and other unobservable variables are all incorporated into the state dynamics. Unique historical events can, however, disrupt the ability of the Kalman filter to estimate system dynamics and thus its ability to forecast. We can use this feature and show that internal and systematic changes in the industry can be identified separately from unique historical events. If it can be shown that the fall in pig prices in late 1997 was due to such an exceptional event that was unique to the industry and yet external then a case for Exceptional Circumstances under the auspices of the Rural Adjustment Scheme Advisory Council (RASAC) would have been established.

In order to use the Kalman filter to capture the dynamics of the industry, a model needs to be developed that explains the structure of the industry.

A state-space model is a representation of a multivariate, dynamic system of time series that encompasses a wide range of models. For example any Gaussian

multivariate stationary model has a state-space representation, including ARMA models[4].

A state-space model allows unobservable variables (the state variables) like structural breaks to be incorporated and estimated along with the observable model. The state-space model uses the Kalman filter to estimate VAR models with changing coefficients. The advantage of this is that coefficients which are changing due to (unobservable) structural breaks can be accurately estimated.

The state space representation of a dynamic system is given by

$$\xi_{t+1} = \mathbf{F}\xi_t + \mathbf{v}_{t+1} \tag{2.1}$$
$$\mathbf{y}_t = \mathbf{A}'\mathbf{x}_t + \mathbf{H}'\xi_t + \mathbf{w}_t \tag{2.2}$$

where $\mathbf{y}_t$, a $(n \times 1)$ vector of variables observed at time t, ξ_t is a (possibly unobserved) $(r \times 1)$ state vector, $\mathbf{F}$, $\mathbf{A}'$, and $\mathbf{H}'$ are $(r \times r)$, $(n \times k)$, and $(n \times r)$ matrices of parameters respectively, and $\mathbf{x}_t$ is a $(k \times 1)$ vector of exogenous variables [15, pp.372-373]. Equation 2.1 is the state equation and equation 2.2 is the observation equation. $\mathbf{v}_t$ and $\mathbf{w}_t$ are a $(r \times 1)$ and $(n \times 1)$ vector of white noise terms respectively with

$$E\left(\mathbf{v}_t\mathbf{v}'_\tau\right) = \begin{cases} \mathbf{Q} & \text{for } t = \tau \\ 0 & \text{otherwise} \end{cases}$$

$$E\left(\mathbf{w}_t\mathbf{w}'_\tau\right) = \begin{cases} \mathbf{R} & \text{for } t = \tau \\ 0 & \text{otherwise} \end{cases}$$

$$E\left(\mathbf{v}_t\mathbf{w}'_\tau\right) = 0 \quad \text{for all } t \text{ and } \tau$$

Given information about $(\mathbf{y}_t, \mathbf{x}_t)$ we can estimate $\mathbf{F}$, $\mathbf{A}'$, $\mathbf{H}'$, $\mathbf{Q}$ and $\mathbf{R}$ and make inferences about the state vector ξ_t using the Kalman filter algorithm.

The formation of the state-space model requires that $\mathbf{A}'$ and $\mathbf{H}'$ are computed through the formation of a VAR model enabling initial estimates of the state vector ξ_t to be formed by canonical correlation analysis [5]. Having obtained an initial estimate of the state vector, $\mathbf{F}$, and $\mathbf{Q}$ can then be estimated through maximum likelihood. Once the state-space model is estimated, forecasts can be produced through the Kalman filter (See [15, pp.377-381]).

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[4]See [4] for a proof of equivalence.

3. Dataset

The dataset used is identical to that used in Purcell and Harrison [18]. The dataset comprises of quarterly data for prices[5] and quantities.

1. Saleyard Price for Baconers ($¢/kg$) (SPQ) Average of dressed weight stock prices weighted by production in each state [1],[19][6].

2. Saleyard Price for Beef Cattle ($¢/kg$) (SBFQ). Average of dressed weight stock prices weighted by production in each state [1].

3. Retail Price for Pork ($¢/kg$) (RPQ). Actual average price of pork in Dec-73 indexed forward by beef subgroup index of the CPI [1].

4. Imports of Fresh, Frozen Pigmeat from Canada (kg) (CANVQ) [10, Series PS-10010].

5. Import Prices for Pigmeat from Canada ($¢/kg$) (CANPQ) Unit value [10, Series PS-10010].

6. Domestic Production of Pigmeat ($Tonnes$) (PPDQ) [3, Table 7215-2].

7. Exports of Pigmeat (kg) (XVQ)[3, Table 7215-2].

Due to commercial-in-confidence reasons exports are not differentiated between farmed and feral pigmeat. Purcell and Harrison [18] found that the combined feral/farmed export series did not have a significant effect on the DGP of producer prices. The export series (described as "Exports of Pork" and "Exports of Bacon and Ham" in ABS cat.7215.0) used in this paper was obtained after the Purcell and Harrison report was published and consistently under-reports exports compared with the combined export series. As such, we suspect that the export series used in this paper does not contain feral pigmeat export data, although the series description does not give an indication that this is so.

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[5]All prices are quoted in cents per kg (Australian dollars) and prices for baconers are expressed as Hot Standard Carcase Weight (HSCW).

[6]Simple average of producer prices by state, indicative only. Jan-84 to Jun-97 from ABARE, Jul-97 to May-98 from Queensland Pork Producers Organisation. The term "Saleyard price" is used used interchangeable with producer prices - pigs are sold direct to abattoirs rather than sold via a saleyard - as this is consistent with ABARE and ABS terminology.

Purcell and Harrison tested the series for seasonal and non-seasonal unit roots, and concluded that all except import volumes and prices contained a unit root which could be removed by first differencing, that is, SPQ, SBFQ, RPQ, PPDQ, XVQ were all $I(1)$. Import volumes and prices were seasonally integrated $SI_4(0,1)$, that is, fourth differences would remove their unit roots. Deterministic seasonality was discovered for the domestic industry variables, that is, quarterly dummy variables needed to be added to the series to account for seasonal fluctuations.

4. Results

A state-space model of the Australian pig industry was constructed to capture the dynamics of market equilibrium, institutional change and exogenous shocks to the industry. Three models were constructed.

The first model assumes that the industry is not subjected to external shocks but the estimation period is restricted to before the end of 1997. This enables the model to ignore the impact of changing imports and exports over the last quarter of 1997 and assume that the industry dynamics have not changed. If prices and quantities significantly deviate from their forecasted values then this implies that a combination of imports, exports and external shocks have impacted on the industry structure.

Since we have not distinguished between the effect of imports, exports and external shocks we can construct a second model to analyse this. A second model is constructed similar to the first, but the estimation period covers the whole dataset period, to the second quarter 1998. The second model also assumes that the industry is not subjected to external shocks and that changes in quantities and prices are explained by movements in other quantities or prices. If prices and quantities significantly deviate from their forecasted values, this implies that external shocks have impacted on the industry structure.

The third model constructed is similar to the second, but contains a structural break dummy covering the period from the last quarter 1997 onwards. The addition of the structural break dummy allows the state-space model to capture the effect of any external shock that occurred after the third quarter of 1997. Note that such external factors cannot be accounted for by the addition of an additional continuous variable. If prices and quantities significantly deviate from their forecasted values, this implies that additional external shocks, other than that occurring during the last quarter of 1997 have impacted on the dynamics of

the market equilibrium.

For all models the state vector was estimated from the VAR model of producer prices (SPQ), retail prices (RPQ), production (PPDQ), saleyard prices for cattle (SBFQ), export volumes (XVQ), import volumes (CANVQ) and import prices (CANPQ), all in stationary form (i.e. SPQ, RPQ, PPDQ, SBFQ and XVQ were $I(1)$ and CANVQ and CANPQ were $SI_4(0,1)$)[7]. The state-space model was estimated over the period 1988:1 to 1998:2[8] and forecast ahead 5 quarters. After the transition matrix $\mathbf{F}$, input matrix $\mathbf{Q}$ and covariance matrix $E(\mathbf{v}_t\mathbf{v}'_\tau)$ are estimated the forecasts for the state-space model are computed. Confidence intervals for the forecasts are calculated and if the actual value in any one period falls outside the confidence intervals, this implies that an exogenous shock to the industry has occurred.. The 90% confidence intervals are presented, and should be interpreted as equivalent to a one-tailed 95% confidence level, that is, we can be 95% certain that the actual value is not significantly greater(or less) than the forecast value.

4.1. A state-space model of the pre 1997:4 pig industry

The first model estimated does not take into consideration events that occurred after 1997:3, enabling the model to assume that events subsequent to this period would follow the same systematic pattern as previous events. The results are presented in Figures 4.1 to 4.4.

The state-space model tracks changes in producer prices very well, with actual producer prices not significantly different than the forecasts for all periods except 1997:2. This indicates that there was a temporary exogenous shock to producer prices at this time period. After 1997:3 the actual producer prices deviate from the forecasted prices, although still within the confidence intervals. The p-value for the actual producer prices in 1998:2 is under 0.06, close to the critical value of 0.05. The actual producer price is not significantly different from the forecasted

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[7]An intercept, time trend and seasonal dummy variables in all combinations were initially added to the model to account for deterministic seasonality and trends over time. In all cases, except when only 1st and 2nd quarter dummy variables were added, the maximum likelihood algorithm failed to converge, possibly due to lack of degrees of freedom to overcome the instability of the initial estimates. Since all latent variables and systematic components are subsumed into the state vector it was decided not to explicitly incorporate trends or seasonal effects into the initial VAR model.

[8]Export data was only available from 1988:1- 1998:2 restricting the time period for analysis to these dates.

Actual and Forecast Saleyard Prices for Baconers
Model without Structural Break, Pre 1997:4

Actual and Forecast Production of Pigmeat
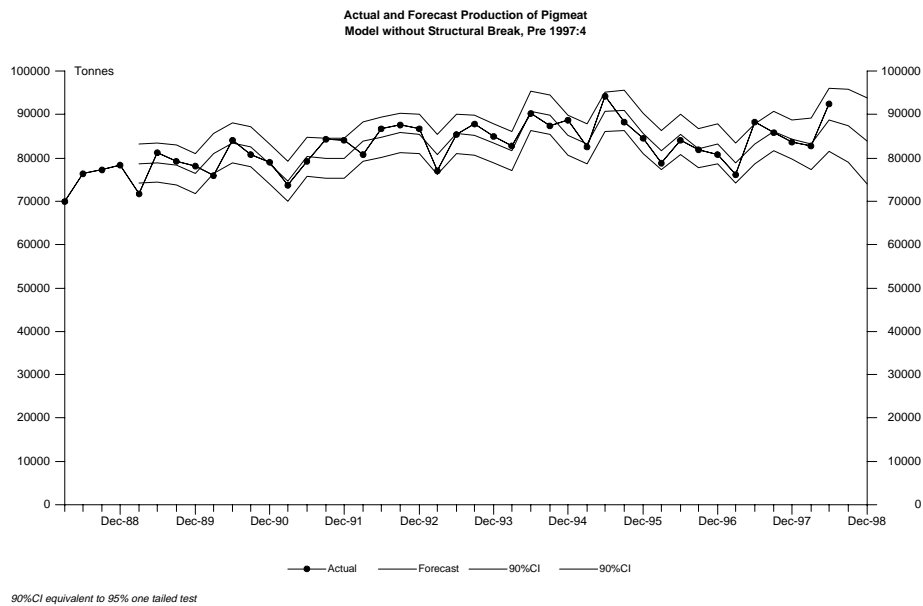**Model without Structural Break, Pre 1997:4**

Figure 4.1: Actual and forecast saleyard prices for baconers and production of pigmeat

11

price due to the deteriorating forecasting ability of the Kalman filter after 1997:3, when the estimation period stopped. After 1997:3 the forecasts for producer prices indicate that the model expects producer prices to dip slightly before continuing to increase to above 210¢/kg at the end of 1998:4. Given the borderline confidence level of the actual producer price, and the observed deviation of actual from forecasted prices, it would be safe to say that producer prices subsequent to 1997:3 do not follow the same data generating process as before and have been impacted on by a combination of changing institutional structure and market equilibrium.

The state-space model tracks changes in production quite well, all except 1997:2, where there is a temporary exogenous shock which pushes production above the upper confidence level. This probably accounts for the unusually low producer price seen in this quarter. Apart from the single shock in 1997:2 the DGP of production seems to be influenced only be systematic and internal changes in the industry.

Changes in the retail price of pork are tracked well by the state-space model, with no exogenous shocks impacting on the DGP for retail prices. The period post 1997:3 also appears to follow the same systematic and internal industry dynamics although retail prices in 1998:2 do seem to deviate from the forecasted values, even though the deviation is not significant. This could indicate that retail prices are adjusting slowly to changes in producer prices. The magnitude of the change in retail price compared with the magnitude of the change in producer price is small, consistent with the market power and asymmetric price transmission between retail and producer prices discovered by Purcell and Harrison [18].

Changes in cattle prices are tracked by the state-space model except for temporary exogenous shocks in 1993:3 and 1996:2. This is to be expected as we have not explicitly attempted to capture the dynamics of the cattle industry as the state-space model concentrates on the pig industry. Even so, it is of interest to note that the Kalman filter does manage quite successfully to track the systematic changes in the cattle industry. The drop in cattle prices from 1994 is tracked quite well by the model, and indicates that changes impacting on the cattle industry are not related to the changes impacting on the pig industry. Thus it is unlikely that the drop in pig producer prices has been caused by a drop in cattle prices.

Changes in exports of pigmeat from Australia are tracked well except for a negative external shock in 1990:1 and an unanticipated increase in exports in 1997:2. There were also declines in exports in 1995:1 and 1997:1 but these were not significant although borderline critical. After reaching a (borderline critical) peak in 1997:3 exports declined. The changes in exports suggest that unanticipated

Actual and Forecast Retail Price of Pork
Model without Structural Break, Pre 1997:4

90%CI equivalent to 95% one tailed test

Actual and Forecast Saleyard Prices for Cattle
Model without Structural Break, Pre 1997:4
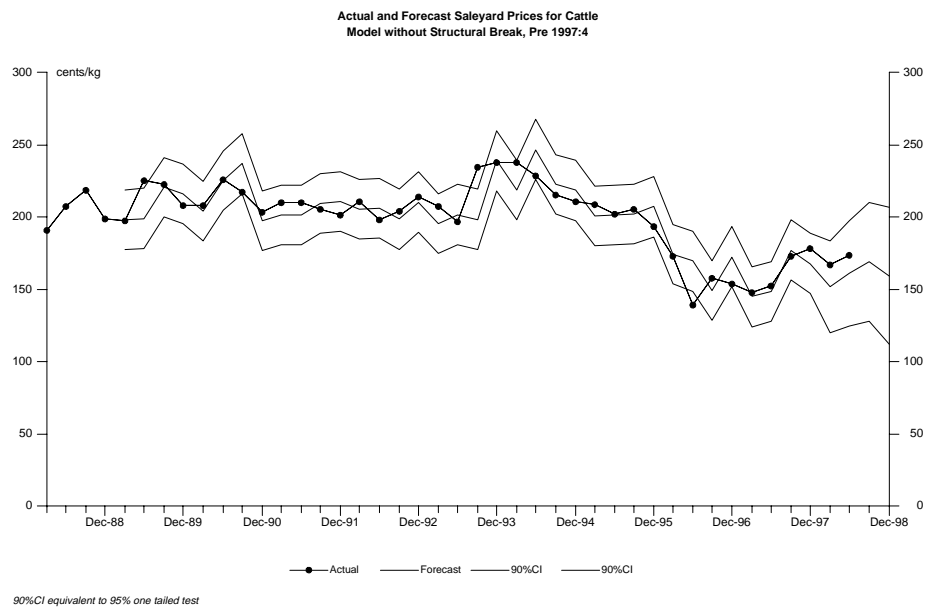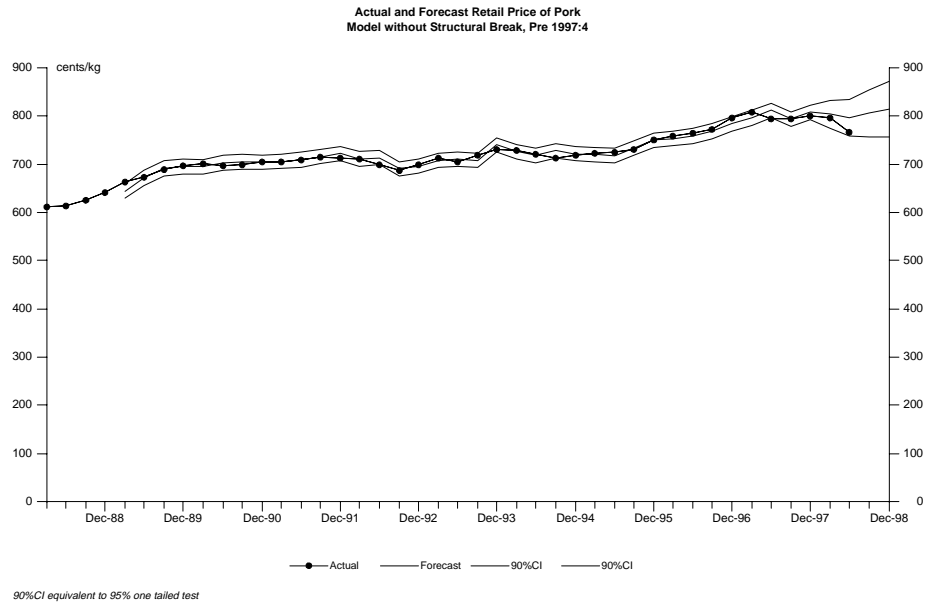

90%CI equivalent to 95% one tailed test

Figure 4.2: Actual and forecast retail prices of pork and saleyard prices for cattle

Actual and Forecast Exports of Pigmeat
Model without Structural Break, Pre 1997:4

90%CI equivalent to 95% one tailed test

Actual and Forecast Imports of Canadian Pigmeat
Model without Structural Break, Pre 1997:4

90%CI equivalent to 95% one tailed test
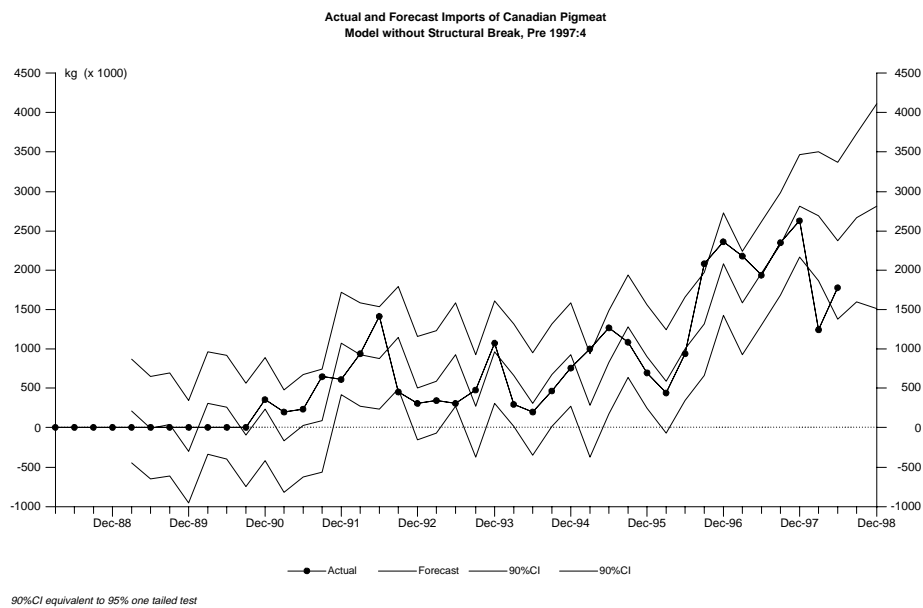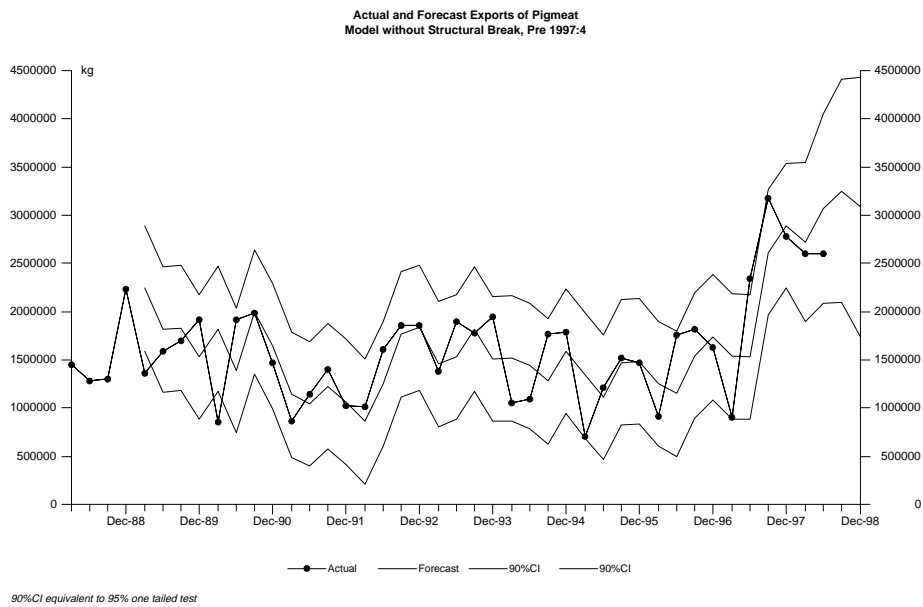
Figure 4.3: Actual and forecast exports of pigmeat and import volumes of Canadian pigmeat

14

changes in exports did have a role to play in changes in the market equilibrium, including changes in producer prices. The role of exports in the depression of producer prices after 1997:3 is not clear cut, as economic theory suggests that increased exports would, ceteris paribus, reduce domestic supply, and cause producer prices to in fact increase. Despite a decline in exports after 1997:3 exports still remain greater than in previous time periods, suggesting that if exports did contribute to the fall in producer prices after 1997:3 such a contribution would not be great.

Changes in import volumes are tracked well by the state-space model except for the periods 1992:3, 1995:1, 1996:3 and 1998:1. The poor foreccasting ability of the state-space model in relation to imports suggests that the DGP for import volumes is mainly exogenous and decisions to import pigmeat into Australia are made without reference to the domestic market equilibrium. Imports peaked in 1997:4 before declining, as importers attempted to capture the Christmas leg ham market. The negative effect of imports on domestic producer prices has been established in previous reports [17, 18]. The level of imports in 1997:4 was anticipated by the state-space model and such a level would clearly exert a downward pressure on producer prices. The significant decline in imports in 1998:1, although relaxing the supply situation in the domestic market, would not have contributed much to relaxing the pressure on prices due to the highly seasonal nature of demand. The seasonality of demand exerts a significant downward pressure on prices post quarter 4. Even though the levels of imports and seasonality contributed significantly to the decline in producer prices, these were anticipated by the state-space model, indicating that the borderline significant depression in producer prices was due to factors other than seasonality or imports.

Changes in import prices are tracked well by the state-space model except for a temporary deviation in 1996:4. The very wide confidence intervals for import prices indicates that the state-space model does not capture the DGP in import prices very well. Again, this is to be expected due to the state-space model concentrating on the domestic Australian industry structure rather than the structure of the Canadian industry. Since the import prices are within the confidence intervals it is unlikely that import prices played an important role in changes in producer prices after 1997:3. This is confirmed by the insignificant relationship between import prices and the domestic market equilibrium found in Purcell and Harrison [18].
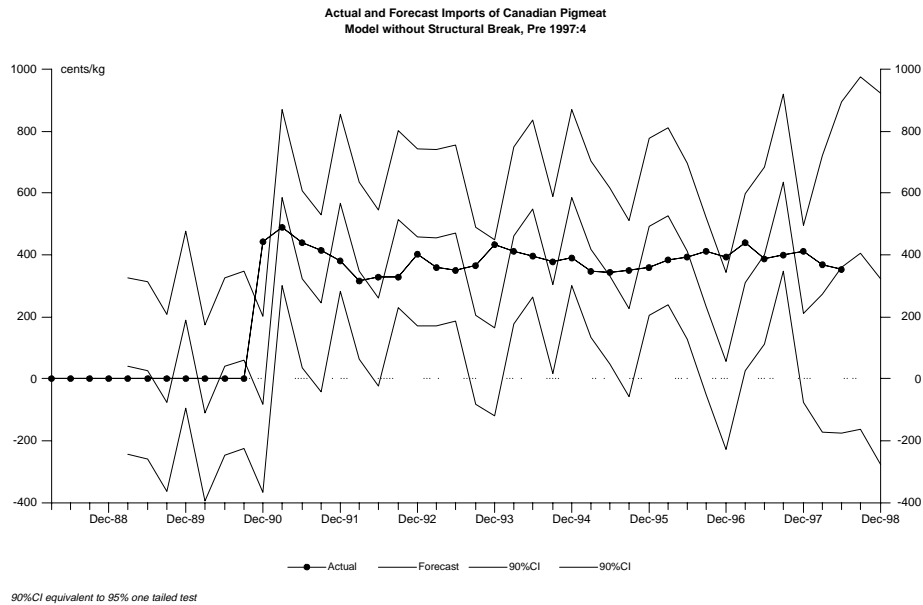
Actual and Forecast Imports of Canadian Pigmeat
Model without Structural Break, Pre 1997:4

Figure 4.4: Actual and forecast import prices of Canadian pigmeat

4.2. A state-space model of the pig industry without an external shock

The results of the first model suggest that the fall in producer prices after 1997:3 has been a combination of seasonal factors, increasing imports, and decreasing exports along with some unobservable, sudden and unexpected changes in the industry structure. The first model is not able to distinguish between the different effects, as the model was estimated over the period 1998:1 to 1997:3 and does not look at changes since this last period. We construct a second model that takes into consideration the effect of seasonal changes, imports and exports over the crucial period 1997:4 to 1998:2. By allowing the model to take into consideration changes in the variables determining market equilibrium we can determine if there was an exogenous shock to the industry or if all the depression in producer prices is attributable to changes to the variables incorporated in the state-space model. The results are presented in Figures 4.5 to 4.8.

The results indicate that endogenous systematic changes in the state-space model are able to account for all changes in pig producer prices except for a significant exogenous shock in 1997:2 and 1998:2. This indicates that there was some event, in addition to changes in imports and exports, which was external to
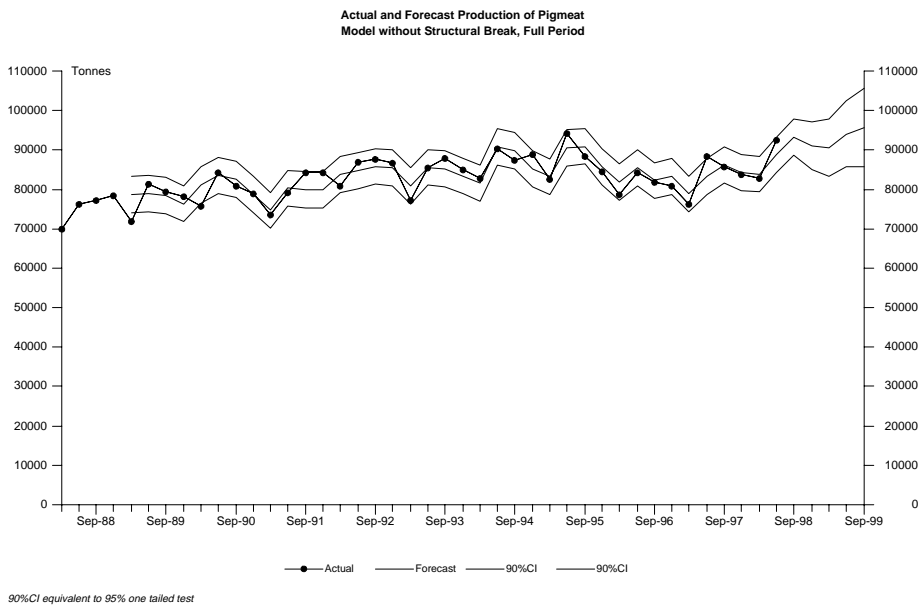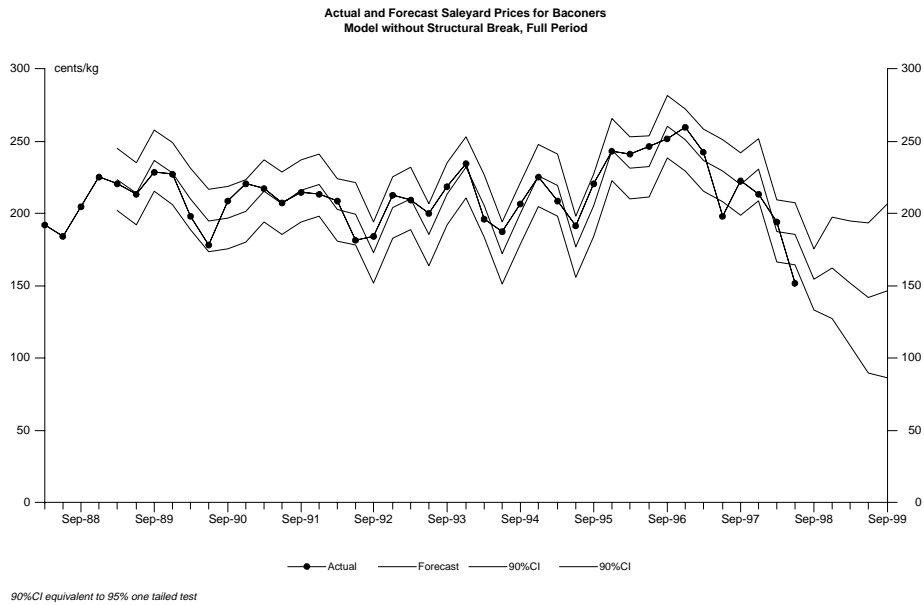
16

Actual and Forecast Saleyard Prices for Baconers
Model without Structural Break, Full Period

90%CI equivalent to 95% one tailed test

Actual and Forecast Production of Pigmeat
Model without Structural Break, Full Period

90%CI equivalent to 95% one tailed test

Figure 4.5: Actual and forecast saleyard prices for baconers and production of pigmeat

17

the industry and contributed significantly to the depression in producer prices.

Production volumes are tracked well by the state-space model, except for an exogenous event in 1997:2. This corresponds to the fall in producer price at this time, indicating that changes in production may have been the cause of falls in producer prices at this point in time. Production of the period 1997:4 to 1998:2 is within the confidence interval, suggesting that shocks to production did not contribute to the fall in producer prices over this period in time.

Retail prices have been tracked quite well by the Kalman filter, with only the last period, 1998:2 significantly below the forecasted retail price. The asymmetric price transmission between producer and retail prices suggests that the small but significant fall in retail prices in 1998:2 is a response to the large and significant fall in producer prices over the previous 3 quarters.

Changes in cattle prices have also been tracked well by the state-space model. Exogenous shocks to cattle prices have occurred in 1993:3 and 1996:2 but the drop in cattle prices have not corresponded to falls in pig producer prices.

The change in exports has been tracked well by the state-space model. Except for a shock in 1990:1 there have been no recent significant exogenous shocks to exports, although some changes have been borderline significant - 1995:1, 1997:1 and 1997:3. These results back up the results obtained in the first model. The borderline critical increase in the level of exports in 1997:3 before a decline in 1997:4 suggests that unanticipated changes in exports may have contributed to the decline in producer prices, even taking into consideration the normal systematic changes in exports captured by the Kalman filter. Industry sources suggest that the decision by a major retailer to cease exports to Asia affected market confidence and resulted in a sharp decline in producer prices [8]. The fall in exports, from a borderline significant peak, and the subsequent fall in producer prices suggests that the contention that market confidence may have been affected by the fall in exports, even though exports did not fall significantly below forecasted values, may have some validity. This seems to indicate some sort of capacity constraint in the domestic market.

Import volumes are tracked reasonably well by the state-space model except for 1992:3, 1995:1, 1996:3 and 1998:1, indicating that the DGP for import volumes is mainly exogenously determined. The results of the first model seem to be confirmed by the results of the second model.

The second model does not change the results or the interpretation of the effect of systematic and exogenous changes in import prices. Since the import prices are within the confidence intervals it is unlikely that import prices play an

Actual and Forecast Retail Price of Pork
Model without Structural Break, Full Period

90%CI equivalent to 95% one tailed test

Actual and Forecast Saleyard Prices for Cattle
Model without Structural Break, Full Period
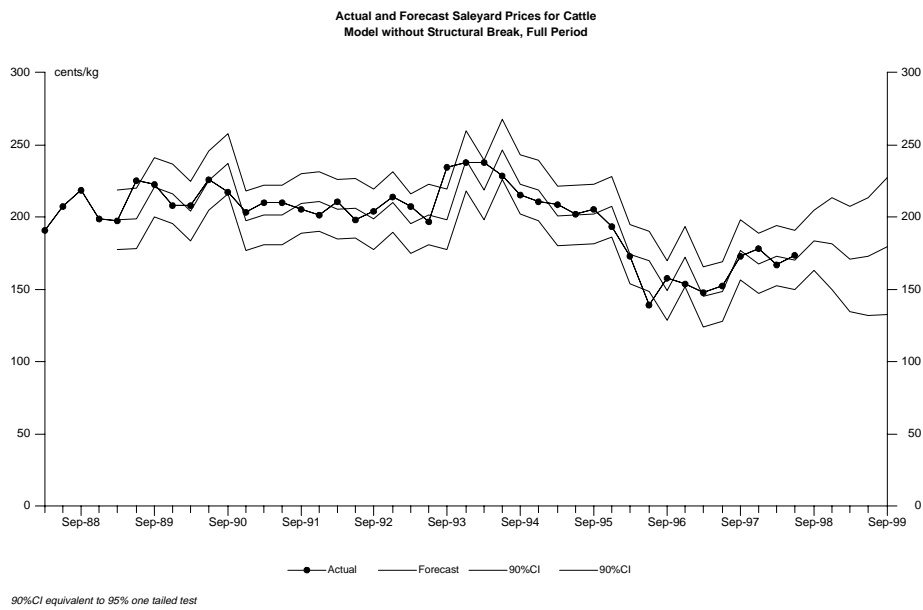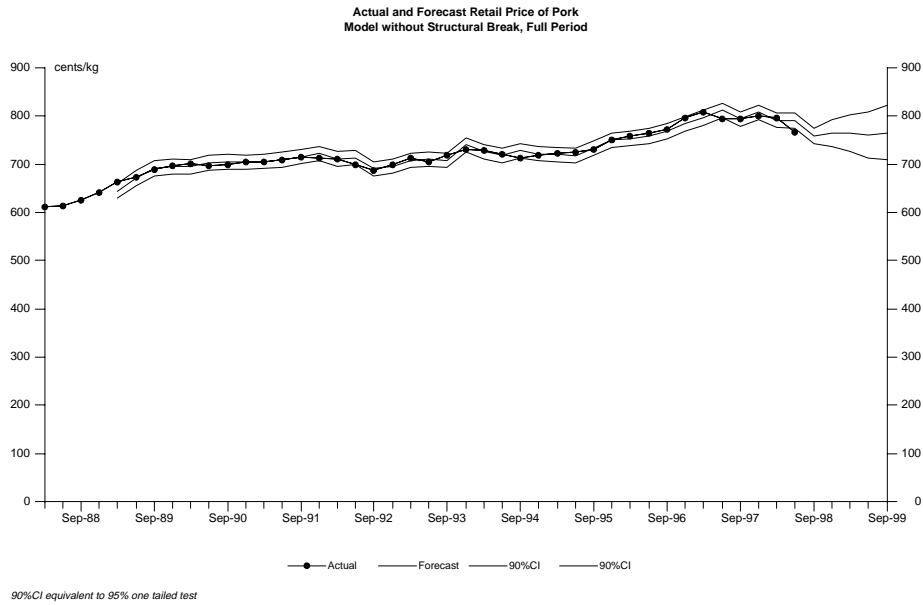

90%CI equivalent to 95% one tailed test

Figure 4.6: Actual and forecast retail prices of pork and saleyard prices for cattle

19

Actual and Forecast Exports of Pigmeat
Model without Structural Break, Full Period

Actual and Forecast Imports of Canadian Pigmeat
Model without Structural Break, Full Period
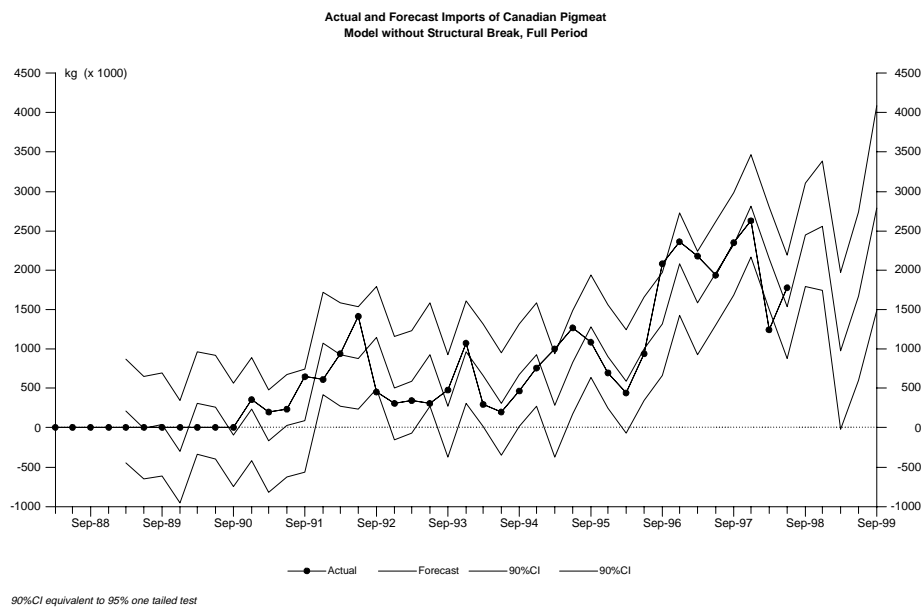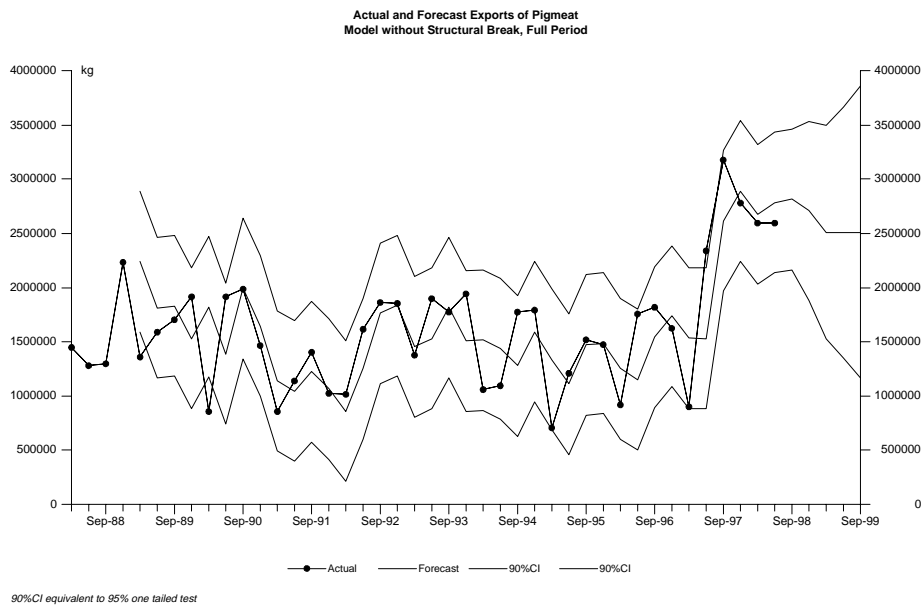
Figure 4.7: Actual and forecast exports of pigmeat and import volumes of Canadian pigmeat

20

Actual and Forecast Imports of Canadian Pigmeat
Model without Structural Break, Full Period

90%CI equivalent to 95% one tailed test
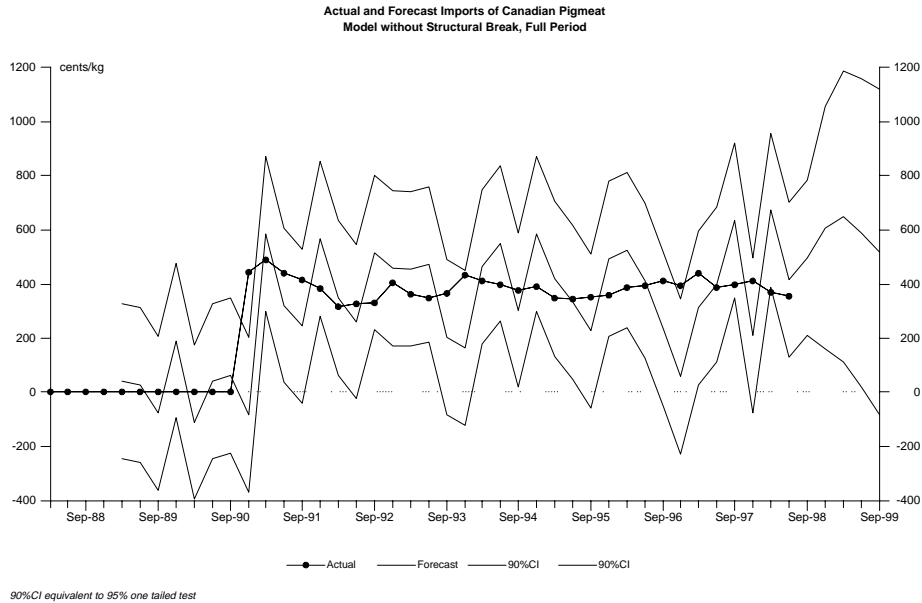
Figure 4.8: Actual and forecast import prices of Canadian pigmeat

important role in changes in producer prices.

4.3. A state-space model of the pig industry with an external shock

The previous two models attempted to identify whether variables like imports or exports or an external event contributed to the decline in producer prices since 1997:3. The results of the first model implied that there had been some external effects, not in the state-space model structure nor systematic effects subsumed into the state vector, that had been the cause of the decline in producer prices. The second model suggested that although unanticipated changes in imports and exports did contribute to the decline in producer prices there was an additional external event, not linked to actual levels of imports and exports, which also contributed to the fall in producer prices. In the third model we incorporate a dummy variable in the state-space model that explicitly accounts for this external event. It must be stressed that we cannot attribute any specific event or series of events to this dummy variable but must rely on market intelligence to identify likely events that could be linked to this variable. The results are presented in

Figures 4.9 to 4.12.

The depression in producer prices is picked up by the structural break dummy variable, indicating that an exogenous change in market structure in 1997:4 has caused the fall in producer prices. The producer price is within the forecast confidence interval suggesting that there was no other external event other than that which occurred in 1997:4 which contributed to the fall in producer prices.

Production volumes are tracked well by the state-space model, with an exogenous event in 1997:2 significantly increasing production volumes. Production was borderline significant in 1998:2, indicating that an exogenously influenced increase in production in this time period may have contributed to the fall in producer prices. The borderline significant increase in production was also captured in the second model, with producer prices still being significantly depressed. The addition of the structural break dummy and the consequent adjustment in the forecasting ability of the state-space model suggests that increases in production was not the sole contributor to declines in producer prices and that an exogenous shock was also a contributor to the fall in producer price.

The fall in retail price in 1998:2 has not been picked up by the structural break dummy in 1997:4, indicating that the fall is independent of the exogenous shock that occurred in 1997:4. This implies that the fall in producer price and the fall in retail price are not linked by the events that occurred in 1997:4.

Like the previous models the incorporation of a structural break dummy variable does not have an effect on cattle prices, further evidence that the fall in pig producer price is not linked to the fall in cattle prices.

The addition of a structural break dummy in 1997:4 has not affected export volumes, indicating that exogenous shock is isolated in it's effect on producer prices and that export volumes have not been influenced by the events occurring in 1997:4.

The addition of the structural break dummy at 1997:4 has changed the forecasts for import volumes. In the previous models the Kalman filter failed to pick up the fall in imports in 1998:2 but the dummy variable for 1997:4 takes into account this fall in import volume. This result is interesting, as it suggests that the external shock negatively impacts on both producer prices and imports. One possible reason for this is that the external shock is a demand shock. Since retail prices have not been affected by the dummy variable the implication is that the demand shock impacts at the processor level. Campbell [13] suggests that excess stocks held by processors in 1998:1 forced processors to refuse to accept pigs for slaughter and this resulted in producer prices falling. The results of the third
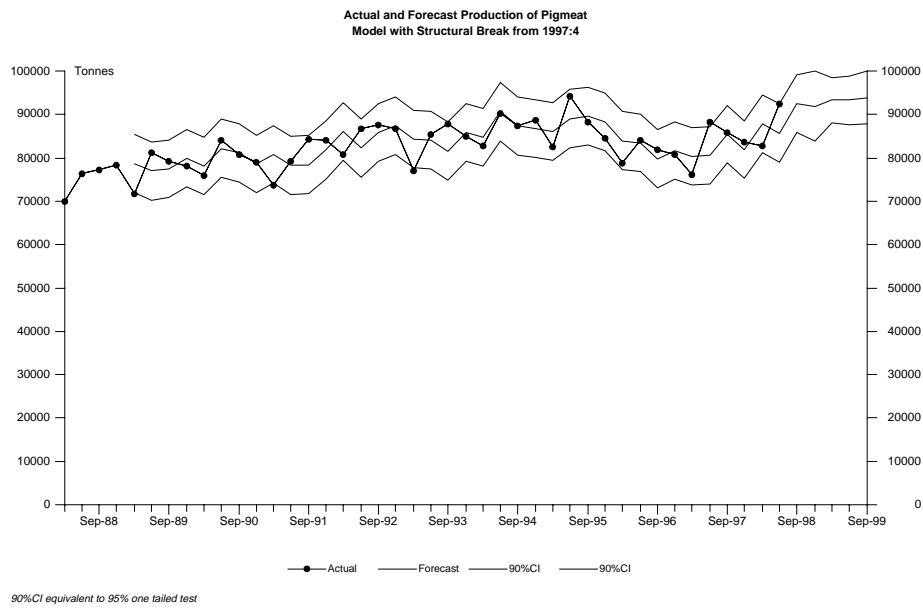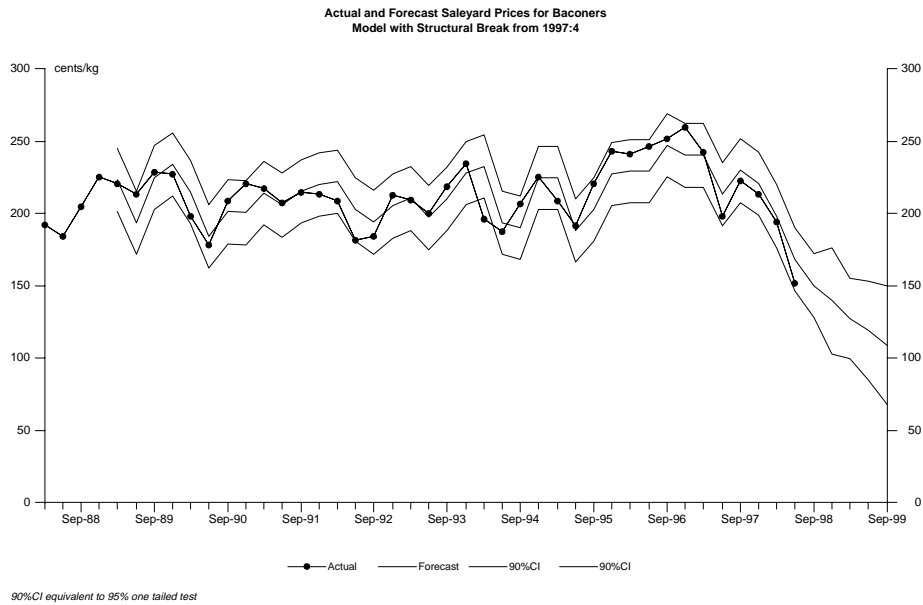
Figure 4.9: Actual and forecast saleyard prices for baconers and production of pigmeat

23

Actual and Forecast Retail Price of Pork
Model with Structural Break from 1997:4

90%CI equivalent to 95% one tailed test

Actual and Forecast Saleyard Prices for Cattle
Model with Structural Break from 1997:4
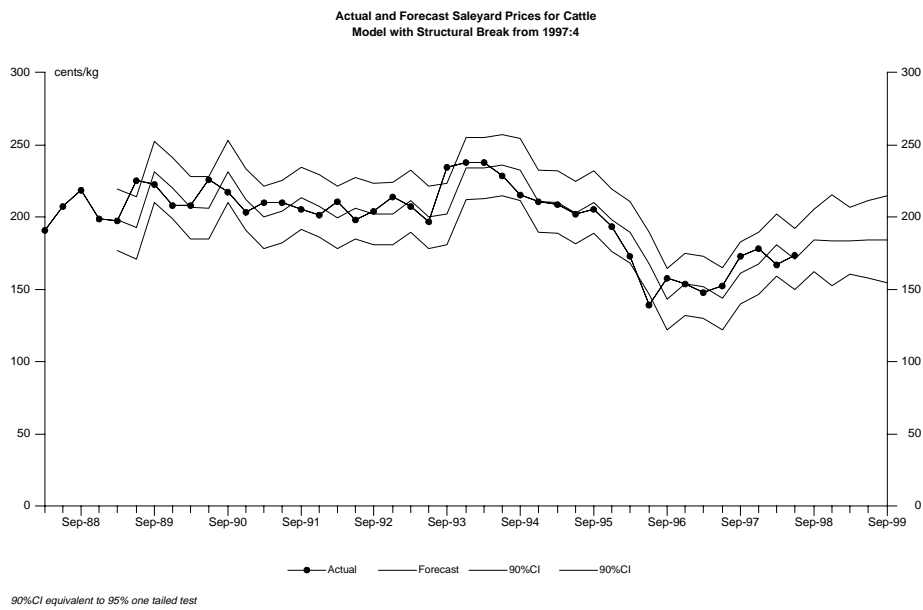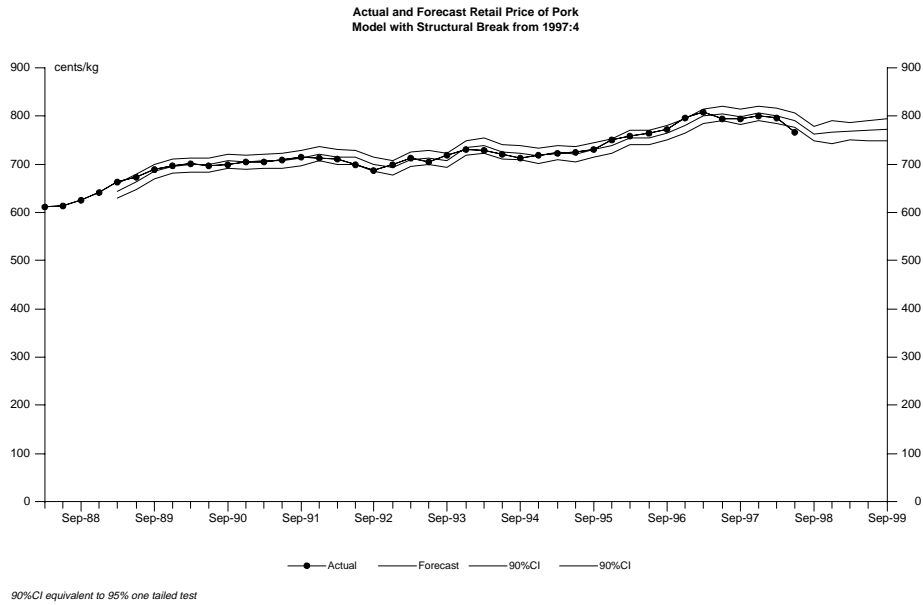

90%CI equivalent to 95% one tailed test

Figure 4.10: Actual and forecast retail prices of pork and saleyard prices for cattle

Actual and Forecast Exports of Pigmeat
Model with Structural Break from 1997:4

90%CI equivalent to 95% one tailed test

Actual and Forecast Imports of Canadian Pigmeat
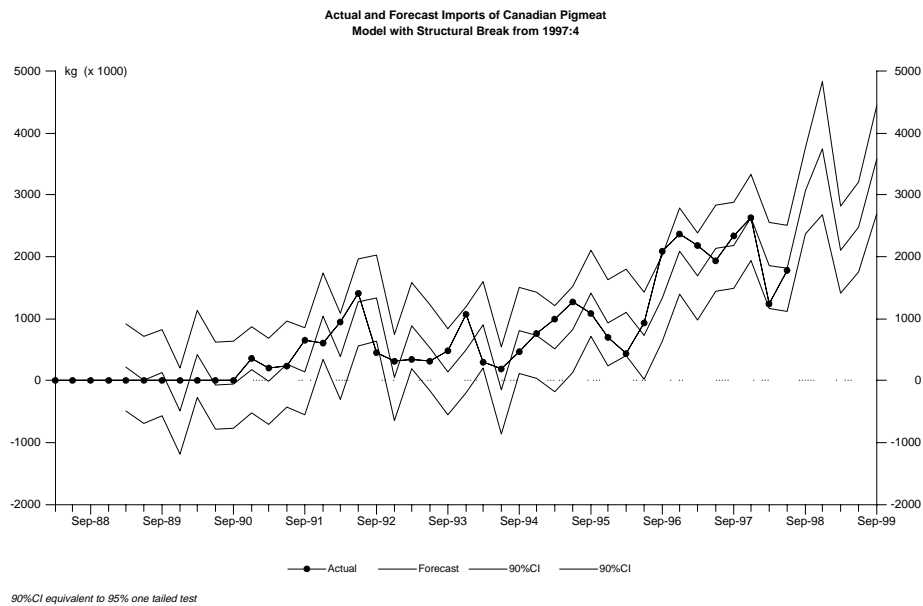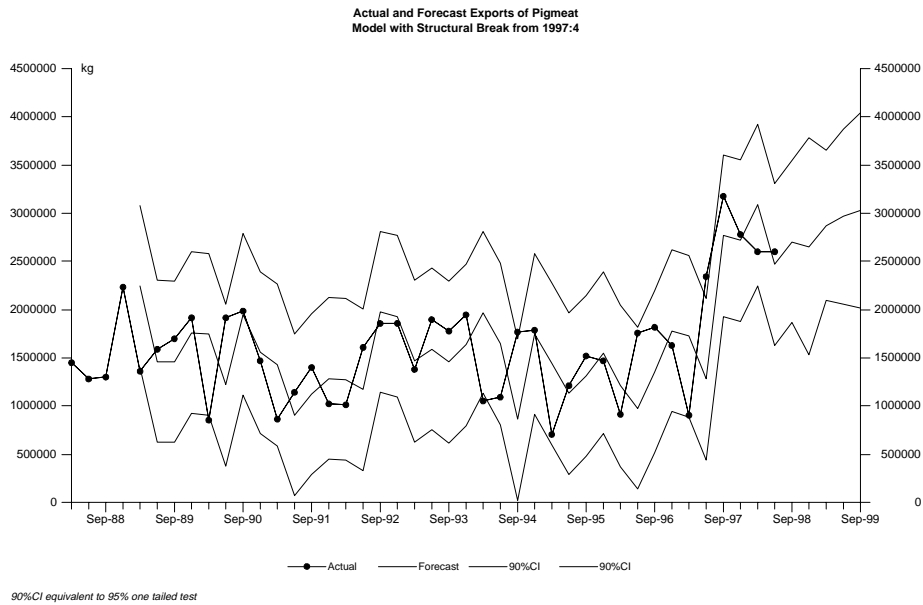**Model with Structural Break from 1997:4**

90%CI equivalent to 95% one tailed test

Figure 4.11: Actual and forecast exports of pigmeat and import volumes of Canadian pigmeat

25

Actual and Forecast Imports of Canadian Pigmeat
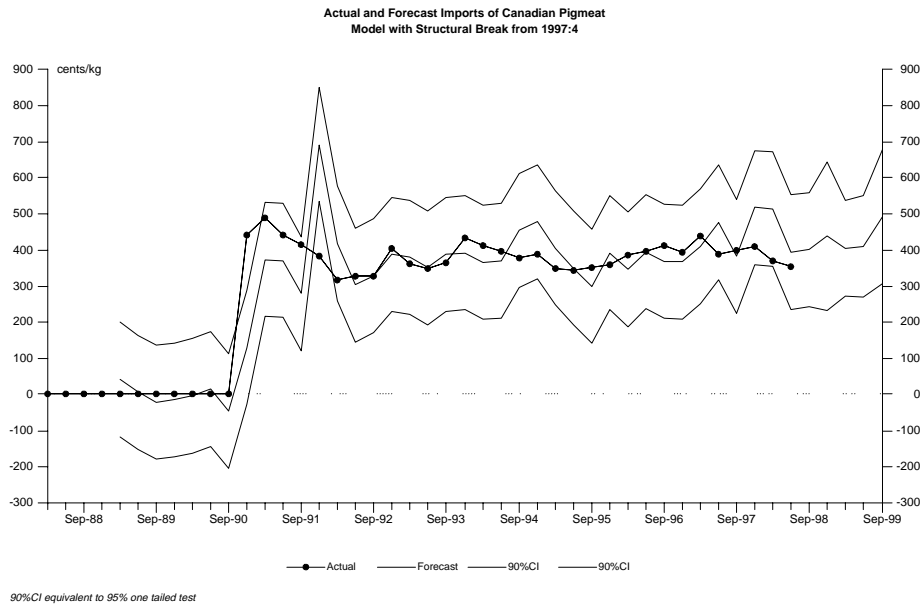**Model with Structural Break from 1997:4**

Figure 4.12: Actual and forecast import prices of Canadian pigmeat

model suggests that this view has some validity and perhaps a kinked processor demand curve may be the cause of the sharp fall in producer price.

Finally, import prices do not seem to be influenced by the inclusion of the structural break dummy term.

5. Conclusions

The results of the state-space models suggest that there has been a combination of factors which have influenced producer prices and caused the depression in prices after 1997:4. The first state-space model attempted to identify if the post 1997:3 market equilibrium was significantly different from the pre 1997:3 equilibrium by forecasting ahead on the assumption that there had been no change in the market equilibrium, and comparing the actual prices and quantities with the forecasted ones. The model suggested that the post 1997:3 equilibrium was different from the pre 1997:3 equilibrium and that unique and unanticipated changes in the institutional structure along with exogenous shocks may have been the cause of the change. Although on the basis of the first model we are unable to identify

the exact causes of the change in institutional structure what does seem obvious is that changes in cattle prices and retail prices have not played a significant role in producer price formation.

Production and exports did seem to play a minor role in the depression of producer price, although their role was not a significant one and was captured by the Kalman filter algorithm. Imports, however, seemed to play a significant role as imports were significantly depressed after their peak in 1997:4 as importers attempted to capture the Christmas leg ham market. The level of imports in 1997:4 was anticipated by the state-space model and such a level would clearly exert a downward pressure on producer prices. The significant decline in imports in 1998:1, although relaxing the supply situation in the domestic market, would not have contributed much to relaxing the pressure on prices due to the highly seasonal nature of demand.

Having identified that production, exports, imports and perhaps some other external factor all contributed to the depression in producer prices after 1997:4, we developed a second state-space model that enabled us to partition the fall in producer price between an unknown external factor and the other factors. By allowing the model to take into consideration changes in the variables determining the post 1997:4 market equilibrium we can determine if there was an exogenous shock to the industry or if all the depression in producer prices is attributable to changes to the variables incorporated in the state-space model.

The results of the second model indicate that changes in exports and imports are able to account for all changes in pig producer prices except for a significant exogenous shock in 1998:2. This indicates that there was some event, in addition to changes in imports and exports, which was external to the industry and contributed significantly to the depression in producer prices. The results of the second model also imply that shocks to production did not contribute to the fall in producer prices over 1997:4 to 1998:2, whereas unanticipated changes in exports may have contributed to the decline in producer prices, even taking into consideration the normal systematic changes in exports.

Having identified that changes in imports and exports have been able to account for most but not all of the decline in producer prices we develop a third state-space model that incorporates a structural break dummy variable for 1997:4 in an attempt to capture the rest of the decline in producer prices. If the state-space model is now able to accurately forecast the fall in producer prices after 1997:3 the implication is that the dummy variable explains the fall in producer prices not explained by imports or exports.

The third state-space model accurately captures the fall in producer prices, indicating that some unique external event, in combination with changes in imports and exports was the cause of declines in producer prices after 1997:3. The slight decline in retail prices in 1998:2 has not been captured by the dummy variable, indicating that the decline in retail price is not related to the cause of the decline in producer prices.

The addition of the dummy variable has not changed the forecasting ability of the state-space model for forecasting export volumes, indicating that exogenous shock is isolated in it's effect on producer prices and that export volumes have not been influenced by the events occurring in 1997:4.

What is interesting in the third state-space model is that the dummy variable increases the forecasting ability of the Kalman filter to forecast changes in import volumes. In the previous models the Kalman filter failed to pick up the fall in imports in 1998:2 but the dummy variable for 1997:4 takes into account this fall in import volume. This result suggests that the external shock negatively impacts on both producer prices and imports.

The results of the three state-space models suggests that there has been a combination of events which have caused the depression in producer prices after 1997:3 (See Figure 5.1). Inital market equilibrium is P_1Q_1 with the processor demand curve DD and domestic supply curve S_1S_1. A reduction in exports, and subsequent diversion of product into the domestic market, shifts domestic supply to S_2S_2 with a fall in price to P_2 (the initial 10¢/kg drop in price observed when the major retailer announced suspension of exports to Asia in September 1997). Combined with a historical high in imports the domestic supply curve shifts to the right (S_3S_3). The structural break dummy picks up the kink in the processor demand curve due to capacity constraints and the subsequent fall in producer price is to P_3.

The scenario suggested is that the announcement by a major retailer in September 1997 to suspend exports to Asia, while at the same time continuing to import pigmeat to cater for the Christmas leg ham market resulted in a loss of market confidence and an initial sharp fall in producer prices. A peak in imports the previous October, designed to capture the lucrative Christmas leg ham market, resulted in processors finding themselves with excess stock of pigmeat in January 1998 and accordingly slashed demand for both domestic and imported pigmeat. Both the fall in exports, resulting in domestic production being diverted to the domestic market and the impact of increased imports resulted in a fall in producer prices. The role of the AQIS decision to lift quarantine restrictions on
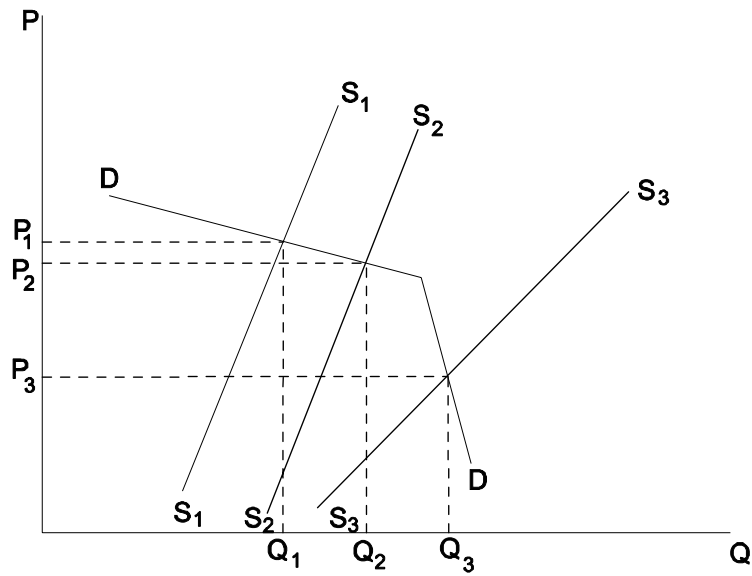
Figure 5.1: Producer supply and processor demand curves under processor capacity constraint

manufactured pigmeat products from Canada is not clear cut, but undoubtedly an opportunity for further importation contributed to the evaporation of market confidence and the subsequent crash in producer price.

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