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The Economic Impact of Imports on the Australian Pig Industry: Is it Time for the WTO's Safeguard Measures? 2. Re-estimating the Productivity Commission's Vector Autoregression and Inverse Demand Models

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Abstract

In its 2008 Inquiry report into the impact of imports on the Australian pig meat industry, the Productivity Commission (PC) concluded that the main reason for the declining profitability of pig farmers in Australia was the higher costs of feed in the domestic market. Movements of the Australian dollar were also found to favour increased imports of pig meat. Based on analyses conducted with data up to 2007, the PC was unable to justify the need for Australia to activate the safeguard measures prescribed under the World Trade Organization (WTO) rules in order to temporarily protect the local pig industry. In a preceding paper, using exactly the same methods but with a dataset updated to 2013, the authors found that domestic production, rather than import volumes or prices, has been affecting the saleyard price and that there was not a strong causal effect between import volume or unit values and domestic production or saleyard price. Thus, based on a straightforward updating of the PC's models, the PC conclusions were confirmed: it is unlikely that a new case could be made for the application of the WTO safeguard measures to the Australian pig meat industry. However, there were a number of statistical problems with the PC models that were simply updated for the previous analysis. In this paper, the PC models are re-specified and re-estimated to overcome these statistical problems. However, the misspecifications do not lead to any different implications of the results.

Key words: pigmeat, imports, vector autoregression, inverse demand

Introduction

In the preceding companion paper (Popat et al., 2017), exactly the same methods as used in the Inquiry report by the Productivity Commission (2008) were applied to a dataset updated to 2013, to examine the impact of pig meat imports on domestic pig meat prices and production levels. In the

updated vector autoregression (VAR) analysis, import volumes and prices continue to have no effect on domestic prices, the cost of feed is no longer important, but there is now a strong interrelationship between domestic production and saleyard price. In the updated regression analysis, unit import values continue to be significant but domestic production has replaced feed cost as the main driver of saleyard prices in both the monthly model and quarterly models. Thus, it seems that the domestic pig meat market is operating in a competitive manner, i.e. that local prices are jointly determined by world prices, since Australia is a large net importer of pig meat, and by domestic production levels. Therefore, based on updates of the PC's models, it is unlikely that a new case could be made for the application of the WTO safeguard measures to the Australian pig meat industry.

However, with the strong likelihood (see below) that the VAR models are misspecified in terms of lag length and stationarity, and the probability that the monthly inverse demand model violates at least one of the assumptions of regression models – correlation between regressors (feed price) and error term – and that the quarterly inverse demand model does not follow the recommended basic structural form of inverse demand models, the credibility of this conclusion is in doubt.

In this paper, those concerns are addressed. The same dataset and broad methodology are used as reported earlier in Popat et al. (2017).

The Vector Autoregression Model

Following the procedures reported by the PC (2008), a number of tests are conducted to ensure the statistical properties of the estimated VAR model are acceptable. These are whether the lag order is optimal, whether the residuals have serial correlation and whether the variables included in the VAR model are stationary.

As the model is conceptually based on a finite lag length (*p*), the choice of *p* in this study is based on the Schwarz Bayesian information criterion[1] (SBIC). The results of this selection are shown in Table 1.

Table 1: Lag order selection criteria

Selection-order criteria
Sample: 127 - 288 Number of obs = 162

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	554.032				2.5e-08	-6.14854	-5.71519	-5.08122
1	925.377	742.69	16	0.000	3.1e-10	-10.5355	-9.97836	-9.16326
2	998.588	146.42	16	0.000	1.6e-10	-11.2418	-10.5608	-9.56461
3	1060.05	122.93*	16	0.000	8.9e-11*	-11.8031*	-10.9983*	-9.82094*
4	1069.22	18.336	16	0.305	9.7e-11	-11.7188	-10.7902	-9.43164
5	1075.91	13.382	16	0.645	1.1e-10	-11.6038	-10.5514	-9.01177
6	1085.29	18.751	16	0.282	1.2e-10	-11.522	-10.3458	-8.62504

[1] The PC (2008) has used different criteria, however, they reported result is based on the lag length suggested by the SBIC.

The likelihood ratio tests show that lag lengths 1, 2 and 3 are all statistically significant, but that lag length 3 best meets the selection criteria on all measures reported. The PC use of lag length 2 is therefore a misspecification, and lag length 3 should be the model used.

The results for the stationarity tests using an augmented Dickey-Fuller (DF) test are reported in Table 2. All of the price and volume variables satisfy the test, at all lag lengths, but the variable "linear trend term" fails to pass the test, again at all lag lengths. Thus, the linear time trend should not be included in the VAR model.

Table 2: DF test for stationarity

Variable	***p*-value**						
	Lag0	**Lag1**	**Lag2**	**Lag3**	**Lag4**	**Lag5**	**Lag6**
impvol	0.0000	0.0001	0.0015	0.0010	0.0095	0.0185	0.0293
prodpig	0.0000	0.0001	0.0059	0.0004	0.0005	0.0044	0.0122
salpig	0.0367	0.0000	0.0006	0.0011	0.0048	0.0164	0.0326
unit	0.0017	0.0009	0.0009	0.0014	0.0006	0.0014	0.0056
feed	0.0196	0.0030	0.0060	0.0054	0.0047	0.0063	0.0079
Linear trend term	0.9960	0.9970	0.9970	0.9970	1.000	0.9970	1.000

Finally, serial correlation of the model residuals is assessed by the Lagrange multiplier (LM) test. As shown in Table 3, similarly to the PC model, the estimated VAR(2) suffers from misspecification problems for violating the residuals serial-correlation assumption. However, as shown in Table 4, when a VAR(3) model is estimated, there is no autocorrelation in the model residuals.

Table 3: LM test for residuals autocorrelation in the VAR(2) model

Lagrange-multiplier test

lag	chi2	df	Prob > chi2
1	**90.9650**	**16**	**0.00000**
2	**44.9004**	**16**	**0.00014**
3	**69.4820**	**16**	**0.00000**
4	**18.6351**	**16**	**0.28804**
5	**8.4590**	**16**	**0.93401**
6	**35.3626**	**16**	**0.00354**
7	**31.5077**	**16**	**0.01158**
8	**21.7660**	**16**	**0.15091**

H0: no autocorrelation at lag order

Thus, to overcome such misspecification issues, a VAR(3) excluding the linear trend term was estimated. The lag length is optimal, the variables in this model are stationary and the VAR(3) does not display problems with serial correlation of the residuals.

The results are reported in Table 5, which is based on Table 2 in Popat et al. (2017) with extra rows added for the VAR(3) results.

Table 4: LM test for residuals autocorrelation in the VAR(3) model

Lagrange-multiplier test

lag	chi2	df	Prob > chi2
1	**15.6699**	**16**	**0.47622**
2	**11.2828**	**16**	**0.79170**
3	**21.3550**	**16**	**0.16527**
4	**22.2080**	**16**	**0.13660**
5	**12.6980**	**16**	**0.69469**
6	**16.3978**	**16**	**0.42556**
7	**18.0867**	**16**	**0.31885**
8	**11.9948**	**16**	**0.74434**

H0: no autocorrelation at lag order

Overall, the VAR(3) results confirm the PC results that import volumes have no significant influence on domestic production or prices.

The VAR(3) results also confirm the PC results that import values have no significant influence on domestic prices. However, contrary to the PC results, the coefficient on the import unit value variable is significant in explaining domestic production. This fits with the argument that the pricing process within the Australian pig industry is now more closely influenced by world prices (PC, 2008); therefore, such significant effects are unlikely to indicate that imports are the cause of damage to the local pig industry. Instead, it suggests the direction of farmers' responses to changes in world prices of pig meat. So, the multiplier effects for this variable suggest that Australian pig farmers respond positively to increased import unit values: for a 1 per cent increase in the import unit values, domestic farmers (on average) will increase their outputs by 0.04 per cent three months later.

The critical result is that the VAR(3) model points to the non-significant effects of volume of imports on either saleyard price or domestic production. This is exactly the same conclusion as reported by the PC.

Such non-significant effects are also highlighted from the impulse response function (irf) test on the VAR(3) estimates, which indicates a maximum and positive response from saleyard price of near 0.01 per cent to shocks on volume of imports (Figure 1a). The maximum response from saleyard price occurs after 3 to 4 months but lasts up to 7 months. In contrast, if shocks occur on saleyard price, imports will increase after 2 months up to near 2 per cent in 6 months later (Figure 1b). Although results from Figure 1a contradict the PC findings that suggest negative responses from saleyard price, Figure 1b displays the same pattern as the Commission findings.

Table 5: Coefficient estimates for the various VAR models

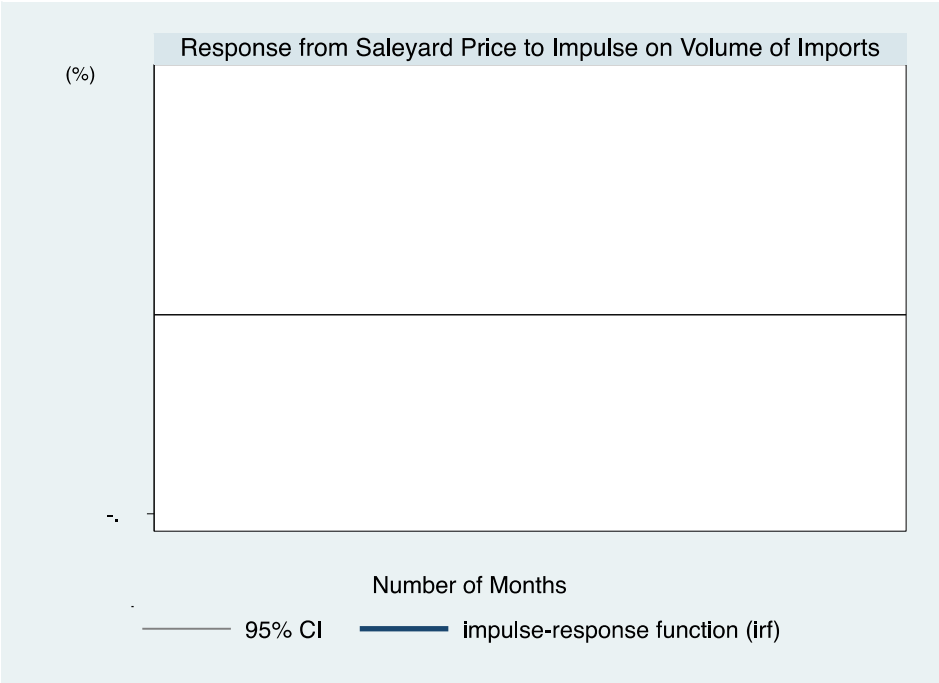
	Endogenous Regressors											
	prodpig			***salpig***			***impvol***			***unit***		
	PC[1]	VAR(2)[2]	VAR(3)[2]	PC	VAR(2)	VAR(3)	PC	VAR(2)	VAR(3)	PC	VAR(2)	VAR(3)
prodpig												
L1	**0.151****	**0.211*****	0.037	0.034	**-0.080*****	**-0.093*****	**-0.892***	**-0.616****	**-0.531***	0.030	0.009	0.001
L2	**0.306*****	**0.349*****	**0.226*****	-0.063	**-0.046***	-0.041	0.270	**0.787*****	**0.738****	-0.074	-0.022	-0.049
L3	–	–	**0.668*****	–	–	0.017	–	–	0.008	–	–	-0.009
salpig												
L1	-0.139	**-0.416*****	-0.187	**1.321*****	**1.558*****	**1.722*****	-0.167	-0.686	-0.462	0.016	**0.320****	-0.097
L2	0.111	0.242	0.087	**-0.377*****	**-0.675*****	**-1.024*****	**1.470***	0.892	1.231	**0.363***	**-0.270****	**0.608****
L3	–	–	0.130	–	–	**0.213*****	–	–	-0.378	–	–	**-0.531*****
impvol												
L1	0.006	0.018	-0.017	-0.007	-0.003	0.002	**0.568*****	**0.586*****	**0.652*****	-0.007	0.004	0.000
L2	-0.002	**-0.050****	-0.013	0.003	-0.007	0.001	0.010	0.054	0.045	**-0.023***	-0.008	0.005
L3	–	–	0.023	–	–	-0.007	–	–	**0.195*****	–	–	**-0.028***
unit												
L1	0.023	0.028	-0.004	0.012	-0.001	0.001	0.030	**0.764****	**0.680***	**0.421*****	**0.863*****	**0.842*****
L2	-0.017	0.089	**0.199****	-0.025	0.039	0.021	**-0.678****	**-0.738****	-0.757	**0.133****	-0.058	-0.008
L3	–	–	**-0.151****	–	–	-0.004	–	–	-0.134	–	–	0.003
Linear trend term	-0.001	-0.278	–	0.002	**-0.213***	–	**0.081*****	**-5.216*****	–	**0.009****	0.443	–
feed	**0.060****	0.011	-0.006	-0.002	0.007	0.010	**0.094****	0.085	0.110	**-0.068****	-0.003	-0.006

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

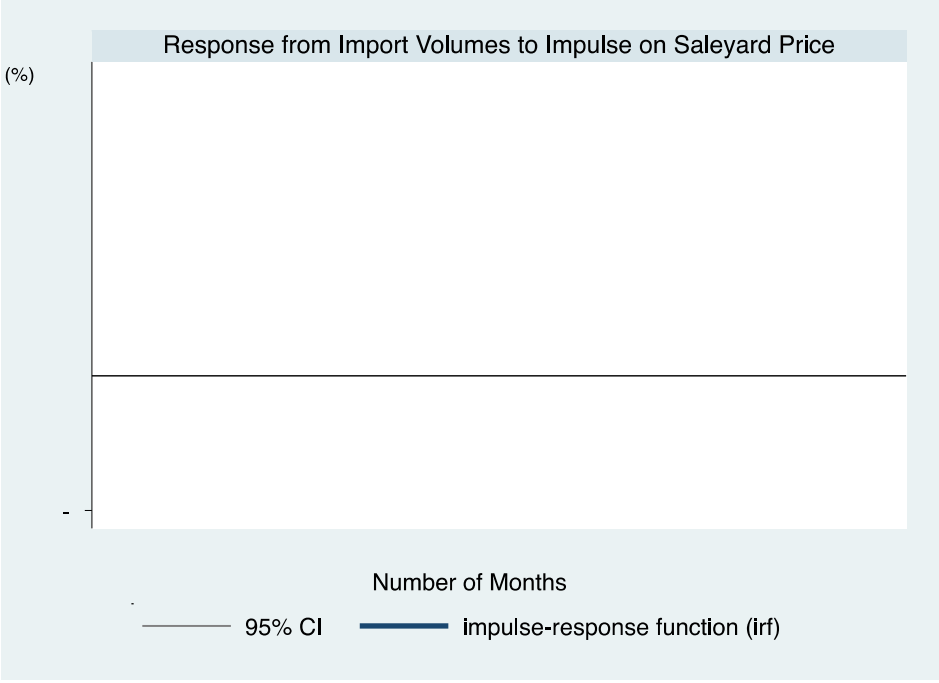
1 Based on data from August 1990 to November 2007; 2 Based on data from January 2000 to June 2013

Figure 1: Impulse response function test

(a): response from *salpig* to shocks on *impvol*



(b): response from *impvol* to shocks on *salpig*



Finally, the results from the Granger causality tests on the VAR(3) summarized in Table 6 show that import volumes do not have a causal effect either on domestic production or saleyard price, while import unit values causes domestic production but does not cause saleyard price. This test also suggests that domestic production and saleyard price cause each other, which is clearly expected from standard microeconomics where price and quantity in a market should be jointly determined. Therefore, the

current VAR(3) and its associated post-estimation tests are consistent with the PC conclusion that imports are not impacting severely on the domestic pig meat industry.

Table 6: Granger test of causality

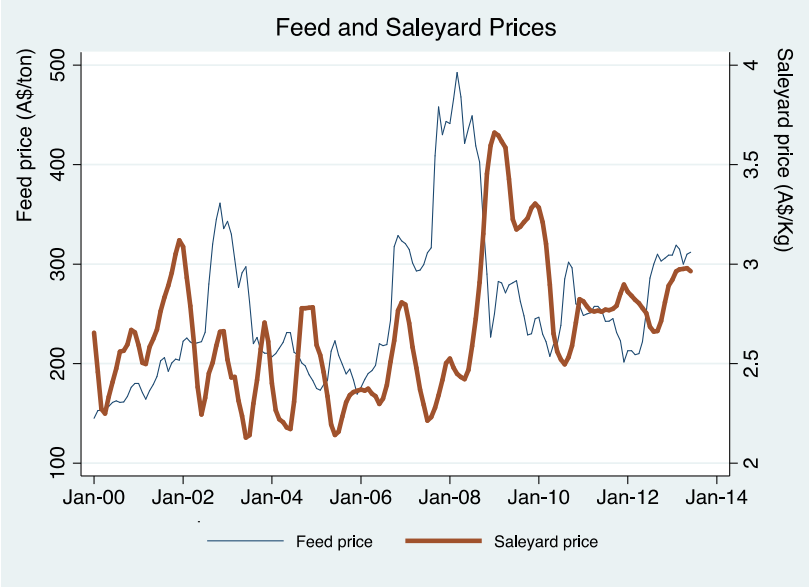
Null hypothesis	Chi2	*p*-value
impvol does not cause prodpig	4.285	0.232
salpig does not cause prodpig	**7.294**	**0.063***
unit does not cause prodpig	**7.921**	**0.048****
impvol does not cause salpig	1.326	0.723
prodpig does not cause salpig	**17.168**	**0.001*****
unit does not cause salpig	1.122	0.772

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

The Monthly Inverse Demand Model

In the monthly ID models reported in Popat et al. (2017), feed prices have quite inconsistent effects; the PC found a significant positive impact on saleyard prices for the period 2000-2007, we found insignificant effects for the periods 2000-2007 and 2000-2013, but for the period 2008-13 we found significant and negative effects. The negative impacts estimated for feed price on saleyard price can be explained by the relationship between these two variables displayed in Figure 4 in Popat et al. (2017), and reproduced below as Figure 2.

Figure 2: Feed (wheat) and saleyard prices (January 2000 to June 2013)



Besides both variables displaying similar patterns, their peaks occur in different points in time and there are periods where one is growing while the other is decreasing. So, by not accounting for lagged feed price, there is the possibility of misspecification problems with the structural form of the monthly ID models that might lead to violation of the zero conditional mean assumption required for unbiased OLS estimates (Hill et al., 2011). In fact, the correlation coefficient between feed price and the error term of

each of our monthly ID models is relatively high at +0.28, +0.55 and +0.10 respectively. Note that for the VAR(3) model this correlation is -0.019, that is, weak and negative.

The monthly ID models were re-estimated with the inclusion of three lagged feed variables (Table 7A). Only one of the nine lagged feed price variables were significant, and the results were qualitatively similar to those without the lagged feed prices, except that import volumes are now significant (but positive) in the 2008-2013 data period.

However, because possible high correlations among the regressors (feed price and its lags) may reduce the efficiency of the least squares, the models in Table 7A were re-estimated using just feed price with three lags. These results are reported in Table 7B. Again, the results were qualitatively similar to those with all of the lagged feed prices, and import volumes are now not significant in the 2008-2013 data period. Over the whole period, the evidence is conclusive that domestic saleyard prices are driven by domestic production and world prices.

Table 7A: ID models estimates with monthly data (all feed price lags)

Explanatory variables	IDm models with data from			
	2000-07 (PC)	2000-07 (IDm1)	2008-13 (IDm2)	2000-13 (IDm3)
feed	**0.053***	0.037	**-0.263***	-0.148
feed (lag = 1)		0.004	0.020	0.153
feed (lag = 2)		-0.122	-0.022	-0.279
feed (lag = 3)		0.130	0.133	**0.281****
prodpig	-0.105	-0.109	**-1.027*****	**-0.719*****
prodbeef	-0.028	0.117	0.063	0.070
prodlamb	**0.124***	-0.150	**0.528*****	0.0640
impvol (3 lag periods)	**-0.040***	0.004	**0.108***	-0.032
unit	**0.545****	**0.540*****	**0.307****	**0.414*****

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Table 7B: ID models estimates with monthly data (just feed price lagged three months)

Explanatory variables	IDm models with data from			
	2000-07 (PC)	2000-07 (IDm1)	2008-13 (IDm2)	2000-13 (IDm3)
feed	**0.053***			
feed (3 lag periods)		0.044[1]	-0.064	0.029
prodpig	-0.105	-0.092	**-1.220*****	**-0.757*****
prodbeef	-0.028	0.114	0.045	0.349
prodlamb	**0.124***	-0.007	**0.587*****	0.042
impvol (3 lag periods)	**-0.040***	0.004	0.109	-0.022
unit	**0.545****	**0.535*****	0.253	**0.396*****

[1] *p*-value = 0.103. Is slightly insignificant at 10%

The Quarterly Inverse Demand Model

The misspecification issue with the quarterly ID models is the inclusion of retail prices in its structural form. The theory of inverse demand models states that the price of a particular good should be expressed as a direct function of its quantities, quantities of alternative goods (not prices) and other demand variables; also known as the "*Hotelling-Wold identity*" (Anderson, 1980; Barten and Bettendorf, 1989; Holt, 2002). While none of the retail price variables are individually significant, there could be joint effects that impact on the significance of other explanatory variables.

Estimates from the re-specified quarterly ID models are reported in Table 8, and it can be seen that the qualitative results do not vary much from the previous ones. In the updated results there is no effect of import volumes on domestic prices, and domestic prices are driven by domestic pig meat production levels, and in the most recent period, also by domestic lamb production levels. Hence, as with the VAR, the misspecifications in the PC methods do not lead to different implications from the results.

Table 8: Restructured ID models estimates with quarterly data

Explanatory variables	IDq models with data from		
	2000-07 (IDq1b)	2008-13 (IDq2b)	2000-13 (IDq3b)
prodpig	-0.432	**-1.767*** **	**-1.154*** **
prodbeef	0.155	0.237	0.037
prodlamb	-0.127	**0.691*** **	-0.112
impvol (1 lag period)	**-0.115***	0.117	-0.082
hh	0.157	-0.189	0.174

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Conclusion

Following the methods proposed by the PC, all of the updated VARs, monthly and quarterly ID models are consistent in rejecting the hypothesis that imports are the main cause of damage for the domestic pig industry in Australia. However, consideration of the PC models led to the supposition that there might be some misspecification in all of the model forms tested. Based on re-specified models to account for the poor specification, there is still not enough evidence to justify the need for application of the WTO's safeguard measures to Australia.

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