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The Economic Impact of Imports on the Australian Pig Industry: Is it Time for the WTO's Safeguard Measures? 1. Replicating and Updating the 2008 Productivity Commission Analyses

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Abstract

It is now 25 years since pig meat imports were first allowed into Australia. Pig producers have argued that import liberalization has caused the decline in the domestic production of pig meat and in the profitability of pig production. In its most recent Inquiry report in 2008, 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. Since then the volume of pig meat imports into Australia has continued to rise so that by 2014 imported pig meat made up nearly 70 per cent of the total pig meat processed domestically and half of total consumption. The question addressed in this analysis is whether the current market scenario of substantial and continuing increases in pig meat imports in Australia could now justify the need for the WTO's safeguard measures. The specific objective is to assess whether the PC's earlier results still hold using exactly the same methods but with an updated dataset. Application of the first of the estimation techniques used by the PC suggests that domestic production has been affecting the saleyard price rather than import volumes or prices, while the second technique used by the PC and its respective post-estimation tests did not suggest a strong causal effect between import volume or unit values and domestic production or saleyard price. Thus, based on 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, there are a number of statistical problems with the PC models that were simply updated for the current analysis. In a companion paper, the PC models are re-specified and re-estimated to overcome these statistical problems.

Key words: pigmeat, imports, WTO, safeguard measures

Introduction

According to the Productivity Commission (PC) (PC, 2005, 2008), from 1985-86 to 2002-03 the pig meat production sector in Australia experienced a huge decline in size with nearly 57 per cent of pig farms being closed. The volume of domestic production also declined. These trends have continued in more recent periods (APL, 2013; Hamann et al., 2014). Aligned to these changes, the domestic manufacturing sector for pig meat in Australia has been relying more on imports to satisfy their increasing demand. For instance, during 2010-11 imports accounted for nearly 70 per cent of the total pig meat processed domestically (Haylen and Fell, 2011).

With imports growing faster in recent periods, domestic producers have been feeling threatened and they are currently shifting their outputs more to the fresh meat market (PC, 2008). As indicated by the Pork Council of Australia Limited (PCAL, 1999), pig farmers have blamed import liberalization as the main cause of the huge decline in the domestic production of pig meat. Since liberalization, domestic producers have been exposed to lower prices particularly for those specific cuts (legs and shoulders for ham, and middles for bacon) demanded by the manufacturing sector (Cutler and Holyoake, 2007; Hamann et al., 2014; PC, 2008). However, the findings from empirical research on the economic impact of pig meat imports on the domestic industry have not supported the producers' attribution of cause. In its most recent Inquiry report, the PC (2008) concluded that the main reason for the declining profitability of pig farmers in Australia was the higher cost of feed in the domestic market. These findings are consistent with earlier results reported by the Department of Agriculture, Fisheries and Forestry (DAFF, 2004) and by Cutler and Holyoake (2007). Moreover, these earlier studies suggested that the appreciating Australian dollar also favoured increased imports of pig meat (Cutler and Holyoake, 2007; DAFF, 2004). Hence, based on its analyses conducted with data from 1990 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 recent years the volume of pig meat imports into Australia has risen dramatically. According to Australian Pork Limited (APL, 2013), from 2007 to 2012 total annual imports rose by 38 per cent, to around 149,000 tonnes shipped weight (SW). With imports rising substantially since the last PC Inquiry report, the question asked in this research is whether the current market scenario of rapidly rising pig meat imports in Australia may now justify the need for the WTO's safeguard measures. The aims of this paper are to assess the economic impact of imports on the Australian pig industry using exactly the same methods as the PC, but with an updated data set to 2013, and to assess whether such an impact could be used to justify the implementation of the WTO's safeguard measures.

In a companion paper (Popat et al., 2017), the PC models are re-specified and re-estimated to overcome a range of statistical problems.

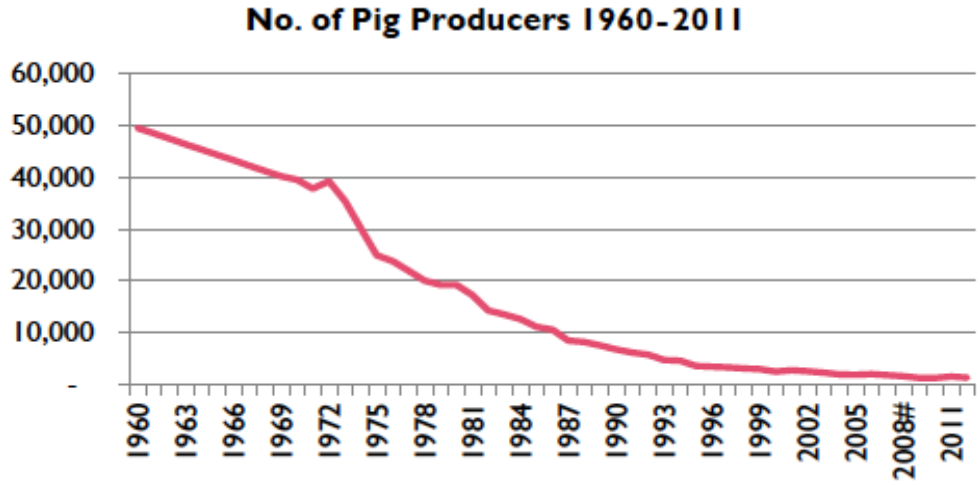
Industry Structure and Trends

Overview of the industry

The majority (70 per cent) of Australian pig farms are located in Queensland, New South Wales and Victoria and, with a rather narrow distribution of size of farm, the local pig meat industry has been considered to be in a stable stage over the recent past (APL, 2014). Nonetheless, the historical data reveal that the structure of the industry has changed considerably. From Figure 1 below it is evident that the number of pig producers has declined significantly from the level of the early 1960s. Between 1990 and 2004 for instance, nearly 5,000 pig growers abandoned the industry with only around 2,000 producers remaining by the end of the period (Cutler and Holyoake, 2007). Nowadays,

it is likely that this number has further decreased according to the trend displayed in Figure 1. One of the major reasons for such a huge decline in the number of Australian pig growers, particularly in recent years, is the increased cost of factors of production. As some studies suggest, input prices, particularly feed, have a significant impact on Australian pig farmers' profitability (Cutler and Holyoake, 2007; DAFF, 2004; PC, 2008). In addition, increased compliance costs associated with on-farm hygiene and environmental requirements have also played a part.

Figure 1: Number of pig producers in Australia, 1960-2011
Source: APL (2013)



In the past, most Australian pig production came from family farms, often associated with grain or milk farms (Cutler and Holyoake, 2007; DAFF, 2004), but this has changed in recent years. The number of small farms, in terms of sow herd, has been decreasing and the number of medium and large farms has been increasing and becoming more vertically integrated and specialized (DAFF, 2004; PC, 2005; Sheales, Apted, and Ashton, 2004). According to Sheales et al. (2004) small producers (operations with fewer than 100 sows) still represent the majority (80 per cent) of pig farms in Australia, but the 1 per cent of large farms (operations with 1,000 sows or more) control around 34 per cent of the total herd.

One of the greater risks for highly specialized farms is their limited capacity to adapt to changes in their business market environment and, hence, their proneness to external shocks that may impact on their profitability (PC, 2008; Sheales et al., 2004). One example of such shocks is the increasing price of feed for Australian pig producers. The findings from the PC (2008) indicate that feed price represents the most important threat affecting negatively the profitability of farmers as well as threatening the sustainability of the domestic pig industry.

However, despite farmers' profitability being connected to feed price, the domestic demand for pig meat is still growing. According to data provided by Hamann et al. (2014), the consumption of pig meat in Australia rose by nearly 10 per cent between 2005 and 2012 reaching around 26.3kg per capita; whilst total production moved in the opposite direction within the same period, showing a decline of a similar percentage (10 per cent) to 351,700 tonnes.

Main market forces for supply and demand

Numerous factors can exert influence on supply and demand for any product or service. In the case of the Australian pig industry, domestic factors such as the price of inputs, technology, the price of

pig meat and its substitutes as well as consumers' tastes and income can be classified as some of the most important market forces (Gans, King, and Mankiw, 2012).

One of the most fundamental inputs for pig growers is animal feed. For Australian pig farmers, this input represents around 55 to 60 per cent of the total costs of production (PC, 2008; PCAL, 1999; Sheales et al., 2004). Since Australian farmers rely exclusively on wheat as the main source of feed (PC, 2007, 2008), an increase in prices for this cereal has impacts on farmers' profitability (PC, 2008; Sheales et al., 2004). For instance, following the increased prices of wheat in 2006, in mid-2007 farmers' average losses in the order of $20 to $30 per pig were reported across the country (PC, 2007).

Beyond the effect of input prices, seasonality is also an important factor for the price of pig meat. Sow fertility cycles and higher demand in summer months (especially for Christmas ham) lead to higher producer prices in that season compared to winter months (PC, 2008). Domestically the elasticity of demand for pig meat is also sensitive to the price of substitutes such as beef, lamb and chicken (PC, 2008; Sheales et al., 2004). Also, Sheales et al. (2004) point to the Australian consumers' income as another factor that influences positively the domestic demand for meats in general (including pig meat).

Aligned to consumers' income, their tastes are also an important component that affects the demand for pig meat. According to the PC (2008), Australians have a strong preference for processed pig meat, particularly in the form of ham and bacon. Nonetheless, between 2002-03 and 2006-07, the total consumption of fresh pork meat in Australia rose by 40 per cent against an increase of only 10 per cent for the processed pig (PC, 2007). The higher increase in demand for fresh pork explains, in part, the strong shift by domestic pig growers to the fresh meat market where they are still protected against competition from international suppliers. This was backed up with heavy discounting at the retail level. Even though the consumption of fresh pig meat has increased, domestic consumers' tastes still show a strong preference for ham and bacon which leads Australian processors to increase their imports of pig meat to satisfy the demand in the local market (PC, 2008).

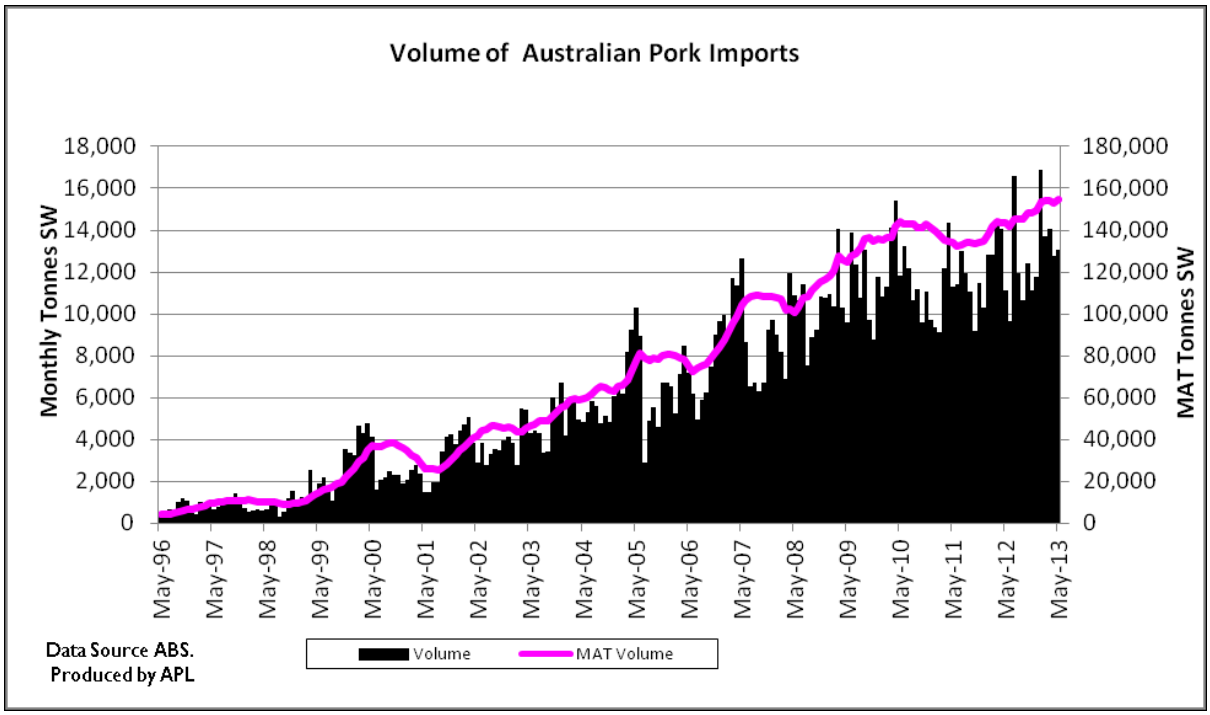
Imports

In Australia, imports of pig meat were legalized in 1990 under the *WTO Agreement on Sanitary and Phytosanitary Measures* (Cutler and Holyoake, 2007; PC, 2008). Initially, the agreement required imports to be in the form of cooked or frozen meat (Cutler and Holyoake, 2007; PC, 2008). However, subsequent amendments were made and currently the procedures require the frozen pig meat to be cooked once it arrives in the country (PC, 2008). According to the PC (2008), such measures restrict imported meat to be used only by smallgoods manufacturers (mainly for ham and bacon), ensuring that the fresh pork market (as well as smallgoods markets for 'ham-on-the-bone' and uncooked salami) are fully supplied by domestic production. Since the liberalization, the import volumes have grown substantially as shown in Figure 2.

Areas of comparative advantage enjoyed by foreign suppliers are likely the key issue that leads to increasing imports. For instance, while in Canada and the United States pig growers rely mostly on corn as the source of feed, Australian farmers depend significantly on wheat, which is more expensive (PC, 2008). In addition, the ability to exploit economies of scale is also an important factor that impacts on producers' comparative advantages. Denmark for instance, while being a small producer of pig meat, is ranked among the world's largest exporters of this meat partly due to its ability to exploit economies of scale and produce high quality meat (Hamann et al., 2014).

Currently, the top suppliers of pig meat into Australia are Canada, Denmark and the United States (APL, 2014; PC, 2008). Whilst Canada (since 1990) and the United States (since 2004) supply mostly legs and shoulders for ham, Denmark (since 1997) has been an important supplier of middles (used for bacon) (PC, 2008). The Netherlands has also been growing as another important supplier in recent years (APL, 2014).

Figure 2: Volume of Australian pig meat imports, 1996-2013 (MAT=moving annual trend)



Although cheaper prices for imports have been beneficial for the manufacturing sector, for Australian pig growers it has been a controversial issue with claimed negative impacts on the domestic industry. Indeed, producers point to import liberalization as the main cause for their profitability losses and lesser attention to the processed meat market (Cutler and Holyoake, 2007; PCAL, 1999). However, findings from DAFF (2004), Cutler and Holyoake (2007) and the PC (2008) suggest that the impact of imports has not caused significant damage to the Australian pig meat industry. Conversely, these authors point to the feed price as the main reason for the reduced profitability of farmers. Further, DAFF (2004), Cutler and Holyoake (2007) and Sheales et al. (2004) also suggest that the positive currency movements of the Australian dollar favors increasing imports. Hence, with results not suggesting that imports are the main cause of damage to the local pig industry, in 2008 the PC was unable to identify strong arguments to justify the need for Australia to activate the WTO's safeguard measures to temporarily suspend imports. This report is reviewed in detail below.

WTO safeguard requirements

The WTO's safeguard measures are ruled under the organization's article XIX of GATT 1994, in which "Safeguard measures are defined as 'emergency' actions with respect to increased imports of particular products, where such imports have caused or threaten to cause serious injury to the importing Member's domestic industry (Article 2)" (WTO, 2014). However, since the Uruguay Round,

safeguard measures can only be granted to a country member in cases where imports are found "to be the 'principal cause' of [serious] injury or threat to its domestic industry" (WTO, 2014).

In order to protect the local industry, the safeguard measures include allowance for the "injured" country to restrict the volume of imports (quotas) or adjust tariffs (WTO, 2014). However, it can only be a temporary measure that should not be applied for more than four years unless it can be strongly justified (WTO, 2014).

PC 2008 Report: Methods and Main Findings

There have been a number of inquiries into this issue by the PC and its predecessor, the Industry Commission. The most recent was published in 2008. The main goal of that report was to identify evidence to sustain the argument that the Australian pig meat industry has been damaged by the increasing volume of imports and, then, to allow the country to activate the WTO's safeguard measures. To address this aim, econometric analyses based on two different methods were adopted by the Commission: the vector autoregressive (VAR) and the inverse demand (ID) models. Both models used monthly data from August 1990 to November 2007.

The PC's monthly VAR model considered relationships between the following variables: the import volumes of pig meat (converted to carcass weight equivalent, cwe, using 0.56 as the conversion factor); import unit values (the ratio between the value of imports and the respective quantity in cwe); domestic production of pig meat; domestic weighted saleyard price of pigs; and feed wheat price. Except for feed wheat price, all the variables were allowed to be endogenous (jointly determined) in the model. The feed wheat price and other, artificial variables (the linear trend term and seasonal dummies) were treated as pure exogenous variables.

The linear trend term was used as a proxy for market demand growth over the sample period, and monthly dummy variables were defined for the months from January to November, skipping December as the base of comparison. Another dummy variable was created to reflect different "regimes of imports", zero for each month from 1990 to 1998 and one for the remaining months. This variable was created to allow for a possible structural break that reflects the increasing imports registered since 1999 (as seen in Figure 2). The model reported by the PC is a VAR with two lagged periods, a VAR(2) model, for the full data sample. However, the Commission also refers to separate estimated VAR models for the sub-periods from 1990 to 1999 and from 2000 to 2007.

The second econometric model considered by the PC, the ID model, was similarly estimated and reported for the full dataset as well as disaggregated for the two sub-periods. Two variants were also estimated for this model: an ID model for monthly data and another for quarterly data. For both ID models, the endogenous variable was the saleyard price of pigs.

In addition to the data used for the VAR model (and excluding the artificial variable "regime of imports"), the ID model with monthly data included the domestic production of beef, lamb and household income[1] as exogenous variables. The ID model with quarterly data was further extended to include the retail prices of the three types of meat (pig, beef and lamb) but excluding the feed wheat price. For the ID model with monthly data, the monthly dummy variables remained similar to the ones defined for the VAR model, while for the ID model with quarterly data the dummies were defined for the ending period for each of the three out of the four quarters of a year (March, June and September). A final difference between these two ID models was in regard to the variable

[1] As an alternative to the linear trend term used for the VAR model, this variable was similarly included as a proxy for the market demand growth.

"volume of imports", which was based on a three month lag for the monthly model and on a one quarter lag for the quarterly ID model.

Both the VAR and ID models led to rejection of the hypothesis that imports are the main cause of profitability losses for Australian pig farmers (PC, 2008, pp. xxvii-xxx). Further, the post-estimation test on the VAR model, the impulse response function (irf) test, suggested that shocks on imports did not lead to a decline in the domestic production of pigs. The estimated effect was positive but not statistically significant at the 10 per cent confidence level. The same shock had a negative, but again insignificant, impact on the domestic saleyard price of pigs.

For the ID model with monthly data, however, results suggested that imports had significant negative effects on saleyard prices of pig for the models estimated with the full dataset and the one for the period from 2000 to 2007. For the period 2000 to 2007, for instance, this model suggested that a 1 per cent increase in the volume of imports led to some 0.04 per cent decline in saleyard prices of pigs three months later. Although with an insignificant effect this time, the same model also suggested that the impact of a 1 per cent increase in domestic production of pig was a 0.11 per cent decline on its saleyard price.

Furthermore, the ID model with monthly data provided some evidence that feed wheat price had a positive and significant effect – up to 10 per cent of significance level for the model with data from 2000 to 2007 – on the saleyard price of pigs. Nonetheless, for the ID model with quarterly data, the PC was cautious about drawing conclusions since the significance of the coefficients had the opposite behavior as for the monthly ID model in the three periods of analyses.

Methods

The aim of this study was to replicate the VAR and ID analyses conducted by the PC, and then extend the analyses to the most recent available data. However, due to problems accessing some of the older data, the "pure" replication component of this study – basically for the ID model – is limited to the period from 2000[2] to 2007. The extension of the analyses uses data for the period up to June 2013. Similar to the approach by the PC, all the quantitative variables in this study are transformed to logs. The software used for the statistical analyses is STATA 13.0.

The technical details of model specification and estimation techniques are provided in Appendix 1 for interested readers.

Data

This study is based on monthly data for import volumes of pig meat, import unit values, domestic production of pig meat and its saleyard prices, feed wheat prices, domestic production of beef and lamb; and on quarterly data for household income and retail prices of pork, beef and lamb. The full dataset used for the analyses in this study covers the period from January 2000 to June 2013 and it was mainly collected from the Australian Bureau of Statistics (ABS), Australian Commodities Statistics reports by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) and APL (2013). The abbreviations for these variables are indicated in Table 1 below and their full respective sources are described in Appendix 2.
Exactly the same procedures were followed as reported by the PC, with two exceptions. Although not specified by the PC, retail prices in this study are in real terms based on the consumer price

[2] Although the full set of available data for this study starts from 1999, to allow consistency with analyses from the PC the year 2000 was taken as the starting point of the dataset.

index (CPI) correction factor. Also, for the ID models with quarterly data, *feed* represents the feed wheat price in the respective ending month of each quarter.

Table 1: Main variables and their codes

Variable	Code	Type of data	Unit
Import volumes	*impvol*	Monthly	Kilotonnes (cwe)
Import unit values	*unit*	Monthly	$A/Kg
Domestic production of pig meat	*prodpig*	Monthly	Kilotonnes
Domestic saleyard price of pigs	*salpig*	Monthly	$A/Kg
Feed wheat price	*feed*	Monthly	$A/Tonne
Domestic production of beef	*prodbeef*	Monthly	Kilotonnes
Domestic production of lamb	*prodlamb*	Monthly	Kilotonnes
Household income	*hh*	Quarterly	(x1,000) $A million
Retail price of pork	*rppig*	Quarterly	$cA/Kg
Retail price of beef	*rpbeef*	Quarterly	$cA/Kg
Retail price of lamb	*rplamb*	Quarterly	$cA/Kg

The relationships between some of the key variables are described in Figures 3 and 4 below, while the descriptive statistics are provided in Appendix 2 for the various data sub-periods. In Figure 3 (a and b) the rapid increase in the volume of imports is shown in relation to the slightly decreasing trend in domestic production during the period around 2005 to 2010, as well as the trend of domestic and averaged international prices of pig meat. The most dramatic change in the saleyard price was observed in 2007-08 near the period the domestic production achieved its lowest value at least over the previous five years. It is also evident that there was a close relationship between saleyard price and import unit value up until mid 2008, but that is no longer the case.

Figure 3(a): Volume of pig meat (imports vs domestic production)

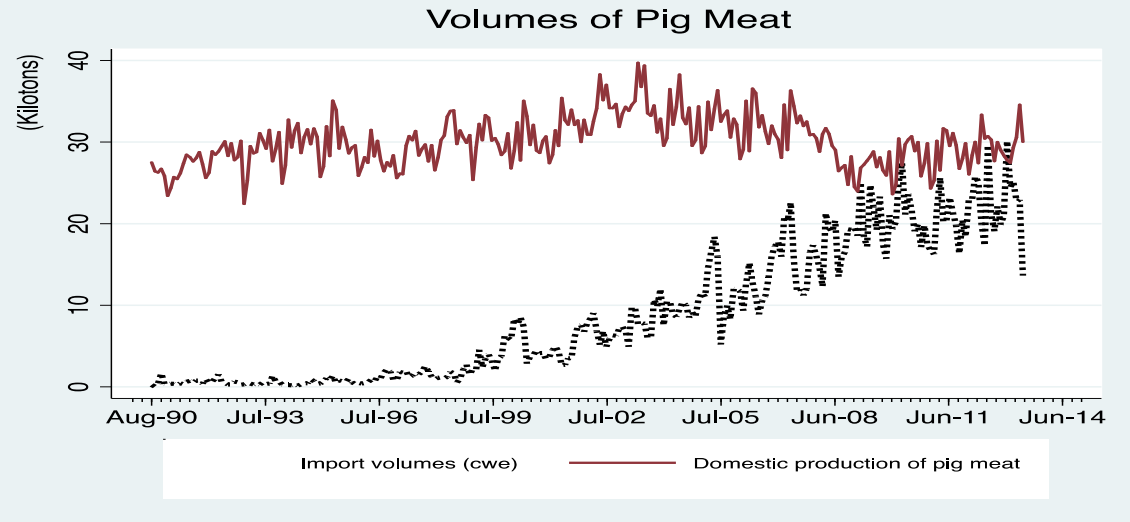


Figure 3(b): Prices of pig meat (imports vs domestic market)

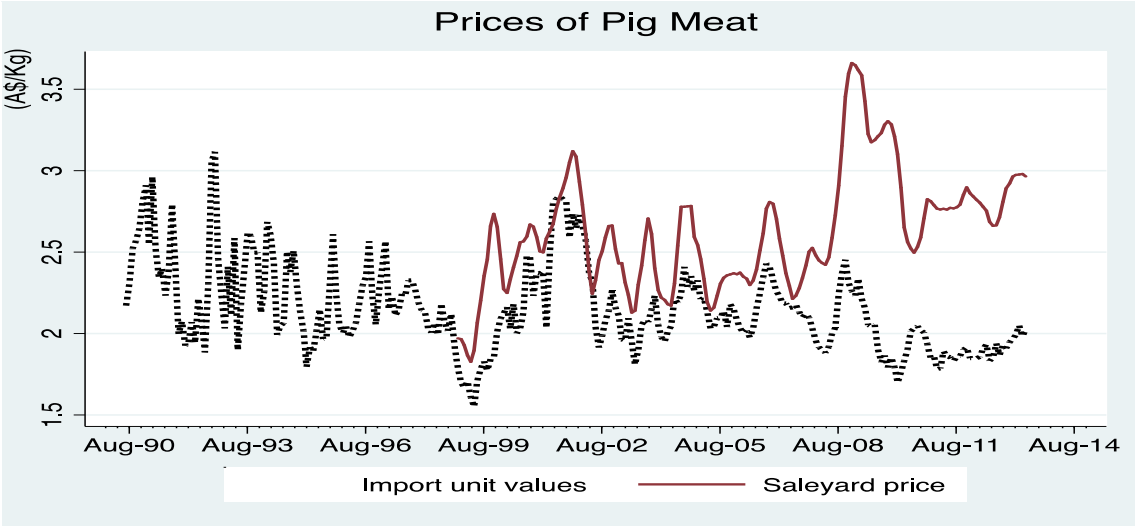
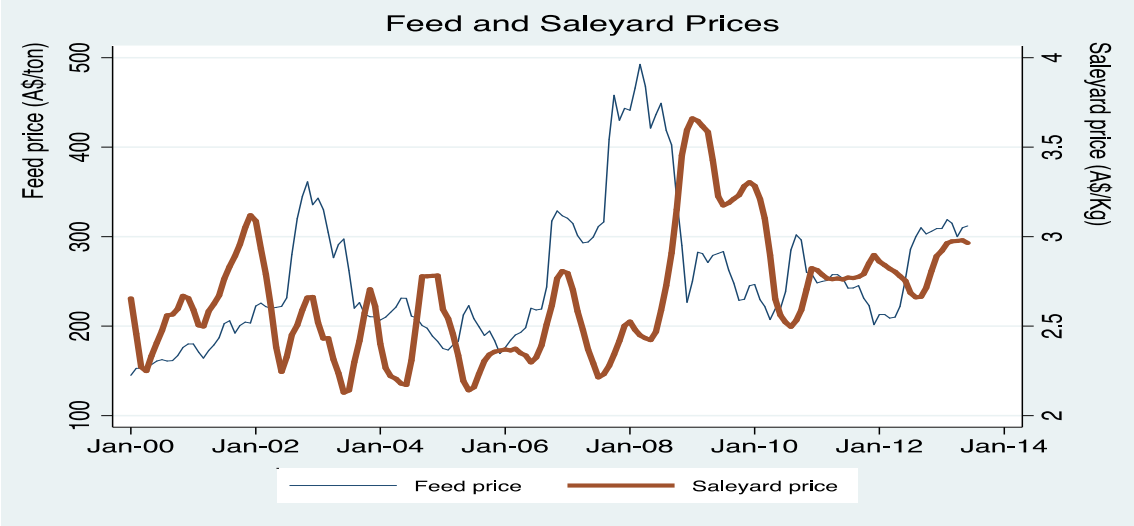


Figure 4: Feed wheat and saleyard prices of pig in Australia



However, as Figure 4 suggests, feed price is likely to be strongly related with saleyard price. From this figure it is seen that peaks in saleyard price follow peaks in feed wheat price some months later. Hence, this scenario may suggest a link or causal effect between these two variables.

Results

VAR model

As shown in Table 2, the estimated VAR(2) model is, in general, qualitatively comparable with the findings from the PC (2008). In particular, as with the PC findings, there are no significant effects of either import volumes or import unit values on domestic prices for pigs. Nonetheless, there are some important differences of interest. Saleyard price and domestic production show a significant

Table 2: Coefficient estimates for the VAR models

		prodpig		***salpig***		***impvol***		***unit***	
		PC[1]	VAR(2)[2]	PC	VAR(2)	PC	VAR(2)	PC	VAR(2)
prodpig									
	L1	**0.151****	**0.211*****	0.034	**-0.080*****	**-0.892***	**-0.616****	0.030	0.009
	L2	**0.306*****	**0.349*****	-0.063	**-0.046***	0.270	**0.787*****	-0.074	-0.022
salpig									
	L1	-0.139	**-0.416*****	**1.321*****	**1.558*****	-0.167	-0.686	0.016	**0.320****
	L2	0.111	0.242	**-0.377*****	**-0.675*****	**1.470***	0.892	**0.363***	**-0.270****
impvol									
	L1	0.006	0.018	-0.007	-0.003	**0.568*****	**0.586*****	-0.007	0.004
	L2	-0.002	**-0.050****	0.003	-0.007	0.010	0.054	**-0.023***	-0.008
unit									
	L1	0.023	0.028	0.012	-0.001	0.030	**0.764****	**0.421*****	**0.863*****
	L2	-0.017	0.089	-0.025	0.039	**-0.678****	**-0.738****	**0.133****	-0.058
Linear trend term		-0.001	-0.278	0.002	**-0.213***	**0.081*****	**-5.216*****	**0.009****	0.443
feed		**0.060****	0.011	-0.002	0.007	**0.094****	0.085	**-0.068****	-0.003

*** 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

interrelationship in the estimated model, import volumes have a negative impact on domestic production for the estimated model, and there is a significant negative trend in saleyard prices, all of which were insignificant in the PC (2008) findings.

The difference in the magnitude of these variables is also substantial between the two models as indicated in Table 2[3]. For instance, whilst a 1 per cent increase in the saleyard price reduced domestic production by 0.42 per cent for the estimated model, for the PC (2008) the impact was a reduction of 0.14 per cent. Another important difference is in regard to the effects of feed price, for which the estimated model did not find any significance. The differences in point estimates may be attributed to the different sample sizes.

ID models

The findings from the ID monthly models contrast with the PC results, even for the "purely" replicated model. The most plausible reason for the differences is likely to be the source of the data; as referred to in Appendix 2, for some variables more than one source had to be used to complete the dataset.

Table 3: ID models estimates with monthly data (IDm)

Explanatory variables	IDm models with data from			
	2000-07 (PC)	2000-07 (IDm1)	2008-13 (IDm2)	2000-13 (IDm3)
feed	**0.053***	0.031	**-0.165****	-0.017
prodpig	-0.105	-0.063	**-1.007****	**-0.723****
prodbeef	-0.028	0.090	0.092	0.037
prodlamb	**0.124***	-0.022	**0.523****	0.029
impvol (3 lag periods)	**-0.040***	0.004	0.082	-0.018
unit	**0.545****	**0.532****	**0.346****	**0.410****

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

As with the VAR model, there is no evidence from the ID model estimates across any of the sample periods to support the hypothesis that the volume of imports has a significant effect on saleyard price, and this is different to the PC findings. However, contrary to the VAR, import unit values are found to have a significant positive effect on saleyard price across all sample periods, and this result is the same as the PC findings.

In contrast to the PC findings, the IDm2 feed price, had a significant and negative effect on saleyard price. This, however, can be explained by the relationship between saleyard price and feed price as depicted in Figure 4. Post 2007, saleyard price appears to respond to changes in feed price. The discrepancy in results could be due to misspecification of the PC ID models (feed price being correlated with the error term), leading to biased estimated coefficients.

Not surprisingly, the previous results are supported by the ID quarterly model estimates. As shown in Table 4, estimates for the IDq models also indicate insignificant effects of a one-lagged quarter volume of imports (though with opposite signs in some cases) on the saleyard price. There are, however, consistent positive impacts associated with import unit values, but not in the last five years of the data, at the 10 per cent confidence level.

[3] For interested readers, the full results from all the estimated models are available from the authors.

Table 4: ID models estimates with quarterly data (IDq)

Explanatory variables	IDq models with data from			
	2000-07 (PC)	2000-07 (IDq1)	2008-13 (IDq2)	2000-13 (IDq3)
rppig	0.233	-0.757	-0. 392	-0.174
prodpig	0.200	-0.040	**-1.860*** **	**-1.256*** **
rpbeef	0.529	0.966	-0.437	0.428
prodbeef	0.133	0.240	0.184	-0.172
rplamb	-0.663	-0.232	0.084	-0.116
prodlamb	-0.115	0.014	**0.670***	-0.238
unit	**0.536*** **	**0.525*** **	0.183	**0.444*** **
impvol (1 lag period)	-0.012	-0.002	0.246	-0.050
hh	0.139	-0.072	-0.662	0.221

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

Discussion

The PC found different results from the different types of models used in their Inquiry. In the VAR analysis, neither import volumes nor prices had any effect on domestic pig production or prices. The cost of feed impacted on domestic production but there was not a strong relationship between domestic production and saleyard prices. In the updated VAR analysis reported here using exactly the same methods, 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 regression models, the PC found cost of feed, import volumes and unit prices to be significant in the monthly model but only unit prices were significant in the quarterly model. In the updated analysis, unit import values continue to be significant but domestic production has replaced feed cost as the driver of saleyard prices in both the monthly model and quarterly models.

It would be easy to conclude 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. Thus, based on 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.

Conclusion

In the updated VAR analysis reported here using exactly the same methods as the PC, 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 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 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, there are a number of statistical problems with the PC models that were simply replicated in the current analysis. Similar to the PC model, the estimated VAR(2) model failed to satisfy the assumption of non-serial correlation. Other misspecifications of this model include the lag order selection, for which the selection criterion suggested a three-period instead of two-period lag, and failure of the variable "linear trend term" to pass the test for stationarity even for higher lag orders. In the monthly ID model at least one of the assumptions of regression models – correlation between regressors (feed price) and error term – is violated, while the quarterly ID model does not follow the recommended basic structural form of inverse demand models.

In the companion paper, we take up these issues (Popat et al., 2017). We provide the evidence for these statistical inadequacies, and then estimate models which meet the statistical requirements.

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Appendix 1. Model Specification and Estimation Techniques

Specification of the VAR model

Similar to an autoregressive distributed lag (ARDL) model, VAR models capture the dynamic effect from past (lagged) values of the exploratory and its explanatory variables, as well as the causal relationship between one variable to another (Hill, Griffiths, and Lim, 2011). Thus, both ARDL and VAR models can be described as multiple regression models that include lagged endogenous and exogenous variables. However, while an ARDL model is based on single equation – and hence a unique explanatory variable – the VAR model recognizes the endogeneity of different explanatory variables and allows them to be related and treated simultaneously as a system of explanatory variables (Hill et al., 2011). In addition, by allowing for lagged variables within the regression model, both ARDL and VAR models can capture the long-run relationships between variables.

Based on Chang and Griffith (1998) and Hill et al. (2011), equation 1 below describes the structural form of the VAR model. This model follows a similar structural form of the VAR estimated by the PC (2008) except that it excludes the dummy variable for the regime of imports. The current model only includes data since 2000, hence the 1999 structural break identified by the PC is excluded to potentially avoid biased estimates (Hill et al., 2011).

$$y_{k,t} = \alpha_0 + \beta_1 x_{i,t-1} + \cdots + \beta_i x_{i,t-p} + \gamma_n \omega_n + \delta_z d_{zt} + \varepsilon_t^k \quad (1)$$

Where:
t = time index;
p = lag length;
k = index for each endogenous variable allowed in the system (k = 1,…, 4);
n = index for each "pure" exogenous variable (n = 1, 2);
y = (k x 1) vector of k endogenous variables (y_k = import volumes of pig meat; import unit values; domestic production of pig meat; and, saleyard[4] price of pig);
x = (i x 1) vector of p lagged y's (i = lagged k and j. $j \neq k$, and j = 1, 2, 3). For instance, if saleyard price is y_k, then y_j = (import volumes of pig meat; import unit values; and, domestic production of pig meat);
ω = (n x 1) vector of pure exogenous variables (ω_n = feed wheat price and linear trend term);
d = (z x 1) vector of dummy variables (z = seasonal dummies for the months from January to November; z = 1, …, 11);
β = (1 x i) vector of the parameters associated with x_i;
γ= (1 x n) vector of the parameters associated with ω_n;
δ = (1 x z) vector of parameters associated with d_z;
α = (k x 1) vector of the intercept term;
ε_t = disturbance term, assumed to be not serially correlated; $\varepsilon_t \sim (0, \sigma^2)$.

In the agricultural economics field, some examples of the application of VAR models include the studies by Taha and Hahn (2014) and Chang and Griffith (1998). The latter example however, is based on the error correction model (ECM), which, according to the authors, is a particular variant of the VAR model.

[4] This variable is abbreviated within the report to just "saleyard price".

Specification of the ID model

As an alternative to the VAR model, the PC (2008) adopted the ID model in order to test the robustness of the results achieved with the former econometric model. The ID model approach has been often used (e.g. Barten and Bettendorf, 1989; Chen and Dharmaratne, 1996; Galdeano, 2004; Hilmer, Holt, and Bishop, 2010; Holt, 2002). This type of model allows the price of a particular good to be treated as an endogenous variable that depends on its demanded quantity as well as other determinant variables of demand (Chen and Dharmaratne, 1996). As Anderson (1980) and Wong (2013) suggest, ID models are of particular importance in analysing changes in price in response to shocks on demand variables. In the agriculture context, Barten and Bettendorf (1989, p. 1510) note the usefulness of ID models for analyses involving perishable products, for which *"supply is very inelastic in the short run and the producers are virtually price takers"* while traders are the price makers on the basis of the available quantities.

There are different specifications for ID models; however, no clear guidelines exists in terms of which is best (Holt, 2002). In studying meat demand in the US, Holt (2002) combined two different specifications of this model. Nonetheless, based on the concept of maximising utility subject to prices and quantities of different goods, the central aspect of ID models consists on estimating *"quantity elasticities"* for different goods as a measure for changes in price of a particular good "*in response to a proportionate increase in all"* goods (Anderson, 1980, p. 284). However, because this part of the study is based on replicating the model adopted by the PC, technical issues on specifications for different ID models are not explored in detail in this report; Anderson (1980), Barten and Bettendorf (1989) and Holt (2002) are some of the relevant references that discuss ID model specifications.

Following the PC (2008) approach, equation 2 below describes the structural form of the ID models considered for this study. One important aspect of this model is its discordance with the structural form of ID models, discussed and adopted by Anderson (1980), Barten and Bettendorf (1989), Holt (2002) and other authors previously referred to in this context.

$$y_t = \alpha_0 + \beta_i x_{it} + \delta_j d_{jt} + \varepsilon_t \qquad (2)$$

Where:
y = saleyard price;
i = index for the exogenous variables x;
j = index for the dummy variables;
t = index of time;
x_i = exogenous variables. For the ID with monthly data (x_i = feed wheat price, domestic production of pig meat, beef, and lamb, import unit values, import volumes with three lag periods and household income), while for the modelwith quarterly data (x_i = previous exogenous variables plus retail prices of pig meat, beef and lamb. However, feed wheat price is excluded while import volume is adjusted to a one lag for the quarter's period);
d_j = dummy variables. For the ID with monthly data (j = seasonal dummies for the months from January to November) and for the one with quarterly data (j = seasonal dummies for the end of quarters: March, June and September);
β_i = parameters associated with each x_i;
δ = parameters associated with d_t;
α = the intercept term;
ε_t = disturbance term, assumed to be not serially correlated; $\varepsilon_t \sim (0, \sigma^2)$.

Estimation methods

The two econometric models described above are estimated by ordinary least squares (OLS). Some examples of VAR models estimated using the least squares' principle are Gordon and King (1982) and Orden and Fackler (1989); and of ID models from Galdeano (2004) and Felt, Gervais, and Larue (2011).

Despite its popularity, estimation with OLS may lead to biased, inconsistent and inefficient estimates if at least one of the basic assumptions of this estimator is violated (Hill et al, 2011). In the case of time-series data, Hill et al. (2011) highlight that serial correlation between the residuals is the most probable assumption to be violated. Non-stationary (or non-cointegrated) variables are also problematic and can lead to spurious regression. To avoid such problems (or at least to acknowledge them), tests on serial correlation and stationarity need to be performed before any statistical inference is made from the estimated models.

Following the procedures by the PC (2008), the serial correlation of the residuals in the VAR model as well as the variables' stationarity are assessed by the Lagrange multiplier (LM) and augmented Dickey-Fuller (DF) tests respectively. As the model is conceptually based on a finite lag length (*p*), the choice of *p* is based on the Schwarz[5] Bayesian information criterion (SBIC). For the ID models however, serial correlation is not assessed. Instead, "*heteroskedasticity and auto-correlation consistent [(HAC)] standard errors*" are imposed. This procedure is recommended for regression models with time-series data that are estimated by OLS without specifying the nature of the residuals' autocorrelation (Hill et al., 2011).

Post-estimation tests

For regression models, a *t*-test on each of the estimated coefficients is a suitable mechanism to assess the statistical significance of the impact of the regressors on the endogenous variable (Hill et al., 2011). For VAR models, other tests such as the impulse response function (irf) test are often used to assess the response of the endogenous variable to its own shocks or shocks on the exogenous variables and vice-versa (Hill et al., 2011). Apart from the PC, this test was also considered in other studies by authors such as McPhail (2011), Chang and Griffith (1998) and Orden and Fackler (1989). The PC (2008) and McPhail (2011) also considered the Granger causality test in their VAR models. This second test allows for the causal links between endogenous variables to be identified (PC, 2008). This study considers these two post-estimation tests for the VAR model.

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

Appendix 2. Data Sources and Descriptive Statistics

Table A2a: Data Sources

Variable	Unit	Source	Type	Period covered
Import volumes (*impvol*)	Kg	Dataset provided by Garry Griffith plus recent data reported by APL[1]	Monthly	Jul-1989 to Jun-2013
Value of imports (required to generate the **import unit values**, *unit*)	$A	Dataset provided by Garry Griffith plus recent data reported by APL[1]	Monthly	Jul-1989 to Jun-2013
Domestic production of pig meat (*prodpig*)	Ton	ABS	Monthly	Jul-1989 to Jun-2014
Saleyard price of pigs (*salpig*)	$A/Kg	ABARES (annual commodities report)	Monthly	Jan-1999 to Sep-2013
Feed wheat prices (*feed*)	$A/Ton	ABARES (annual commodities report)	Monthly	Jan-1998 to Jun-2013
Domestic production of beef (*prodbeef*)	Ton	ABS	Monthly	Jul-1989 to Jun-2014
Domestic production of lamb (*prodlamb*)	Ton	ABS	Monthly	Jul-1989 to Jun-2014
Household income (*hh*)	$A million	ABS	Quarterly	Jun-1989 to Mar-2014
CPI (consumer price index)		ABS	Quarterly	Jun-1989 to Jun-2014
Retail price of pork (*rppig*)	$cA/Kg	Dataset provided by Garry Griffith plus recent data from ABARES[2] (annual commodities report)	Quarterly	Jan-1998 to Jun-2013
Retail price of beef (*rpbeef*)	$cA/Kg	Dataset provided by Garry Griffith plus recent data from ABARES[2] (annual commodities report)	Quarterly	Jan-1998 to Jun-2013
Retail price of lamb (*rplamb*)	$cA/Kg	Dataset provided by Garry Griffith plus recent data from ABARES[2] (annual commodities report)	Quarterly	Jan-1998 to Jun-2013

[1] From July 2006; [2] From January 1999

Table A2b: Descriptive statistics for the full sample data collected (Aug-1990 to Jun-2013)

Code	Unit	N	Mean	stdev	min	max	CV
impvol (cwe)	Ton	275	8,656.32	8,206.49	31.76	30,128.57	0.95
unit	$A/Kg	275	2.15	0.27	1.55	3.12	0.13
prodpig	Ton	275	30,099.39	3,047.55	22,430.00	39,721.00	0.10
salpig	$cA/Kg	174	262.51	35.93	182.60	366.06	0.14
feed	$A/Ton	186	242.54	76.83	143.00	492.50	0.32
prodbeef	Ton	275	164,031.50	21,050.20	115,049.00	219,441.00	0.13
prodlamb	Ton	275	28,669.40	5,795.18	17,951.00	44,096.00	0.20
hh	$A (x1000) million	91	181.94	76.52	91.88	332.51	0.42
rppig	$cA/Kg	91	965.24	215.66	686.21	1,389.82	0.22
rpbeef	$cA/Kg	91	1,263.91	263.82	945.51	1,627.06	0.21
rplamb	$cA/Kg	91	968.04	317.71	544.60	1,498.47	0.33

Table A2c: Descriptive statistics for the period Jan-2000 to Jun-2013

Code	Unit	N	Mean	stdev	min	max	CV
impvol (cwe)	Ton	162	13,903.66	6,806.04	2,648.84	30,128.57	0.49
unit	$A/Kg	162	2.11	0.24	1.70	2.84	0.11
prodpig	Ton	162	30,893.27	3,214.07	23,616.00	39,721.00	0.10
salpig	$cA/Kg	162	265.96	33.84	212.80	366.06	0.13
feed	$A/Ton	162	254.73	74.87	145.00	492.50	0.29
prodbeef	Ton	162	173,456.50	19,446.39	118,189.00	219,441.00	0.11
prodlamb	Ton	162	32,343.97	4,370.45	21,255.00	44,096.00	0.14
hh	$A (x1000) million	54	230.81	61.66	141.31	332.51	0.27
rppig	$cA/Kg	54	1,115.30	146.49	834.45	1,389.82	0.13
rpbeef	$cA/Kg	54	1,455.06	162.38	1,048.26	1,627.06	0.11
rplamb	$cA/Kg	54	1,188.18	217.38	715.25	1,498.47	0.18

Table A2d: Descriptive statistics for the period Jan-2000 to Dec-2007

Code	Unit	N	Mean	stdev	min	max	CV
impvol (cwe)	Ton	96	9,417.43	4,413.03	2,648.84	22,597.90	0.47
unit	$A/Kg	96	2.22	0.23	1.81	2.84	0.11
prodpig	Ton	96	32,515.30	2,733.65	26,784.00	39,721.00	0.08
salpig	$cA/Kg	96	249.13	22.85	212.80	312.00	0.09
feed	$A/Ton	96	233.17	69.28	145.00	458.00	0.30
prodbeef	Ton	96	172,121.10	19,496.42	118,189.00	208,209.00	0.11
prodlamb	Ton	96	30,610.30	4,045.29	21,255.00	43,588.00	0.13
hh	$A (x1000) million	32	186.36	31.92	141.31	250.68	0.17
rppig	$cA/Kg	32	1,046.34	114.55	834.45	1,212.35	0.11
rpbeef	$cA/Kg	32	1,370.83	162.86	1,048.26	1,564.80	0.12
rplamb	$cA/Kg	32	1,056.28	178.36	715.25	1,238.09	0.17

Table A2e: Descriptive statistics for the period Jan-2008 to Jun-2013

Code	Unit	N	Mean	stdev	min	max	CV
impvol (cwe)	Ton	66	20,429.09	3,648.57	12,294.64	30,128.57	0.18
unit	$A/Kg	66	1.96	0.16	1.70	2.45	0.08
prodpig	Ton	66	28,533.94	2,264.40	23,616.00	34,582.00	0.08
salpig	$cA/Kg	66	290.44	32.34	242.18	366.06	0.11
feed	$A/Ton	66	286.10	72.00	201.50	492.50	0.25
prodbeef	Ton	66	175,398.90	19,356.34	121,975.00	219,441.00	0.11
prodlamb	Ton	66	34,865.67	3,535.28	26,775.00	44,096.00	0.10
hh	$A (x1000) million	22	295.46	26.46	256.80	332.51	0.09
rppig	$cA/Kg	22	1,215.59	130.40	1,065.01	1,389.82	0.11
rpbeef	$cA/Kg	22	1,577.59	29.13	1,533.80	1,627.06	0.02
rplamb	$cA/Kg	22	1,380.02	85.06	1,248.97	1,498.47	0.06