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Does Consumer Interest in the Live Export Trade Affect Australian Meat Demand?

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Abstract

The long-distance transport of live sheep, cattle and goats by ship from Australia to Asia and the Middle East is an ongoing, contentious issue in Australia due to concern for the welfare of the animals during and after the voyage. This concern has been driven by internet-based and televised campaigns against animal cruelty which have triggered a significant reaction of anger from the Australian public. This study investigates a novel method of capturing and measuring the impact of these concerns on Australian meat demand. This is done by incorporating an aggregated live export Google Trends index as a proxy for consumer response to live export information in a demand system for Australian meat. This study provides an alternative method for capturing consumer response to non-traditional demand shift variables and provides insight into how Australian meat demand is affected by interest in the live export trade, as well as price, income, seasonality and pre-committed consumption.

Keywords*:* Australian meat demand; generalized almost ideal demand system; pre-committed demand, live export

Introduction

The long-distance transport of live sheep, cattle and goats by ship from Australia to Asia and the Middle East is an ongoing, contentious issue in Australia due to concern for the welfare of the animals during and after the voyage. Media coverage of animal abuse in the live export trade has triggered a significant reaction of anger from the Australian public (Munro, 2015) and led many to question whether the trade should be continued or replaced with exports of Australian meat products (Coombs and Gobbett, n.d.). This study seeks to determine whether the public interest in the live export trade has been sufficient to effect change in consumer behaviour; specifically, whether it has had any impact on Australian meat consumption patterns.

The Australian live export trade gained mainstream attention in 1990 when Saudi Arabia rejected a consignment of live sheep due to scabby mouth (*pustula dermatitis*), subsequently closing their market to Australian sheep for the next 11 years. In 2003, Saudi Arabia rejected a second consignment of approximately 58,000 sheep due to scabby mouth. These two events led to a series of rolling policy developments intended to improve the animal welfare standards of the trade and regulate the supply chain (Jackson and Adamson, 2018). The 2003 event prompted animal activist groups to investigate and televise the treatment of animals involved in the live export trade (Animals Australia, 2016). The first investigation was aired on Australian television in 2004 and detailed the treatment of Australian sheep during and after a voyage to Kuwait (Live Export Shame, 2004). Several other investigations and media reports on the trade followed (Animals Australia, 2016).

To date, the most high-profile media coverage has been a televised report on the treatment of Australian cattle shipped to Indonesia in 2011. This report captured the attention of the mass media and led to over 60,000 media stories worldwide (Animals Australia, 2016), prompted the Australian Government to further modify Australian live export trade practices (DAFF, 2011), and triggered a significant vociferous response from the Australian public (Munro, 2015). Tiplady, Walsh and Phillips (2013) conducted a survey to investigate this response by the Australian public. When asked what actions they took after viewing the report, 8 per cent of survey respondents indicated that they contributed to a blog/online discussion and 5 per cent indicated that they stopped eating meat, specifically beef.

Overall, Tiplady et al. (2013) concluded that the Australian public were emotionally affected by the media coverage of animal cruelty, but that it did not translate into significant behavioural change. Since the introduction of live export media campaigns, changes in the meat consumption habits of Australian consumers, and by extension the potential impacts of the live export trade on Australian consumer demand for meat, have not been quantified. Potential impacts could include own-effects on the demand for lamb and beef as well as cross-effects impacting the demand for other meats. Further, a modelling framework to investigate the potential impact of the live export trade on consumer meat demand has not been developed in the Australian context. The primary objective of this study is to investigate whether the consumer attention attracted to the live export trade has impacted on Australian meat consumption. The secondary objective is to test the effectiveness of a Google Trends live export index as a novel proxy for Australian consumer response to the live export trade.

Research dedicated to Australian consumer demand response to non-traditional variables is extensive. It includes advertising (Piggott, Chalfant, Alston and Griffith, 1996), research and development (Mounter, Griffith, Piggott, Fleming and Zhao, 2008), improvements in eating quality (Griffith and Thompson, 2012; Mounter, Villano and Griffith, 2012), new technology adoption (Griffith, Vere, and Bootle 1995), and health attributes (Bellhouse, Malcolm, Griffith, and Dunshea 2010). To date, the impact of consumer attitudes to the Australian live export trade on Australian meat demand has not been investigated. However, information pertaining to farm animal welfare has been shown to affect demand for meat in the US (Tonsor and Olynk, 2011) and Belgium (Verbeke and Ward, 2001). Tonsor and Olynk (2011) estimated a Rotterdam model and found a small but statistically significant decline in meat demand in the US due to animal welfare media attention. Verbeke and Ward (2001) estimated an AIDS model and found that negative television coverage had a statistically significant negative impact on beef demand in favour of pork demand in Belgium.

Tighe, Piggott, Cacho, Mounter and Villano (2019) found the existence of pre-committed levels of chicken consumption, seasonal factors, and time trends using quarterly data spanning 1996(1)-2016(4). This study extends that work by employing a more recent sub-set of the same dataset and attempting to measure the impact of live export welfare concerns on Australian meat demand.

When testing for the impact of non-traditional demand shifters on meat consumption, a common method of index construction has been the summation of the number of published journal articles, newspaper and popular press articles, or televised news stories, pertaining to the demand shifter of interest (Burton and Young, 1996; Piggott and Marsh, 2004; Tonsor, Mintert and Schroeder, 2010; Tonsor and Olynk, 2011; Verbeke and Ward, 2001). Alternative methods of capturing consumer response to non-traditional meat demand variables and media information is needed (Tonsor and Olynk, 2011). The sources of extant information available to consumers need to be updated to add to mass media the newer forms of information dissemination, such as internet-based news sites and social media. This study addresses this need by incorporating a Google Trends index as a proxy for consumer response to live export events and information in a demand system for Australian meat.

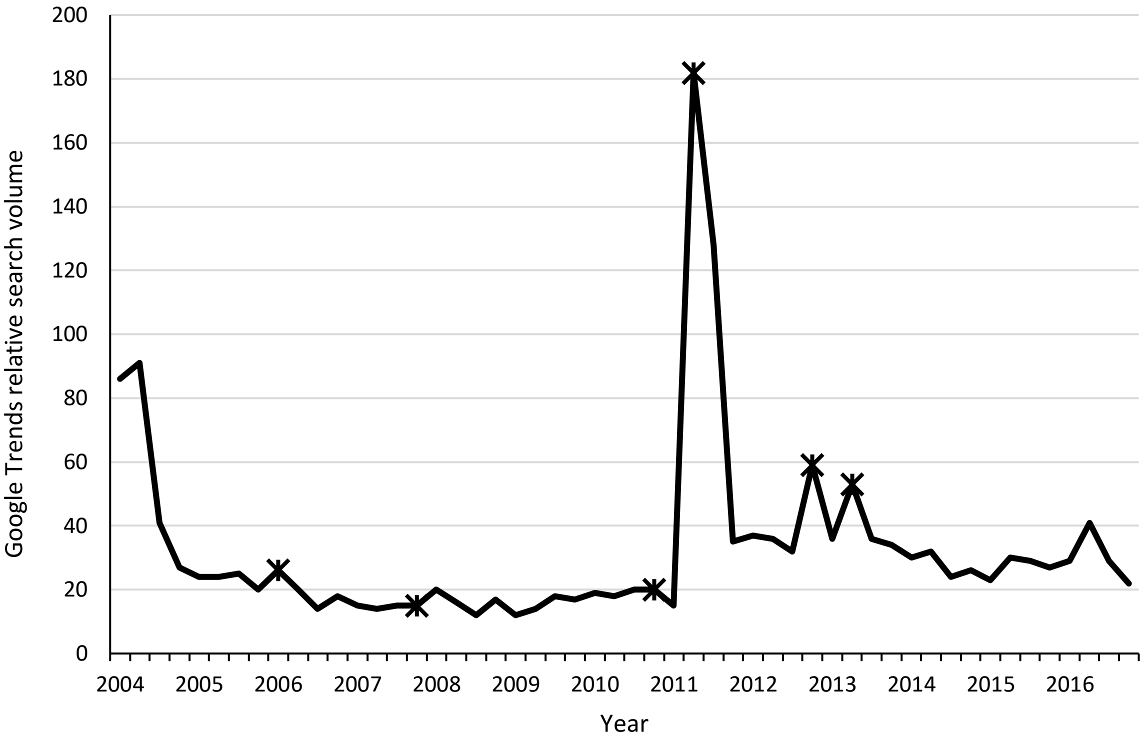
Researchers are adopting Google Trends as a tool for forecasting population behaviour. Studies have applied the tool in a myriad of ways across a range of fields. Preis, Moat and Stanley (2013) used Google Trends data to analyse stock market trading behaviour in the US and found that increases in search volumes for keywords relating to "financial market" precipitated stock market falls; Guzman (2011) investigated the use of Google Trends data as a predictor of real-time inflation; and, Samaras, García-Barriocanal and Sicilia (2012) showed that Google Trends could have been used to forecast the peak of scarlet fever in the UK five weeks prior to its arrival. Choi and Varian (2012) provide coverage of the diverse applications of Google Trends data. Further, in a review of the use of Google Trends in healthcare research, Nuti et al. (2014) report on the effectiveness of Google Trends as a research tool, and found that, when validated against trusted, external datasets, a large number of studies found moderate to strong associations with Google Trends search information.

This study adds to the literature in two useful ways. First, as the first study to empirically test for the impact of live export information on Australian meat demand, it will provide insight into the representative Australian consumer response to the live export trade. This should assist the meat industry develop targeted animal welfare policies and campaigns to enable better-informed meat purchasing decisions. Second, this is the first study to test the effectiveness of a demand shift index constructed using internet search data. This novel approach may provide a more relevant and contemporary method of capturing aggregate consumer response to potential non-price and non-income demand-shift variables going forward.

The Live Export Index

Google Trends keyword search volumes were used to construct a demand shift index as a proxy for consumer response to live export events and information over time. Google Trends provides a relative measure of search volume for the Google search engine (Google LLC, 2018). Data for the Live Export (LE) index were obtained by exporting from Google Trends monthly search volumes of keywords related to the Australian live export trade that occurred in Australia between 2004 and 2016. These search volumes were then linearly aggregated to construct the quarterly live export index plotted in Figure 1. Further documentation of the Google Trends search methodology, including key words and filters, is available in Appendix A.

Figure 1. Google Trends live export index 2004(1) – 2016(4)



* indicate the occurrence of a televised live export report

The most searched keyword used in the construction of the LE index during the study period was "live exports" in the second quarter of 2011. Google Trends normalised all other keyword search volumes relative to this search volume. This live export peak coincided with the televised documentary on the treatment of Australian cattle shipped live to Indonesia mentioned previously.

Breaking the LE index into its keyword components reveals high search volumes for both live cattle export and live sheep export events that have been captured under non-species-specific search terms such as "live exports". For this reason, an aggregated live export index is tested in this study, instead of a species-specific (cattle or sheep) index.

Earlier studies (Nocella, Hubbard and Scarpa, 2010; Piggott and Marsh, 2004; Tonsor and Marsh, 2007; Tonsor and Olynk, 2011; Tonsor and Wolf, 2011; Verbeke and Ward, 2001) assumed that publicly available information influences consumer perceptions of product quality, which in turn influences purchasing decisions. Further, they assumed media coverage relating to relevant meat information in popular press articles, scientific journals or televised news reports affected consumer perceptions of product quality. Similarly, this study assumes that consumer interest in the live export trade, measured by the number of times relevant keywords are searched using an internet search engine, affects consumer perceptions and definitions of product quality, and influences purchasing decisions. It is presumed that consumer interest in live export animal welfare is most unlikely to arise unprovoked. Rather, we assume that it has been triggered by mainstream media coverage of live exports, of which the only persistent focus (ever) has been related to animal welfare issues and this, in turn, triggers media search by people disturbed by the negative reports. It is further assumed that search is inversely related to perceived product quality (more or less deficient welfare (credence) attributes in the meat produced by Australian meat producers) and that consumers react accordingly. That is, concern for animals exported live causes consumers to purchase less of the meat type afflicted by the concern, meaning an inward shift of the demand curve.

The previously noted studies made no distinction between tone, severity, directional content (i.e. demand harming or demand improving), or source of the information used to construct their media indices. Similarly, this study makes no distinction between these factors. While tone, severity or directional content can be inherent in the search terms used, for example “animal cruelty” or “live export ban”, the LE index is constructed from the frequency of keywords searched in Google and does not capture the consumer’s motivation behind the search or the sites they visit as a consequence of the search. As such, the LE index serves as a proxy for consumer interest in LE events and information and not exposure to information that can be categorised as positive or negative in nature. It is presumed, given the nature of popular media events over the period, that published information surrounding live exports naturally attract more negative attention than positive. As such, the expectation is for a negative impact on consumer demand for lamb and beef due to their live trade. Specifically, an inward shift of the demand curve for lamb and beef is expected.

Consumer interest, initiated by any form of media or social event (television, press, social media or word of mouth) can be captured using the consumer’s search for further information via internet search engines. As such, the index incorporated into the model would reflect that portion of the population interested enough to seek further information on the relevant subject matter, as well as those with internet access. The assumption that this group within the population is more likely to act on their interest, by changing their meat consumption habits for example, would need validation. This method does, however, provide a modern and novel alternative to index construction. While newspapers and journal articles may be high in volume at times, they may go unread by the broader consumer base: media reach does not equate with exposure to specific media content. In contrast, search engine information provides a measure of interest from a motivated population.

Demand Model

A Generalised Almost Ideal Demand System (GAIDS) (Bollino, 1987) is estimated to capture the direct and indirect LE expenditure effects on Australian meat demand. This GAIDS model allows the LE index to be incorporated as a function of pre-committed quantities via a demographic translating procedure. Here, the pre-committed quantity represents the portion demanded of a good that is independent of price and income effects. Thus, the remaining supernumerary quantity represents the portion demanded that is dependent on price and income effects. By incorporating the LE index as a non-discretionary determinant, the demand system remains flexible, and consistent with economic theory. As per Piggott and Marsh (2004), the empirical model specification augments the pre-committed quantities defined by the standard GAIDS to depend linearly upon time variables and the LE index. When testing for the existence of pre-committed Australian meat demand, Tighe et al. (2019) found statistically significant pre-committed chicken demand existed only when tested jointly with seasonal and time trend variables. Following their finding, seasonal and time trend variables are included as demand shifters in the model. In contrast to the species-specific indices tested by Piggott and Marsh (2004), this study incorporates the LE index into the GAIDS as a single index.

This analysis follows the approach taken by Piggott and Marsh (2004) to incorporate non-traditional demand shifters into the GAIDS (Bollino, 1987), and extends the model specification investigated by Tighe et al. (2019), to derive the generalised demand function as

$$E(\mathbf{p},u) = E^0(\mathbf{p},\mathbf{C}) + E^*(\mathbf{p},u) = \mathbf{p}'\mathbf{C} + E^*(\mathbf{p},u), \qquad (1)$$

where $\mathbf{p}$ is a *N*-vector of prices, $\mathbf{C}$ an *N*-vector of pre-committed quantity parameters and u is utility. $E^0(\mathbf{p},\mathbf{C}) = \mathbf{p}'\mathbf{C}$ identifies the pre-committed portion of total expenditures and $E^*(\mathbf{p},u)$ is the remaining, or supernumerary expenditures, allocated across the *N* goods. Applying dual properties and Shepard's Lemma, the expenditure function

$$q_i^*(\mathbf{p},u) = C_i + q_i^*(\mathbf{p},u)$$

represents the pre-committed (C_i) and the supernumerary $q_i^*(\mathbf{p},u)$ quantities demanded of each good $q_i(\mathbf{p},u)$. The share form of the demand functions for the GAIDS are expressed as

$$w_i = \frac{C_i \times P_i}{M} + \left(\frac{M^*}{M}\right) \times \left[\alpha_i + \sum_{j=1}^{n} \gamma_{ij} \times \ln(p_i) + \beta_i \times \ln\left(\frac{\mathrm{M}^*}{\mathrm{P}}\right)\right], \qquad (2)$$

where

$$M^* = (M - \sum_{i=1}^{n} C_i \times P_i),$$

represents supernumerary expenditure, *M* denotes total expenditure and the non-linear price index vector is defined as

$$\ln(\mathrm{P}) = \delta + \sum_{j=1}^{n} \alpha_j \times \ln(p_j) + (1/2) \times \sum_{k=1}^{n} \sum_{j=1}^{n} \gamma_{kj} \times \ln(p_k) \times \ln(p_j), \qquad (3)$$

and total pre-committed expenditure is expressed as $\sum_{i=1}^{n} C_i \times P_i$.

As proposed by Alston, Chalfant, and Piggott (2001) and tested by Piggott and Marsh (2004), the intercepts of the GAIDS share equations are modified using a translating procedure to incorporate seasonal, time-trend, and demand shift components. This method specifies the pre-committed quantities (c_i's) as functions of the demand shifters. Incorporating the demand shift variables in this way maintains the desired theoretical properties of the GAIDS by ensuring the estimated economic effects remain invariant to units of measurement (Alston et al., 2001). No additional restrictions on the demand shift parameters are necessary. Modified to be functions of seasonal, time-trend, and the LE index, the pre-committed quantities are defined as

$$\widehat{C_i} = C_{i0} + \sum_{k=1}^{3} \theta_{ik} \times qt_k + \omega_i \times CHICK + \tau_i \times t + \varphi_i \times t^2 + \pi_i \times LE_t \qquad (4)$$

where the C_{i0} parameters to be estimated represent the pre-committed quantity of each good that is not influenced by the incorporated demand shift variables during the sample period; θ_{ik} are seasonality parameters for the respective quarterly dummy variables qt_k ; $\omega_i CHICK$ is a dummy variable equal to one for quarters 2010(2) through 2016(4) and zero for all other quarters. This dummy variable was included due to a series break in the chicken production data used in the calculation of per capita chicken consumption. This break was reported by the ABS (ABS, 2016b) and was also identified in this study and by Tighe et al. (2019) using breakpoint analysis. τ_i and φ_i are time trend parameters for the respective linear (t) and quadratic (t^2) terms; and π_i is the parameter to be estimated for the LE index, LE_t. The share form of the GAIDS that incorporates the demand shift variables can be expressed as

$$w_i = \frac{\hat{C}_i \times P_i}{M} + \left(\frac{M^*}{M}\right) \times \left[\alpha_i + \sum_{j=i}^{n} \gamma_{ij} \times \ln(p_i) + \beta_i \times \ln\left(\frac{M^*}{P}\right)\right], \quad (5)$$

where

$$M^* = \left(M - \sum_{i=1}^{n} \hat{C}_i \times P_i\right). \quad (6)$$

Theoretical demand restrictions can be imposed in the GAIDS using the same parameter restrictions as the AIDS (Deaton and Muellbauer, 1980): homogeneity is imposed by $\sum_{j=1}^{n} \gamma_{ij} = 0$; adding-up by $\sum_{i=1}^{n} \beta_i = 0$ and $\sum_{i=1}^{n} \alpha_i = 1$; and symmetry by $\gamma_{ij} = \gamma_{ji} \forall_i \neq_j$.

No adding up restrictions are imposed on the LE index across pre-committed quantities. That is, the LE index can have a positive or negative effect on each meat's pre-committed quantity. The only required restriction is that the sum of changes in expenditures on pre-committed quantities must be equal and opposite to changes in supernumerary expenditures, leaving total expenditures unchanged.

Data and Estimation Procedures

This study extends a recent model of Australian meat consumption (Tighe et al., 2019) and utilises the same quarterly Australian consumption and price series data for lamb, beef, chicken, and pork, for the period 2004(1)-2016(4) to estimate the GAIDS. The quantity variables shown in Table 1 correspond to quarterly per capita consumption in kilograms of carcase weight. Quarterly total apparent consumption data were provided by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) (ABARES, 2016), and divided by quarterly population statistics (ABS, 2016a) to form per capita consumption estimates. During the sample period, per capita consumption averaged 2.49, 7.64, 10.30, and 6.36 kg per quarter for lamb, beef, chicken and pork[1], respectively. Retail price estimates[2] were provided by the ABARES (ABARES, 2016) and deflated using the ABS food and beverage consumer price index (ABS, 2017) to form real price estimates.

Tighe et al. (2019) reported frequent structural change and high data variability as limitations of the Australian meat consumption and price dataset. Following Tighe et al. (2019), to ascertain the reliability and quality of the results from this analysis, checks for structural change within the consumption and price time series for the shorter time period utilised in this study were investigated for each meat using breakpoint analysis. The breakpoint analysis was undertaken in R version 3.3.3

[1] Includes processed and preserved meat.

[2] Price estimates are formed by indexing forward from actual average prices of beef, lamb and pork during December quarter 1973, based on meat subgroup indexes of the consumer price index. These indexes are based on average retail prices of selected cuts (weighted by expenditure) in state capitals.

(R Core Team, 2017) using the package 'strucchange' (Achim, Christian, Walter and Kurt, 2003; Achim, Friedrich, Kurt and Christian, 2002; R Core Team, 2017). Seven breakpoints were identified in the per person consumption time series, and seventeen in the meat price time series. This analysis was performed to help ascertain the reliability of model results.

Table 1. Summary statistics of quarterly data 2004(1)-2016(4)

Variable	Mean	Std dev.	Min.	Max.
Lamb consumption (kg per capita)	2.41	0.27	1.90	3.05
Beef consumption (kg per capita)	7.64	1.33	4.96	10.25
Chicken consumption (kg per capita)	10.30	1.21	8.44	12.51
Pork consumption (kg per capita)	6.36	0.52	5.44	7.58
Retail lamb price ($ per kg)	12.07	2.28	8.16	15.66
Retail beef price ($ per kg)	15.13	2.43	10.62	20.59
Retail chicken price ($ per kg)	5.07	0.63	3.99	5.83
Retail pork price ($ per kg)	10.21	1.78	6.65	13.04
Lamb expenditure share	0.11	0.01	0.09	0.13
Beef expenditure share	0.44	0.05	0.35	0.54
Chicken expenditure share	0.20	0.03	0.15	0.26
Pork expenditure share	0.25	0.03	0.19	0.32
Live export index (LE)	32.75	29.77	12.00	182.00

Sources: ABARES, 2017; ABS, 2017b; Google LLC, 2018; and own estimates

As per previous studies on aggregate meat demand by Australian consumers (Alston and Chalfant, 1991; Cashin, 1991; Griffith, I'Anson, Hill, Lubett and Vere, 2001; Martin and Porter, 1985; Mounter et al., 2012; Piggott et al., 1996) meat is treated as weakly separable, so that consumption of each meat depends only on group expenditure, meat prices, seasonal and time trends and potentially LE information. In this instance, the meat separability assumption constrains consumer interest in LE to have a net-zero impact on total meat demand. Effects of seasonality and time on meat demand are included in the models as quarterly and annual demand shift (binary) variables.

Models were estimated using iterative non-linear SUR estimation techniques in SAS/STAT software version 9.4 (SAS Institute Inc., 2015). Homogeneity and symmetry restrictions were imposed as a maintained hypothesis in all models. The singular nature of the share system requires one of the equations be deleted (pork) and the remaining equations estimated (lamb, beef, and chicken). The parameters of the pork equation were subsequently recovered using the imposed theoretical restrictions noted above. Correlation and collinearity coefficients for the LE index and model variables were calculated using the Correlation Analysis task and COLLIN option in SAS/STAT software version 9.4 (SAS Institute Inc., 2015).

Utilizing the same dataset over a longer time period (1996-2016), Tighe et al. (2019) reported that the inclusion of the time squared trend (t^2) was preferred in terms of model outcomes when compared with the inclusion of a chicken dummy variable ($\omega_i CHICK$). To determine the need for these variables in the final model specification for the shorter time period used in this study Bewley (1986) small-sample adjusted likelihood ratio tests were used to compare model outcomes with and without these variables at the 5 per cent significance level. These tests were also used to test the robustness of model results with and without the LE index. Following previous studies (Piggott et al., 1996; Piggott and Marsh, 2004; Tighe et al., 2019; Tonsor and Marsh, 2007) the preferred model was then estimated using three autocorrelation corrections (Berndt and Savin, 1975); a null matrix (N-R^{matrix}) wherein all elements of the R matrix are restricted to zero to specify no autocorrelation correction ($\rho_{ij} = 0\ \forall_{ij}$); a diagonal correction matrix (D-R^{matrix}) wherein all diagonal elements are restricted to be identical and all off-diagonal elements to be zero ($\rho_{ij} = 0\ \forall_{i \neq j}$ and $\rho_{ij} \neq 0\ \forall_{i=j}$); and a full correction matrix (F-R^{matrix}) wherein all elements are allowed to differ individually from zero ($\rho_{ij} \neq 0\ \forall_{ij}$). The Bewley (1986) adjusted likelihood ratio tests were calculated using:

$$LR_B = 2\ \times (LL^u - LL^r) \times [(MT - k^u)/MT] \quad (7)$$

where LR_B denotes the Bewley (1986) likelihood ratio test, LL^u (LL^r) is the maximum log likelihood value of the unrestricted (restricted) model, *M* is the number of estimated equations, *T* is the sample size and k^u is the number of parameters in the unrestricted model.

Price and expenditure elasticities for the preferred models were calculated as per Piggott and Marsh (2004) using the following formulas:

$$\eta_{ij} = -\delta_{ij} + \left(\frac{1}{Mw_i}\right)\left[c_i p_i (1 - w_i^*) + M^*\left(\gamma_{ij} - \beta_i\left\{\frac{C_i * p_i}{M^*} + \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \times \ln(p_j)\right\}\right)\right] \quad (8)$$

and

$$\eta_{iM} = 1 + \left[\frac{1}{M}(-c_i p_i + (M - M^*)w_i^*) + \beta_i\right]/w_i \quad (9)$$

where η_{ij} denotes the uncompensated (Marshallian) price elasticity for quantity *i* with respect to price *j*, δ_{ij} is the Kronecker delta ($-\delta_{ij} = 1$ for $i = j$, $\delta_{ij} = 0$ for $i \neq j$) and η_{iM} denotes the expenditure elasticity.

The compensated (Hicksian) price elasticities were calculated using the elasticity form of the Slutsky equation:

$$\varepsilon_{ij} = \eta_{ij} + w_j \eta_{i_M} \quad (10)$$

To test whether the curvature requirements of negative semi-definiteness of the Slutsky matrix holds globally, the elasticities were computed at every observation using the predicted expenditure shares to verify the percentage of observations that are non-positive.

As per Tighe et al. (2019), this study assumed 100 per cent of the predicted supernumerary quantities must be positive for correct model specification. Further, due to the inherent limitations of the dataset, model outcomes were assessed on statistical criteria (goodness-of-fit and likelihood ratio tests), as well as consistency with economic theory (Slutsky negative semi-definiteness, positive supernumerary quantities and, price and income elasticities). Thus, models were only deemed adequate if they met both statistical and economic criteria.

Due to the quarterly time step used in this study, any impact of the LE index on Australian meat demand is expected to be largely contemporaneous. Thus, a distributed lag effect was not investigated.

Following Piggott and Marsh (2004), uncompensated (Marshallian) demand responses to live export events and information are calculated for the direct and total effects on consumption. The direct effect measures the percentage change in the pre-committed quantity of the *i*th meat in response to a 1 per cent increase in the LE index, LE_t, alternatively, as $\varepsilon_i, LE_t = \partial ln\hat{c}_{i,t}/\partial lnLE_t$. Total effects account for both direct and indirect live export effects on meat consumption. The indirect effect comprises two components; a reallocation effect which captures the reallocation of pre-committed expenditures to supernumerary expenditures, and a supernumerary effect which captures the magnitude of the reallocation effect on supernumerary quantities. This total elasticity is calculated as a measure of the share-weighted sum of the direct and indirect elasticity as

$$\psi_{i,LE_t} = \frac{\partial lnx_{i,t}}{\partial lnLE_t} = \left(\frac{\partial ln\hat{c}_{i,t}}{\partial lnLE_t}\right)\left(\frac{\hat{c}_{i,t}}{x_{i,t}}\right) + \left(\frac{\partial lnx^*_{i,t}}{\partial lnM^*_t}\right)\left(\frac{\partial lnM^*_t}{\partial lnLE_t}\right)\left(\frac{x^*_{i,t}}{x_{i,t}}\right). \qquad (11)$$

Model Results

The intercept term (α_0) was not statistically different from zero across autocorrelation corrections and was removed from the final model specifications for parsimony. In contrast to the results reported by Tighe et al. (2019), Bewley test statistics indicated that the GAIDS should be rejected in favour of the GAIDS with the chicken dummy variable (*CHICK*) when estimated using the shorter sample period used in this study. Further, the chicken dummy variable co-efficient (ω_i) was found to be statistically significant across all model specifications and resulted in model outcomes that were compliant with the economic criteria previously stated. Model results from this specification with and without the LE index and no autocorrelation correction are consistent with results reported by Tighe et al. (2019) and identify statistically significant seasonal and time trend coefficient estimates, as well as pre-committed quantities of chicken (c_{c0}). A new result identified in this specification is the statistically significant pre-committed quantity of lamb (c_{s0}). Parameter estimates, standard errors, and test statistics from this model are presented in Appendix B.

Table 2 shows the Bewley likelihood ratio test results for the three alternative autocorrelation corrections for the GAIDS with (GAIDSLE) and without (GAIDS) the LE index.

Table 2. Bewley adjusted likelihood ratio tests for significance of autocorrelation corrections for the GAIDS and GAIDSLE

	H_0: N – R^{matrix} H_a: D – R^{matrix}	H_0: D – R^{matrix} H_a: F – R^{matrix}	H_0: N – R^{matrix} H_a: F – R^{matrix}
GAIDS	9.416	8.037	17.170
GAIDSLE	8.928	8.574	17.230
df	1	8	9
$\chi_{0.05,\ df}$	3.841	15.507	16.919

Notes: *df* denotes the degrees of freedom; $\chi_{0.05,\ df}$ is the Chi-square critical value of comparison; and * denotes statistical significance at the 0.05 level.

In both cases, the test statistics indicate that the null and full matrix corrections should be rejected in favour of the diagonal correction matrix. Low level correlation between the LE index and model variables was detected. Overall, as test results indicate in Table 3, the preferred model is the GAIDS without the LE index and corrected for autocorrelation with a diagonal R matrix.

Table 3. Bewley adjusted likelihood ratio tests for significance of the GAIDS and GAIDSLE

	H_0: GAIDS H_a: GAIDSLE
LR_B	1.153
df	4
$\chi_{0.05,\ df}$	9.488

Notes: LR_B denotes the Bewley (1986) likelihood ratio test; *df* denotes the degrees of freedom; $\chi_{0.05,\ df}$ is the Chi-square critical value of comparison; and * denotes statistical significance at the 0.05 level.

Table 4 shows the estimated coefficients, their standard errors, and the test statistics of the preferred GAIDS model, as well as the model with the LE index (GAIDSLE), both corrected for autocorrelation with a diagonal R matrix. The adjusted R^2 for the preferred model is 0.751 for the lamb equation, 0.953 for the beef equation, and, 0.974 for the chicken equation. Further, 75 per cent of observations meet the curvature requirements of negative semi-definiteness of the Slutsky matrix and 100 per cent of the supernumerary quantities estimated are positive. Combined, these measures indicate a reasonable model fit despite the structural changes present in the dataset.

Table 4. Estimated coefficients for the preferred GAIDS model and the GAIDSLE

GAIDS			GAIDSLE		
Parameter	Estimate	Std err	Parameter	Estimate	Std err
α_s	0.146***	0.038	α_s	0.145***	0.038
α_b	0.321**	0.151	α_b	0.313**	0.161
α_c	0.168***	0.055	α_c	0.173***	0.059
β_s	-0.011	0.007	β_s	-0.010	0.008
β_b	0.074**	0.034	β_b	0.075*	0.038
β_c	-0.027**	0.012	β_c	-0.029**	0.014
γ_{ss}	0.063***	0.017	γ_{ss}	0.066***	0.017
γ_{sb}	-0.058***	0.016	γ_{sb}	-0.062***	0.016
γ_{sc}	-0.005	0.004	γ_{sc}	-0.006	0.004
γ_{bb}	0.149***	0.044	γ_{bb}	0.153***	0.045

γ_{bc}	0.005	0.018	γ_{bc}	0.006	0.020
γ_{cc}	0.008	0.020	γ_{cc}	0.008	0.021
c_{s0}	1.508**	0.596	c_{s0}	1.486**	0.640
c_{b0}	2.389	2.599	c_{b0}	2.186	2.890
c_{c0}	7.466***	1.147	c_{c0}	7.340***	1.210
c_{p0}	2.756	1.763	c_{p0}	2.634	1.876
ϑ_{s1}	-1.824	1.191	ϑ_{s1}	-1.820	1.287
ϑ_{s2}	-1.662*	0.973	ϑ_{s2}	-1.553	1.023
ϑ_{s3}	-13.636	9.333	ϑ_{s3}	-13.079	9.770
ϑ_{b1}	-8.667	7.112	ϑ_{b1}	-8.390	7.531
ϑ_{b2}	-8.032	5.545	ϑ_{b2}	-7.274	5.721
ϑ_{b3}	-110.350	84.691	ϑ_{b3}	-99.398	80.662
ϑ_{c1}	-3.120*	1.585	ϑ_{c1}	-3.136*	1.663
ϑ_{c2}	-2.804**	1.374	ϑ_{c2}	-2.652*	1.401
ϑ_{c3}	-5.782	8.896	ϑ_{c3}	-5.482	8.875
ϑ_{p1}	-4.686	3.138	ϑ_{p1}	-4.644	3.307
ϑ_{p2}	-3.514	2.573	ϑ_{p2}	-3.249	2.634
ϑ_{p3}	-29.345	22.623	ϑ_{p3}	-27.492	22.783
τ_s	0.017	0.011	τ_s	0.017	0.012
τ_b	0.095*	0.054	τ_b	0.097	0.058
τ_c	-0.002	0.018	τ_c	$-0.2\text{x}10^{-4}$	0.019
τ_p	0.064**	0.030	τ_p	0.065**	0.031
ϕ_s	$-3.5\text{x}10^{-4}$*	$1.8\text{x}10^{-4}$	ϕ_s	$-3.5\text{x}10^{-4}$*	$1.9\text{x}10^{-4}$
ϕ_b	-0.002**	0.001	ϕ_b	-0.002**	0.001
ϕ_c	0.001**	$3.0\text{x}10^{-4}$	ϕ_c	0.001**	$3.1\text{x}10^{-4}$
ϕ_p	-0.001	$4.7\text{x}10^{-4}$	ϕ_p	-0.001	$4.8\text{x}10^{-4}$
ω_s	-0.151	0.135	ω_s	-0.142	0.138
ω_b	0.335	0.613	ω_b	0.285	0.629
ω_c	1.430***	0.222	ω_c	1.417***	0.227
ω_p	-0.019	0.327	ω_p	-0.005	0.338
π_s			π_s	$-2.1\text{x}10^{-4}$	0.002
π_b			π_b	0.003	0.009
π_c			π_c	0.001	0.002

π_p			π_p	0.47x10-4	0.004
P	0.342***	0.081	P	0.341***	0.083
Test statistics					
LL	584.039		LL	584.800	
R^2 lamb	0.751		R^2 lamb	0.758	
R^2 beef	0.953		R^2 beef	0.953	
R^2 chicken	0.974		R^2 chicken	0.973	
P_{NSD}	74.510		P_{NSD}	74.510	
P_{PSQ}	100		P_{PSQ}	100	

Notes: *, **, and *** denote statistical significance at the 10 per cent, 5 per cent and 1 per cent levels, respectively. P_{NSD} is the percentage of observations that comply with the curvature requirements of negative semi-definiteness of the Slutsky matrix. P_{PSQ} is the percentage of estimated positive supernumerary quantities.

The results for the preferred model in Table 4 indicate that a number of the coefficients are individually significant at the 10 per cent, 5 per cent or 1 per cent levels. Based on these results, the constant component of the pre-committed quantity of chicken (c_{c0}) is estimated to be 7.47 kilograms per person per quarter and the pre-committed quantity of lamb (c_{l0}) 1.51 kilograms per person per quarter. When compared with the sample mean, this estimate suggests that 72 per cent of total chicken consumption is routinely pre-committed by Australian consumers. This result is comparable with the 5.76 kilograms of pre-committed chicken consumption (60 per cent of total chicken consumption) reported by Tighe et al. (2019). Similarly, 63 per cent of lamb consumption is routinely pre-committed. These results imply that factors other than price, income, seasonality and time trends significantly impact underlying Australian consumer demand for chicken and lamb. The coefficient of the chicken dummy variable in the chicken equation is highly significant with a p-value less than 1 per cent, indicating the inclusion of the chicken dummy variable is necessary and correctly specified.

Results for the GAIDSLE specification are very similar to those of the preferred model. The estimated coefficients for the LE index (π_i), however, are not statistically significantly different from zero for all four demand equations. Despite the lack of significance, the direction of the LE effects are noteworthy for chicken and lamb in the presence of statistically significant pre-committed quantities for these meats. The positive coefficient for chicken implies that consumers increase chicken consumption in response to their search for information on live exports. In contrast, the negative coefficient for lamb implies consumers reduce lamb consumption in response to their search for information on live exports. While the results for the LE index are not statistically significant, their influence on chicken and lamb are consistent with expectations based on the prevalence of negative media attention surrounding the live export trade throughout the study period.

Estimated Economic Effects

Table 5 shows the estimated price and expenditure elasticities for the preferred GAIDS model. The uncompensated own-price elasticities of demand in the preferred model are estimated to be -0.403 for lamb, -0.817 for beef, -0.287 for chicken, and -0.443 for pork. There is some variation in both sign and magnitude of the chicken price elasticities when compared with those reported by Tighe et al. (2019). This is not an unexpected result due to the inclusion of the chicken dummy variable in the model specified in this study. Further, a direct comparison is difficult due to differences in model specifications, time periods and structural changes present in both datasets. With the exception of the larger value for chicken identified in this study, the expenditure elasticities are comparable when compared to those reported by Tighe et al. (2019).

Table 2. Estimated price and expenditure elasticities for the preferred model

	Lamb	Beef	Chicken	Pork
Uncompensated (Marshallian) price elasticities				
Lamb	-0.403	-0.198	-0.034	0.115
Beef	-0.421	-0.817	0.146	-0.244
Chicken	-0.183	-0.230	-0.287	-0.111
Pork	0.231	-0.374	-0.013	-0.443
Expenditure elasticities				
Expenditure elasticities	0.776	1.618	0.188	0.683

Price and expenditure elasticities for the LE model with diagonal R matrix demonstrate the soundness of the model specification and show that the inclusion of the LE index does not affect price and expenditure elasticities (Table 6). Also included in Table 6 are the direct (on pre-committed quantities demand) and total (on the total quantities demand) effects of the LE index on consumption to provide insight into the outcomes of the Google Trends LE index.

Table 3. Estimated price, expenditure and live export elasticities for the GAIDSLE model

	Lamb	Beef	Chicken	Pork
Uncompensated (Marshallian) price elasticities				
Lamb	-0.378	-0.203	-0.041	0.118
Beef	-0.457	-0.807	0.153	-0.251
Chicken	-0.201	-0.224	-0.285	-0.115
Pork	0.236	-0.372	-0.015	-0.445
Expenditure elasticities				
Expenditure	0.800	1.606	0.189	0.694
Live export effects				
Direct	0.031	-0.007	0.005	-0.002
Total LE effects	-0.008	0.004	0.001	-0.004

The direct elasticities measure the percentage change in the pre-committed quantity of the *i*th meat in response to a 1 per cent increase in the LE index. As such, direct effects provide an estimate of a true LE effect. The statistical significance of each of the direct LE elasticities can be inferred from the coefficient estimates (Piggott and Marsh, 2004) and are thus not statistically significant. This result is not surprising given two of the four meats were not found to have statistically significant pre-committed quantities. The direct elasticity for lamb indicates there would be a 0.031 per cent reduction in the pre-committed quantity of lamb consumption in response to a 1 per cent increase in the LE index. The direct elasticity for chicken indicates there would be a 0.005 per cent increase in the pre-committed quantity of chicken consumption in response to a 1 per cent increase in the LE index. Based on the mean pre-committed lamb quantity of 1.49 kilograms per person per quarter, this direct effect implies a decrease in pre-committed lamb consumption of 0.00005 kilograms per person per quarter. Alternatively, this represents an increase in the quantity of lamb demand that is determined by price and income. Similarly, based on the mean pre-committed quantity of chicken of 7.34 kilograms per person per quarter, the direct effect implies an increase of 0.0004 kilograms of pre-committed chicken consumption would occur as a result of a 1 per cent increase in the LE index.

The direct effects for beef and pork are negative and even smaller when compared with the direct effects for chicken and lamb. If pre-committed quantities existed for beef and pork, they would be less susceptible to the LE index when compared with chicken and lamb, and an increase in the index would result in a decline in pre-committed consumption of both meats.

The total lamb and chicken live export effects average -0.008 and 0.001, respectively.

Conclusions

This study investigated a novel method of demand shift index construction to test whether consumer attitude to the live export trade has impacted on lamb, beef, pork and chicken consumption in Australia over the past decade. Pre-committed quantities of lamb and chicken consumption were determined to exist, with consumers purchasing 1.51 and 7.47 kilograms per quarter per person, respectively. While the pre-committed demand for these meats was influenced by seasonal and time trends, it was not statistically significantly impacted by the LE index. This finding lends support to the notion that the majority of Australian consumers do not act on live export information when making their meat purchasing decisions. Rather, as results from this study indicate, price and income factors are more influential on consumer purchasing decisions when compared with their interest in animal welfare and the live export trade.

Weak economic modelling outcomes and specification difficulties encountered when using the Australian meat consumption and price dataset in this study, and reported by Tighe et al. (2019), highlight the importance of data quality and correct model specification. To account for the procedural break in the chicken consumption series, Tighe et al. (2019) reported an improvement in model outcomes with the inclusion of a time squared variable in the GAIDS when compared with the inclusion of a dummy variable. In the longer study period (1996-2016) employed in that work, the time squared trend was a suitable surrogate for the series break. In the shorter time period investigated here both the time squared variable and the chicken dummy variable were necessary inclusions for the model results to meet the economic criteria.

Further exploration of Google Trends search volumes, or alternative internet search engine data when available, as a means of contemporary index construction may improve model outcomes. For example, a species-specific farm animal welfare index may more appropriately capture the effects of consumer interest in live export and animal welfare concerns in the Australian context when compared with the single index used in this study. This method of index construction may also alleviate any questions around bias toward a particular meat species within the index and could be easily extended to alternative index topics such as consumer attitudes to meat advertising campaigns or organic farming practices.

A number of interesting extensions on this initial live export study exist for future work. These extensions were considered outside the scope of this first attempt at generating indices and trialling them with the Australian dataset and GAIDS. First, other factors that may influence Australian consumer meat demand may be correlated with live export events that are not explicitly controlled for in the present model should be investigated. This would involve a multi-staged study to first identify interacting factors, and then determine how to produce relevant indices for model input to control for the correlation. Second, weak separability is typically a maintained assumption in the estimation of aggregate meat demand systems. Testing the validity of this assumption in the live export model would be an interesting extension of this study. The live export model specified in this study forces at least one species to benefit from the live export index and at least one to be harmed. Given the dominance of live sheep and cattle searches within the index and the negative nature of media events relating to the live export trade, this condition on the live export index is fitting in the first assessment. This condition could be relaxed in future work to test the validity of these observations.

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Appendix A

Google Trends search parameters

On 31 July 2019 an extensive list of search terms related to the Australian live export trade were entered in Google Trends and the relative search volume of each term downloaded. Search volume data were restricted to Australia for the period 1 January 2004 to 31 December 2016 using the default ‘‘all category’’ query option. This period was used to capture the longest available time series.

Google Trends output does not convey absolute search volume, rather, it represents search interest relative to the search term with the highest search frequency for the specified parameters[3]. A group of five search terms can be input at any one time. As data for more than five search terms was needed to construct the live export index, the most frequently searched term related to the subject was determined. This term was included in each group of five search terms to ensure the data was equally scaled. For example, if at most 20% of searches in Australia between January 2004 and December 2016 were for “live exports”, it would be considered 100 and the other search terms for that index scaled to this term. When sufficient search volumes are available, Google Trends also provides a list of popular topics or queries related to the search terms entered. This allowed for thorough coverage of search terms relevant to the live export trade, and a robust index. A full list of the keywords used to construct the index are provided in Table 1.

In January 2008 Google Trends added a “news” category to the search options. Prior to this date only the “web” search category was available. The welfare index was constructed using relative “web” search volumes only between January 2004 and December 2016. The most frequently searched terms related to the Australian live export trade within the specified search parameters was “live export”. This term was included in each query to ensure the search volume was scaled consistently.

Summary of search parameters
Access Date: 31 July 2019, second access and download date was 1 October 2019 to check for consistency of the data over time
Time Period: 1 January 2004 – 31 December 2016 inclusive
Location: Australia
Query Category: “all categories” (default query option)
Query type: web search
Search Input: Table 1 (a) provides the list of search terms used to construct the LE index. Search volumes for the terms in section (b) were 0 relative to the term “live export”.

3 The exact analytical techniques used by Google Trends are proprietary. Information relating to how the search frequencies are adjusted and other aspects of the search tool are provided at www.googletrends.com.au

Table A1. Search terms and syntax used in the construction of the LE index

a. Relative search volumes included in the LE index
live export
ban live exports
live cattle export
live sheep export
live export australia
live export trade
cattle export indonesia
australian cattle indonesia
cattle export
sheep export
vietnam live export
indonesia live export
b. Search terms with zero relative search volume
australian sheep kuwait
live export kuwait
cormo incident
australian sheep saudi arabia
live export saudi arabia
live export cruelty
live export investigation
middle east live export
israel live export
cormo express sheep

*Search terms were entered as displayed.

Appendix B

Table B1. Estimated coefficients for the GAIDS with and without the LE index and no autocorrelation correction

GAIDS			GAIDS with LE index		
Parameter	Estimate	Std err	Parameter	Estimate	Std err
α_s	0.147***	0.037	α_s	0.135***	0.038
α_b	0.378**	0.152	α_b	0.369**	0.163
α_c	0.157**	0.061	α_c	0.167**	0.065
β_s	-0.010	0.008	β_s	-0.007	0.008
β_b	0.069*	0.036	β_b	0.067	0.040
β_c	-0.030**	0.014	β_c	-0.030*	0.016
γ_{ss}	0.070***	0.019	γ_{ss}	0.075***	0.019
γ_{sb}	-0.063***	0.018	γ_{sb}	-0.068***	0.017
γ_{sc}	-0.005	0.005	γ_{sc}	-0.007	0.006
γ_{bb}	0.143***	0.049	γ_{bb}	0.153***	0.049
γ_{bc}	0.014	0.021	γ_{bc}	0.011	0.022
γ_{cc}	-0.003	0.024	γ_{cc}	0.003	0.025
c_{s0}	1.416**	0.628	c_{s0}	1.376*	0.725
c_{b0}	1.949	3.037	c_{b0}	1.325	3.714
c_{c0}	7.585***	1.039	c_{c0}	7.276***	1.222
c_{p0}	2.958*	1.573	c_{p0}	2.627	1.845
ϑ_{s1}	-1.695	1.229	ϑ_{s1}	-1.733	1.383
ϑ_{s2}	-1.456	0.931	ϑ_{s2}	-1.603	1.156
ϑ_{s3}	-13.856	11.403	ϑ_{s3}	-13.465	11.405
ϑ_{b1}	-7.682	7.159	ϑ_{b1}	-7.957	7.985
ϑ_{b2}	-6.695	5.212	ϑ_{b2}	-7.727	6.503
ϑ_{b3}	-104.666	96.229	ϑ_{b3}	-94.605	86.528
ϑ_{c1}	-2.526*	1.373	ϑ_{c1}	-2.676	1.588
ϑ_{c2}	-2.171*	1.125	ϑ_{c2}	-2.437*	1.390
ϑ_{c3}	-0.800	9.189	ϑ_{c3}	-2.836	9.021
ϑ_{p1}	-3.711	2.811	ϑ_{p1}	-3.904	3.154
ϑ_{p2}	-2.493	2.143	ϑ_{p2}	-2.920	2.625
ϑ_{p3}	-26.088	23.645	ϑ_{p3}	-24.840	22.956
τ_s	0.024*	0.013	τ_s	0.022	0.015

τ_b	0.112	0.075	τ_b	0.114	0.083
τ_c	-0.005	0.014	τ_c	-0.003	0.016
τ_p	0.069**	0.029	τ_p	0.069**	0.032
ϕ_s	4.4 x 10-4**	2.1x10-4	ϕ_s	-3.9x10-4*	2.2x10-4
ϕ_b	-0.002*	0.001	ϕ_b	-0.002	0.001
ϕ_c	0.001**	2.3x10-4	ϕ_c	0.001**	2.5x10-4
ϕ_p	-0.001	4.6x10-4	ϕ_p	-5.0x10-4	4.9x10-4
ω_s	-0.195	0.154	ω_s	-0.207	0.161
ω_b	0.343	0.810	ω_b	0.200	0.862
ω_c	1.600***	0.192	ω_c	1.564***	0.204
ω_p	-0.146	0.330	ω_p	-0.159	0.352
π_s			π_s	0.001	0.001
π_b			π_b	0.006	0.007
π_c			π_c	0.001	0.001
π_p			π_p	0.003	0.003
Test statistics					
LL	577.961		LL	578.834	
R^2 lamb	0.7253		R^2 lamb	0.731	
R^2 beef	0.940		R^2 beef	0.942	
R^2 chicken	0.9734		R^2 chicken	0.973	
P_{NSD}	74.510		P_{NSD}	74.510	
P_{PSQ}	100		P_{PSQ}	100	

Notes: Numbers in parentheses are the estimated standard errors. *, **, and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. P_{NSD} is the percentage of observations that comply with the curvature requirements of negative semi-definiteness of the Slutsky matrix. P_{PSQ} is the percentage of estimated positive supernumerary quantities.