Disentangling Supply and Demand Shocks to Identify Changes in the Live Cattle's Market Structure Post Livestock Mandatory Price Reporting Act

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Introduction

In 1999, the U.S. Congress passed the Livestock Mandatory Price Reporting (LMPR) Act requiring meat packers that annually slaughter 125,000 cattle or more, to report transaction data that includes average prices paid to feeders.[1] The purpose of this provision was to facilitate the availability of open, transparent price information and provide livestock market participants with comparable levels of market information. Prior to this legislation, meat packers reported such transactions voluntarily to the U.S. Department of Agriculture (USDA). The LMPR Act was passed in response to concerns over price discovery (i.e. lack of available market price information), as well as market power at the meat packing level, given the increased concentration in the livestock industry and increased use of captive supplies (Koontz and Ward, 2011). In particular, the national four-firm concentration ratio for steer and heifer slaughter - an indicator of industry concentration - increased from 25 percent in 1976 to 85 percent in 2012; rising further than prior to 2010, where concentration had remained at around 81 percent since the mid-1990s (USDA Grain Inspection, Packers and Stockyards Administration, 2013). This legislation has been subject to several sunset provisions, with the last one taking place in 2015. However, in September 2015 the act was again renewed through 2020, creating new debate and interest about the effects of the LMPR Act in cattle markets.

In the past decade, the effectiveness of the LMPR Act has been a largely debated public policy issue. One matter of controversy surrounding this policy has evolved around concerns that packers may use the additional information gathered from the act to collude and exercise market power at the expense of feeders. This was indicated in an earlier study by Wachenheim

[1] The LMPR Act also applied to swine and lamb markets. This paper addresses the effects on cattle markets, leaving other markets for future study.

and DeVuyst (2001), referencing specific empirical cases of markets where pricing information became openly available (e.g. airlines and long-distance telephone services). Conversely, Azzam (2003) developed a theoretical model and finds that lower levels of market information uncertainty - as a consequence of additional availability due to the LMPR act - may derive in higher competition among packers. Njoroge (2003) develops a theoretical model that assumes meat packers have asymmetric prior information of livestock prices, which after LMPR implementation may lead to promoting collusive behavior. However, an empirical study done by Azzam and Salvador (2004) of five different regional markets, find statistical evidence of non-collusive behavior for at least one of the five markets and the rest being inconclusive. More recently Cai et al. (2011) find evidence of packers attaining higher market power after the LMPR act. They use a long data set for pre and post LMPR periods, and mention the plausibility that factors other than the LMPR act could have an effect on the meatpackers' increased market power. Boyer and Brorsen (2013) explore the potential change in market power exerted by beef packers utilizing an agent-based auction structure for cattle purchases. They find that cattle feeders benefit from the LMPR policy, irrespective of the decreasing price uncertainty for packers and/or feeders. As may be noted from these studies, the literature is still mixed in this regard.

A different venue investigating welfare effects resulting from the availability of new market information is studied by Njoroge et al. (2007). They incorporate in their model the notion of collusion by meat packers and examine two possible cases. The first case considers that the (lower) risk effect from increased market transparency dominates the ensuing colluding effect among meat packers, resulting in greater livestock procurement and thus gains not only for packers but also for feeders. The second case considers the collusive effect from market transparency being dominant over the (lower) risk effect, resulting primarily in an increase of meat packer's market

power in detriment of livestock purchases. For either of the two cases examined, their findings are that overall social welfare increases with the LMPR act. Perry et al. (2005) study captive supply aspects regarding the act and also address price volatility pre and post implementation of the policy. They find that price volatility actually increases after the act is implemented. Koontz and Ward (2011) note that this increased volatility may respond to 'filtered observations' considered in the voluntary program prior to LMPR, thus leaving out maximum or minimum values which post LMPR may amplify the variability of prices. In addition, Fausti et al. (2010) study the premiums and discounts that are priced into the fed cattle marketed as beef (i.e. grid pricing of beef carcasses). They find that after the LMPR act, the variations in premiums and discounts were significantly higher and conclude that LMPR increased the dispersion of information regarding beef carcass prices as well as improved price transparency.

A study investigating spatial market integration among the five largest regional cattle-feeding states (Colorado, Iowa-Southern Minnesota, Kansas, Nebraska, and Texas-Oklahoma) was conducted by Pendell and Schroeder (2006). They find an increase in market integration among these five states following the implementation of LMPR. Conversely, Fausti et al. (2007) compare South Dakota fed cattle markets under LMPR (from prior State legislation) to Nebraska prices having voluntary price reporting, and arrive at the conclusion that MPR had no effect on spatial market integration for the former case.

As such, researchers have focused on evaluating the economic and policy implications of LMPR in the context of market power, market efficiency, price discovery, and market integration post LMPR Act (Mathews, et al., 2015); however, as noted by Koontz and Ward (2011), much research is still necessary. I.e. little evidence is available regarding how this provision has affected the live cattle market structure. More specifically, changes in supply and demand dynamics. This

study is intended to fill this gap in the literature.

The objective of this study is to identify potential changes in the supply and demand structure of the U.S. live cattle market after passage of the LMPR Act. More specifically, we aim to determine and compare supply and demand elasticities pre and post LMPR Act periods. For this purpose, we propose a novel approach based on Kilian (2009) who studies the structure of the crude oil market by fundamentally partitioning elements - that impact this crude oil market - in terms of supply and demand factors. Specifically, the author structurally decomposes the real price of crude oil into three components – one representing crude oil supply, another characterizing global demand of all industrial commodities and a third depicting the specific demand to the crude oil market. This enables to separate the indirect effect of global demand shocks on oil prices, distinguishing changes in the latter due solely to its particular demand shocks.

We use monthly time series data from 1992 to 2015 of live cattle slaughtered (quantity demanded), cattle on placement (quantity supplied), and real price of live cattle; and estimate a structural vector autoregression (SVAR) model for each pre and post LMPR period. This allows us to determine supply and demand shocks in the live cattle market. Identification of these shocks is important not only for explaining fluctuations in the real price of live cattle, but also for understanding the effects of LMRP on the live cattle market structure - through calculation of demand and supply elasticities. These elasticities are computed using results from the impulse response functions, conducted via Monte Carlo integration. The advantage of using this semiparametric approach is that there is no need to impose functional forms to estimate supply and demand equations. Moreover, this approach allows us to determine supply and demand elasticities for both the short and long run.

As may be anticipated, we find differences in supply and demand elasticities of the U.S.

live cattle market after the implementation of the LMPR Act. Our results have important implications for the cattle feed and beef packing industries. First, understanding changes in the live cattle market structure is conducive to evaluating market efficiency. I.e., determining how quickly and completely the market forces of supply and demand converge after a shock to the real price of live cattle, enables to infer the level of existing efficiency in the market. Second, elasticity estimates may be used to conduct welfare analysis, particularly at the cattle feeder level. Finally, estimates of supply elasticities for cattle feeding can be used to measure the degree of oligopsony power at the beef packing level. Thus results from this study provide insightful market information for policy makers.

The paper proceeds with a description of the methodology applied, estimation results along with discussion and concluding remarks.

Methods

We employ a multivariate VAR model in levels to examine the relationship between supply, demand and real price of cattle. Denote the supply, the demand and real price of live cattle in month t by S_t, D_t and P_t, respectively. In order to examine structural relationships between model variables, one has to recover the structural parameters, which implies imposing model restrictions. For this project the structural VAR model was identified using a sign restrictions approach with penalty function, in the spirit of Uhlig (2005). The advantage of this approach is that one can impose sign restrictions not only on the contemporaneous effects matrix, which is the most common way of identifying SVAR models, but also on the impulse responses several periods after the shock. Below we briefly discuss the procedure used. For more detailed analysis we refer the reader to Uhlig (2005). We start with the following reduced from VAR model:

$$y_t = A_o + \sum_{j=1}^{6} A_j y_{t-j} + e_t \qquad (1)$$

where $y_t = (S_t, D_t, P_t)$, $A_j \ j = 1, \ldots, 6$ are the reduced form coefficients, and $e_t \sim (0, \Sigma)$ are the reduced form residuals which are uncorrelated with the variables in period $t - 1$and earlier. The lag length ($p = 6$) was chosen to be consistent with the literature in order to avoid the problems associated with overfitting (Baumeister and Kilian, 2015). We assume that e_t is related to the fundamental underlying shocks according to $e_t = B\varepsilon_t$. We can rewrite (1) in terms of the structural shocks by pre-multiplying by B^{-1}.

$$B^{-1}y_t = B^{-1}A_o + \sum_{j=1}^{6} B^{-1}A_j y_{t-j} + \varepsilon_t$$

where $\varepsilon_t = Be_t$ are the mean zero structural shocks with unit variance.

$$\Sigma = B(e_t e_t') = BE(\varepsilon_t \varepsilon_t')B' = BB' \qquad (2)$$

Equation (2) shows that if one were to just identify the model, one must impose $n(n-1)/2$ number of restrictions. There are several ways to recover structural shocks, short run, long run and sign restrictions. Short run restrictions are imposed on the impact matrix B and the behavior of impulse response functions (IRF) depends on how the restrictions are placed. Sign restrictions, on the other hand, allow the researcher to "throw out all impulse responses inconsistent with some given set of theories, some of which are at odds with the conventional wisdom." (Uhlig, 2005).

For this project, we assume that price of cattle reacts positively to a price shock 6 through12 periods after the shock. Similarly, supply is positively affected in the months 6 through 12 after the orthogonal price shock, while demand is negatively affected in the same periods. This identification scheme leaves the behavior of variables in the first 5 months after the shock unrestricted, which would not be possible to implement if one were to use short run and long run restrictions.

One drawback of using pure sign restrictions to draw inferences about the model is that all impulse response vectors that satisfy sign restrictions are considered equally likely. To tackle this problem, Uhlig proposes a penalty function approach, which, unlike pure sign restrictions that is based on the acceptance and rejection of IRF draws, is based on finding an impulse vector that comes as close as possible to satisfying sign restrictions. This approach is based on minimizing an asymmetric function that penalizes sign restriction violations. (Danne, 2015).

Empirical Results

The data used in this analysis corresponds to supply, demand and real price of live cattle. Supply is specified as the number of steers and heifers placed on feed, lagged six months (1,000 head, 7 States Total). Demand is estimated by subtracting the number of steer and heifer imports from commercial steers and heifers slaughter (1,000 head). The live cattle price is estimated as the weighted average of steer and heifer 5-Area prices ($/cwt), and was adjusted for inflation using the consumer price index. These data were obtained from the Livestock Marketing Information Center.

Four different periods, using monthly data, were estimated via a Bayesian SVAR model. As mentioned previously, the first period considered was from July 1992 to April 2001; i.e.

sample1, which is prior to LMPR implementation. The three estimated post LMPR periods are designated as sample2 considering data from May 2001 to April 2006; sample3 for data from May 2001 to April 2011, and sample4 which includes data from May 2001 to December 2015.

The three estimated post LMPR periods enable to compare how the elasticities of supply and demand have evolved through time. For IRF calculations, shocks were applied by imposing an economic sign restriction. Specifically, a positive shock was applied to real price of live cattle and it is restricted to an increase in supply and a decrease in demand.

The IRFs are in Figures 1, 2, 3 and 4 for sample1, sample2, sample3 and sample4, respectively. The results from shocks applied are in terms of percentage changes. Moreover, the resulting impulse responses are accompanied by their respective error band. In Figure 1, prior to LMPR implementation, a shock to real price of live cattle produces a sharp increase in quantity supplied in the order of four percent; however, after approximately two months this increase in supply has dwindled to zero. The shock's result in demand is insignificant during the first months, and then after six to seven months shows a steady decrease in demand in the order of 0.2 percent.

Following the LMPR implementation, Figure 2 illustrates IRFs for the briefest estimated period and shows that there is no significant increase in supply from a shock to real prices of live cattle. This is in contrast to a resulting decrease in demand ranging in the order of 0.5 to one percent, after seven months until a year and a half later - where it becomes insignificant. Shocks for the second and longer estimated post LMPR period are in Figure 3 and the results again show no significant change for supply. However, a resulting significant drop in demand is observed in a smaller order of 0.2 to 0.4 percentage - which occurs for a longer period beginning after eight months until 24 months. Shocks applied for the last and longest post MPR estimated period – Figure 4 - result again in a non-significant change in quantity supplied; conversely, the quantity

demanded decreases steadily from 0.2 percent after six months to 0.6 percent after a year and a half; i.e. this decrease is permanent.

Contrasting these results, we observe that prior to LMPR implementation an increase in real prices of live cattle resulted in a significant, albeit, brief period of response in the increase of supply. This effect is no longer observed after LMPR implementation. Moreover, prior to LMPR implementation, there is a permanent though small decrease in demand to a shock in real prices, observed after five months. This declining demand effect is larger after LMPR implementation, though it is not permanent except for the last/longest period estimated.

The elasticities for supply and demand during each estimated period are obtained by dividing the resulting respective IRF by the price. The supply elasticities – which are inelastic - become a bit more inelastic post LMPR implementation, as can be observed from Figures 5b, 5c and 5d in comparison to prior LMPR period as shown in Figure 5a. In contrast, the demand elasticities – again inelastic - seem to become just a bit more elastic for the first estimated post LMPR period as shown in Figures 6a and 6b, respectively. This however subsides for the longer estimated periods, where the elasticities seem to revert to rates similar to the period prior LMPR implementation.

Conclusions

There have been numerous studies investigating and evaluating economic and policy implications of LMPR act in the context of market power, market efficiency, price discovery, and market integration among others. However, up to date little evidence is available regarding how this provision has affected the live cattle market structure. More specifically, changes in supply and demand dynamics. This study intends to fill this gap in the literature.

This paper has sought to identify potential changes in the supply and demand structure of the U.S. live cattle market after passage of the LMPR Act. More specifically, we determine and compare supply and demand elasticities for periods of pre and post implementation of the LMPR Act. For this purpose, we apply a novel approach based on Kilian (2009) to study the structure of the U.S. live cattle market by fundamentally partitioning elements in terms of supply and demand factors. We use monthly time series data from 1992 to 2015 of live cattle slaughtered to represent quantity demanded, cattle on placement to represent quantity supplied, and real price of live cattle. We estimate a Bayesian structural vector autoregression (SVAR) model for each pre and post LMPR period and for the post LMPR period we estimate three different periods; i.e. from May 2001 to April 2006, from May 2001 to April 2011, and from May 2001 to December 2015. Thus we account for any variations that may have occurred through time.

Estimated results of IRFs determine that prior to LMPR implementation, an increase in real prices of live cattle resulted in a significant, albeit brief period of response in the increase of supply. This effect is no longer observed after LMPR implementation. I.e., there is no significant change in supply from an increase in price. Moreover, prior to LMPR implementation, there is a permanent though small decrease in demand in response to a shock in real prices – which is observed after five months. This declining demand effect is determined to be larger after LMPR implementation, though it is not permanent except for the last/longest period estimated.

The supply elasticities – which are inelastic - become a bit more inelastic post LMPR implementation, in comparison to prior LMPR period. In contrast, the demand elasticities – again inelastic - seem to become just a bit more elastic for the first estimated post LMPR period. This effect however subsides for the longer estimated periods where the elasticities seem to revert to rates similar to the period prior LMPR.

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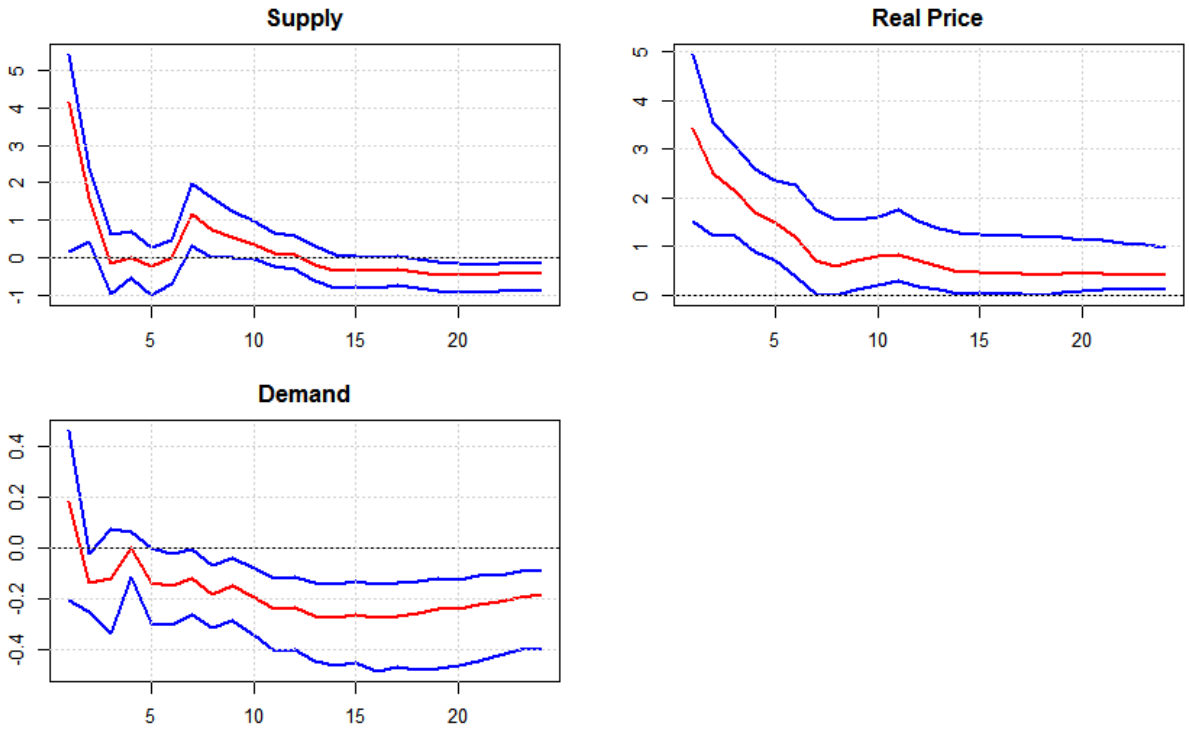


Figure 1. Impulse Response Functions of Supply, Demand and Real Price of Live Cattle following a One-Standard Deviation Shock to the Price of Live Cattle during period Pre-LMPR (July 1992 – April 2001)

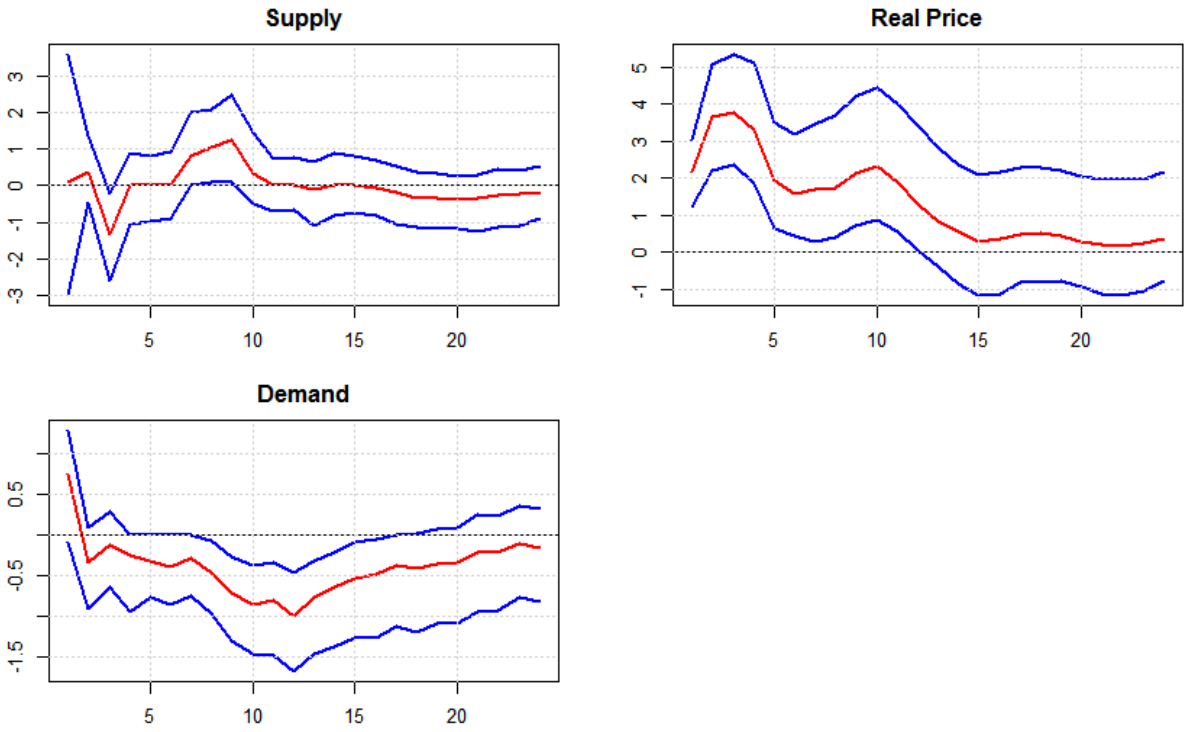


Figure 2. Impulse Response Functions of Supply, Demand and Real Price of Live Cattle following a One-Standard Deviation Shock to the Price of Live Cattle during period Post-LMPR (May 2001 – April 2006)

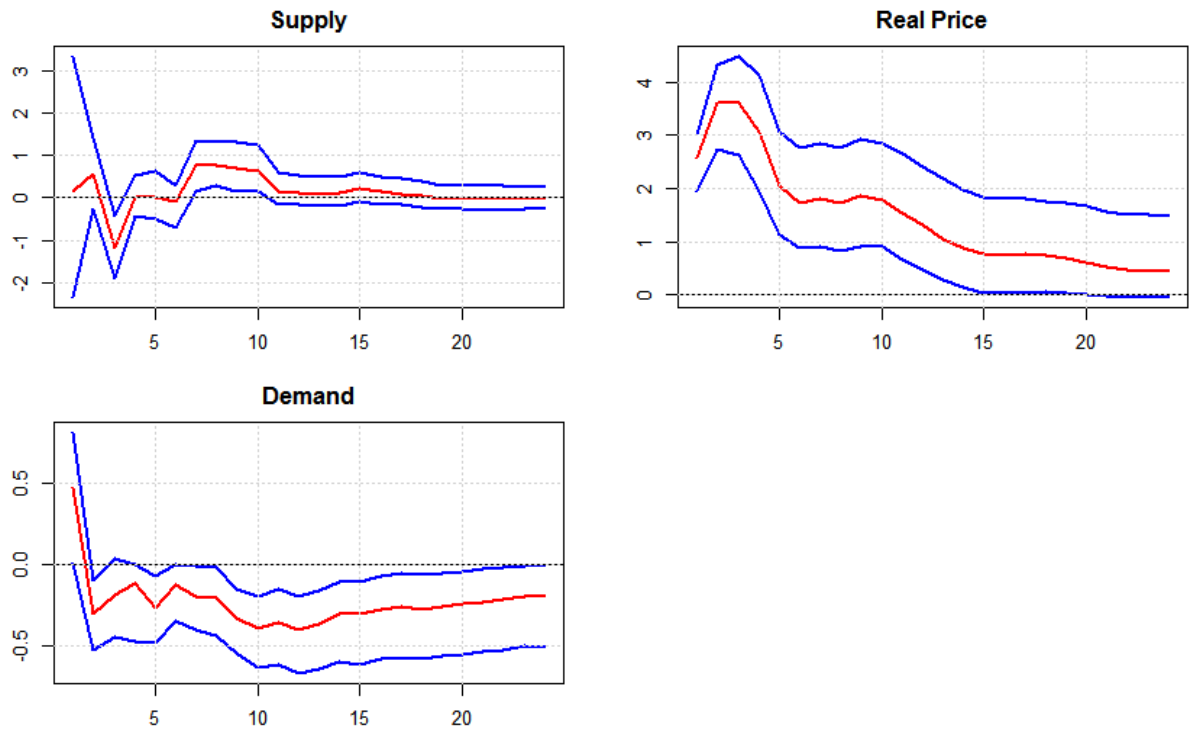


Figure 3. Impulse Response Functions of Supply, Demand and Real Price of Live Cattle following a One-Standard Deviation Shock to the Price of Live Cattle during period Post-LMPR (May 2001 – April 2011)

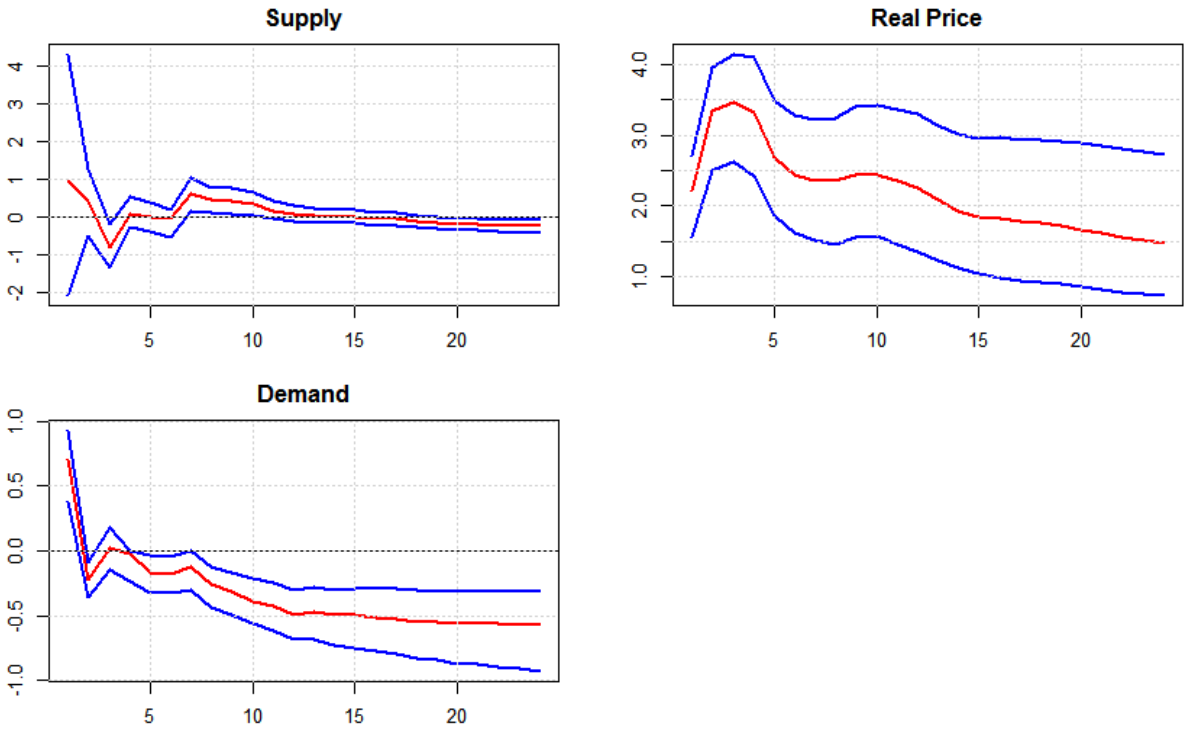
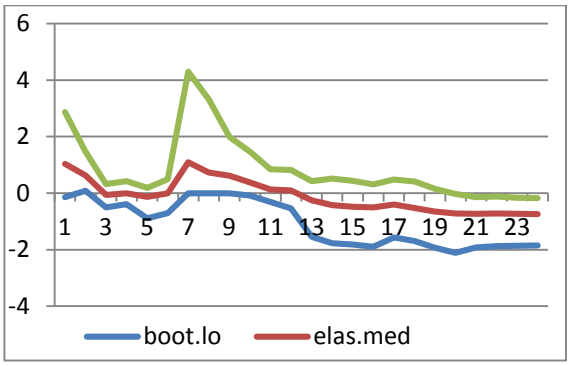
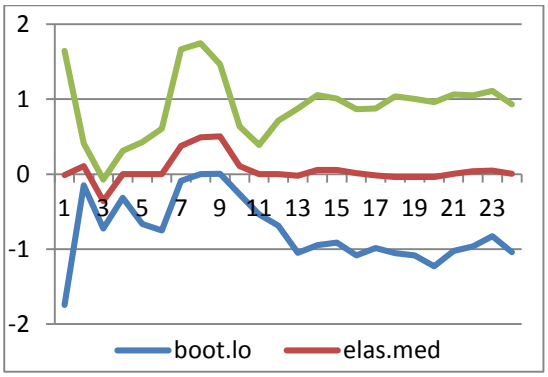


Figure 4. Impulse Response Functions of Supply, Demand and Real Price of Live Cattle following a One-Standard Deviation Shock to the Price of Live Cattle during period Post-LMPR (May 2001 – April 2015)



5(a)



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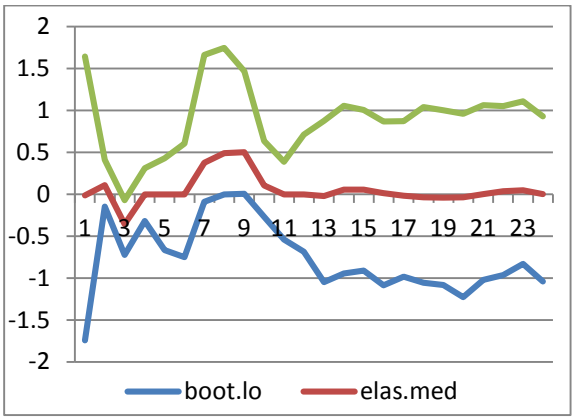
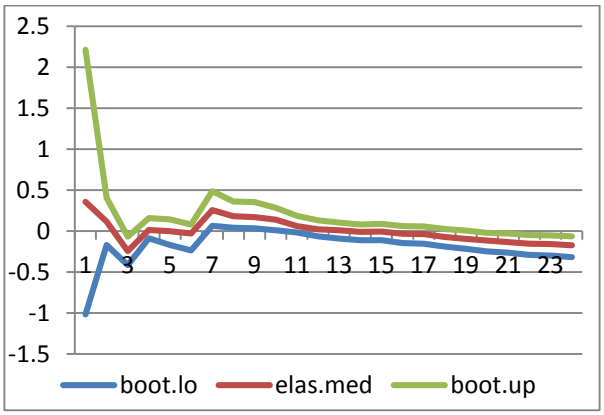
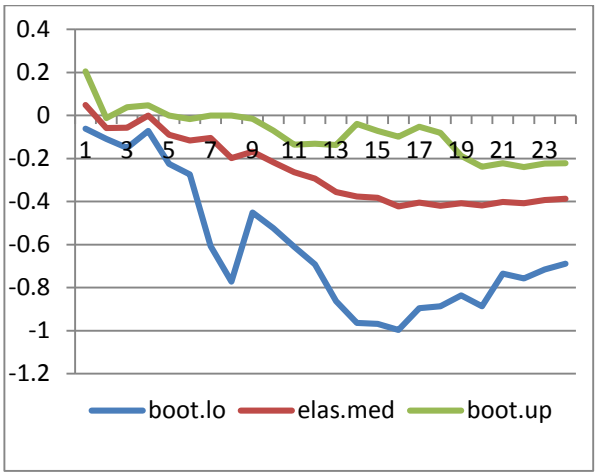


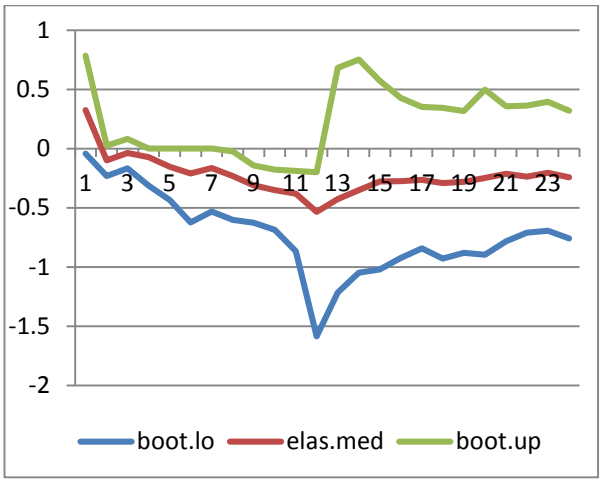
5(c)



5(d)

Figure 5. Estimated Supply Elasticities





6(a) 6(b)

Figure 6. Estimated Demand Elasticities